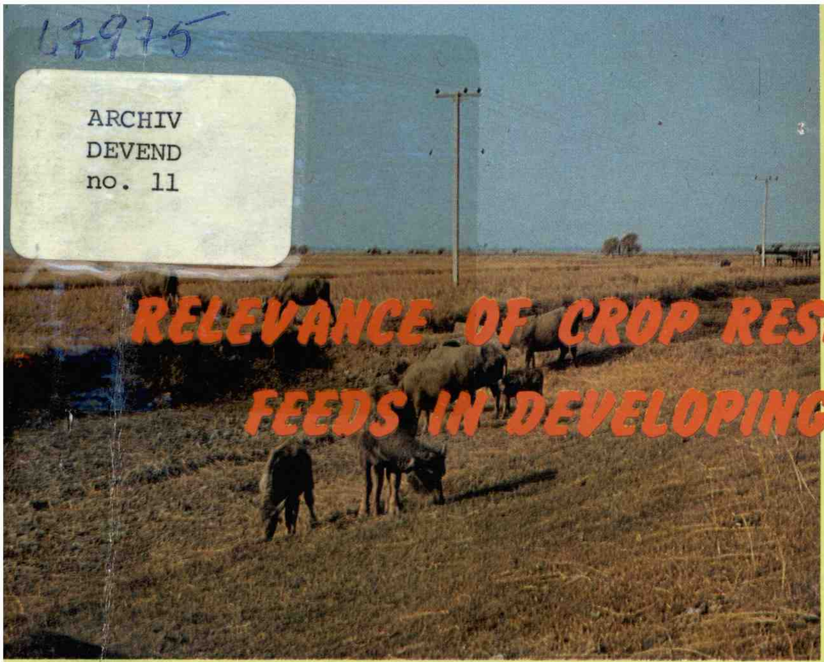
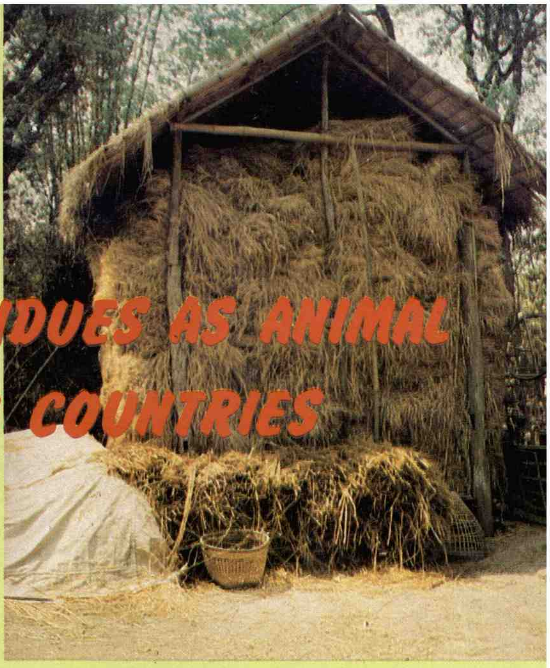
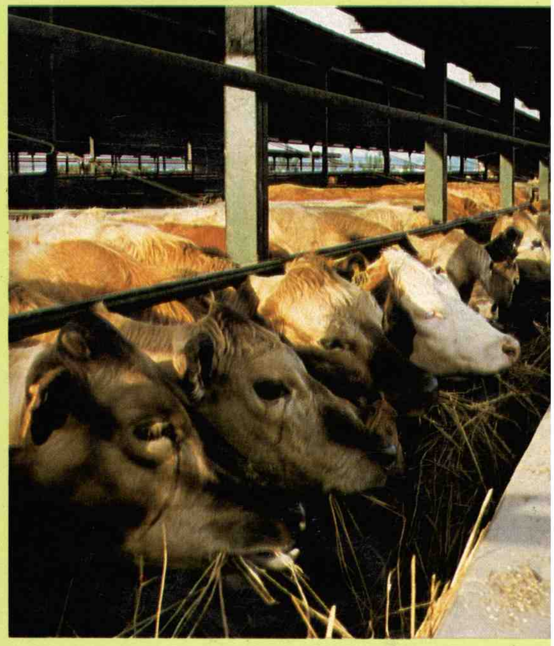
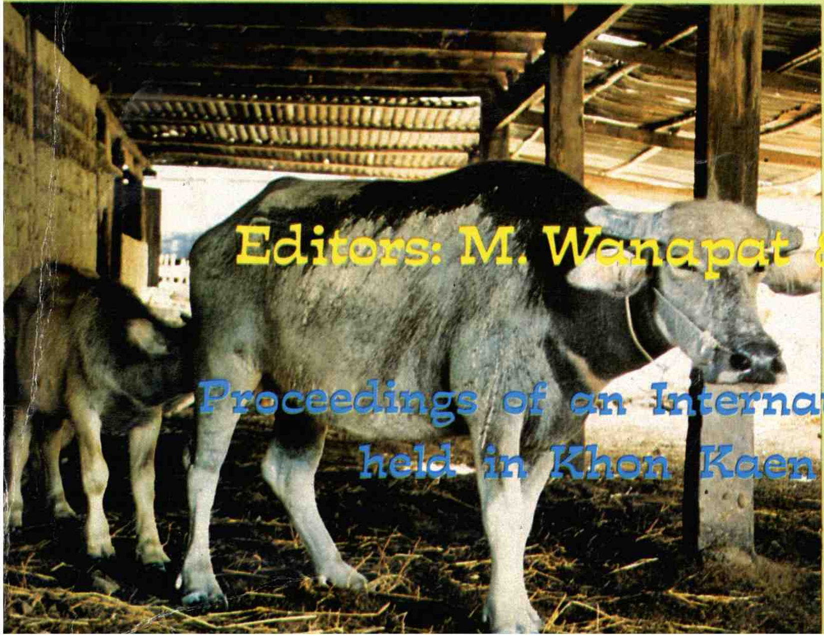
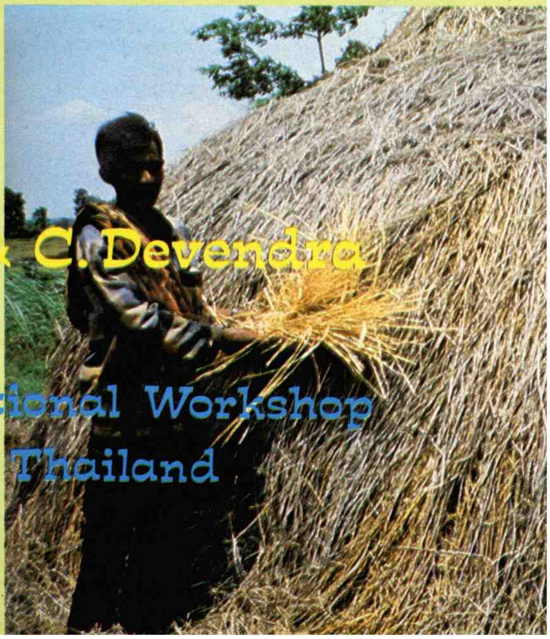
RELEVANCE OF CROP RESIDUES AS ANIMAL FEEDS IN DEVELOPING COUNTRIES



Editors: M. Wanapat & C. Devendra

Proceedings of an International Workshop held in Khon Kaen Thailand

RELEVANCE OF CROP RESIDUES AS ANIMAL FEEDS IN DEVELOPING COUNTRIES

Proceedings of an international workshop held in Khon Kaen, Thailand
November 29-December 2, 1984

Edited by

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FOREWORD

In recent years several Workshops have been held on various aspects of crop residues utilization in developing countries, principally dealing with characteristics and types of crop residues and, particularly, the utilization by ruminants, noticeably, buffaloes, cattle, goats and sheep.

However, no meeting focused on the relevance of the research work that have been conducted, especially in regard to their application in real farm situation and the extent to which the technology that has been gathered hitherto can be extended to other parts of the region. It was with these broad objectives in view and consciousness of the benefits of how such a workshop will bring to animal nutritionists, researchers and all those concerned with extension that the International Foundation for Science (IFS) willingly and wholeheartedly supported this workshop. It was held at Khon Kaen University, Thailand during November 29-December 2, 1984. The workshop was attended by approximately 140 participants from 18 countries and turned out to be a very fruitful one with the dissemination and discussion of various aspects concerned with crop residues and their utilization as animal feeds.

This Proceedings is the product of the collective efforts contributed by numerous researchers. It embodies the papers presented and a set of important recommendations based on the discussion. I wish to thank the efforts of the two editors, Drs. Metha Wanapat and C. Devendra, for making this publication available. Moreover, I would like to take this opportunity to thank all the committee members who had devoted their time and efforts to the successful arrangements of this Workshop.

Kavi Chutikul

(Dr. Kavi Chutikul)
Dean, Faculty of Agriculture,
Khon Kaen University
Chairman, the Organizing Committee of the Workshop

Opening Address by Dr. B.K. Soni, FAO/APHCA, Bangkok :
Mr. Thanom Charnuwong, Deputy Governor of Khon Kaen;
Dr. Nopadol Tongsopit, Rector of Khon Kaen University;
Ladies and Gentlemen :

I consider it as a great honour to be invited to give an opening address at the International Workshop on Relevance of Crop Residues Utilization as Animal Feeds in Developing Countries organised by the Khon Kaen University and International Foundation for Science (IFS).

The Khon Kaen University has the unique distinction of being leader not only in the academic field but also in research and extension for Northeast of Thailand. The Faculty of Agriculture, though small, has been conducting problem oriented research to meet the needs of the small, poverty stricken farmers of this areas. I am glad that International Foundation of Science has also been supporting the staff in the effort. Some of us who have been associated with this Foundation, know that IFS Research Grants are given to individual scientists from developing countries and working in the Universities or Research Institutions in developing countries. These grants though small as far as international grants are concerned, have been very popular with scientists in the developing countries. The whole amount is available to the scientists for much needed chemicals and small equipments. In some cases these are the missing links in the facilities at otherwise well endowed Universities or Research Institutions.

Workshops such as the one we are attending here is another important support provided by IFS. Regional Workshops on subjects like utilization of crop residues not only highlight the research work done by the grantees but also provide from for discussion and thus help in identifying areas for international collaboration.

The Asia and the Pacific is a region having a population which is more than half the world population (56%) and two thirds (70%) of world's farming households. The problems of this region are therefore problems of half of the world. I have therefore thought it fit to share with you my views on Regional Strategies for Improving the Utilization of Crop Residues as Animal Feeds.

Farm animals in this region as well in developing countries of other regions are actually "extenders" of food supplies. They are generally fed materials which otherwise would not be consumed by humans. Ruminant animals harvest grasses and other forage materials and convert them into meat or milk for human consumption. Livestock raising offers the farmers opportunity of utilizing labour year round, of spreading their risk between crop production and livestock production, of making use of grass and farm waste and unproductive land which otherwise have no alternate use.

It has been estimated that annual world production of straw and stovers is approximately 2,000 million tons. In the tropical countries, large portion of it is used to feed livestock. This is actually most efficient use of straw. In the countries which use it as bedding for livestock or plough it down or burn it, are actually wasting a large amount of scarce energy. The ruminants however,have their own limitation in utilizing the straw and other crop residues.

Over a considerable number of years, the FAO has emphasized the need to improve the utilization of poor quality roughage. In November 1976, a Technical Consultation was organized by FAO in Rome on New Feed Resources. This Consultation devoted most of its time to the improved utilization of poor quality roughages and other agro-industrial by-products. It was noted that a number of methods of treating straws to improve their feeding value have been developed and that wide spread application of their methods could substantially increase effective feed resources. As a follow-up Dr. M.G. Jackson was requested to make an assessment of the feasibility of straw treatment from both technical and economic points of view. His report was published as FAO Animal Production and Health Paper No. 10 entitled "Treating Straw for Animal Feeding". Since then the emphasis has been to train the trainers in utilization of straw in countries in this region. FAO Regional Animal Production and Health Commission for Asia, the Far East and the South-West Pacific (APHCA) has been providing lead in arranging these training courses. National training course on "Treatment and Utilization of Straw for Animal Feeding under Small Farm Conditions" were conducted during 1984 in Sri Lanka, Bangladesh, Thailand and Bhutan. Similar training courses have been planned for 1985 in other countries of the region. FAO Regional Dairy Development and Training Team (RDDTT) for this region has also arranged such training courses. The Regional Office of FAO now plans to bring out a manual on treatment of straw at small farm level in order to provide handy guide for the extension worker.

Another international agency which has been active in this field is the Australian-Asian Fibrous Agricultural Residues Research Network. This is an activity of the Australian Universities International Development Programme assisted by the Australian Development Assistance Bureau (ADAB). In addition to bringing out "Fibrous Agricultural Residue Newsletter", this network arranges Annual Workshops to discuss the progress of the research work done by the member institutes of the network.

ADAB with the help of DANIDA organized a number of International Seminars in Bangladesh on Maximum Livestock Production from Minimum Land where Treatment of Crop Residues has always been discussed.

Almost every country in the region is doing research to improve the utilization of straw and other crop residues. But the important question is how many farmers are making use of the methods available for improving the nutritive value of straw. Bringing in a personal note, I may add that in late sixties when early work on treatment of straw was done at Pantnagar University in India, I was the Dean there. I was quite sure that farmers will make full use of the new technology for feeding their livestock. Even after fifteen years of work very few farmers are treating their straw. There is something missing in all the technologies developed. Farmer is our best judge. He will accept a new technology only if it pass his "test". For this we have to keep in view following problems :-

a) Appropriate Technology
b) Technology Transfer
c) Economical Problem
d) Institutional Problem

I hope this International Workshop will give its attention to all these components and make suitable recommendations.

Key-Note Address by Dr. Christina Arosenius, IFS Scientific Secretary :

Dean, Deputy Governor Thanom, Rector Nopadol, Dr. Soni, distinguished participants, ladies and gentlemen :

As a representative of the International Foundation for Science, I have the pleasure to welcome you to this workshop on "Relevance of Crop Residues Utilization as Animal Feed in Developing Countries". At the same time, I will take the opportunity to give you the best wishes of good luck on behalf of everyone working in the office of the Foundation in Stockholm.

For those of you here present that are not very familiar with the activities of IFS, I will now give a brief information. The International Foundation for Science is a non-governmental, international organization founded in 1972. It is not a big organization, the total budget last year was approximately two million US dollars. Our support is given to promising young scientist, that are not to established in the scientific world, coming from developing countries and wanting to do research in such countries. The grants cover purchase of equipment, expendable supplies, literature and local travel. The salary of the investigator must be covered by his institution or university. The grants are usually limited to a maximum of USD 10,000, and can be renewed up to three times.

To this date, IFS has given nearly 800 research grants to young scientists in 78 countries in Asia, Africa, Latinamerica and the Pacific. The scientific areas included in the IFS programme are Aquaculture, Animal Production, Food Crops, Afforestation and Mycorrhiza, Fermentation and Applied Microbiology, Natural Products, and Rural Technology. Anyone here present who would like to know more about IFS and its work is welcome to contact me during the workshop.

The promotion of individual contact between scientists and especially between the IFS Grantees has considerable interest for the

Foundation. This is why we organize workshops within our scientific areas. The different experiences in different geographical regions, as well as the exchange of ideas could be of importance to solve problems encountered during the work of the grantees.

The theme of this workshop is of great importance. The possibility to find feed for livestock and poultry that does not compete with human food is of global interest. In many developing countries, the land must be used to produce crops necessary to feed people and alternatives must be found for the animals. The possibility to import prefabricated feed for the animals is in most countries too expensive, and these are limiting factors in animal production. Among the 150 IFS projects within the area of Animal Production, about 50% deals with nutrition.

In September this year, IFS hosted a workshop in the Dominican Republic on the same topic as the one, "Alternative Feed Resources". It was held in Spanish for our latinamerican grantees. This shows that the problems you are facing in Asia are exactly the same as on the other side of the earth. The proceedings will be available shortly, but they are in Spanish with only summaries in English. For those interested, however, I have a list of the participants and titles of the papers presented.

The workshops previously organized by IFS in the area of Animal Production have been : Rabbit Husbandry in Tanzania, 1978, Camels in Sudan, 1979, Animal Production Systems for the Tropics, Philippines, 1980, and Small Ruminant Research in Ethiopia, 1983. Some are still available at the Secretariat and can be ordered.

At IFS, we hope that you will all be able to profit from this workshop, that you will discuss your projects and form new ideas on how to approach problems. We have the hope that this might be the start of joint activities within the field of animal nutrition in this part of the world and that you will make new contacts with fellow researchers. We believe that the problems you are facing are basically the same in your different countries and that together you might find good solutions.

Finally, I want to give the Foundation's thanks to our grantee, Dr. Metha Wanapat, for his dedicated and time-consuming work in organizing this workshop. Since I have just had my own experience with the workshop in Santo Domingo, I know exactly what it take to organize this kind of events.

My thanks also go to the University of Khon Kaen for their help and for giving us the opportunity to visit them, as well as for the work their staff has given organizing this event.

Welcom Address by Associate Professor Dr. Nopadol Thongsopit, Rector of Khon Kaen University :

Dear Dr. Soni, FAO/APHCA : Dr. Arosenius, IFS Scientific Secretary; Mr. Thanom Charnuwong, the Deputy Governor of Khon Kaen; Overseas participants and Distinguished Guests,

On behalf of the staff and the organizing committee, I whish to extend our cordial welcome and appreciation of your participation in this international workshop on "Relevance of Crop Residues Utilization as Animal Feeds in Developing Countries".

One common characteristic of all developing countries is the low consumption of animal protein. The limited supplies of animal products in developing countries are caused by many factors. I believe that one of these factors is the lact of adequate systems for the integration of animal production in to the systems of crop production. Because of the rapid increase of population in developing countries, most of the arable land is used for crop production. The more edible and digestible parts of the crops such as grain and tuber are used for human consumption; only the parts of crops which human does not consume are available for feeding animals.

Therefore, it will be a great benefit to animal production in developing countries if crop residues can be used efficiently as animal feeds. Indeed, one of the major recommendations made by the Fifth World Conference on Animal Production held in Tokyo in August last year was the utilization of crop residues as animal feeds. This workshop may be regarded as a sequel to promote the implementation of this recommendation. Dr. Metha Wanapat of the Department of Animal Science of Khon Kaen University, who participated in the last World Conference on Animal Production, proposed to the International Foundation for Science (IFS) to organize this workshop. I take this opportunity to thank the International Foundation for Science in particular and other agencies in making this workshop possible.

It is a great honour to the Department of Animal Science, Faculty of Agriculture of Khon Kaen University to host this workshop, since one of the major purposes of this university is to promote development of the rural agricultural sector. I am sure that this workshop will contribute towards this end by increasing out understanding, knowledge, and implementation of utilization of crop residues as animal feeds. The organizing committee will do their best to help you enjoy your stay in Khon Kaen. If you need help with anything, please do not hesitate to ask them.

Lastly, I wish to thank everyone again and welcome to the International Workshop.

Closing Address by Asso. Prof. Dr. Chaitat Pairin,
Deputy Rector for Administration, Khon Kaen University :

Dear Dr. Arosenius and all distinguished participants :

On behalf of Khon Kaen University, I would like to congratulate all of you for the very sucessful workshop. I am sure that during the past four days all of you have had a very fruitful time in gaining new knowledge and understanding on utilization of crop residues as animal feeds, in exchanging though-provoking ideas, in making valuable contacts with scientists from many countries and institutes. I thank The International Foundation for Science which supports this seminar. I thank all of you for your enthusiastic participation in all aspects of the seminar. I hope you have enjoyed your stay in Khon Kaen. On behalf of the organizing committe I do apologize if there have been any inconveniences. I wish everyone a pleasant journal back home and a very fruitful contribution towards more efficient utilization of crop residues as animal feeds in your future work. Thank you again and congratulations to everyone.

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RELEVANCE OF CROP RESIDUE UTILIZATION AS ANIMAL FEEDS ON SMALL FARMS

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SUMMARY

Crop residues have been used as a major component in animal diet by small farmers, especially in rural areas. The available amount of crop residues is generally large,most of them are not fully utilized and some of them have not been utilized as animal feeds at all. The crop residues are generally low in digestible crude protein and/or metabolizable energy, as well as some minerals. Much research has to be undertaken in order to improve their feeding qualities.

Crop residue technologies have to be based on the potential and limitations of the small farmers and their farming systems. Sequential steps in crop residue research, research network, as well as crop residue information center have been proposed.

Key words : crop residues, by-products, ruminants.

INTRODUCTION

Most of human population (60-80%) in Southeast Asia(SEA) is engaged in agriculture. More than 90% of these tropical farms are less than 5 ha in size. In Thailand, about 80% of the population belongs to the agricultural sector, most of them depend on paddy and field crop farming. The national average farm landholding, as reported by the Office of Agricultural Economics (1984) for the 1982/83 crop year, was only 4.3 ha. Most of the farmers are rural smallholders, they have traditionally integrated their livestock and crop production. Livestock production in the rural areas could be referred to as backyard or traditional or subsistence production.The contribution of rural small-scale or traditional livestock production to the total livestock economy in Thailand is quite significant as shown in the following figures.

	≃ Percent of total population
Cattle	>99
Buffalo	100
Dairy	99
Swine	>85
Chicken	<50
Ducks	>50

The traditional livestock production on small farms under village conditions is generally characterized as a complement to crop production, a mean for utilization of non-marketable farm products and available grazing areas as well as surplus family labor.It is generally non-market oriented production (except for dairy and swine) with relatively very low degree of risk, and requires minimal cash input, simple and traditional technology.

The usual orders of priorities of the Thai farmers for keeping animals on small farms are (1) rendering services, e.g.traction, fertilizer, fuel; (2) accumulation of capital; (3) reduction of risks from cropping; (4) generating income; (5) providing food; (6) satisfying cultural needs; (7) ensuring status of prestige. In general in SEA countries, the small farmer's priorities for keeping animals are obviously different from those in developed countries. These features of animal production on small farm in SEA countries put certain implications on the development of science and technology of crop residue utilization.

Crop residues : Potential and limitations

Livestock, especially ruminants, on small farm depends largely on crop residues, besides natural fodders and weeds, as their main source of feeds. During cropping (rainy) season and the summer season, crop residues become more important sources of feed supply, either due to limited grazing areas or shortage of natural fodders and weeds in the fields (see Table 1). Generally, animals on small farm will lose their body weight and/or their reproductive ability during this period of time, except in some cases where abundant supply of crop residues is available. Without crop residues such as rice straw, in some areas, cattle and buffaloes may not survive through a long dry season since no other supplementary feeds are given to these animal under village small farm conditions. The use of rice straw and stubble, as well as other crop residues, as animal feeds, will continue to play important role in the traditional animal production. During the past two decades, in Thailand, the development of large commercial dairy and beef production appeared to be relatively very small. In this production system, again, crop residues appeared to be a very important source of roughage for dairy and beef production.

In Table 2, as reported by Khajarern and Khajarern (1984), a large amount of crop by-products such as rice straw, sugarcane leaves and tops, corn stover, banana leaves and stems, etc., is available for animal feeding each year. Certainly, as can be expected, these crop by-products and residues have not been fully utilized, either for animal feeding purpose or other purposes. Rice straw and stubbles in some areas in the central region are disposed by farmers through burning. Sugarcane leaves and tops have not been used as animal feeds at all. And there are many other examples of crop residues which have not been fully utilized for animal feeds or any other purpose.

Why crop residues not fully utilized

Crop residues, in Thailand, have been mainly used by animals but not used as animal feeds by man (farmers), with rice straw as the

Table 1. Seasonal relationship between rice cultivation and livestock husbandry in Thailand.

Items	JA	F	MR	AP	MY	JN	JL	AG	S	O	N	D	Remarks
									x x				x = Rain
Season						x x		x x	x x	x x			D = Dry
	D D	S S	S S	S S	x x	x x	x x	x x	x x	x x	x D	D D	S = Summer
Rice Cultivation						x		Land Prep.					x = Transplant
						x	x					H H	H = Harvest
						x	x x				H H	H H	
Livestock Feed Supply	F	S	S S	S S	S S	S S	S S	S S	S S	S S			F = Feeds
	F F		S S	S S	S	S S	S S				F	F F	S = Shortage
	F F	F		S S							F F	F F	
											F F	F F	
Husbandry Practices :													
- Cattle & buf in the field	x x	x x	x x	x x	x						x	x x	
- Breeding	8 8	0 0	0 0	0 0								0 0	
- Calving	+ +	+ +	+ +								+	+ +	
- Disease outbreak					FMX	FMX	FMD						
- Insect pests		x x	x x	x x	x x								

Table 2. Thailand's some major crop and by-product yields in crop year 1982/1983 (Thousand tons)

Crop	By-products	Main product	By-products: Concengrates	By-products: Roughages
Rice (*Oryza sativa*)	Rice straw	16,879.0		18,567.0
	Rice hulls			2,700.6
	Rice bran		1,687.9	
	Broken rice		844.0	
Maize (*Zea mays*)	Maize stover	3,002.3		3,002.3
	Maize husk			420.3
	Maize cob			600.5
Cassava (*Manihot esculenta*)	Cassava leaves	17,788.0		1,423.0
Banana (*Musa spp.*)	Banana leaves and stems	2,021.0		4,446.2
	Banana fruit wastes			606.3
Pineapple (*Ananas comosus*)	Pineapple wastes	1,800.0		1,260.0
Sugar-cane (*Saccharum officinarum*)	Sugar-cane molasses	24,407.4	976.3	
	Sugar-cane leaves and tops			7,322.2
	Sugar-cane bagasse			5,369.6
Soybean (*Glycine* max)	Soybean meal	113.4	82.3	
	Soybean stover and pods			226.8
Mungbean (*Phaseolus mungo*)	Mungbean stover and pods	281.2		562.4
Groundnut (*Arachis hypogaea*)	Groundnut meal	145.3	78.5	
	Groundnut vines			71.2

Khajarern and Khajarern (1984).

only exception. The seasonality of availability of crop residues and their amount seems to be a clear answer. In Table 1, it is clear that crop residues become available at the post-harvest time when grazing areas are available and abundant of natural plants as well as stubble or stover. Any crop residues available in small amount on each individual farm will be left in the field and not collected for future use as feed supply. Problem of collection and storage of some crop residues partly contributed to underutilization. Lack of training and interest of farmers in putting additional efforts to improve draft animal feeding prevent effective use of crop residues. In general, farmers are psychologically interested in immediate response in animals due to additional treatment. But, in general, this cannot be expected from feeding crop residues.. In the case of cattle and buffaloes in Thailand (a population of more than 11 million), although farmers observe that animals would lose body conditions and weight during very dry summer months, i.e. during late February till early May (see Table 1), but they also learn from their experiences that these animals will recover from the stresses and attain their compensatory growth in the following post-harvest time. Since calf crop (calving percentage) and body weight gain in draft animals are not so important as in beef production, therefore, most crop residues have been mainly utilized by animals in crop fields, but not utilized by farmers for animal feeds. Except for rice straw, being available in sizable amount at home site,which has been used by farmers as supplementary feed for ruminants during very hot summer months mainly for animal's survival.

Some nutritional aspects of crop residues

As being well-known by animal scientists that many crop residues, as animal feeds, are low in crude protein and/or energy, as shown in Table 3 (Khajarern and Khajarern, 1984). Hence, supplementation with energy and/or protein is a prerequisite for their efficient utilization in livestock feeding. Also, the limited date available on the mineral composition of these fibrous crop residues suggest that deficiencies of certain minerals such as P, Na or Cu are

Table 3. Proximate composition of the most prevalent fibrous by-products.

By-products	Proximate composition, % of dry matter				
	CP	EE	CF	Ash	NFE
Rice straw	4.2	0.9	27.5	15.2	47.3
Rice hulls	2.5	0.9	36.2	16.0	44.4
Maize stover	6.1	1.6	36.8	8.5	46.9
Maize cob	3.0	0.6	34.6	2.4	59.4
Sorghum stover	3.5	1.6	35.0	3.9	56.0
Cassava leaves	22.6	2.9	8.1	6.0	60.4
Sweet potato vines	20.0	3.1	15.3	17.4	44.2
Banana leaves and stems	4.9	4.1	27.6	17.8	46.4
Pineapple wastes	4.8	1.9	25.5	4.5	63.3
Sugar-cane leaves and tops	6.4	1.7	33.9	7.6	50.4
Sugar-cane bagasse	2.7	0.3	37.4	5.7	53.9
Soybean stover and pods	4.2	0.9	38.5	6.1	50.2
Mungbean stover and pods	9.2	1.5	38.1	11.3	39.9
Kenaf leaves and tops	25.9	4.0	11.2	10.0	48.9

Khajarern and Khajarern (1984).

most likely to occur (Little, 1984). Hence, in order to improve utilization of crop residues for animal feeding on small farm appropriate ways and means of nutritional improvement of crop residues have to be developed. A large numbers of treatments (Appendix Figure 1) have received attention as methods of improving the digestibility and voluntary intake of crop residues by ruminants (Ibrahim, 1983). However, as noted by Ranjhan (1983), in India where straws have been a major component of the ruminant's diet since inmemorable time the most practical treatment of straws appears to be only chopping-and-soaking. But, in Thailand, even chopping and soaking of rice straw for animal feeding is not practiced in any small farm.

Traditionally, green fodders like grasses,legumes, leuceana leaves, or other tree leaves are fed to animals along with rice straw. And, it has been accepted that straws mixed with green fodders in the ratio of 3:1 and 1:1 are good for animal maintenance and growth (Ranjhan, 1983). From farmers's practical point of views,it is believed that supplementation of rice straw with green fodders or other cheap and locally-available sources of protein and/or energy such as dry chicken manure or molasses can be more practical and economical. Supplementation with low-cost concentrates, urea and molasses, along with mineral block, can become practical feeding systems in Thailand, especially in larger dairy farms or beef fattening operation.

Research and development strategies

Appropriate technologies

So much has been said about appropriate technologies (AP) during the past decade but not many AP's have been found and proved to be effective under small farm conditions. Crop residue technology also fall under this criticism. In Thailand, research interest in crop residues has increased in the last decade but it seems that only the technique of ensiling rice straw with urea that has received little interest among few dairy producers.

Crop residue is definitely a clear case of appropriate technology, however, very little research supports and relatively very few animal nutritionists have contributed into this field. Another pitfall in crop residue research is a lack of well-planned and stepwise research investigation. Crop residue research should follow sequential steps, as generally outlined by Devendra (1983),these are:

(1) complete identification of crop residue resources,

(2) inventorization in terms of quantities available, location, seasonality of supply and chemical composition,

(3) determination of nutritive value : DCP, ME, etc.,

(4) large-scale feeding trials involving potentially valuable feeding systems (farm level).

It is quite obvious that in order to complete all these necessary steps in crop residue research, long-term supports must be available. Besides, research network, both national and regional or international, should be formulated and coordinated in order to motivate effective crop residue research activities.

Transfer of technology

As mentioned earlier, in spite of numerous straw treatment methods have been known by scientists but none of these techniques has been adopted by small farmers. Part of the problem could be attributed to additional cost and burden in using these techniques, but another aspect is a lack of effective source of information on crop residue utilization and farmer training programs. On-farm testing of crop residue feeding systems can be used as a part of farmer training as well as technology verification. More emphasis should be given to on-farm crop residue research.

An information bank or center on crop residue, aiming not only at collection but mainly on dissemmination of both scientific and extension information, would be a very useful tool in the process of technology transfer and regional research cooperation.

CONCLUSION

Crop residues have been a major component in animal diet at small farm level. The available and potential supply of crop residues in great and much of the available supply have not been utilized or not fully utilized. Most crop residues are low in digestible crude protein and/or energy as well as certain minerals. Researchers for nutritional improvement of crop residues have emphasized mainly on methods of treatment in order to increase digestibility and animal intake, while supplementation of crop residues with green fodders or other cheap and locally-available sources of protein and/or energy appears to be more practical for small farmers.

Research scientists who work with crop residues improvement should always ask themselves' for whom shall technologies be produced'. Otherwise, as indicated by Chantalakhana (1984), crop residue research will have little relevance and usefulness for the development of small-farm livestock production in the integrated farming systems. Small farmers and farming systems ought to be kept as the central point, while their potential and limitations should be understood by crop residue scientists. Appropriate crop residue technologies developed for small farmers must always be based on their potential and limitations. If not, then the impact of the crop residue research on development will be quite disappointed. As Madamba (1978) noted, in a case of crop research, ".... In fact, the breakthroughs attained by IRRI plus those in wheat research at the Centro Internacional de Majoramiento de Maiz y Trigo (CIMMYT) in Mexico in the Sixties, triggered off what is now popularly called the "Green Revolution". But 17 years and many more HYVs later, the research community is still wondering why our farmers can harvest only an average of 1.75 tons of rice per hectare per crop when research scientists produce an average of 8 tons of rice per hectare per crop in experimental farm".

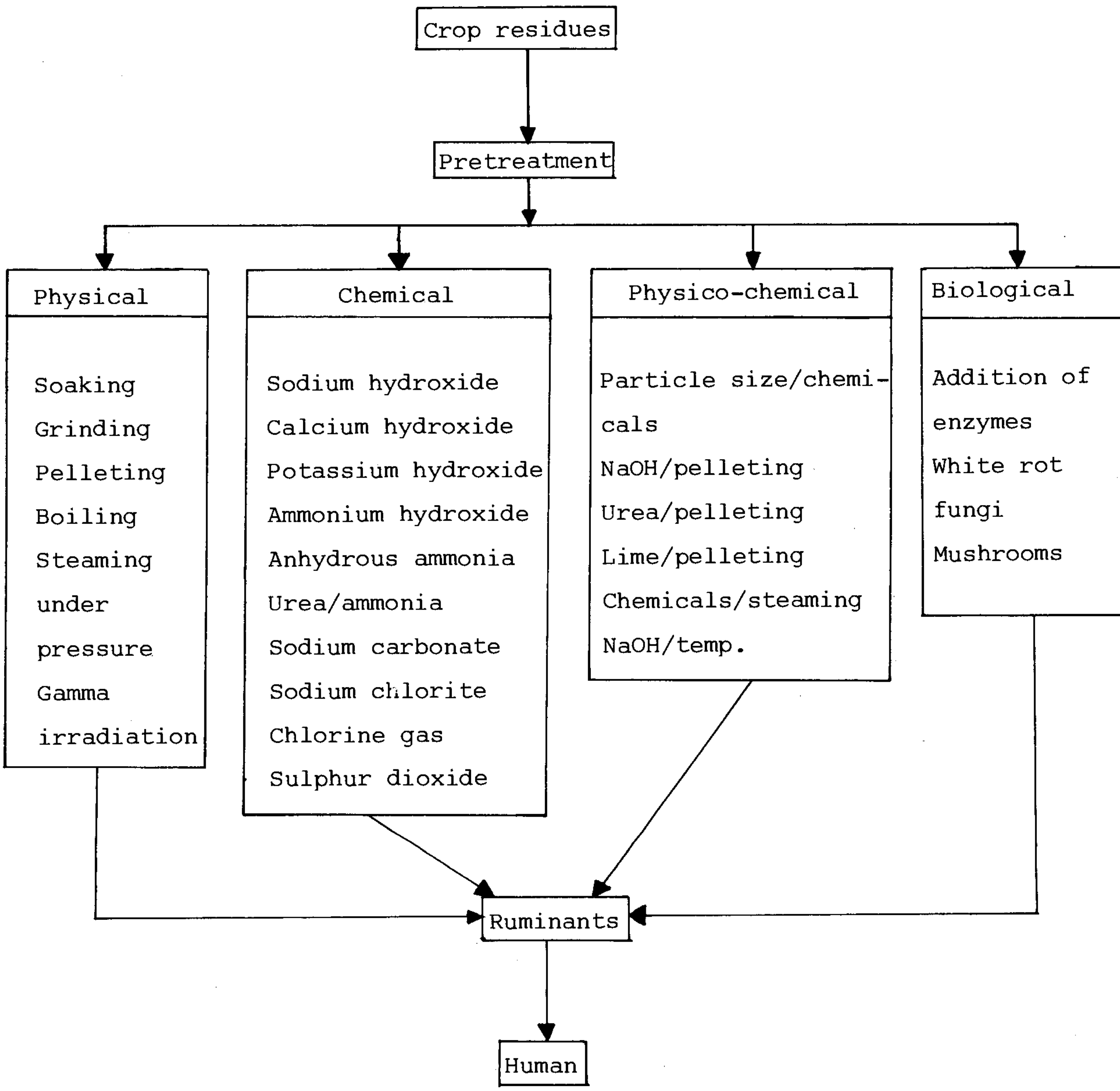

Figure 1. Methods that have been used to treat crop residues (Ibrahim, 1983).

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SOME ASPECTS OF BUFFALO AND CATTLE PRODUCTION IN A VILLAGE OF NORTHEAST THAILAND

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SUMMARY

The field work was carried out in Don Daeng village from the middle of September till the middle of November in 1983. It was found in this village that buffaloes were owned by 68.6% of total households while cattle were raised by 10%. Number of buffalo per household mostly ranged from 1 to 4 ($\bar{X}$ = 2.9) and 1 to 2 for cattle ($\bar{X}$ = 2.7). The calf production rate of buffalo was 37.5% and that of cattle was 33.7%. Calf motality rate was calculated to 12.5% for buffalo and 2.6% for cattle. One household sells buffalo every 3 years on the average and buys one every 5 years. A cattle is sold every 2 years and bought every 4 years. The average purchasing price of buffalo during the last 6 years was 4,589 bahts while the selling price was 5,383 bahts. Those for cattle were 4,020 bahts and 4,473 bahts, respectively. Both buffaloes and cattle were mostly purchased through neighbours. Fifty-nine percent of buffaloes were sold to neighbours and the rest to the middlemen and butchers. Sixty-seven percent of cattle were sold to butchers.

Key works : cattle, buffalo, production system.

INTRODUCTION

There are 6.12 million of buffalo and 4.47 million of cattle in Thailand. Sixty-five percent of buffalo and 39% of cattle are raised in the northeast region (Anon, 1981). These animals, which are reared by traditional methods, have multiple meanings to villagers life; draft power, food supplier, a means of saving etc.

Although there were some reports on ruminant production in northeast Thailand (Rufener, 1975; Chantalakhana, 1983), further information is yet to be accumulated in order to evaluate animal production adequately in the region.

MATERIALS AND METHODS

The survey has been done from the middle of September till the middle of November in 1983. Number of buffalo and cattle were counted in every households in Don Daeng village, where is located about 10 km southeast of Khon Kaen city which is a central town of the northeast Thailand. Percentages of buffalo and cattle grazing in the fields during daytime were also counted. Practices of feeding, managing, reproduction and marketing were surveyed for the 43 sample households in which larger number of animals were reared comparing with the other households.

RESULTS AND DISCUSSION

Most of the buffalo and cattle were taken out to the field in early morning (a.m. 6:00-a.m. 9:30) and back to their barns around the time of sunset (p.m. 5:00-p.m. 7:00). Generally, the ground under the raised floor of the houses on stilts serves as a barn. In the field, animals were fastened with a rope of 10 to 15 m long. It was found from the survey work for 2 days before harvesting rice that 97% of buffalo and 98% of cattle were taken out to fields during daytime. Only new born calves and their dams, and sick ones remained in the barns.

As shown in Table 1, buffaloes were owned by 68.6% of total households in the village. The total number of buffalo raised in the village increased by 25% during the 1981-1983 period, though, there was little difference in number of households keeping buffalo during the

Table 1. Numbers of livestock and households.

	No. of owners of livestock		Livestock	
Year	1981	1983	1981	1983
Buffalo	119 (67.6%)	118 (68.6%)	273	342
Cattle	24 (13.6%).	18 (10.5%)	62	48

Parenthesis represents percent of total households in the village. Figures for 1981 were cited from the data by socio-economic group, the other member of the project.

same period. According to the survey by Mizuno (1971) about 2 decades ago, number of households raising buffalo were 75 and total 200 heads of buffalo were raised. Cattle were reared by about 10% of total household. Both the total number of cattle and number of households keeping them decreased during the last 2 years. Cattle population was 63 and the number of households keeping them was 16 in 1964. Most of cattle had white hair and appeared to be Brahman or Brahman cross breed.

Table 2 shows number of livestock per household. Number of buffalo per household mostly ranged from 1 to 4 while that of cattle were mostly from 1 to 2. Averages were 2.90 for the former and 2.67 for the latter. The respective figures for 1963 were 2.67 and 3.90 (Mizuno, 1971). This means that number of buffalo per household is slightly greater in 1983 than twenty years ago while that of cattle is apparently smaller in 1983 than in 1963.

Sex ratio is presented in Table 3. In case of buffalo calves, there was little difference between sexes,while there was only one male cattle calf against 14 female ones. Male young cattle tended to be sold out at the younger age than female ones. Twice more adult female buffalo than adult males were found. Male buffaloes

Table 2. Number of livestock per household in 1983.

	Number of livestock									Average per household
	1	2	3	4	5	6	7	8	12	
Buffalo	23	18	29	22	4	9	3	1	0	2.90
Cattle	5	8	1	3	0	0	0	0	1	2.67

Table 3. Numbers of male and female livestock.

	Adult		Calf	
	Male	Female	Male	Female
Buffalo	70	149	59	64
Cattle	0	33	1	14

were sold out or slaughtered earlier than females. The latter might be more valuable for being kept than the former because of reproductivity of female. Spread of artificial insemination (A.I.) might further enhance the deminishing trend of males.

There was no adult male cattle in this village at the time of this study in 1983. As far as the 43 sample households are concerned, it has not been kept by any of them since 1978. Absence of adult male cattle might be due to A.I.. An A.I. center is located about 7 km west of the village. Oxen are not used as draft animal in this village recently.

Reproduction of buffalo and cattle raised by 43 households from 1977 to 1983 are summarized in Table 4 and 5. Total number of

Table 4. Numbers of buffalo and produced calf in 43 sample households.

	Year						
	1977	1978	1979	1980	1981	1982	1983
Total number	94	104	109	105	110	124	144
Adult male (including castrated male)	36	35	37	29	28	21	26
Adult female	26	32	35	42	44	58	61
Produced calf	-	8	7	10	17	18	28

Table 5. Numbers of cattle and produced calf in 43 sample households.

	Year						
	1977	1978	1979	1980	1981	1982	1983
Total number	30	25	42	38	32	36	37
Adult male (including castrated male)	2	0	0	0	0	0	0
Adult female	23	15	21	20	21	21	23
Produced calf	-	5	9	7	4	11	3

buffalo raised by those households increased steadily during the 7-year period. One and a half time more buffaloes are reared in 1983 than 1977. The increase in due to increase in number of adult females and calves while males decreased. This might indicate that calf production is becoming more emphasized than before by virtue of a more significant source of cash income in this village.

On the other hand, there was not any significant difference in neither total number, number of adult female nor that of calves of cattle for the past 7 years. The reason is not clear. It might be due to the facts that cattle were not used for draft power and that villagers were more accustomed to raising buffalo than cattle.

As shown in Table 6, 264 heads of female buffalo produced 88 heads of calf and 98 heads of female cattle had 39 heads of calf. The calf production rate was a little higher in cattle than in buffalo,that is, 37.5% for cattle and 33.3% for buffalo. Since the pregnant period of buffalo is longer than that of cattle, being 10 months, it is natural that calf production rate was higher in cattle than in buffalo. However, the average 3-year interval for a dam to give birth is not regarded as satisfactory. There might be certain causes of low calf production rate such as poor nutrition of mother animal, farmers' lack of earnest to reproduction, disease and so on.

As presented in Table 7, 88 buffalo calves were born and 11 calves died during the 7-year period in the village. Buffalo calf motality was calculated to be 12.5%. On the other hand, only one cattle calf died among 39 newly born calves during the same period; the rate being 2.6%. These rates are not so low since the veterinary service around the village, was not available.

Transactions of livestock by 43 sample farms are shown in Table 8. All of the sample households raise buffalo while only 16 raise cattle. On average, one household sells a buffalo every 3 years and purchases it every 5 years. A cattle is sold every 2 years and purchased every 4 years.

Table 6. Calf production rates in buffalo and cattle (7-year averages of 43 sample households).

	Buffalo	Cattle
Dam, heads	264	98
Calf, heads	88	39
Calf production rate, %	33.3	37.5

Table 7. Calf mortality rates in buffalo and cattle (7-year averages of 43 sample households).

	Buffalo	Cattle
New born calf, heads	88	39
Died calf, heads	11	1
Mortality, %	12.5	2.6

The average selling and purchasing prices of buffalo during the 6-year period were 4,589 bahts and 5,383 bahts, respectively. And those prices of cattle were 4,020 bahts and 4,473 bahts, respectively. The prices of buffalo tend to be higher than those of cattle and selling prices are cheaper than purchase prices of buffalo and cattle. It was calculated from the above that, on average, one household earned 1,514 bahts by selling buffalo and spent 1,022 bahts for purchase in a year. In case of cattle, a household earned 2,372 bahts by selling and spent 1,029 bahts for purcahsing in a year.

Transaction of both buffalo and cattle was more frequent in 1979 and 1980. In 1979, a severe flood hit the village. Those who suffered might have sold animals to those who had little damage. It is said that buffalo and cattle husbandry was a way of saving, which

Table 8. Livestock purchased and sold by 43 sample households.

	Year					
	1977	1978	1979	1980	1981	1982
Buffalo						
Number of buffalo sold	9	13	21	19	10	12
Price per head (bahts)	3344	3415	4529	4763	5050	6433
Number of buffalo purchased	3	7	14	9	5	11
Price per head (bahts)	7333	5329	4231	5300	5320	4782
Cattle						
Number of cattle sold	15	2	10	13	11	6
Price per head (bahts)	4067	3250	3430	3738	4300	5333
Number of cattle purchased	2	4	9	2	1	4
Price per head (bahts)	4600	5118	2522	3500	6000	5100

could be cashed whenever cash is needed (Rufener, 1975; Mongkonpunya et al., 1981; Suntraporn, 1980; McDowell; 1972). Average selling price of buffalo increased throughout the period but not the purchasing price.

As shown in Table 9,male buffaloes are more expensive than females while the reverse is true for cattle. Male buffaloes might be more expensive than females because the males could be used for draft power. Male cattle seem to be useless from the standpoint of draft animals and breeding males because of prevailing A.I..

Table 9. Comparison in price of male and female livestocks (7-year averages of 43 sample households).

	Male (including castrated male)	Female
Buffalo		
Number of buffalo sold	58	23
Price per head (bahts)	5079	3526
Number of buffalo purchased	26	24
Price per head (bahts)	5846	4444
Cattle		
Number of cattle sold	12	47
Price per head (bahts)	3791	4277
Number of cattle purchased	-	26
Price per head (bahts)	-	4558

Since engine tractors commence to be introduced in this village and official technicians are trying to extend A.I.for buffaloes, there is a possibility to change the extent of importance of male buffalo.

Table 10 represents marketing routes of buffalo and cattle. Both buffalo and cattle were mostly purchased from neighbours though a few buffaloes were bought from middlemen.

Table 10. Marketing routes of buffalo and cattle.

	Buffalo		Cattle	
	Purchase	Sale	Purchase	Sale
Neighbours	51 (91.1%)	52 (59.1%)	24 (92.3%)	12 (20.0%)
Relatives	3 (5.4)	4 (4.5)	2 (7.7)	1 (1.7)
Middlemen	2 (3.6)	17 (19.3)	0 (0)	7 (11.7)
Butchers	0 (0)	15 (17.0)	0 (0)	40 (66.7)

Parenthesis means percent of total heads purchased or sold.

Buffaloes were sold variously; 59% to neighbours, 19% to middlemen and 17% to butchers. In the case of cattle, 67% were sold to butchers, and smaller proportion to neighbours and middlemen. This reflects the fact that cattle raising is primarily for meat market through butchers.

Nearly 70% of households own buffaloes and 10% raised cattle in Don Daeng village. For all day long, animals are usually within a very close distance from family members. And buffaloes were still used as draft animal in farming. Therefore, these animals intimately connected with villagers' life. Cash earned by selling them, 1,514 bahts for buffalo and 2,372 bahts for cattle earned by a household in a year, is not a small sum to villager's home economy. Among many possible means to improve the productivity, improvement of calf production rates might have to be first attempted.

Buffalo and cattle were fed with only naturally grow grasses in the rainy season and with rice straw in the dry season. There appeared to be little surplus grasses around the village. Therefore, as far as grasses are only source of feed, the rapid increase in large ruminants population seems to be impossible. Confinement with other feed sources such as concentrate rations would be required to increase population of ruminants in northeast Thailand. Improvement of amount and quality of produced grasses might also enable to increase the capacity of animal husbandry but it seems to be not easy.

As stated previously, a household sold a buffalo once every 3 years and a cattle once every 2 years, while a buffalo and cattle were purchased with 5 years- and 4 years-interval, respectively. Considering the sale intervals, purchase intervals might be very short. Raising more calves in their own barn would bring about higher income to the villagers.

The majority of buffaloes and cattle were purchased from and sold to neighbours. This indicates that the marketing system of livestock has not been established yet. Even the middlemen did not play an important role. Market places appeared to be necessary to promote more commercialized livestock production.

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CROP RESIDUES AS ANIMAL FEEDS IN DEVELOPING COUNTRIES
USE AND POTENTIAL USE

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SUMMARY

Ungrading of crop residues such as straw has a long history and has been practised in Europe in times of fodder shortage due to war or climate. The intense developing-country interest in the last five years stems from being able to improve intake and digestibility by treatment with ammonia generated from urea, and from a greater understanding of supplementation. Hundreds of papers and many workshop proceedings have been published-their recommendations and outlined. The quantity of crop residue produced (2/3 from cereals) is vast-sufficient to provide 2.0 t dry matter annually for each 500 kg livestock unit throughout developing countries. Factors limiting the use of crop residues are outlined, but detailed information is lacking. Their potential use as feed is demonstrated by experimental results from Sri Lanka showing large production improvements in heifers and buffaloes due to ammoniating rice straw and supplementing with tree forage. Action needed to realise this potential is listed, and includes more research and education, more comprehensive information on production patterns and factors limiting use, demonstrating the benefits of upgrading and supplementation in village -level/systems situations and setting up a by-product information centre to speed up interchange of international information, emphasising development and practical application.

Key words : crop residues, ruminant feeds, supplementation, treatment.

INTRODUCTION - BACKGROUND AND CURRENT INTEREST

Utilization of crop residues (and other low-quality roughages) is now the subject of intense research and development world-wide. However the search for ways of overcoming the low nutritive value of residues such as cereal straw has a long history (e.g. Lehman, 1891); and the fact that straws have a low feed value has been acknowledged for centuries.

Treatment of straws with sodium hydroxide (Beckmann Method, Homb, 1984) to improve digestibility and intake has been practised on farms in Europe during periods of acute fodder shortage due to war (e.g. in UK, 1939-45) and/or climate (e.g. in Norway, 1940-1970). There is therefore a long history to the subject, particularly in Europe.

The current world-wide interest began 20 years ago following publications by Lampila (1963) and Wilson and Pigden (1964). These described "dry-treatment" of straw with sodium hydroxide which overcame some of the disadvantages (particularly high water-requirements and leaching losses) of the traditional Beckmann Method.

Interest in low-quality roughage utilization (particularly upgrading of crop residues) has accelerated rapidly in the past five years as evidenced by hundreds of papers which have been published in scientific journals and workshop proceeding (e.g. OECD, 1981, 1984; Kategile et al., 1981; Jackson et al., 1981; Stark and Wilkinson, 1981; Doyle, 1982, 1984; Preston et al., 1982. El-Shazly et al., 1983;Pearce, 1983; Shaklady, 1983; MAFF, 1984a, Carlsberg Research Centre, 1984; FAO and ILCA, 1984).

The subject has also been reviewed at various symposia (e.g. Owen, 1979; Ørskov, 1980; Kristensen et al., 1981; Mason, 1981;Wilkins, 1981; Greenhalgh, 1984) and elsewhere (Jackson, 1977, 1978; Klopfenstein, 1981; Devendra, 1981). Aspects of research and development in the UK have been considered at various conferences (Oxford, Anon, 1982; Stomeleigh, Anon, 1984) and elsewhere (MAFF, 1984b). Recently an attempt has been made to 'take stock' of the subject in book form (Sundstøl and Owen, 1984). Research networks have been established (e.g. Australian-Asian Fibrous Agricultural Residues Research Network, Melbourne University; African Research Network for Agricultural By-products, ILCA, Addis Ababa; OECD Cellulose Programme). The number of institutions researching by-product utilization is now large (FAO, 1982a). The FAO is encouraging development of the subject (FAO, 1982a, 1982b, 1982c, 1984). Other organisations are also helping (e.g. NORAD, Norway; DANIDA, Denmark; IFS, Sweden; ADAB, Australia; IDRC, Canada; ILCA, Addis Ababa).

Relevance in developing countries

Must of the interest stems from, or is aimed at developing countries in the tropics and sub-tropics. This is understandable as inadequate nutrition (of man and animal) is a major limiting factor. Large numbers of ruminants (in a multipurpose role) and large quantities of low-quality roughages (dry-season standing hay or crop residues) are dominant features. In many developing countries (e.g. India and Bangladesh) there is a long tradition of having to rely on low quality roughages for ruminant feeding (Verma and Jackson, 1984). The fact that crop residues can be upgraded by low-technology treatments, such as ammonia generated from fertilizer urea (Sundstøl and Coxworth, 1984), has had a major influence in accelerating research and development on the subject in the tropics. A further interest-stimulator has been the realization that supplementation of crop residues (Preston and Leng, 1984) has a vital role to play.

Previous workshops-recommendations

A feature of the numerous workshops cited earlier is the issuing of recommendations. The similarity of the recommendations from each workshop suggests that there is general agreement on what further action is needed. However, the fact that each successive workshop feels obliged to make the same pleas might also suggest that little progress is being made. The present workshop should attempt to take stock of this, particularly regarding the extent to which improved methods of utilizing crop residues is being achieved in practice, in developing countries.

The following are recurring issues deemed by previous workshops as needing further research and/or development.

- Undertake comprehensive inventories of crop residues etc. available; define (and develop methods of defining) their characteristics.
- Develop straw etc. treatment methods which combine appropriate technology and economics.
- Methods of supplementing low quality roughages, with emphasis on local resources.
- Emphasise use of appropriate experimental techniques.
- Undertake basic research, e.g. cell-wall chemistry, plant breeding to improve by-product quality.
- Develop village-level application commensurate with an appropriate overall strategy for integrated farming systems.
- Promote faster interchange of international information.

Detailed consideration of many of these issues is made in other presentations to this workshop. Subsequent discussion in the present paper will aim at an overview of by-product production, indicate factors limiting their use, point to their potential use as feeds and how we might assist achievement of the potential.

Production of crop residues

The most recent global assessment of annual production of straw and other fibrous by-products is that of Kossila (1984a, 1984b). Earlier estimates were made by Owen (1976) and Balch (1977). A common feature is that by-product is estimated from FAO statistics for the primary product such as grain, assuming grain: straw ratios (multipliers). The uncertainty of the latter can be judged by the different multipliers used by Owen (1976) (e.g. 2:1 straw:grain for maize)and Kossila (1984a) (e.g. 3:1 straw

: grain for maize). This stems from the remarkable lack of reliable information on yields of straw etc. in relation to grain. This is turn reflects the past preoccupation with the primary product and disinterest in by-products shown by cereal breeders and agronomists. Hopefully this will change in the future. The FAO (FAO 1982b)and others (e.g. ARNAB, 1984) are engaged in collecting more reliable information on production of by-products.

Notwithstanding the case for more reliable data, Table 1, from Kossila (1984a)emphasises the enormous quantity of crop residues produced annually in different regions. Quantities produced in individual countries have also been estimated (Kossila, 1984b).

Cereal by-products form the main source (approximately two thirds), particularly in Asia, Africa and the Developed regions. It is also clear that quantities produced have increased substantially from 1970 to 1981-by 23 and 31% in Africa and Asia, and by over 50% in Developed regions. Quantities of by-product in relation to livestock units are also shown in Table 1 and these show less of an increase from 1970 to 1981. It is notable that annual production amounts to about 2.0 t dry matter per 500 kg live-weight unit, in developing countries, with the figure being 3.0 t DM/unit in Asia. Also evident is the fact that grass eaters (mainly ruminants)make up about 90% of the livestock units in Africa and Asia. The 2.0 t DM/livestock unit of crop by-product generated each year in developing countries would maintain a 500 kg beast for 6 months (assuming daily dry matter requirement to be 2.2% live weight). On this basis, the quantity of by-product involved is enormous.

The above is a global and simplistic overview,but highlights the magnitude of the resource represented by crop residues. Following the FAO technical consultation in 1976 on new feed sources (FAO, 1977), Devendra (1981)has recently undertaken a comprehensive assessment of non-conventional feed resources in Asia and the Far East.This detailed report considers non-conventional sources of protein as well

Table 1. Estimated production of fibrous by-products from cereals and other crops in relation to livestock units (Kossila, 1984a).

		Total dry matter (DM) produced t 10^6 DM (*)	Total livestock unit+ 10^6 (≠)	By-product per livestock unit t DM
Africa	1970	278.3 (66.5)	145.7 (4.4)	1.9
	1981	343.6 (68.8)	165.8 (5.5)	2.1
N and C	1970	717.4 (65.0)	202.6 (16.9)	3.5
America	1981	1193.4 (68.6)	217.8 (17.9)	5.5
S. America	1970	221.9 (56.3)	185.8 (7.1)	1.2
	1981	380.3 (48.2)	222.7 (8.6)	1.7
Asia	1970	1245.0 (66.9)	476.8 (12.6)	2.6
	1981	1628.9 (68.4)	551.7 (17.1)	3.0
Europe	1970	403.0 (63.7)	193.1 (29.4)	2.1
	1981	504.3 (67.4)	215.2 (33.7)	2.3
Oceania	1970	32.1 (61.1)	53.5 (2.4)	0.6
	1981	53.2 (67.7)	52.2 (3.3)	1.0
USSR	1970	358.1 (65.9)	120.9 (21.5)	3.0
	1981	320.4 (66.7)	148.5 (26.1)	2.2
Developed	1970	972.9 (67.3)	361.6 (20.1)	2.7
	1981	1515.2 (69.8)	380.5 (22.4)	4.0
Developing	1970	1249.9 (59.6)	707.6 (5.6)	1.8
	1981	1679.8 (59.5)	812.0 (6.8)	2.1
Centrally	1970	1033.0 (69.8)	309.2 (27.8)	3.3
Planned	1981	1228.9 (72.0)	381.3 (35.0)	3.2
World	1970	3255.8 (65.2)	1378.4 (14.4)	2.4
	1981	4423.9 (66.5)	1573.8 (17.4)	2.8

* Percentage from cereals

\+ One unit corresponds to 500 kg live weight and includes grass eaters (horses, mules, asses, cattle, buffaloes, camels, sheep, goats) and grain eaters (pigs, poultry).

≠ Grain eaters, percentage of total.

as fibrous crop residues and further illustrates the large quantity and diversity of by-products generated in the region.

Use and factors limiting use

The voluminous production and the tradition of feeding these during drought periods has been discussed, but detailed information on both of these aspects is lacking. This is clear from the recent FAO survey (FAO, 1982b) involving more than 100 countries, mostly in developing regions. Devendra (1981) has also identified such lack of information in Asia and the Far East. Owen (1976, 1980) also drew attention to it. Information is particularly scanty regarding production and usage patterns within countries. Clearly questions such as when and where residues are produced need answering, as do those relating to when, where and for what animals are the residues needed as feed. Such information is required for each farming system/ecological zone in each country. Indeed there is need to give much more consideration to a "system approach" (e.g. Gartner, 1984) to the subject.

Site of producing crop by-products has a major bearing on usage and potential usage particularly regarding whether they are field-produced (e.g. cereal straws) or centrally-produced (e.g. bagasse).

Field-produced by-products are used as animal feed,animal bedding and crop mulches. However, they are frequently burnt as a means of disposal, because it is impractical (lack of transport and roads) and uneconomic to transport them to where they could be used by ruminants. The bulky nature of straw (and its low feed value) makes it particularly expensive to transport, even over short distances. Animal agriculture and crop cultivation are often completely divorced, e.g. sugar cane paltntations with no associated animal enterprises.

A further limiting factor which is often overlooked is the difficulty of handling and storing crop residues particularly on small farms (Hilmersen et al. 1984) and when rain is common (e.g. 'boro' and 'aus' harvests in Bangladesh-Dolberg et al. 1982).

Centrally-produced by-products, as pointed out by Devendra (1981), have the advantage of not suffering transport costs,provided they can be utilized at the processing plant. Currently they are often burnt to fuel the factory (e.g. bagasse and rice hulls). Their use for feeding animals adjacent to the plants is hampered by the peri-urban location of many of the plants. FAO (1982b) also point to agro-industrial by-products being more likely to attract investment to develop their utilization because of the large quantities available at one point and the existence of an infrastructure in which to apply 'industrial' processes. Nevertheless respondents to the FAO survey (FAO, 1982b) and Devendra (1981) talked of the difficulties of attracting investment capital for processing by-products. These were though to be due to lack of technical and economic feasibility studies, absence of economic incentives, lack of assured markets for "processed" by-products, shortage of funds to undertake research and development,lack of skilled manpower (and scientists) and community predjudices.

Undoubtedly the underlying constraint to greater usage of crop residues as ruminant feed is the fact that they have (or appear to have) low nutritive value.

Potential use as feed

Cereal straws are characterised by low digestibility(<50%) hence low metabolizable energy content (< 7.5 MJ/kg DM), low crude protein content (< 60 g/kg DM), low intake (? 10-15 g DM/kg liveweight day) and low content of available minerals and vitamins. As sole feeds they are therefore considered too poor, even,to maintain adult ruminants.

The above is generally true, but the generalisation can be misleading as there is considerable range in the apparent nutritive value within, and between, by-products. This is particularly so with cereal straws, as evidenced by research in UK (Jewell, 1984;

Hartley et al., 1984), Australia (Pearce, 1984) and Sri Lanka (Sannasgala and Jayasuriya, 1984). The word "apparent" is used as assessments are confined to laboratory evaluation and researchers have not tested whether differences in animal production would occur. Indeed there is much need for a laboratory method of evaluating crop residues and upgraded residues which is simple and yet accurately assesses feeding value (MAFF, 1984a; FAO, 1984; Devendra, 1981).

The other misleading generalisation is to imply that all ruminants are the same in their ability to utilize crop residues. Bangladeshi cattle appear to have a greater ability to consume straw than European cattle (Mould et al., 1982). Buffaloes are claimed to be better roughage utilizers than cattle (see bibliography by Jayasuriya and Owen, 1983). Large ruminants (cattle and buffaloes) fare better than small ruminants (sheep and goats) on low quality roughages (Van Soest, 1982). Within a species, the expected level of productivity affects the extent to which crop residues can contribute to the diet.

As mentioned earlier when discussing the relevance of the subject to developing countries, the exciting issue is that the low levels of animal productivity which are so commonplace,are in the same "league" as those on high-straw diets. Furthermore, dramatic improvements in "productivity" can be achieved by straw treatment and/or supplementation. This contrasts with the situation in developed countries where high levels of productivity are economically essential and thus scope for high-straw diets is much less (e.g. Kristensen, 1984).

An example of the large improvement in productivity made possible by upgrading straw with ammonia treatment (urea-ensiling method) is shown in Table 2. This is an experiment carried out in Sri Lanka by Perdok et al., (1982). The growth improvement of the Surti heifers is impressive, although the authors caution that some of the response could be increased gut contents. There is therefore need to corroborate this type of data with information on carcass weight and composition.

Table 2. To demonstrate effect of ammonia treatment (By urea-ensiling[1]) of rice straw on growth of Sanhiwal heifers (Perdok et al., 1982).

	Untreated straw	Treated straw
Intake[2], kg DM/d		
Straw	2.09	2.84
Total	3.84	4.59
Total per 100 kg W	2.31	2.58
Live weight, kg		
Initial	165	167
Final	170	191
Dialy gain	0.073	0.346
DM conversion	53	13

[1] Paddy straw (900 g DM/kg) sprayed with 1.0 l/kg of 40 g/kg urea solution and ensiled in polythene bags for at least 28 days.

[2] Straw fed ad. lib. with daily supplements of 6.0 kg grass silage, 0.5 kg concentrate, 20 g minerals and 20 g sodium sulphate.

Table 3, also from Perdok et al. (1982) in Sri Lanka, demonstrates performance improvement in lactating buffaloes and suckling calves when fed untreated or ammonia-treated rice straw, with and without gliricidia leaves. This trial not only demonstrates the benefit of upgrading, but shows the improvement possible by supplementing with locally-available tree forage.

Many examples of large responses to upgrading crop residues with ammonia (mainly urea treatment) and supplementing them, are reported in the workshop proceedings cited earlier. It should be said,

Table 3. To demonstrate effect of supplementing untreated or ammonia-treated (urea-ensiling[1]) rice straw with gliricidia forage for lactating buffaloes[2] in Sri Lanka (Perdok et al., 1982).

	Untreated straw		Treated straw	
	Minus Gliricidia	Plus Gliricidia	Minus Gliricidia	Plus Gliricidia
Cow data :				
DM itnake, g/kg W.d.	28	28	37	40
Live-weight change, g/d	-93	+59	+59	+126
Milk yield[3], kg/d	2.17	2.56	2.97	3.35
Milk fat, %	6.71	6.94	7.54	7.62
Milking after 84 d, %	60	90	100	90
Calf data :				
Live-weight gain, g/d	165	265	295	344
Milk intake, kg/d	0.95	1.03	1.03	1.15

[1] Treatment as in Table 2.

[2] All cows also received : 1.0 kg/d concentrate and minerals.

[3] Effects due to straw treatment and to gliricidia were significant at $P < 0.01$.

however, that many of the experiments are understandably of short duration and often involve few animals. More comprehensive experimentation would doubtless be undertake if resources for research were not so limiting.

Realising the potential

A question the present workshop should be addressing is, why is upgrading and/or supplementing crop residues etc. not being practised, if the benefits are so dramatic?

One answer is that understanding and technology are still under development. This suggests the need for more research and education. Indeed the ILCA/FAO consultation in Addis Ababa recognised this and a manual on how to determine the nutritive value of crop residues etc. and optimise their utilization in practice is now in preparation.

Other needs/answers can be put forward.

There is a need, raised earlier, for more information on by-product production within countries and identifying the constraints to their greater utilization. One constraint is likely to be ignorance and therefore a need for manpower training. Infrastructure to collect village-type information is already being developed for monitoring animal health improvement schemes (e.g. Second Specialist Workshop on Epidemiological Techniques in Animal Health, Khon Kaen, 12-23 November 1984).

Much of the information to date is based on experiments at research stations and in universities. There is a need to demonstrate the practical and economic value of upgrading and/or supplementing in village-type/systems situations and to do this over a convincingly-long period. The case for a system approach (Gartner,1984) was made earlier.

A further need, identified at many previous workshops, is to set up a by-product information centre to promote more rapid interchange of international information, with an emphasis on development and practical application.

As noted at the outset, there is enormous interest in the subject. This reflects the large potential role for by-products as ruminant feed. This role will have to be realised increasingly in the future because of world population increase (estimated to double by 2025, with 80% living in developing countries). Some consolation can be gained by remembering that crop residues are inevitably produced when cereals are grown for man. Residue production will therefore increase in the future, crop residue utilization will also have to increase.

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VARIATION IN THE NUTRITIVE VALUE OF RICE STRAW IN NORTHERN THAILAND : II Voluntary feed intake and digestibility by sheep

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SUMMARY

Five popular varieties of rice straw Kaew Khao, Sanpatong, Mali, RD_1 and RD_7 were collected from various locations in Chiang-Mai. The first two varieties are glutinous and the latter three are non-glutinous. The first three varieties are wet season rice and the latter two are dry season rice. They were chopped and fed with a supplement of salt to determine voluntary feed intake and digestibility by using total fecal collection method and using acid insoluble ash (AIA) as an internal indicator.

Average digestion coefficients of DM, OM, NDF, ADF and ADL were 49.5, 55.8, 52.3, 48.0 and 20.5% respectively. RD_1 had higher digestion coefficients of DM, OM,NDF and ADF than the other four varieties. No significant differences in these parameters between Glutinous and Non-glutinous straw or wet and dry season straw were found with the exception of NDF digestibility. Non-glutinous straw had higher NDF digestibility than glutinous and dry season straw had higher NDF and ADF digestibility than wet season straw. Variety did not affect voluntary feed intake. Sheep consumed glutinous or non-glutinous as well as wet or dry season straw equally. The two methods used in digestibility determination, total fecal collection and AIA, had a high correlation (r = 0.95).

Key words : rice straw, digestibility, voluntary intake.

INTRODUCTION

Various reports tend to indicate considerable variation in composition and digestibility value among varieties of rice (Roxas et al. 1984a; Sannasgala and Jayasuriya, 1984). Roxas et al. (1984b) shows that variety affected ($P < 0.05$) organic matter, crude protein, neutral detergent fibre,cellulose content, IVDMD and IVOMD. Organic matter and NDF contents were lower ($P < 0.05$) and in vitro digestibilities were higher ($P < 0.05$) in straws from wet season crops. Straws used in those analyses were gathered from experimental stations under controlled conditions. Effect of variety grown under farm conditions on these parameters has been little investigated.

As it was mentioned in a previous report (Cheva-Isarakul and Cheva-Isarakul, 1984), wet season straw which is harvested during November-December is usually kept for ruminants and the price is rather high, expecially in the dry period. On the other hand dry season straw (harvested during May-June) is often discarded or burnt in the north of Thailand. Wether the dry season straw is unpalatable to animals or contains lower nutritive value has not been fully reported.

The objectives of this study are to investigate :

1) The acceptability and digestibility of certain nutrients among popular varieties grown under farm conditions and to find the difference in these parameters between a) Glutinous VS Non-glutinous straw and b) wet VS dry season non glutinous straw.

2) The corretation of digestibility coefficients between the total collection method and indicator method (AIA)..

MATERIALS AND METHODS

Straw collection

Five varieties of rice straw (about 200 kg each) were collected directly from farmers from various locations in Chiang Mai. Three of them which were wet season rice were harvested in December 1983, while the other two were dry season rice and harvested in June 1983. The wet season varieties were Kaew Khao and San Patong (Glutinous) and Khao Dok Mali (non glutinous). The dry season varieties were RD_1 and RD_7, both non-glutinous rice.

Digestibility trials

The straws were chopped into 2 inch lengths and fed with a supplement of salt to 4-7 wethers, whose average age and weight were about 4 years and 30 kg, respectively, in order to determine voluntary feed intake and digestibility. The animals were housed individually in metabolism cages and fed 2 times daily at 8.30 am. and 3.30 pm. Drinking water was available at all times. The 24 day digestion trials were divided into 2 periods. The preliminary period lasted 2 weeks, during the first 10 days of which animals were fed ad lib and the other 4 days restricted at 2%of body weight. This was followed by a 10 day collection period, during which feed consumed and feces excreted were recorded. Ten % of feces excreted each day were accumulated in a deep freezer, while feed was sampled daily and accumulated for analysis of moisture,crude protein and ash according to the Weende System of Proximate Analysis. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined by the method of Georing and Van Soest (1970).

Digestion coefficients of nutrient were also determined by using acid insoluble ash (AIA) as an internal indicator. Grab sampling of feces was done at 12:00 am daily during the collection period. All samples of the same animal were composited and representative portions were taken for determination of AIA by the method of Van Keulen and Young (1977).

Statistical analysis

Effects of variety on voluntary feed intake (as a percentage of body weight and gram per kilogram metabolic body weight) as well as on digestibility coefficient of each nutrient were tested by Analysis of Variance and the mean values of each variety were compared using Duncan's New Multiple Range Test(Steel and Torrie,1960). Differences among group (wet season VS dry season non glutinous rice and glutinous VS non glutinous rice) were determined by Orthogonal comparison (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Proximate composition and voluntary feed intake

There was little variation in proximate component and fibre fraction of 5 varieties of straw collected for this study (Table 1). Average DM, OM and ADL were 91.9, 81.8 and 5.0%,respectively. Protein content was in the range of 3.0-4.0% with the exception of RD_1 (6.1%). The high protein content of RD_1 may be due to high N-fertilization (Roxas et al., 1984b). NDF and ADF were in the range of 73.8-74.9% and 53.1-55.0% with the exception of RD_7 which was higher (77.6 and 56.0% respectively).

No significant difference in acceptability and voluntary feed intake (VFI) by sheep were found among straw varieties(Table 2). Animals needed only 2 days for adaptation to straw. Average VFI as a percentage of body weight and as gram per kilogram metabolic body weight (g/kg $W^{0.75}$) were about 2.2 and 52.3, respectively.

Table 1. Proximate composition and fibre fraction of 5 rice straw varieties.

	Kaew Khao	Sanpatong	Mali	RD_1	RD_7
DM	90.8	92.8	92.8	91.4	91.9
CP	3.0	3.1	4.0	6.1	3.6
OM	82.3	82.5	81.0	82.6	80.6
NDF	74.9	74.9	73.8	74.3	77.6
ADF	53.1	55.0	55.0	53.5	56.0
ADL	4.3	5.2	5.2	4.7	5.5

Table 2. Voluntary feed intake of rice straw.

	Kaew Khao	Sanpatong	Mali	RD_1	RD_7
g feed (air dry)	634.6±132.9	576.2±94.6	563.8±58.0	670.8±191.9	852±181.9
% BW	2.3±0.4	2.1±0.1	2.2±0.2	2.2±0.5	2.4±0.3
g/kg $W^{0.75}$	53.6±8.4	48.2±3.2	50.3±3.4	51.4±11.7	57.8±8.3

Digestibility among rice straw varieties and among rice straw groups

Digestion coefficient of dry matter and organic matter of the 5 rice varieties were in the range of 47.2-55.2 and 52.8-60.5% respectively, while that of NDF, ADF and ADL were 48.5-58.9%, 45.3-55.4% and 12.8-29.7%, respectively (Table 3). Significant differences among varieties were found in these parameters. RD_1 showed higher digestibility in DM, OM, NDF and ADF than other varieties. This may be due to its higher protein content and relatively lower fibre fraction. Digestibility coefficient among the remaining four varieties were nearly the same.

Table 3. Digestion coefficient of nurrients and fibre fractions in straw varieties.

Item	Kaew Khao	Sanpatong	Mali	RD_1	RD_7
DMD	50.2^{b}	47.2^{b}	47.7^{b}	55.2^{a}	47.4^{b}
OMD	56.5^{ab}	52.8^{b}	54.5^{b}	60.5^{a}	54.9^{b}
NDF	50.3^{b}	48.6^{b}	48.5^{b}	58.9^{a}	55.2^{a}
ADF	47.7^{b}	46.2^{b}	45.3^{b}	55.4^{a}	45.3^{b}
ADL	18.7^{a}	21.1^{a}	20.0^{a}	12.8^{a}	29.7^{b}

^{ab} Means on the same row with different superscripts differ ($P < 0.05$).

Kind of rice (Glutinous VS Non-glutinous) as well as planting season (wet VS dry) had less effect on digestibility and voluntary feed intake. Sheep digested nutrients in these straws to the same degree with the exception of NDF and ADF. Non-glutinous straw showed higher NDF digestibility than glutinous, while dry season straw had higher NDF and ADF digestibility than wet season straw. This difference had no effect on voluntary feed intake by sheep.

The result of this study further supports the previous conclusion of Cheva-Isarakul and Cheva-Isarakul (1974) that the low utilization of dry season rice straws as animal feed is not due to their lower nutritive value or palatability. On the contrary, it is due primarily to the abundance of green roughage after rice harvesting.

Total collection method VS AIA method

Digestion coefficient of nutrients determined by total fecal collection or by using acid insoluble ash (AIA) as an internal indicator are closely related (Fig. 1). The correlation coefficients (r) between these two methods was found to be 0.95. This agrees with Sriwattanasombat and Wanapat (1984) who found no significant difference in digestibility determination of straw basal diet in buffaloes by these two methods.

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Table 4. Average digestion coefficients and voluntary feed intake by sheep of glutinous VS non-glutinous straw and wet VS dry season non-glutinous straw.

Item	Glutinous VS	Non-glutinous	Non-glutinous: Wet season VS	Dry season
DM	48.7^a	50.1^a	47.7^a	51.3^a
OM	54.6^a	56.6^a	54.5^a	57.7^a
NDF	49.4^a	54.2^b	48.5^a	57.0^b
ADF	47.0^a	48.7^a	45.3^a	50.4^b
ADL	19.9^a	20.8^a	20.0^a	21.2^a
VFI, % BW	2.2^a	2.3^a	2.2^a	2.3^a
VFI, g/kg $W^{0.75}$	50.9^a	53.0^a	50.3^a	54.4^a

[ab] Means on the same row under appropriate heading with different superscripts differ ($P < 0.05$).

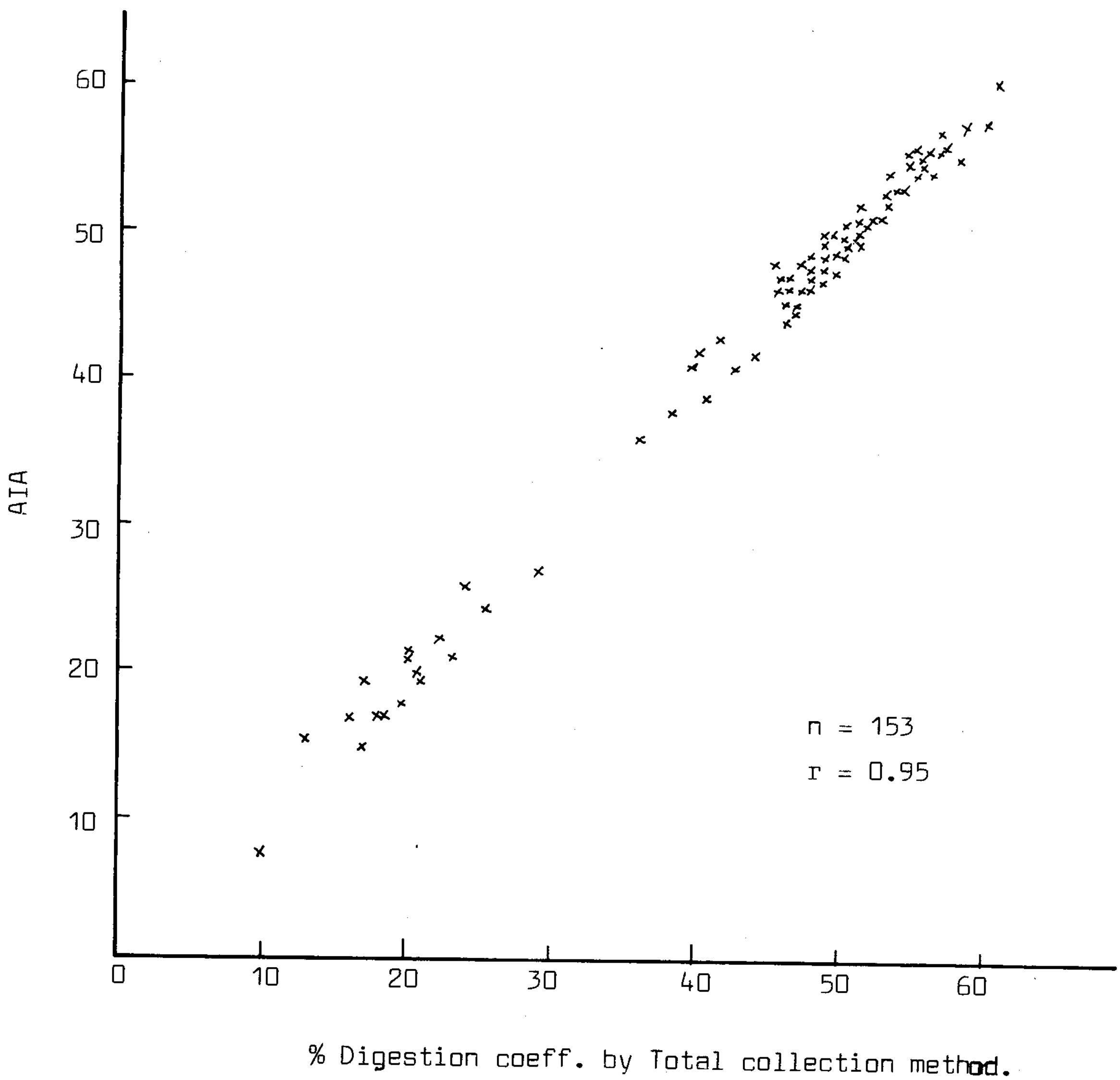

Figure 1. Correlation of digestion coefficients between AIA and Total collection method.

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YIELD AND NUTRITIVE VALUE OF GROUNDNUT VINES AT THE POD HARVESTING STAGE

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SUMMARY

This experiment was conducted to determine the yield and nutritive value of groundnut vines at the pod harvesting stage. A digestibility trial was also used to study the effect of supplementing groundnut vines to a rice straw ration on the feed intake and digestibility of various nutrients for sheep.

Average dry matter yields of whole groundnut vines (excluding roots) were in the range of 2,281 to 2,988 kg/ha, whereas the average dry matter yield for the groundnut vine tops (approximately 1 ft length from the top of the plant) was 638 kg/ha. Groundnut vine tops contained more crude protein (15.1 % vs 12.1 %)but less neutral-detergent fiber (44.3% vs 46.0 %) than the whole groundnut vines.

A randomized complete block design with 4 replications and 4 treatments utilizing sixteen wethers (averaging 20 kg liveweight)was conducted to determine nutrient digestibility and nitrogen balance. Four of the wethers were randomly assigned to one of the four dietary treatments, namely: 1) whole groundnut vines; 2) groundnut vine tops; 3) rice straw and 4) rice straw + groundnut vine tops in equal proportions (air dry basis). It was found that the digestibility of most nutrients for the whole and the groundnut vine tops were similar. Incorporation of groundnut vine tops to rice straw increased the amount of absorbed nitrogen from -0.11 to 2.80 g/h/d and nitrogen retention from -1.15 to 0.30 g/h/d. The intake of crude protein and energy in terms of total digestible nutrients (TND) for sheep fed on rice straw supplemented with

groundnut vine tops were approximately 230% and 40% higher, respectively, than those fed on rice straw alone.

The results of the chemical composition, nutrient digestibility and nitrogen balance determinations would indicate that there is an imbalance between the protein and energy contents of the groundnut vines especially from the tops. The ratio of total protein and digestible protein to TDN intake for the whole vines were 1:4.28 and 1:7.80 and for the tops were 1:3.53 and 1:6.63, respectively. According to the standard requirements for ruminant animals, however, the recommended ratio for the intake of total protein to TDN is in the range of 1:6 to 1:7 or 1:9 to 1:11 when expressed in terms of digestible protein to TDN intake.

Key words : groundnut residues, digestibility, sheep.

INTRODUCTION

Groundnut (*Arachis hypogaea*) is one of the most important cash crops for Thailand. In 1981, the planted area for groundnut in the whole country was 122,240 ha with a total dry pod (unshelled) yield of 146,800 tons which gives an average yield of 1,200 kg/ha. (Office of Agricultural Economics, 1982). It has been reported that groundnut vines, a by-product from groundnut production,represent a dry matter yield approximately 2 to 3 times that of pod yield (Suwanarat et al., 1983). Unfortunately, this large quantity of available groundnut by-product are greatly underutilized at the present, it is being left to rot or to be burned in the field after harvesting the pods.

Unlike other legume crops such as mungbean or soybean, much of the green leaf still remains on the groundnut plant at pod harvesting time. The data from Vearasilp et al. (1981) and the feeding tables from Kearl (1982) show that groundnut vines at the pod harvesting stage are relatively high in nutritive value. Their protein and energy contents are comparable or even higher than that of good quality paragrass (*Brachiaria* *mutica*) (Holm, 1971). This suggests that this groundnut by-product could be efficiently utilized by ruminant animals. It has been shown that the feeding quality of fresh groundnut vines is better than when they are preserved as hay or silage (Kearl, 1982 and Vearasilp et al., 1981). Since farmers generally harvest the whole groundnut field in a short period of time, the use of fresh vines will be limited as small farmers usually own very few head of cattle and buffalo. Therefore, there is a need to preserve the groundnut vines either as hay or silage for feeding or supplementing cattle and buffalo over the period of critical feed scarcity in the dry season.

The experiment reported here was conducted to determine the yield and the nutritive value of groundnut vines at the pod harvesting stage and also to evaluate the effect of supplementing groundnut vines to rice straw rations using sheep as the experimental animals.

MATERIALS AND METHODS

Two different kinds of groundnut vines were used in this study: whole groundnut vines (excluding the root portion)and groundnut vine tops (approximately 1 foot length from the top of the plant). The whole groundnut vines were derived from Dr. Winit Chinsuwan who is in charge of The Groundnut Strippers Project sponsored by The International Development Research Centre (IDRC). The groundnut vines were collected from the groundnut growers at Kalasin province at harvest time in July and August, 1983. The groundnut vine tops, were derived from fields at The Northeast Regional Office of Agriculture (NEROA), Khon Kaen province and were harvested in November, 1983. Both kinds of groundnut were Tainan 9 variety. The harvested groundnut vines were sun dried, chopped (approximately 2 cm in length), thoroughly mixed and kept for digestion and balance trials. During harvesting time, representative samples of groundnut vinew were also sampled to estimate yield.

In the digestion trial, sixteen wethers averaging 20 kg liveweight were used. The wethers were assigned to 4 treatments in a randomized complete block design with 4 treatments replciated 4 times. The four dietary treatments were :

1) whole groundnut vines
2) groundnut vine tops
3) rice straw
4) rice straw + groundnut vine tops (ratio 1:1)

Prior to the start of the trial, all wethers were dewormed and injected intramuscularly with vitamins A, D and E. A twelve-day preliminary period was followed by a six-day standardlization period and a seven-day collection period. The wethers were individually fed twice daily in metabolism creates with water available at all times.The wethers were allowed to consume as much feed as desired during the preliminary period. During the standardization and collection periods, feed intake of each wether was reduced to approximately 10% of the ad libitum intake to minimize feed refusals.

Feed, feces and urine samples were collected daily during the collection period. Hydrochloric acid was used as a urinary preservative in glass collection bottles. All of the composites of feed, feces and urine were stored in a freezer until analyzed. Proximate and detergent analyses of samples were determined according to A.O.A.C. (1970) and Goering and Van Soest (1970). Statistical analysis was conducted by analysis of variance and least significant difference (LSD) was used to test for significant differences among treatment means.

RESULTS AND DISCUSSION

The data in Table 1 show that the average yield of dry groundnut vines (excluding roots) and dry pods were 2,281 and 1,450 kg/ha, respectively (Dr.Winit Chinsuwan, personal communication). The vine: pod ratio of the groundnuts was 1.57:1. Average dry matter yield of groundnut vine tops (approximately 1 ft length from the top of the plant) was 638 kg/ha. Additional measurements on the yield of

Table 1. Dry matter yield and vine : pod ratio of groundnut vines at harvesting time.

Groundnut vines		DM yield (kg/ha)	Vine: pod ratio 4/
Whole plant	1/	2281	1.57:1
	2/	2988 ± 763	2.06:1
Tops	3/	638 ± 275	0.44:1

1/ Groundnut vines used in this experiment.

2/ Groundnut vines harvested at NEROA (not included in this experiment). Means and standard deviations are based on 7 samples.

3/ Groundnut vines used in this experiment. Means and standard deviations are based on 20 samples.

4/ All vine: pod ratios were calculated using the average dry pod yield of 1,450 kg/ha as derived from 1/ (Dr. Winit Chinsuwan, unpublished data).

groundnut vines were also conducted at the NEROA during another harvesting time (May, 1984). It was found that the average dry matter yield of these whole groundnut vines (not included in this study) was 2,988 kg/ha. There is limited information on the yield of groundnut vines and vine : pod ratio of groundnut. Guzman (1980) reported that the extraction rate of groundnut vines, a by-product from groundnut growing,was approximately 41 to 57%. Estimation of vine : pod ratio from the data of Suwanarat et al. (1983) was in the range of 2:1 to 3:1. The differences in the results on the yield of groundnut vines and vine :pod ratio obtained from this study and other reports may have been due to various factors such as variety differences, planting and harvesting seasons as well as the differences in cultural practices, etc. It should also be noted from the

Table that there was quite a large variation (large standard deviation values) among samples even though they were sampled in the same field.

Table 2 shows that the leaf : stem ratio of groundnut vine tops was 1:1.75. The leaves contained higher protein but lower fiber contents than those found in the stem. The quantity of protein (23.2%) and fiber (13.5%) of groundnut leaves was comparable to that of good alfalfa leaf meal. This suggests that certain amounts of groundnut leaf could be successfully used as sources of protein, some minerals and vitamins in the rations for nonruminants e.g. poultry and swine.

Table 2. Proximate constituents of leaf and stem of groundnut vine tops[1/].

	Groundnut vines		
	leaf	stem	leaf + stem
	% DM		
CP	23.2	11.0	15.5
CF	13.5	29.2	23.7
EE	2.7	1.8	2.3
Ash	10.4	8.8	9.6
NFE	50.3	49.2	48.9

1/ leaf : stem ratio was 1:1.75.

The chemical composition of groundnut vines, rice straw and rice straw mixed with groundnut vine tops are presented in Table 3. Groundnut vine tops contained more protein but less ash than the whole groundnut vines. The protein and ash contents of the tops and whole groundnut vine were 15.1, 8.3% and 12.1, 13.2%, respectively. The chemical composition of whole groundnut vines obtained from this study was similar to that of Vearasilp et al. (1981). They reported that

Table 3. Chemical composition of the experimental diets.

	Groundnut vines		Rice straw	Rice straw + Groundnut vine tops
	Whole plant	Top		
	% DM			
Proximate analysis				
DM	88.4	88.8	92.5	89.7
CP	12.1	15.1	3.6	8.6
CF	29.2	28.1	35.3	32.8
EE	2.0	2.2	1.7	1.9
Ash	13.2	8.3	11.1	9.9
NFE	43.5	46.4	48.3	46.8
Detergent analysis				
NDS	53.9	55.7	25.5	41.3
NDF	46.1	44.3	74.5	58.7
ADF	39.3	39.3	45.9	42.3
ADL	7.5	8.1	3.6	5.2
PML	9.4	10.5	4.3	6.7
AIA	4.2	1.0	8.1	4.2
Hemicellulose[1/]	6.7	5.1	28.7	16.3
Cellulose[2/]	31.8	31.1	42.2	37.1

1/ Hemicellulose = NDF - ADF

2/ Cellulose = ADF - ADL

whole groundnut vines at the pod harvesting stage contained 12.3% crude protein and 29.0% crube fiber. However, the ash content values given by Vearasilp et al. (1981) were relatively high (24.9 to 25.4%). The feeding tables from Kearl (1982) indicate that although the chemical composition of groundnut vines varied due to differences in planting locations, maturity stages, physical forms and handling methods, the ash contents of all groundnut vines were in the range of 8 to 12%. Therefore, it is possible to conclude that the high ash content of whole groundnut vines obtained from this study and those reported by Vearasilp et al. (1981) may be caused by soil contamination. This is due to the fact that the leaf and stem portions of the plant were easily contaminated with soil during pod harvesting. Goering and Van Soest (1970) and Van Soest and Jones (1968) explained that the silica which was recovered in the plant samples can be derived from 2 sources: plant origin and soil contamination. However, there is no precise method to analyse silica from these two sources separately.

As compared to rice straw alone, incorporation of groundnut vine tops with rice straw in equal proportions increased the protein content from 3.6 to 8.6% and decreased the fiber and ash contents from 35.3 and 11.1% to 32.9 and 9.9%, respectively.

Detergent analyses showed that whole groundnut vines contained higher neutral-detergent fiber (NDF) or cellwall constitutents (CWC) but lower neutral-detergent soluble (NDS) or cellular contents (CC) than groundnut vine tops. The concentration of acid insoluble ash (AIA) was found to be as high as 4.2% in the whole groundnut vines, whereas only 0.97% was found in the tops. Since it has been shown that the major component of AIA fraction is silica (Goering and Van Soest, 1970), the high AIA content found in the whole groundnut vines may possibly come from soil contamination as discussed previously.

It is evident that rice straw, which is classified as a low quality roughage, was characterized by a high content of a less digestible NDF fraction (74.5%) or a low content of an easily digestible NDS fraction (25.5%). Of the total ash content of 11.3%, almost 8.1% was recovered as AIA which represents approximately 73% of the total ash. This is in close agreement with Clawson and Garrett (1970) who reported that about 3/4 or even more of the ash in rice straw is composed mainly of silica. Rice straw contains lower lignin content expressed either in terms of acid detergent lignin (ADL) or permanganate lignin (PML) but higher hemicellulose content than the groundnut vines. When comparing chemical composition between grass and legume forages, Van Soest (1967) found that legumes generally had a higher lignin but lower hemicellulose content.

It is obvious from the Table that incorporation of groundnut vine tops with rice straw resulted in an increase in the NDS fraction from 25.5% to 41.4% or alternatively decreased the NDF fraction from 74.5 to 58.7%.

The feed intake and digestion coefficients of various nutrients in the experimental diets are shown in Table 4. All of the intake data reported here were based on approximately 90% of the ad libitum intake of sheep measured during the preliminary period. Feed intake of sheep fed with the whole or the groundnut vine tops was similar with actual values of 2.87 and 2.77% BW or 61 and 59 g/W $kg^{0.75}$ respectively. As might be expected, the intake of sheep fed only rice straw was very low (only 1.63% BW or 35 g/W $kg^{0.75}$). This was primarily due to a very high content of fibrous materials(CF and NDF) presented in the rice straw. In studies of various forages, Van Soest (1965, 1967)reported that voluntary intake is highly negatively correlated with the concentration of the total fibrous NDF fraction. As this fraction increases, voluntary intake of forages by animals declines.

Although sheep fed rice straw supplemented with groundnut vine tops consumed less feed than those fed both groundnut vines, their feed intakes were higher than those fed only rice straw. The increases in feed intake of sheep on supplemented rice straw as compared to those on unsupplemented rice straw could result from the decrease in the NDF fraction from 74.5% to 58.7%.

Table 4. Dry matter intake and apparent digestion coefficients of the experimental diets.

	Groundnut		Rice straw	Rice straw + Groundnut vine tops
	Whole plant	Tops		
Feed intake[1/]				
DM intake, g/d	574	568	351	481
DM intake, % BW	2.87	2.77	1.63	2.42
DM intake, g/kg $W^{0.75}$	61	59	35	51
Digestibility[2/], %				
DM	52.1 ± 1.10^a	52.0 ± 1.04^a	46.2 ± 1.80^b	46.8 ± 1.10^b
OM	58.8 ± 0.31^a	54.2 ± 1.07^b	51.4 ± 1.38^c	49.2 ± 1.20^d
CP	55.8 ± 1.24^a	53.2 ± 1.69^a	-5.2 ± 9.49^c	41.8 ± 2.54^b
CF	56.6 ± 0.48^c	59.0 ± 1.02^b	66.5 ± 2.13^a	54.0 ± 2.38^d
EE	32.1 ± 0.42^c	54.7 ± 1.64^a	25.4 ± 3.69^d	47.9 ± 0.71^b
Ash	7.6 ± 6.79^b	27.7 ± 3.15^a	14.5 ± 1.32^b	26.1 ± 5.29^a
NFE	62.5 ± 0.62^a	55.8 ± 1.02^b	45.9 ± 2.07^c	47.0 ± 0.90^c
NDS	48.0 ± 2.78^a	52.6 ± 0.62^a	9.3 ± 8.43^c	40.6 ± 3.05^b
NDF	57.0 ± 1.54^a	51.2 ± 2.00^b	58.7 ± 0.91^a	51.2 ± 2.06^b
ADF	51.1 ± 1.53^b	47.2 ± 1.32^c	53.6 ± 2.03^a	46.6 ± 1.64^c
Hemicellulose	91.7 ± 3.11^a	82.3 ± 9.38^a	69.2 ± 5.32^b	59.1 ± 6.38^c
Cellulose	58.8 ± 1.02^b	62.6 ± 0.59^a	57.7 ± 2.15^b	49.9 ± 1.38^c
Total digestible nutrients (TDN)	51.9 ± 0.28^b	53.2 ± 0.90^a	44.6 ± 1.07^c	45.3 ± 1.28^c

1/ Based on approximately 90% of ad libitum intake of sheep weighing about 20 kg.
2/ Means within a row followed by different superscripts significantly differ ($P < 0.05$).

A comparison of the 2 types of groundnut vines showed that the dry matter (DM) and crude protein (CP)digestibilities were similar. However, because whole groundnut vine had a higher AIA concentration, the digestibilities of organic matter (OM) was higher but that of ash was lower than the groundnut vine tops. The digestibilities of NDS and NDF of the whole groundnut vines and the tops were 48.0, 57.0 and 52.6, 51.2 %, respectively. The lower NDF digestibility found in groundnut vine tops was due to its high content of lignin, since lignin content has been shown to be negatively correlated to the digestibility of NDF (Van Soest and Moore, 1965).

A negative CP digestibility obtained from sheep fed on rice straw alone indicated inadequate protein in rice straw to meet the requirements of the animals. It should be noted that the digestibility of crude fiber (CF) in the rice straw was higher than the nitrogen free extract (NFE). This demonstrates a disadvantage of the Weende method for analysing the fibrous materials in animal feeds as previously shown by Van Soest (1963). From detergent analyses, it was found that the digestibility of the readily available NDF fraction in the rice straw was very low (9.3 %). This is because rice straw has a very low NDS content (25.5 %), consequently only a small amount of NDS was received by the sheep. Since rice straw contained a lower concentration of lignin but higher concentration of NDF and acid detergent fiber (ADF), the digestibility of NDF was higher than that of groundnut vines. It has been shown by Marten (1976) and Van Soest and Moore (1965)that lignin affects only the digestibility of NDF and not that of the readily available NDS fraction of forage and that the lower digestibility of legume fiber as compared to grass fiber is due primarily to the higher degree of lignification of its fiber fraction.

One obvious effect of supplementing a rice straw ration with groundnut vines is an improvement in CP digestibility. The digestibility of CP was increased from a negative value of -5.3 % to a positive value of 41.8 %. Incorporation of groundnut vines also increased the digestibility of NDS from 9.3 to 40.6%. In constrast, the NDF digestibility decreased from 58.8 to 61.2 %. The lower digestibility of NDF in the groundnut vine supplemented ration compared to the rice straw ration is due to the alteration of lignin,NDF and ADF concentrations. It should be pointed out that the similarity in the overall DM digestibility between this two rations was obtained from different intakes. Various reports indicate that the DM ingestibility of roughages or forages decreases with increased levels of intake (Blaxter and Graham, 1956; Brown, 1966;Campling and Freer 1966; Schneider and Flatt, 1975). Therefore, the DM digestibility of rice straw supplemented with groundnut vine can be expected to be better than that of rice straw alone if the intakes of both rations are the same.

Table 5 illustrates the effects of supplementing rice straw with groundnut vine tops on the intake of feed,protein and energy expressed in terms of total digestible nutrients (TDN). Supplementation of rice straw with an equal amount of groundnut vine tops accounted for an increase in the total CP intake of 231.9 % and for TDN of 40.3 %. Average daily intakes of total CP, digestible CP and TDN of sheep fed on rice straw without supplementation were 12.6, -0.66 and 156.5 g/h and for groundnut vine tops supplementation were 41.8, 17.5 and 219.7 g/h, respectively. From these experimental results, it can concluded that the improvement in the nutritive value of rice straw when supplemented by groundnut vines is through the increase in both digestible protein and energy intakes by the animals.

Results of the nitrogen balance in sheep fed the four different experimental diets are given in Table 6. Average nitrogen intake and absorption were highest in sheep fed groundnut vine tops and lowest in sheep fed rice straw. The indequate protein requirement of sheep fed rice straw only was indicated by a negative value of nitrogen absorbed (-0.11 g/d) and retained (-1.15 g/d). The amounts of nitrogen absorbed and retained were increased to 2.80 and 0.30 g/d, respectively, when rice straw was supplemented with an equal amount of groundnut vine tops.

Table 5. Total and digestible nutrient intake of the experimental diets fed to sheep[1/].

	Groundnut vines		Rice straw	Rice straw + Groundnut vine tops	Percentage improvement[2/]
	Whole plant	Tops			
Total intake, g/d					
DM	574	568	351	484	38
OM	499	521	312	437	40
CP	69	86	13	42	232
Digestible intake, g/d					
DM	299	295	162	227	40
OM	293	282	180	238	32
CP	38	45	-0.66	17	-
TDN	298	302	156	220	40
Ratio of CP intake : TDN,g/g	1:4.28	1:3.53	1:12.42	1:5.25	-
Ratio of digestible CP intake : TDN, g/g	1:7.80	1:6.63	-	1:12.57	-

1/ Based on approximately 90% of ad libitum intake of sheep weighing about 20 kg.

2/ Comparison was made between rice straw alone and rice straw with groundnut vine tops.

Table 6. Nitrogen balance of the experimental diets fed to sheep.

	Groundnut vines		Rice straw	Rice straw + Groundnut vine tops
	Whole plant	Tops		
N balance, g/d				
Intake	11.0	13.7	2.0	6.7
In feces	5.0	6.4	2.1	3.9
Absorbed	6.0	7.3	-0.1	2.8
In urine	4.2	6.0	1.0	2.5
Retained1/	1.9[a]	1.3[b]	-1.1[d]	0.3[c]
N Retained, % intake	16.8	9.2	-	4.5
N Retained, % absorbed	30.8	17.3	-	10.7

1/ Means within a row followed by different superscripts significantly differ ($P < 0.05$).

It is interesting to note that although sheep fed groundnut vine tops had a higher amount of nitrogen absorbed, their nitrogen retention was lower than sheep fed whole groundnut vines. The greater urinary excretion and eventually lower nitrogen retention may be to the protein in the groundnut vine tops being more soluble. Various reports have shown that highly soluble dietary protein is degraded at a very rapid rate in the rumen leading to high ruminal ammonia production which results in high urinary excretion and low retention of nitrogen (McDonal, 1952, 1954; Chermers and Synge, 1954; Lewis, 1962; Tillman and Sidhu, 1969). In addition, a low intake of available energy in relation to the relatively high protein intake of groundnut vine tops may be another factor contributing to the poor protein utilization. Many reports have shown that an increase in the available energy intake will improve nitrogen utilization by increasing nitrogen retention (Lofgreen et al., 1951; Stone and Fontenot, 1965, Putnam et al. 1966).

The results of the chemical composition, nutrient digestibilities and nitrogen balance determinations might suggest that there is an imbalance between protein (nitrogen) and energy presented in both types of groundnut vines. The ratio of protein : energy (TDN) seems to be too narrow. This means that the content of available energy in groundnut vines is inadequate for the optimum utilization of its relatively high content of protein. As shown in Table 5, the intake of total protein to TDN for sheep fed on the whole groundnut vines or only the tops was in the ratio of 1:4.28 and 1:3.53,or equal to 1:7.80 and 1:6.63, respectively, when expressed by the ratio of digestible protein to TDN intake. However, the standard requirements for ruminant animals published by Kearl (1982)recommend that the ratio of protein to TDN intake should be in the range of 1:6 to 1:7,or 1:9 to 1:11 in terms of digestible protein to TDN intake.

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THE UTILISATION OF TWO TROPICAL GRASSES BY CATTLE

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SUMMARY

Six Friesian Steers (350 kg liveweight), prepared with rumen cannulae, were fed paspalum (artificially dried at 65°C) at three stages of maturity and kikuyu at two stages of maturity. Both forages were fed at three levels of organic matter intake (OMI)(approx. 4.3, 3.5 and 2.7 kg/d). There were 90 animal observations in total. The indigestible markers were chromium EDTA and ytterbium nitrate. Microbial protein was labelled with ^{15}Nitrogen. Digesta leaving the rumen was sampled at the omasum by manually inserting a suction tube into the omasum via the rumen fistula. The true degradation of forage OM in the rumen was estimated from the disappearance of total OM to the omasum plus the OM contributed by microorganisms. The true degradation of forage protein in the rumen was estimated by subtracting microbial and endogenous protein from the total protein flowing to the omasum. The apparent digestion of OM and crude protein (CP) in the overall gastrointestinal tract (GIT) was measured using the marker ratio technique.

The main finding are that for paspalum there was a reduction in the degradability of OM in the rumen and also in the digestion of OM in the overall GIT with advancing maturity. For kukuyu there was no significant effect of the stage of maturity on the disappearance of OM in the rumen or the GIT. The levels of OMI (4.3 to

2.7 kg/d) had only a small effect on the OM and protein disappearance in the rumen and GIT and also on the efficiency of microbial protein synthesis.

For paspalum and kikuyu there was no significant effect of the stage of forage maturity on the true degradation protein in the rumen. For both paspalum and kikuyu there was a reduction in the apparent digestibility of CP in the overall GIT with increasing maturity of the forage. The efficiency of microbial protein synthesis was reduced at the advanced stage of maturity of kikuyu (20 versus 12 g microb. N/1000 g truly FOM), but for paspalum there was no reduction with advancing maturity.

Key works : tropical forages, protein degradation,microbial protein systhesis.

INTRODUCTION

The object of the present study was to investigate three factors which effect the degradability of protein and OM from tropical grass in the rumen of cattle. The three factors examined were the species of grass, the stage of maturity of the grass and level of organic matter intake.

There is very little information in the literature on the degradability of protein from grass in the rumen of cattle. There are three main reasons for this. Firstly, it is difficult to sample directly the end products of fermentation in the rumen, secondly it is difficult to distinguish protein of dietary, microbial and endogenous origin in the GIT and thirdly it takes a lot of time and labour to collect enough grass to conduct an experiment using cattle.

In the present experiment and attempt was made to overcome these problems by firstly sampling digesta from the omasum to obviate the problem of abomasal secretions contaminating the end products of rumen fermentation. Secondly ^{15}Nitrogen (^{15}N) was used to label microbial protein and thirdly endogenous protein leaving the rumen was estimated in a pilot study where a diet containing no degradable protein was fed in order that additional protein of endogenous origin could be measured by difference.

MATERIALS AND METHODS

Forage

Pastures of Paspalum dilatatum were harvested at three stages of physiological maturity in northern NSW, Australia. The first harvest occurred when approximately 10% of the plants were flowering. The medium harvest occurred at 80% flowering while the late harvest was at the post flowering stage.

Pastures of Kikuyu (*Pennisetum clandestinum*) were harvested at two stages of maturity. The early harvest was of young leafy material while the late harvest was of senescing stoloniferous material.

Both Paspalum and Kikuyu were harvested with a precision chop forage harvester and blown directly into a following truck.The harvested grass was then taken directly to an oil operated grass drier. The drier consisted of a large chamber approximately 10 by 6 metres with a perforated base through which the hot air was forced. The temperature of the incoming air was approximately 65°C. During the drying process, which lasted between 6 and 8 hours, the grass was forked over several times to facilitate the drying process.

Animals

Six Friesian steers weighing approximately 350 kg were used. They were cannulated in the rumen and housed in individual pens with continuous automatic feeders, ad libitum water and 24 hour lighting.

Feeding regime

The steers were adapted to the forage for 3 weeks, during which their ad libitum intake was established. The adaptation period between the different stages of maturity was also 3 weeks, while 2 weeks was allowed between different levels of OMI. During the experimental period the steers were fed forage sprayed with markers for one week, with digesta collections occurring on the last 3 days. There were a total of 9 collection periods for the paspalum and 6 collection periods for the kikuyu. The forage was offered in 8 equal quantities at intervals of 3 hours from automatic feeders. The three levels of OMI were approximately 90%, 70% and 40% of their ad libitum intake. The mean OMI for paspalum was 4.20, 3.36 and 2.26 kg/d and 4.31, 3.52 and 2.77 for kikuyu. For statistical reasons the ad libitum intake of both forages was set at the level of the animal with the lowest intake consuming the most mature forage.

Digesta and microbial markers

The indigestible liquid and particle phase markers were chromium EDTA and ytterbium nitrate respectively. Solutions of Cr EDTA and Yb (5% volume of solution to mass of forage DM) were sprayed onto the forages at 280 and 160 ppm respectively.

A single injection of ^{15}N-ammonium sulphate (100 mg ^{15}N) was administered into the rumen and samples of microorganisms were taken from the omasum approximately 7 hours later.

Collections

Digesta leaving the rumen was sampled at the omasum by manually inserting a tube via the rumen fistula into the omasum and withdrawing approximately 100 ml of digesta by suction. This was done 3 times during the day and the samples were bulked over 3 days. Rumen fluid was taken at the same time for ammonium analysis. Fae ces were sampled throughout the day and a total collection of urine was also made.

At approximately 7 hours after the single injection of ^{15}N-ammonium sulphate, a 200 ml sample of omasal digesta was taken for determining the proportion of microbial N in total N.

Sample preparation and chemical analysis

Rumen fluid samples were acidified with 18 N sulphuric acid (pH 2) and frozen (-20°C). Omasal digesta was acidified to pH 4. The microbial fraction was immediately isolated by differential centrifugation. The first spin was at 1,800 rpm for 10 minutes. The supernatent from this process was spun at 15,000 rpm. The sediment was re-suspended in saline and again spun at 15,000 rpm. Finally the sediment was re-suspended in distilled water and stored at -20°C.

Dacron polyester material (50 micron)was used to separate whole digesta into filtrate and filtrand for reconstitution purposes.

Chromium and ytterbium were analysed using the atomic absorption spectrophotometer. The method of Faichney (1975) was followed for calculating the true flow of digesta and constituents.

The total N content of feed,omasal digesta and faeces was measured with the standard micro kjeldahl technique. The true protein content of forage was estimated by suspending finely ground samples of forage in phosphate buffer, then precipitating protein with tungstic acid (Winter et al. 1964). Similarly the true protein content of omasal digesta was measured using tungstic acid.

Ammonia was analysed by the colourimetric method adapted from Chaney and Marbach (1962). ^{15}Nitrogen was determined by mass spectrometry.

Forage protein N degradability =

$$1 - \frac{\text{Total omasal N-(microb. N + endog. protein N* + NPN)}}{\text{Forage true protein N}}$$

* Endog. protein N = 2.2 g N per kg DMI

OM degradability =

$$1 - \frac{\text{Total OM flow to moasum - microbial OM flow}}{\text{Forage OM intake}}$$

Statistical analysis

The experiment was a factorial design with the treatments being species of forage, stage of maturity of the forate and the level of OMI.

An analysis of covariance was carried out an arc sin transformed data.

RESULTS

Table 1. The nitrogen (N), acid detergent fibre (ADF) and acid detergent lignin (ADL) content of paspalum and kikuyu.

Component	Paspalum			Kikuyu	
	10% flowering	80% flowering	Post flowering	Early	Late
N	1.10^{a}	1.12^{a}	0.92^{b}	2.09^{c}	0.99^{d}
ADF	37.4^{a}	40.1^{b}	38.4^{c}	29.4^{d}	34.5^{e}
ADL	4.68^{a}	5.16^{b}	5.14^{b}	2.9^{c}	3.8^{d}

[abcd]Values with different superscripts differ ($P < .01$).

The N concentration declined with advancing maturity while the ADF and lignin concentration increased with advancing maturity for both forage species ($P < 0.01$).

There was a reduction in the degradability of OM to the omasum as well as a depression in the apparent digestion of OM in the overall GIT with advancing maturity of paspalum. However for kikuyu the stage of maturity had little effect on the degradability in the rumen or digestion in the GIT.

At the high level of intake of paspalum three was a depression in the apparent digestibility of OM in the GIT. For the remaining treatments there was either a small or an inconsistant effect of the level of OMI on the digestion of OM in the GIT.

For paspalum and kikuyu the stage of forage maturity had little effect on the true degradation of forage protein in the rumen. However there was a depression in the apparent digestion of CP in the GIT with advancing forage maturity for both species.

The level of OMI had little effect on the true degradation of protein from paspalum and kikuyu.

There was a higher level of rumen ammonia at the medium stage of maturity of paspalum. However there was little effect of the stage of maturity of paspalum on the efficiency of microbial protein synthesis.

For kikuyu there was a reduction in both the level of rumen ammonia and the efficiency of microbial protein synthesis at the most advanced stage of maturity.

Table 2. The true degradation of forage OM in the rumen and the apparent digestion of OM in the overall gastrointestinal tract (GIT) of steers.

Measurement	Level OMI	Paspalum				Kikuyu		
		Early	Med.	Late	Mean	Early	Late	Mean
True degrad.	High	44.9	51.9	40.1	45.6[a]	60.8	56.3	58.6[a]
of forage OM	Med.	52.9	48.3	48.4	49.9[a]	55.7	56.2	56.0[ab]
to omasum.	Low	46.9	49.1	44.3	46.7[a]	49.4	58.6	54.0[b]
(% OMI)	Mean	48.2[ab]	49.8[a]	44.3[b]	47.4	55.3[a]	57.0[a]	56.2
Apparent digest.	High	49.1	45.5	39.8	44.8[a]	62.7	56.6	59.7[ab]
of OM in	Med.	57.9	46.0	46.2	50.0[b]	62.9	60.6	61.8[a]
GIT	Low	57.8	46.8	48.1	50.9[b]	58.9	58.8	58.8[b]
(% OMI)	Mean	54.9[a]	46.1[b]	44.7[b]	48.6	61.5[a]	58.7[a]	60.1

[ab] Values within rows and columns with different superscripts differ ($P < .05$).

Table 3. The true degradation of forage protein in the rumen and the apparent digestion of crude protein (CP) in the overall GIT of steers.

Measurement	Level OMI	Paspalum				Kikuyu		
		Early	Med.	Late	Mean	Early	Late	Mean
True degrad. of	High	70	76	72	72^a	83	84	83^a
forage protein in	Med.	76	64	77	72^a	83	75	79^a
the rumen (% of	Low	73	70	76	73^a	84	79	82^a
intake)	Mean	73^a	70^a	75^a	73	83^a	79^a	81
Apparent digest	High	32	31	24	29^a	60	53	57^a
of CP in GIT	Med.	37	27	27	30^a	60	47	54^a
(% of intake)	Low	34	32	29	32^a	61	43	52^a
	Mean	34^a	30^{ab}	26^b	30	61^a	48^b	54

[ab] Values within rows and columns with different superscripts differ ($P < .05$).

Table 4. Rumen ammonia levels and the efficiency of microbial protein synthesis.

Measurement	Level	Paspalum				Kikuyu		
	OMI	Early	Med.	Late	Mean	Early	Late	Mean
Rumen ammonia	High	1.0	3.3	0.7	1.7[a]	7.7	4.0	5.8[a]
(M mole)	Med.	1.4	2.6	1.6	1.9[a]	8.0	8.0	5.5[a]
	Low	1.4	2.8	1.4	1.9[a]	7.7	2.0	4.8[b]
	Mean	1.3[a]	2.9[b]	1.2[a]	1.8	7.7[a]	3.0[b]	5.3
Effic. microb.	High	22	20	22	21[a]	18	14	16[a]
protein synth.	Med.	17	20	20	19[a]	18	11	14[a]
(g microb. N per	Low	18	19	22	20[a]	24	11	18[a]
1000 g TFOM*)	Mean	19[a]	20[a]	21[a]	20	20[a]	12[b]	16

* Truely fermented organic matter.

[ab] Values within rows and columns with different superscripts differ ($P < .05$).

DISCUSSION

Chemical composition

The reduction in the proportion of N and the increase in ADF and ADL with advancing maturity of the forage is similar to other studies reported in the literature (Waite et al., 1964; Weston and Hogan, 1968; Hogan et al., 1969).

The depression in the true degradation of OM in the rumen and the apparent digestibility in the overall GIT with advancing maturity of paspalum is consistent with the increase in ADF and ADL concentration of the plant. Similar findings have been made with sheep by Weston and Hogan (1968) and Hogan and Weston (1970). However this result did not occur with the kikuyu forage. In view of the marked decrease in the quality of the kikuyu with advancing maturity, there appears to be no obvious explanation for this result, apart from the fact that kikuyu is known to retain a high digestibility when mature (Göhl, 1981). Also kikuyu has been reported to become toxic under certain conditions of moisture and warmth (Busch et al., 1969; Cordes et al., 1969; Smith and Martinovich, 1973) which may have depressed the degradability of OM at the early stage of maturity.

The lack of effect of the level of OMI on the degradability of OM in the rumen may be attributed to the relatively small difference in the levels of forage intake (2.8 to 4.3 kg OMI/d). Unfortunately the maximum intake was only 4.8 kg OM/d for these tropical grass diets. However there was a depression in the apparent digestion of OM from paspalum in the GIT at the highest level of intake.

Results in the literature on the effect of the level of OMI on the degradability of OM in the rumen of sheep are variable. Both enhanced and depressed degradabilities of OM have reported with increasing levels of OMI (Ulyatt et al., 1975; Ulyatt and Egan, 1979; Egan and Doyle, 1983).

The small effect of the stage of forage maturity on the true degradability of forage protein from paspalum and kikuyu in the rumen is similar to the studies in sheep by Corbett et al. (1982). Other studies have shown in increase in the degradability of forage protein in the rumen with advancing maturity (Weston and Hogan, 1968; Hogan et al., 1969; Hogan and Weston and Hogan, 1971) or a decrease in the degradability (Hogan and Weston, 1970 and Weston and Hogan, 1971).

The reduction in the apparent digestion of CP in GIT for both paspalum and kikuyu with advancing maturity is similar to the results of most studies reported in the literature.

The apparent digestion of CP from paspalum is considerably less than that of kikuyu (30 versus 54%). A possible explanation for this result is that because the concentration of N in the paspalum is low compared with kikuyu (Table 1), the influx of metabolic faecal nitrogen (MFN) would cause a marked reduction in the apparent digestion of CP for paspalum. If a value of 5 grams of MFN/kg of DMI is adopted (ARC, 1980) the true digestion of CP from paspalum would be approximately 77%.

The level of OM intake had little effect on the true degradation of forage protein in the rumen or on the apparent digestion of CP in the GIT for both paspalum or kikuyu. This is consistent with the results for the disappearance of OM in the rumen and the GIT.

Levels of ammonia in rumen fluid reflected the extent of the degradation of protein in the rumen. However there appears to be no obvious explanation for the higher levels of rumen ammonia at the medium stage of maturity of paspalum. The similarity in the efficiency of microbial protein synthesis across stages of maturity of paspalum is consistent with the similarity in the degradation of OM and protein in the rumen for the same stages of maturity. For kikuyu the decrease in the efficiency of microbial protein synthesis with advancing maturity is in accordance with the trend towards a reduced degradation of forage protein in the rumen and the lower concentration of ammonia in rumen fluid.

For both paspalum and kikuyu, the small effect of the level of OMI on the efficiency of microbial protein synthesis in the rumen is consistent with the results for the degradation of OM and protein in the rumen.

CONCLUSION

Estimating the degradability of protein in the rumen involves a compounding of errors because of the indirect, factorial nature of the calculation involving many measurements. Hence it is difficult to obtain precise answers using this approach. However it is clear that for the two species of forage studied in the present experiment, the protein was readily degraded in the rumen regardless of the stage of maturity or level of OMI. This is in contrast to the degradability of OM which was on average 24 percentage units lower than that of protein.

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EFFECTS OF *STYLOSANTHES* COMPANION CROP ON THE PRODUCTION AND QUALITY OF CASSAVA RESIDUE

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SUMMARY

A field experiment has been carried out for 10 months to study the effect of various cutting heights and cutting intervals of stylo (*Stylosanthes guyanensis* cv. Schofield) sown under cassava (*Manihot esculenta* var. Valenca). on the yield, chemical composition and nutritive value of the cassava residue comprised of leaf blade, stem and tuber peel. The completely randomized block design arrangement comprised 3 cutting intervals (4, 8 and 12 weeks) and 3 cutting heights (5, 10 and 15 cm) of the stylo sown under the cassava, 2 cassava (with and without fertilizer) grown alone and 10 replicates in each treatment.

Under sowing cassava with stylo did not significantly (P >.0.05) affect the yield of the cassava residue and cutting the stylo at different height and interval did not also have a significant effect. A similar trend was also observed for the crude protein and the starch content. The HCN content of the leaf blade decreased, whereas that of the stem and the tuber peel changed inconsistently, as the cutting height and interval of the stylo increased. The IVDMD and IVOMD of the leaf blade and stem of the cassava increased, whereas that of the tuber peel decreased as the cutting height and cutting interval of the stylo increased.

The present result indicated that undersowing cassava with stylo did not affect the yield of the cassava residue, but affected its quality and nutritive value.

Key words : legume, production, residues, ruminant feed.

INTRODUCTION

In the intensively farmed dryland farming area in Bali, root crops (i.e. cassava, sweet potato), cereals (i.e. corn, sorghum) or pulses (soybean, dolichos) are grown as cash crop, while livestock is integrated in such farming system as draft animals, for meat production and export earnings. In this system, the crop residue becomes an important component of the livestock feed (Nitis et al., 1980).

Experiments have shown that undersowing cassava with *stylosanthes* did not adversely affect the cassava tuber yield, and at the same time the quantity and quality of green feed increased due to the presence of stylo (Nitis and Suarna, 1976, Nitis, 1979).

The present paper describes the effect of various cutting heights and intervals of stylo sown under cassava on the yield, chemical composition and digestibility of the cassava residue comprised of leaf blade, stem and tuber peel.

MATERIALS AND METHODS

Field Trial

The field experiment was carried out in one Ha land at 45 m elevation with 2,299 mm average annual rainfall distributed in 103 rainy days mainly during the November to March rainy season. The soil is silt loam yellowish brown latosol (Dai and Rosman, 1970) with pH ranges from 6.0-6.5 at 0-60 cm depth, containing 0.12-0.19% N and 0.091-0.102% P_2O_5.

The experiment was arranged in a completely randomized block design, consisting of 3 cutting heights (5, 10 and 15 cm) and 3 cutting intervals (4, 8 and 12 weeks) of stylo (*Stylosanthes guyanensis* cv. Schofield) grown together with the cassava of sweet variety (*Manihot esculenta* var. valenca), 2 pure cassava stands(with 165 kg urea/ha and without urea) and 10 replications in each treatment.

After ploughing and harrowing, the land was divided into plots of 3.4 m x 3.4 m and hand-ridged into 30 cm raised beds. Spacing between plots was 60 cm. The cassava stick of 25 cm length was planted with its sharpened end peppendicular to the ground at 10 cm depth with 80 cm x 80 cm spacing between the sticks. The stylo seed was inoculated with specific rhizobium strain and sown at the rate of 4 kg/Ha. The seeds were drilled into 5 holes forming a cluster at diagonal crossing of the 4 cassava sticks. This method of sowing has been shown to give the best cassava-stylo association (Nitis and Suarna, 1976). The stylo was sown 3 weeks after the cassava planting. After being established, the stylo was thinned into 5 plots per cluster and the cassava branch into one branch per stick. Weeding was carried out monthly.

The cassava was harvested at 10 months old, since beyond this growth stage the flesh of the tuber become too fibrous for home consumption (Darjanto and Murjati, 1959). A sample was taken from 4 plants in the middle area of the plot having one guard row surrounding these 4 plants. The cassava residue consisted of tuber peel and shoot (stem, petiole and leaf blade).

Chemical Analyses

Ten percent sub-samples from the appropriate samples was put into paper bags and dried in a forced-draught oven at 70°C to a constant weight. For the chemical analysis, proportion of the dried sample was pooled by mixing the ten replicates of each treatment to become 3 replicates. These respective samples were ground to pass 1 mm screen and stored in sealed bottles.

Protein (N X 6.25) was determined by the semi-micro Kjeldahl method using nitrogen destillation apparatus described by Ivans et al. (1971). HCN was determined by the alkaline titration method described by AOAC (1970) with a slight modification. Starch was determined firstly by basic hydrolysis followed by titration of Luff-schoorl method (1931) and using the AOAC (1965) invert sugar table to calculate the starch content. Dry matter (DM) was determined by drying the sample in an oven at 105°C to constant weight. Organic Matter (OM) was determined by ashing the sample in a muffle furnace at 500°C for 6 hrs. All results were expressed on DM basis.

In vitro digestibility

Two fat-tailed castrated sheep fitted with rumen fistula according to the method described by Norton (1974), were used as source of inoculum. Each sheep was fed 2.18 kg fresh grassed supplemented with the tested material either the cassava tuber peel (0.05 kg air dried) or the cassava shoot (0.25 kg fresh weight). 14 days adjustment period was imposed before testing the new sample.

The in vitro dry matter digestibility (IVDMD) and organic matter digestibility (IVOMD) were determined according to the method described by Minson and McLeod (1972)using tared ashless whatman No. 40 filter paper instead of washing the indigestible residue into a tared container.

Statistical Analysis

Data were subjected to analysis of variance according to the method described by Snedecor and Cohran (1967). When a significant difference was observed ($P < 0.05$) a comparison of mean difference due to treatments were evaluated by the Duncan multiple range test (Steel and Torrie, 1960).

RESULTS

Dry matter yield

Varying the cutting height and cutting interval of stylo

Table 1. Cassava residue yield (DM gm/m^2) in relation to the stylo cutting interval and cutting height.

Treatment to the cassava	Treatment to the stylo		Stem	Petiole	Leaf blade	Shoot	Tuber peel
	Cutting interval (week)	Cutting height (cm)	(a)	(b)	(c)	(a+b+c)	
With stylo	4	5	596.56a[1/]	4.37a	29.61a	630.54a	102a
		10	587.20a	4.32a	29.33a	620.85a	99a
		15	592.42a	4.15a	29.60a	626.17a	98a
With stylo	8	5	562.28a	4.16a	29.71a	596.18a	102a
		10	554.30a	3.89a	29.17a	587.36a	101a
		15	565.87a	3.84a	29.53a	599.24a	99a
With stylo	12	5	576.31a	4.30a	29.41a	610.02a	102a
		10	566.67a	3.93a	29.62a	600.22a	101a
		15	562.13a	4.04a	29.91a	596.08a	100a
Cassava only	-	-	554.77a	4.31a	28.86a	587.94a	98a
Cassava only fertilized with urea	-	-	711.04b	4.58a	29.88a	745.50b	142b
	S.E.M.		69.49	0.63	3.71	76.16	10.60

1/ Values in the same column bearing similar superscripts were not statistically significant ($P > 0.05$).

Table 2. Crude protein content (%) of the cassava residue in relation to the cutting interval and cutting height of the stylo.

Treatment	Treatment to the stylo		Shoot		Tuber peel
	Cutting interval (week)	Cutting height (cm)	Leaf blade	Stem	
With stylo	4	5	29.51a[1/]	3.97a	5.03a
		10	31.01a	4.24a	4.87a
		15	30.43a	3.86a	5.10a
With stylo	8	5	31.21a	4.01a	4.91a
		10	31.86a	4.16a	5.01a
		15	31.35a	3.89a	4.80a
With stylo	12	5	30.38a	3.99a	5.35a
		10	31.96a	3.94a	5.54a
		15	31.79a	3.74a	5.01a
Cassava only	-	-	30.98a	4.26a	4.91a
Cassava only fertilized with urea	-	-	31.02a	3.58a	4.55a
	S.E.M.		0.23	0.05	0.07

1/ Values in the same column bearing similar superscripts were not statistically significant ($P > 0.05$).

Table 3. Starch content (%) of the cassava residue in relation to the cutting interval and cutting height of the stylo.

Treatment to the cassava	Treatment to the stylo		Shoot		Tuber peel
	Cutting interval (week)	Cutting height (cm)	Leaf blade	Stem	
With stylo	4	5	11.91a[1/]	32.84a	49.67a
		10	10.55a	32.32a	49.80a
		15	11.01a	31.39a	48.25a
With stylo	8	5	10.32a	31.20a	49.97a
		10	10.53a	32.91a	47.94a
		15	11.68a	32.26a	48.54a
With stylo	12	5	12.57a	32.70a	49.35a
		10	12.21a	31.27a	46.72a
		15	12.07a	32.41a	47.15a
Cassava only	-	-	12.18a	32.36a	46.35a
Cassava only fertilized with urea	-	-	10.89a	32.78a	48.73a
	S.E.M.		0.44	0.45	0.62

1/ Values in the same column bearing similar superscripts were not statistically significant ($P > 0.05$).

sown under cassava did not significantly ($P > 0.05$) affect either the shoot yield or its stem, petiole and leaf blade components (Table 1). The highest yield was obtained, when the stylo was cut every 4 weeks at 5 cm high;and such value was 7.25% higher than that of the cassava grown alone, eventhough such differences were not statistically significant ($P > 0.05$).

A similar trend was observed for the tuber peel.

Chemical composition

Varying the cutting height and cutting interval of the stylo sown under cassava did not significantly affect the crude protein (CP) percentage of the leaf blade, stem and tuber peel (Table 2). The highest values for the leaf blade and tuber peel was obtained, when the stylo was cut every 12 weeks at 10 cm high;and such value was 3.16% and 12.8% higher than those of cassava grown alone, respectively.

Undersowing cassava with stylo did not significantly affect the starch percentage of the leaf blade, stem and tuber peel of the cassava (Table 3). Varing the cutting high and cutting interval of the stylo sown under the cassava did not significantly affect the above-mentioned parameters.

Delaying the cutting interval and increasing the cutting height of the stylo sown under cassava decreased the HCN content of the leaf blade, stem and tuber peel, eventhough some of the differences were not statistically significant (Table 4). The lowest value for the leaf blade was obtained when the stylo was cut every 12 weeks at 15 cm high and the lowest value for the stem and tuber peel, when the stylo was cut every 4 weeks at 10 cm high. For the leaf blade, the value was similar to that of the cassava grown alone, but for the stem and the tuber peel the value was 17.6% and 16.96% lower ($P < 0.05$) than those of the cassava grown alone, respectively.

Table 4. HCN content (ppm) of the cassava residue in relation to the cutting height and cutting interval of the stylo.

Treatment to the cassava	Treatment to the stylo		Shoot		Tuber peel
	Cutting interval (week)	Cutting height (cm)	Leaf blade	Stem	
With stylo	4	5	86.52a[1/]	113.76a	148.83a
		10	86.48a	101.52b	135.72b
		15	83.52a	109.44ab	144.96a
With stylo	8	5	86.04a	112.32a	152.28c
		10	79.20a	116.23a	156.96c
		15	65.88b	110.16ab	154.44c
With stylo	12	5	66.72b	114.40a	172.09d
		10	66.60b	127.08c	163.80e
		15	63.96b	120.52a	161.72e
Cassava only	-	-	65.88b	122.40a	163.44e
Cassava only fertilized with urea	-	-	89.36a	134.28c	183.96f
	S.E.M.		1.15	1.92	5.52

1/ Values in the same column bearing similar superscripts were not statistically significant ($P > 0.05$).

In vitro digestibility

Delaying the cutting interval and increasing the cutting height of the stylo increased the IVDMD of the leaf blade and stem, but decreased the IVDMD of the tuber peel, eventhough some of the differences were not statistically significant (Table 5). The highest value for the leaf blade (52.58%), stem (22.81%) and tuber peel (35.69%), was obtained, when the stylo was cut at the interval and height of 12 weeks at 5 cm, 12 weeks at 15 cm and 4 weeks at 15 cm, respectively.

A similar trend was observed for the IVOMD of the leaf blade, stem and tuber peel (Table 6).

DISCUSSION

Quantity and quality

The present result supports the previous findings (Nitis and Sumatra, 1976, Nitis and Suarna, 1976) that undersowing cassava with stylo did not exert an adverse effect on the cassava DM yield. The non-significant effect of the various cutting heights and cutting intervals of the stylo on the cassava yield indicates that cassava was more efficient in utilizing the nutrients than stylo. Furthermore,the nitrogen contribution of the stylo trough its root nodule, which was equivalent to 20 kg urea/Ha(Nitis,1977) was not high enough to stimulate a significant increase in the cassava yield. This is supported by the finding that shoot yield of the cassava fertilizer with 165 kg urea/Ha was 26.79% higher than that of cassava without urea application.

The purpose in varying the cutting height and cutting interval of the stylo is to reduce the compiting ability of the stylo. The non-significant effect of such treatments on the starch and CP contents of the cassava residue again indicating

Table 5. In vitro dry matter digestibility (%) of the cassava residue in relation to the cutting interval and cutting height of the stylo.

Treatment to the cassava	Treatment to the stylo		Shoot		Tuber peel
	Cutting interval (week)	Cutting height (cm)	Leaf blade	Stem	
With stylo	4	5	48.21a[1/]	19.28a	34.41a
		10	48.92a	18.12a	33.98a
		15	48.34a	18.02a	35.69a
With stylo	8	5	50.48ab	20.47b	35.48a
		10	51.51ab	19.64b	35.59a
		15	50.72ab	21.47b	34.53a
With stylo	12	5	52.58b	22.01b	34.22a
		10	51.84b	21.25b	31.42b
		15	52.14b	22.81b	30.86b
	S.E.M.		0.44	0.47	0.47

1/ Values in the same column bearing similar superscripts were not statistically significant ($P > 0.05$).

Table 6. In vitro organic matter digestibility (%) of the cassava residue in relation to the cutting interval and cutting height of the stylo.

Treatment	Treatment of the stylo		Shoot		Tuber peel
	Cutting interval (week)	Cutting height (cm)	Leaf blade	Stem	
With stylo	4	5	48.19a [1/]	17.87a	33.03a
		10	48.78a	16.53a	29.91ac
		15	47.82a	17.05a	33.88a
With stylo	8	5	49.47ab	19.50b	33.63a
		10	51.46b	17.24a	30.95a
		15	49.28ab	20.16b	29.91ac
With stylo	12	5	54.34b	21.49b	28.14bc
		10	51.57b	20.23b	29.86ac
		15	53.97b	21.11b	23.95b
	S.E.M.		0.59	0.42	0.50

1/ Values in the same column bearing similar superscripts were not statistically significant ($P > 0.05$).

that cassava was more efficient than stylosanthes. On the other hand, the lower HCN content of the cassava leaf blade and the inconsistent HCN change of the stem and tuber peel as the cutting height and interval of the stylo increased, cannot be explained. It is not due to more N contributed by the stylo, since the HCN content of the cassava residue fertilized with urea was higher than those without urea application.

The increase of the *in vitro* digestibility of the leaf blade and stem and the reverse for the tuber peel as the cutting height and interval of the stylo increased cannot be explained. The possible effect of the lignin and the individual nutrients merit further study.

As feeds

In the present farming system in Bali, cassava leaf blade is mainly used as a vegetable for human consumption, so that very little is left as feedstuffs. The cassava petiole, and stem, on the other hand, are fed to ruminants, particularly during the dry season. It is not uncommon for farmers to store the cassava sticks under the shade for 4-6 months, before being chopped to be fed to cattle.

The cassava tuber peel which is mainly as pig feed, is dried in the sun to a certain condition and then stored in a basket. It is boiled first before being mixed with other feed ingredient to be fed to pigs.

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EVALUATION OF AMARANTH (*Amaranthus cruentus*) RESIDUE AS A FORAGE FOR BEEF CATTLE

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SUMMARY

Four lots of amaranth crop residues were collected at harvest. The mean chemical analysis of amaranth was : crude protein (CP), 12.4; acid detergent fiber (ADF), 17.4; and neutral detergent fiber (NDF), 34.1% for the leaf, and CP, 3.2; ADF, 48.5; and NDF, 61.4% for the stem. The semi quantitative tests indicated that the plants contained no hydrocyanic acid and only a small amount of nitrate. Six beef steers, average initial liveweight 120 kg were randomly allocated into three treatment diets. The animals were fed concentrate at 1.5 kg/hd/d plus the following roughage : Diet 1-control, grass *ad libitum* (CGD) Diet 2, grass 3 kg/hd/d and amaranth straw *ad libitum* (CGA); and Diet 3, amaranth straw *ad libitum* (GAS). Daily dry matter intake (DMI) was 2.39, 2.29 and 2.10% body weight; average daily gain (ADG) was 580, 510 and 350 g; and feed conversion ratio (FCR) was 4.74, 5.15 and 7.17 for the animals in group 1, 2 and 3 respectively.

Key words : amaranth, residue, cattle feed.

INTRODUCTION

Amaranth is widely distributed throughout the world. Because the grain is rich in protein (16% CP) and minerals. It contains high level of the essential amino acid especially lysine, the limiting amino acid in corn and rice. When amaranth is used in combination with common grain, it provides a balanced protein source

(Saunders and Becker, 1981; Kauffman and Haas, 1982; Seneft, 1980).

Amaranth has been introduced into Thailand by Thailand Institute of Scientific and Technology Research (TISTR) and National Academy of Science, USA., since January, 1983. *Amaranthus cruentus*, a variety imported from Mexico,grows well in the northeast of Thailand. It is drought resistant and can be grown not only in the rich soil but also in the semi-arid areas throughout the year. It has the potential to become an important crop in Thailand. The seeds, leaves, and inflorescences were consumed readily by poultry and swine (Laovaravit, 1983; Seneft, 1980).

The objectives of this research were : 1) to determine nutritive values of *Amaranthus cruentus* crop residue, in different part of the plant tissue 2) to determine dry matter intake and steer performance fed amaranth straw.

MATERIALS AND METHODS

Amaranthus cruentus,Mexican grain type was grown in plots at Kasetsart University, Kampaengsan, Nakornpratom Province by TISTR in June 1984, the grain was harvested at 75-d after planting, the remained residue was cut, chopped into 7-15 cm. and sun dried. Fresh plant material was semiquantitative tested for nitrate with 0.5 g of phenylamine and 80% sulfuric acid mixed solution. Hydrocyanic acid was detected with alkaline picrate solution(Nowosad and Macvicar, 1940). Amaranth plant was randomly taken at 5 different locations. Stem, leaf, and inflorescence, were seperated, weighed, and averaged for calculating the proportion of this plant tissue. The straw was dried in an oven under vacuum seal at 70°C and ground through a 1 mesh screen in a wiley mill and then ground through a 40 mesh screen in another wiley mill. Samples were analyzed for dry matter by AOAC procedure (1975), ADF and NDF by the methods of Goering and Van Soest (1975). Crude protein was determined by utilizing an autoanalyzer.

Six Charolais crossbred steers with average body weight of 120 kg (111-132 kg) were randomly allocated into three treatment diets. The treatments were : 1) concentrate 1.5 kg/hd/d plus grass *ad libitum* (10% refusals), 2) concentrate and grass 1.5 and 3 kg/hd/d, plus amaranth straw *ad libitum* (10% refusal) and 3) concentrate 1.5 kg/hd/d plus amaranth straw *ad libitum* (10% refusal). The concentrate ration contained 42% maize, 37% cassava,10% soybean meal, 10% cotton seed meal, 1% urea, and 2% mineral.

The animals were housed in an individual pen with adequate water and fed twice daily at 7.30 a.m. and 3.30 p.m. The steers were adjusted to amaranth straw for one week before initiation of the feeding trial. Refused feed was removed from feeders and weighed prior to each feeding during the 60-d trial. Total feed intake was recorded during the 60-d trial. The animals were weighed on 2 consecutive days at the beginning and the end of the trial. The weight was averaged and used as the initial and final weight. Subsequently, a single weight, was taken at 12-d intervals during the experiment. All the animals were in good condition throughout the experiment. Samples of feed and refusal were taken 10-d interval and accumulated throughout the trial for chemical analysis.

Treatment differences were tested by analysis of variance and the means were compared by Duncan's New Multiple Range Test (Steel and Torrie, 1960).

RESULTS AND DISCUSSIONS

The chemical composition of amaranth was shown in Table 1. Proportion of leaves : stems : inflorescences were 3:7:2.7. The leaves had a higher crude protein and cell content than the stems. When the grain was harvested, the remained crop residue was more stemmy. The semiquantitative tests indicated that the amaranth plant contained no hydrocyanic acid and only a small amount of ni-

Table 1. Chemical composition of amaranth (% of dry matter).

Component	Fresh plant		Amaranth straw
	Leaf	Stem	
Dry matter	17.43	15.55	82.35
Crude protein	12.36	3.19	7.24
ADF	17.39	58.48	49.14
Cell wall (NDF)	34.06	71.42	62.35
Cell content	65.94	28.58	37.65
Hemicellulose	16.67	12.94	13.21

trate. However, this level has been reported that it can be used for human consumption (Marderosian et al., 1979)and the presence of this nitrate does not significantly detract from the excellent nutritional quality of amaranth greens.

Dry matter intake and liveweight changes during 60-d period of cattle was shown in Table 2. All the animals gained weight during the trial. The weight gain was greatest in the last 36-d. Dry matter intake (% of body weight) was similar in all treatments but feed intake did not reach to the expected total intake(2.5%BW).

In spite of similar dry matter intake for all treatment groups, the steers on concentrate plus amaranth straw had a higher FCR, and lower weigh gain ($P < 0.05$). It indicated that the animals fed CAS diet were less efficient in utilizing that nutrients, they would not have gained much as they have. Because straw had a low level of cell content and high level of cell wall which (Table 1) should have resulted in lower digestibility. So the animals received CAS diet did not get much nutrient as those on other diets. Therefore, it is recommended that amaranth straw could replace grass up to 50% without any adverse effects.

Table 2. Dry matter intake and performance of steers.

Parameter	Group 1	Group 2	Group 3
Initial wt, kg	128.0	114.5	119.5
Final wt, kg	162.5	145.0	140.5
Liveweight gain, kg	34.5[a]	30.5[a]	21.0[b]
ADG, kg	0.58[a]	0.51[a]	0.35[b]
Conc. DMI, kg/d	1.42	1.42	1.42
Grass DMI, kg/d	1.64	.52	-
Amaranth straw DMI, kg/d	-	.69	1.09
Total DMI, kg/d	3.06	2.63	2.51
Total DMI, % BW	2.39	2.29	2.10
Feed conversion ratio	4.74[a]	5.15[a]	7.17[b]

[a,b] Means in the same row with different superscripts differ ($P < 0.05$).

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ASPECT OF DIGESTION AND METABOLISM WHEN RUMINANTS ARE GIVEN DIETS BASED ON POOR QUALITY CROP RESIDUES

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SUMMARY

In recent years there has been an increased interest in maximizing the use of low quality roughages, especially straw and other poor quality by-products for the nutrition of ruminants. The reasons for this increased interest vary from location to location and range from problems of disposal of a by-product and pollution caused by disposal to a better realization of the potential nutritive value of the resources. Regardless of the motive it has led to a better understanding of several aspects concerning both fibre digestion and low level nutrition of ruminants. Much is still unknown but in our paper we would like to draw attention to some advances in understanding of fibre digestion and host animal metabolism.

Key words : Digestion, metabolism, crop residues, ruminants.

Constraints in utilization of straw and other poor quality by-products

There are essentially two aspects relating to digestion which are characteristic of the material itself; that is constraints relating to the potential extent of digestion, and the rate at which digestion occurs. These aspects have been discussed in detail (Chesson & Ørskov, 1984) and will not be further discussed here except to point out that two feeds with equal digestibility or extent of digestion can result in different feed intakes by the animals due to differences in rate of digestion. Such characteristics of feeds can be described by the nylon bag method as described by Ørskov et al. (1980). The other characteristic of a feed which is difficult to measure as it also relates to the animal is the speed at which particles are reduced in size from long to particles which can pass out of the rumen. Relatively little is known about this factor since it is very difficult to measure in a quantitative manner. The most important animal characteristic relating to poor quality roughages is the rumen volume and the potential rate at which particles can leave the rumen. Since this aspect of roughage digestion has been discussed in some detail recently I would like to concentrate on aspects relating to evaluation of poor quality roughages.

Methods of evaluating poor quality roughages

Description of feed values in most western countries are based on in vivo measurements of digestibility,usually at the maintenance energy level of feeding. In more sophisticated systems it is based on metabolizability which can be calculated when methane production and urine energy are also determined. While these measurements are very useful to express the digestibility or extent of digestion of a feed, they provide no information on how much animals are likely to eat if the diets were then to be given ad libitum. It is important to consider therefore whether and to what extent these measurements are relevant to problems of utilization of poor quality roughages. We would submit that the relevance of such information depends largely on the circumstances of the user.

This is perhaps best illustrated by trying to evaluate whether a given chemical treatment or other method of improving the quality of straw is cost effective. Let us consider an example in which three feed materials are available. Unimproved roughage, improved (treated roughage)and concentrate. Let us also assume that the relative cost of these materials are 1.0, 2.0 and 5.0. (These values are reasonably realistic). We can now ask the question as to how much the nutritive value of the improved material has to be increased in order to be cost effective. Let us first assume no change in intake by the animal and describe the relative costs of isoenergetic diets based on feed materials with relative costs of 1.0 and 5.0 or on 2.0 and 5.0. This is shown in Figure 1 (top line). From the example here (Fig. 1)it can be seen that the nutritive value has to be increased by a factor of about 1.3 in order to be cost effective. In other words if the digestibility of the unimproved roughage was 40% it had to be increased to 52%to recover the cost of making the improvement. This evaluation is however only correct for the user who is already using all the roughages that are available. Any additional cost he incurs must be completely recovered as an increase in nutritive value.

For users who have more of the poor quality feed material than they can normally use,or can obtain additional poor quality feed material cheaply another aspect becomes important,namely how much more of the poor quality material can not be used. Let us assume that intake was increased by 50% as a result of treatment. This is shown in Fig. 2 (bottom line). The effect of the increased intake is that a greater proportion of the roughage can now be fed and an increase in intake of 50% (due to treatment) would be cost effective <u>even if there was no improvement in digestibility</u>. Thus the evaluation of low quality roughages and the value of improvement relate to the circumstances of the user. This importance of intake will apply whether intake is increased as a result of treatment of the roughage, or by the use of a better quality of roughage.

Differences in nutritive value varieties of straw

It was mentioned earlier that differences in the effective nutritive value of straw will be defined by both the rate of digestion and the extent of digestion and these characteristics can have a very pronounced effect on the feeding value particularly when intake is a limiting factor. Relatively little is known about varietal differences in nutritive value of straw. In a recent experiment we have compared four varieties of barley straw

THE EFFECT OF DIGESTIBILITY ALONE AND DIGESTIBILITY COMBINED WITH 50% INCREASE IN INTAKE ON COST EFFICIENCY OF TREATED STRAW

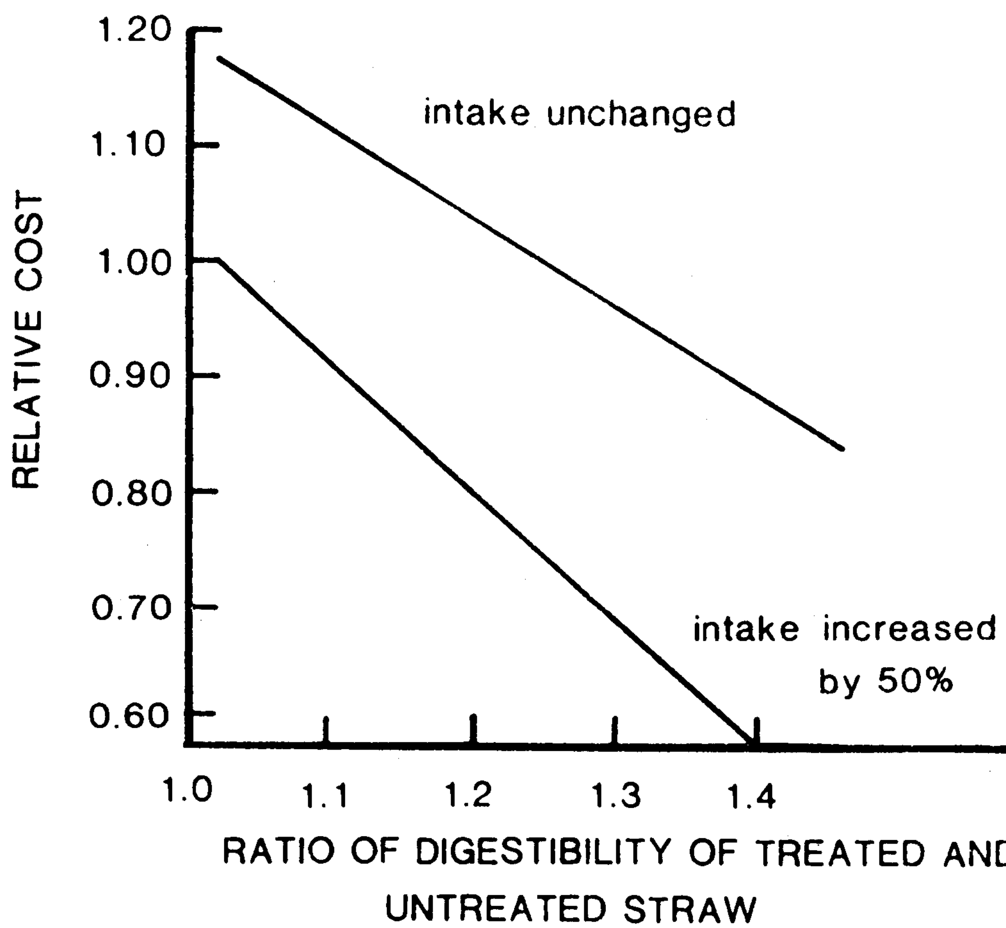

Figure 1. Effect of level of energy input as protein balance in depleted cows (D), well nourished cows (N) steers and lambs.

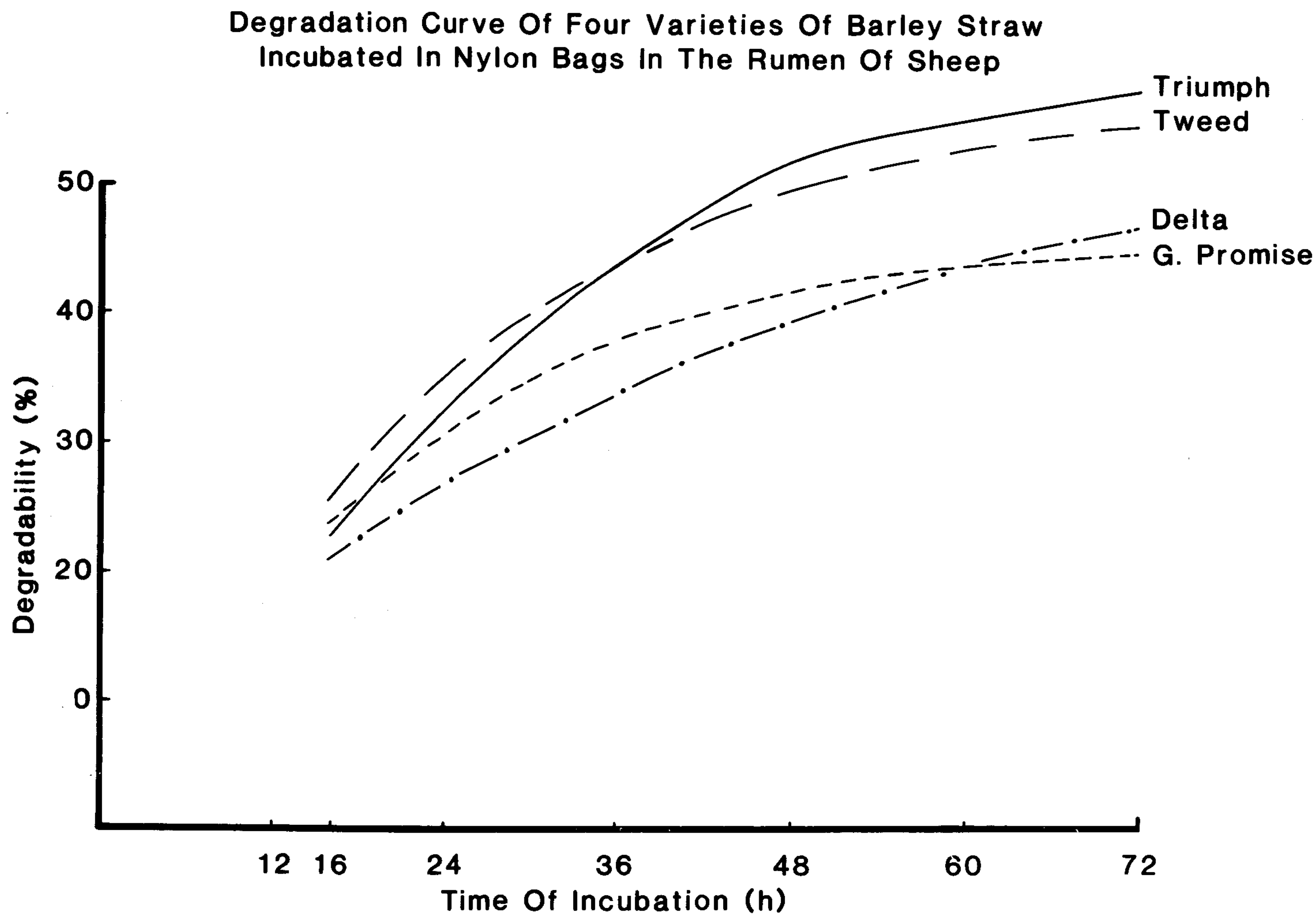

Figure 2. Degradation curve of four varieties of barley straw incubated in nylon bags in the rumen of sheep.

by incubating them in nylon bags in the rumen of sheep. The digestion of the four straws is illustrated in Figure 2. It can be seen clearly that important differences were apparent. These varieties of barley were grown under identical conditions. The yield of grain and straw were similar. The results indicate to us that it may well be possible to select varieties of grain which produce the best quality straw without any sacrifice in the yield of grain. A small difference in rate and extent of digestion can have large effects on intake, and thus the value of straw from one variety could be more than twice that of another due to the effect on intake. Such differences will be of great interest since more straw can be used for animal production, but it is crucial that the plant breeder is made aware of it. It is also crucial that a reliable and simple method of measuring nutritive value is developed.

Upgrading of poor quality roughages

We do not intend here to discuss different methods of upgrading straw as this has been discussed in detail recently by Sundstøl et al. (1984). We would therefore only limit our remarks to some aspects of upgrading of straw which needs to be emphasized. First of all, when more nutrients are made available the microbial protein production will increase but so of course will the microbial requirement for nutrients other than energy. While this is well recognized as far as N is concerned (see Ørskov, 1982) it is possibly not always recognized that the need for other nutrients also increases, the most important of which is sulphur. When ammonia is used or urea as a source of ammonia, the N which adhere to the straw after treatment is usually sufficient to meet the need of the rumen microbes but these compounds do not contain sulphur which is an important element in methionine and cystine. Lack of sulphur can depress digestibility and intake and must be supplied in the required quantities relative to degraded N. Other nutrients may also be limiting depending on the locality and of the type of by-product concerned. It is perhaps useful to consider that the additional nutrients made available as a result of alkali-treatment is similar to a purified diet.

Optimising rumen environment for cellulolysis

It is well known that if diets based on fibrous roughages are supplemented with a high proportion of starchy concentrate or sugars (e.g. molasses) then cellulose digestion is depressed and in some circumstances is completely inhibited. There are several reasons for the inhibition the most important of which is low rumen pH. Mould et al. (1983) showed that at a rumen pH of less than or about 6.2, cellulose digestion became increasingly inhibited. Such low pH values are often found when concentrates are given as a high proportion of the diet and at a high level of feeding. Sometimes partial inhibition of cellulose digestion may occur when a high proportion of sugar is included in a diet, even if pH is optimal due to competition for essential nutrients in the rumen by the micro- organisms.

It is perhaps less well known that in certain circumstances with an adequacy of all essential nutrients, an optimal pH and with no concentrate supplementation, the rate of cellulsoe digestion can be low due to low substrate availability. This effect is mediated through a low number of micro-organisms in the rumen which results in a reduced rate of colonization of the roughage particles and consequently a reduced rate of degradation. We became aware of this phenomenon when we examined the results of an experiment reported by Silva and Ørskov (1984a) in which rumen cannulated sheep were given either untreated straw, ammonia treated straw or hay. The same three roughages were then incubated in the rumens of these sheep to see if the rate and extent of digestion was similar in the three rumen environments. (Urea and sulphur were added to the untreated straw and the hay diet so that the N content for the three feeds were similar). The most important observation was that untreated straw fermented faster and to a greater extent when it was incubated in the rumen of sheep (see Table 1)given ammonia treated straw than when incubated in the rumen of sheep given untreated straw even though rumen NH_3 and pH were similar. These results indicate that the rumen environment created by feeding of untreated straw could be improved by the supplementation of a substrate which would be fermented by cellulolytic bacteria in order to increase the number of organisms. Sugar beet pulp (see Table 2) was subsequently found to improve the rate of digestion of straw while molasses did not (Silva and Ørskov, 1984b). In a subsequent experiment beef cattle were shown to increase intake of straw substantially when a small supplement(15%) of sugar beet pulp was given. Other supplements likely to give a similar effect are citrus pulp and legumes or other green materials (provided they contain rapidly degradable B-linked polysaccharides).

Effect of protein supplements

The effect on intake when protein supplements are given have often been reported. These results are often difficult to interpret since both post-ruminal effects of protein (Egan and Moir, 1965) and ruminal effects may be present. If the post-ruminal increase in protein supply result in an increase in host animal metabolism, an increased intake can occur due to stimulation of blood flow and rumen motility though these effects are inadequately understood. It is also possible that protein supplements such as fish meal supply essential nutrients which unknowingly are deficient in the basal feeds.

Protein supply during low level nutrition with poor quality roughages

The digestible dietary protein contained in poor quality roughages is generally almost completely degraded by rumen micro-organisms so that virtually only microbial protein is available to the animal. Some estimates of microbial production of protein at energy maintenance can be made if we assume (ARC, 1984)that the microbial N pro-

Table 1. Effect of different rumen environments on the disappearance of dry matter from nylon-bags incubated in the rumen for 48 h (n 8).

Feed	Rumen pH	Rumen ammonia (mg/l)	Disappearance of dry matter from nylon-bags (mg/g)		
			Untreated straw	Ammonia-treated straw	Hay
Untreated straw	6.9	268	443	607	605
Ammonia-treated straw	6.8	244	541	648	652
Hay	6.5	212	495	629	638
SEM	0.1	19	18	19	21

Table 2. Rumen pH, rumen NH_3 concentrations and DM disappearance from nylon bags of straw incubated in the rumens of sheep fed on either untreated straw or on a diet containing 150 g sugar beet pulp and 850 g untreated straw/kg.

Sugar beet pulp in the diet (g/kg)	Rumen pH	Rumen NH_3 (mg/l)	DM disappearance of incubated untreated straw (mg/g) after (h) :				
			8	16	24	48	72
0	7.0	151	166	293	386	463	515
150	6.9	129	179	308	407	503	547
SE of difference	0.09	29.5	5.8	8.7	6.9	8.9	9.8

duction is 1.32 g N/MJ of ME and that the maintenance energy required is about 0.4 MJ of ME/kg $W^{0.75}$. We know then that 1.32 x 0.4 = 528mg microbial N is available/kg $W^{0.75}$ Only 80% of microbial N consist of amino acids (AA-N) and of the AA-N only 85% is digestible in the small intestine and of the AA-N absorbed from the small intestine 80% is retained (ARC, 1984). We have then 528 x 0.80 x 85 x 80 = 287 mg net AA-N is available/kg $W^{0.75}$ at energy maintenance.

We now have estimates of the net AA-N required at energy maintenance determined using the technique of intragastric nutrition (Ørskov, 1982). If we express the minimal excretion relative to metabolic weight we find that they vary from 300 to 400 mg/kg $W^{0.75}$ For mature animals the values are in the region of 300 mg and for young ruminants they are sometimes 400 mg or more. The ARC (1984) use an average value of 350 mg/$kg^{0.75}$. It can then be seen that only in mature animals is the contribution of microbial protein adequate in animals given maintenance energy diets.

The consequence for the young ruminant is that at energy maintenance it will lose body protein and thus live weight. It also shows that if the energy intake is well below energy maintenance they will lose even more protein from the body. In addition to a protein loss at low level nutrition the animal is getting older and does not attain the weight for age it could have achieved under normal conditions. The animal will have a low protein status and when energy intake is restored or protein supply restored the animal will show compensatory growth. The extent of the compensatory growth will depend on the degree of undernutrition and length of time of low level feeding.

Another aspect relating to low level nutrition is the observation that the animals can achieve protein balance well below energy maintenance when body reserves are available. This became very clear in experiments carried out at the Rowett Institute (Ørskov et al., 1983; Hovell et al., 1983) in which lambs, steers and cows intragastric nutrition were given protein only in quantities sufficient to sustain protein maintenance and a small excess. It can be seen from Figure 3 that the animals achieved protein balance even if no energy nutrients were given. The first energy increment indicated on the Y axis consisted of protein alone. The following increments were in the form of a mixture of VFA.

An experiment conducted to explore these finding in a more practical type trial has been reported by Fattet et al.(1984). Lambs were given different amounts of alkali treated straw and some were given fish meal. The important findings are given in Table 3 which show that body fat can be used as a source of feed from which to grow when sufficient protein is supplied. It can be seen that the lambs could gain considerably in weight and lose fat at the same time. These findings are very important and can be exploited in areas in which for instance a lot of fat animals are available at the end of the wet season or summer. It is possible to feed the animals for a period on low quality roughages at less than energy maintenance. Provided protein is given the animal can gain or at least maintain weight and possibly increase in slaughter value during a period in which only low quality roughages are available. Thus an understanding of protein nutrition during low level feeding can also help to exploit the value and usefulness of low quality roughage. It should also be pointed out of course that the many responses recently obtained when poor quality roughages are supplemented with sources of rumen undegradable protein can readily be explained by the findings discussed above. It can also be readily understood that the protein requirement relative to body weight can only be accurately assessed with a knowledge of the previous nutrition of the animal. Thus tables given to indicate protein requirement relative to body weight have to be considered in the light of these findings.

Effect of level of energy input as protein balance in depleted cows (D), well nourished cows (N) steers and lambs

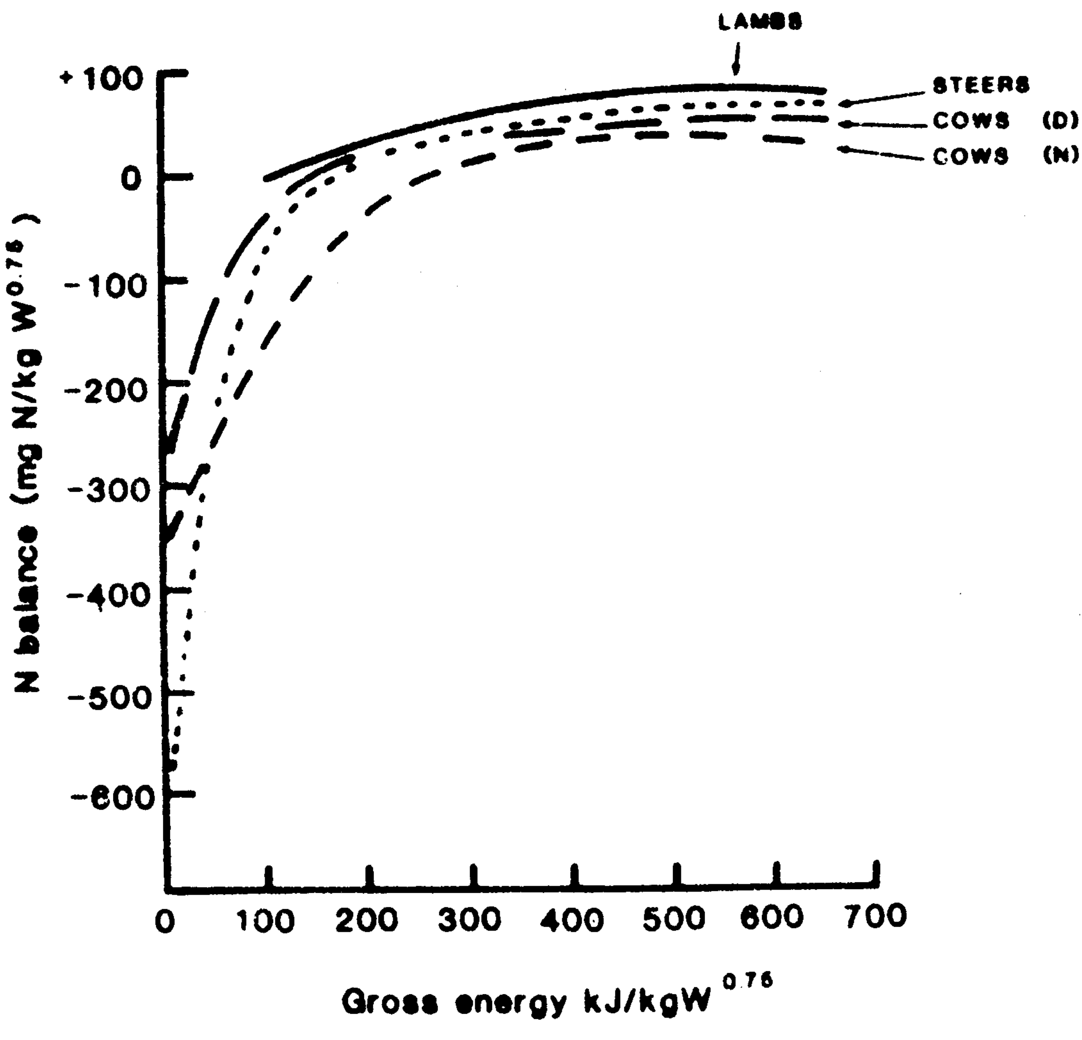

Figure 3. The effect of digestibility alone and digestibility combined with 50% increase in intake on cost efficiency of treated straw.

Table 3. The effect of the feeding of fish meal (FM) to sheep given a low level (LS) , medium (MS) or high straw (HS) diet on changes in body composition during a 92 d feeding period.

Treatment	LS	MS	HS	LS + FM	HS + FM
Energy intake, KJ/kg $W^{0.75}$	235	362	456	307	488
Initial weight, kg	41.9	43.1	44.5	43.1	43.0
Final weight, kg	37.6	42.1	44.5	43.2	49.1
Change in LW, kg	-4.3	-1.0	0	0.1	6.1
Change in empty body weight, kg	-5.1	-2.9	-0.8	0.64	4.2
Change in fat, kg	-3.5	-2.8	-1.4	-1.5	-0.9
Change in protein, kg	-0.5	-0.1	-0.1	0.5	0.9

Fattet et al. (1984).

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RECENT ADVANCES IN DEVELOPMENT AND UTILIZATION OF CHEMICALLY TREATED LOW QUALITY ROUGHAGES

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SUMMARY

Recent experiments with ammonia treatment of straw indicate that high density bales are treated effectively with ammonia and that differences in digestibility of the straw due to species and weather damage are not fully eliminated by ammonia treatment. Steers fed ammonia-treated straw gained 400 g more per day than those fed untreated straw (Egypt). In both cases 1 kg concentrate was fed along with the straw. Danish experiments with dairy cows showed that ammonia-treated straw gave higher milk yields than did untreated straw but could not compete with grass silage as roughage in the first 24 weeks of lactation. Ammonia treatment improved the in sacco degradation of bean haulm by 6 percentage units.

The optimal conditions for urea-ammonia treatment of straw seems not fully defined yet. In temperate countries urea-ammonia treatment has not been really successful so far, but a recent study showed positive effect of treating high moisture (50%) straw with 7% urea in DM for 8 weeks (UK). Dipping of straw in a urea solution followed by storage for 4 weeks showed positive results. The same did a combination of urea and lime. Addition of urease in the form of soya beans or glyricidia seems to speed up the reaction between urea and the straw. The improvement in intake and digestibility usually obtained by urea-ammonia treatment of straw may change the growth rate in animals from negative to positive and allow cows to produce milk without loosing too much of weight.

The role of urine as a source of urea should be studied further and attention should be given to possible ways of organizing collection of urine.

Sodium hydroxide treatment of straw is of less interest in developing countries at present. Several studies have shown, however, that treatment of straw in a NaOH-solution is the most efficient alkali treatment and that differences in the quality of the straw due to species and weather conditions may to a great extent be eliminated by such treatment (Dip treatment). Daily gains up to 800 g/d have been observed in heifer fed Dip treated straw plus 1 kg of concentrate.

The results obtained with calcium hydroxide are in general very variable. Newer studies indicate that it has a role to play in combinations with either sodium hydroxide or urea. Since CaO often is cheaper than $Ca(OH)_2$ it might be preferred because the heat developed when reacting with water may enhance the effect.

Both hydrogen peroxide and sulfur dioxide have proved to be effective in treatment of straw but none of these seems to have reached practice yet.

Key words : roughages, chemical treatment, ruminants.

INTRODUCTION

In some places of the world the area of farm land per capita is so small that no specialized fodder production can take place. The farm animals in these areas have to rely on by-products from the food production of which straw is the major one,and on road side grass etc. In other regions land is not so limiting but if more straw was used as feed, more land could be used for food and other cash crops.

In some densely populated areas the amounts of crop residues and by-products are not sufficient to cover the feed requirements of the farm animals. In order to get more out of the straw, chemical treatment has been introduced. Treatment of straw with sodium hydroxide (NaOH) has been practiced by Norwegian farmers for more than 40 years. By this treatment (Beckmann) the energy value of the straw was doubled, making it equivalent to early cut grass. It was a popular feed even for high yielding dairy cows. The method had several disadvantages (heavy, pollution etc.) and in the sixties and seventies "dry" procedures for straw treatment were developed without making a real break-through. Treatment of straw with ammonia was tried at several occasions since the beginning of the century. In 1969-74 a practical method for straw treatment with ammonia was developed in Norway and since then a number of ammonia treatment methods have appeared. Ammonia is not as efficient in improving the energy value of the straw as NaOH, but because of the many advantages it has become popular in many countries.

In the following I consider the basic concepts of the methods to be known. For further information see Sundstøl and Owen, (1984).

Ammonia treatment

Anhydrous and aqueous ammonia are the main sources of ammonia used for straw treatment in the temperate countries. They are efficient in use but pressurized containers and a well developed infrastracture is required.

The low density of straw is often a problem for storage and transport. Higher density would make it more economical to transport straw say from grain producing areas to livestock production areas.

The influence of densification of straw on the effect of ammonia treatment was studied by M. Russell, E. Owen and V. Mason (unpublished results, 1984). Straw bales weighing 96.5 kg/m^3 were densified to weigh 211.0 kg/m^3 and treated by ammoniated and heated air in an oven (Fma). Digestibility experiments with sheep showed that the high density bales were satisfactorily treated with anhydrous ammonia.

Weather damage of straw has for some years been a serious problem in areas with humid climate. Kjos and Sundstøl (unpublished results, 1984) studied the effect of ammonia treatment of good quality barley, oat and wheat straw versus weather damaged straw of the same species. The weather damaged straw was left in the field for 36 days after harvest and was exposed to 168 mm of rain. The organic matter digestibility (OMD) of weather damaged straw was on average 3.7 percentage units lower than that of straw collected immediately after harvest. For ammonia-treated straw this difference was reduced to 2.5 percentage units. The over all effect of ammonia treatment was an improvement in OMD of 9.3 percentage units. It may be concluded from this study that reduced quality of straw due to weather damage will also be seen after ammonia treatment, although the difference seems to be slightly diminished.

Other crop residues than cereal straw may also be upgraded through ammonia treatment. S.T.M. Fahmy, F.S. Ali and M.H. Ahmed (unpublished results, 1984) treated haulm of Vicia faba with 3% anhydrous ammonia which increased the degradation of organic matter in sacco from 44.7 to 50.4%. In this case the material was probably too dry to give optimum effect of the anhydrous ammonia. When fed together with concentrate (0.5 kg) ammonia-treated bean haulm (1 kg) resulted in a peak NH_3 concentration in the rumen liquor of 20.0 mg NH_3/100 ml versus 12.9 mg NH_3/100 ml for untreated bean haulm. One interesting observation was that rumen pH went down to 5.6 when untreated bean haulm and concentrate was fed whereas pH did not go below 6.0 when ammonia-treated haulm and concentrate were fed. Apparently the ammonia released from the feed had a buffering effect (Table 1).

In Egypt Creek et al. (1983) compared untreated and ammonia-treated straw as basal feed for steers fed increasing amounts of concentrates. The results showed that at 1 kg concentrate per day the animals fed ammonia-treated straw gained 400 g more per day than those fed untreated straw.

Table 1. Ammonia concentration and pH of rumen liquor from sheep fed untreated or ammonia-treated bean haulm (S.T.M. Fahmy, F.S. Ali and M.A. Ahmed, unpublished results, 1984).

	Hours after feeding					
	0	1	2	3	5	7
NH_3, mg/100 ml:						
Concentrate + bean haulm	5.4	11.4	12.9	10.2	6.6	6.4
Concentrate + NH_3-bean haulm	8.5	14.9	20.0	16.9	12.8	10.0
pH :						
Concentrate + bean haulm	6.2	6.1	5.9	5.8	5.6	6.0
Concentrate + NH_3-bean haulm	6.6	6.3	6.2	6.0	6.0	6.2

This difference diclined with increasing amounts of concentrate. The potential for saving concentrate by ammonia treatment of straw was demonstrated clearly in this study.

In a production trial in Denmark, Kristensen et al. (1984) compared untreated straw and ammonia-treated straw as basal feed for dairy cows. The daily rations and the results are presented in Table 2.

The cows were fed a fixed amount of 4.6 kg oil cake mixture per day. The rest of the diet was offered ad libitum as a mixture. In spite of the higher proportion of ammonia-treated straw (41% of DM) than of untreated straw (28%) the milk yield ($P < 0.01$) and milk fat content ($P < 0.001$) was significantly higher for the cows fed ammonia-treated straw.

Table 2. Daily rations and milk production in dairy cows fed untreated and NH_3-treated barley straw (Kristensen et al., 1984).

	Untreated	Ammonia-treated
Ration :		
Barley straw, kg DM	3.6	5.4
Beet-top silage, kg DM	2.9	3.1
Fodderbeets, kg DM	2.4	2.0
Molasses, kg DM	2.4	1.7
Concentrates, kg DM	5.9	5.4
Milk production :		
Number of cows	19	19
Milk, kg	20.1	20.7
Milk fat, %	3.89	4.12
4% FCM, kg	19.7	21.0

In another experiment Kristensen et al. (1984) found that a mixture of 62.6% NH_3-treated straw, 24.1% molasses, 8.5% soybean meal, 1.1% urea and 3.7% minerals was inferior to grass silage the first 24 weeks of lactation (Table 3).

After 24 weeks of lactation, there was no difference between the grass silage and the straw mixture. The authors draw the conclusion that high quality forage should be reserved for high yielding dairy cows and in the first half of the lactation. Ammonia-treated straw may be used in late lactation and in the dry period.

Ammonium hydrogen carbonate (NH_4HCO_3) is a salt which releases ammonia when heated up to 60°C. Use of this chemical when pelleting straw was suggested by Bergner and Marienburg (1972) in East

Table 3. Straw mixture* as feed for dairy cows in various parts of the lactation, compared with grass silage (Kristensen et al., 1984).

Weeks post partum	Group 1	Group 2	Group 3	Group 4
0-12	Grass sil.	Grass sil.	Grass sil.	Straw mix.
13-24	"	"	Straw mix.	"
25-	"	Straw mix.	"	"
	kg 4% FCM			
0-12	27.2[a]	27.1[a]	26.4[ab]	25.2[b]
13-24	22.2[a]	22.5[a]	21.0[b]	20.5[b]
25-32	18.9[a]	18.6[ab]	17.2[b]	17.7[ab]
0-32	23.3[a]	23.2[a]	22.1[ab]	21.6[b]
Number of cows	32	30	34	33

* NH_3-treated straw	62.6% of DM
Molasses	24.1 "
Soya beans	8.5 "
Urea	1.1 "
Minerals	3.7 "

Germany. Later developments indicate that NH_4HCO_3 may be used when treating straw in ovens where the temperature is increased up to 90°C. A solid chemical is always easier to handle than compressed gas.

Urea is also a solid chemical of which nitrogen comprises about 46%. Therefore it also has advantages over anhydrous and aqueous ammonia. One disadvantage with urea may be that the ammonia is released only when the enzyme urease is present and at certain temperatures and moisture contents. This may explain why urea treatment of straw has not proved to be successful in some investigations in temperate countries (Ørskov et al., 1983, Wanapat et al. 1985). A recent study (R.S. Sherwood, unpublished results, 1984) showed that straw containing 50% moisture added 70 g urea per kg DM and stored for 8 weeks had a D-value (in vitro)of 56% compared with 41% for untreated straw. Up to now ensiling has been the most used method. Another method which gave positive effect was to dip the straw in an urea solution and let it "ripen" for a period up to 4 weeks before feeding (Sherwood, cited by Owen, 1984). Further studies in Reading show interesting results of ensiling straw with combinations of urea and calcium-hydroxide (see Table 12).

Since Dolberg, Saadullah and co-workers did their experiments with urea-ammonia-treated rice straw in 1979-80, a great number of reports on this topic have appeared. In view of the great impact this method may have in a number of tropical countries this is understandable and appropriate. One major factor is that by urea-ammonia-treatment the energy value as well as the protein value of straw is increased.

Many investigations have been carried out to find the optimal conditions for urea-ammonia treatment of straw. Jayasuriya and Perera (1982) studied the effect of increasing level of urea and increasing time of treatment. They found that the time of treatment had little influence on the nitrogen content and the in vitro organic matter digestibility of the straw, whereas both parameters increased steadily from 0 to 10 g urea per 100 g of milled straw. They also showed that 20-25% of the nitrogen in urea-treated straw was lost as ammonia within 2 hours of exposure to the atmosphere. Treatment in closed cement pits tended to be better than open stacks and 3 days of treatment seemed to be sufficient when soybean meal was added as a source of urease. Kumarasuntharam et al. (1984) have published results from a comparison of ensiling times in closed cement pits or open heaps. Some of the main results are presented in Table 4.

Table 4. Intake and daily gain of cross bred bull calves fed urea-ammonia-treated rice straw (Kumarasuntharam et al., 1984).

	Straw intake kg $DM.d^{-1}$ per kg $W^{0.75}$	Daily gain in 77 days, g
1. Untreated straw + 8.5% ground soybean at feeding	79	141
2. 27 days closed in cement pits	105	213
3. 9 days closed in cement pits	105	307
4. 9 days open in heaps	114	207
5. 3 days closed in cement pits + 8.5% ground soybean at ensiling	89	336
6. 3 days open in heaps + 8.5% ground soybean at ensiling	95	308

In a very recent study by Karunaratne and Jayasuriya (1984) urea-ammonia-treated rice straw had a similar organic matter digestibility (65.6) as sodium hydroxide treated straw (64.8) and considerably higher than that of untreated straw added urea at the time of feeding. In a second experiment 5% (w/w) of finely chopped gliricidia leaves was added to the urea rice straw mixture prior to ensiling for three days. The purpose of this was to supply urease to enhance ammonia production from urea. Results from the digestibility experiments with buffaloes showed that the digestibility of urea/rice straw/gliricidia after 3 days was at least as high as for rice straw ensiled with urea for 21 days.

Dias-da-Silva and Sundstøl (1984) also found that treatment of wheat straw with urea/ammonia improved the intake and digestibility in sheep (Table 5). Highest digestibility (56%) was found for

Table 5. Intake and digestibility of urea-ammonia-treated wheat straw in sheep (Dias-da-Silva and Sundstøl, 1984).

	DM intake $g.day^{-1}/kg\ W^{.75}$		Organic matter digestibility $g.\ kg^{-1}$	
	Expt.1	Expt.2	Expt.1	Expt.2
1. Untreated straw	58.9^{a}	57.1^{a}	437^{a}	436^{a}
2. Untreated straw + 2% urea at feeding	64.7^{a}	63.6^{ab}	484^{b}	508^{b}
3. Untreated straw + 12.5% urea-molasses at feeding		64.7^{ab}		520^{ab}
4. Anhydrous ammonia-treated straw	74.9^{b}		509^{c}	
5. Urea-treated straw stored in silo	75.3^{b}	72.0^{b}	564^{d}	557^{c}
6. Urea-treated straw stored in stack		62.3^{ab}		525^{bc}
7. Urea + NaOH treated straw stored in silo	76.6^{b}		556^{d}	

straw ensiled with 40 g urea, 10 g dicalsiumphosphate and 2 g $NaSO_4$ per kg dry straw for 60 days. The relatively low level of digestibility is primarily due to poor quality of the original straw, but a higher moisture content of the straw might have improved the digestibility. The marked increase in straw intake is perhaps more important than the improvement in the digestibility, resulting in 60% increase in digestible organic matter intake. The sum effect may be that instead of losing weight the animals may gain weight as shown by Tinnimit (1984) (Table 6) or it may increase a poor growth rate manyfold.

Table 6. The performance of sheep fed untreated and urea-ammonia-treated rice straw plus rubber seed meal (RSM) (Tinnimit, 1984).

	Rice straw + RSM	Urea-ammonia-treated rice straw	Urea-ammonia-treated rice straw + RSM
Roughage intake, g $DM.d^{-1}$	38.8	324.8	216.2
RSM intake, g $DM.d^{-1}$	410.1	-	519.5
Total DM intake, $g.d^{-1}$	448.9	324.8	735.7
Initial weight, kg	12.80	11.95	13.03
Daily gain or loss, g	-9.6	36.5	74.0

Similar results were obtained with buffaloes by Wongsrikeao and Wanapat (1984). Treatment of straw with either 3 or 6% urea improved the daily DM intake from 2.03 kg (untreated straw) to 2.17 and 2.52 kg per 100 kg live weight respectively. The corresponding live weight changes during the experiment were -130 g (untreated straw), -50 g and +210 g daily and the dry matter digestibilities43.2, 52.7 and 55.4%.

Promma et al. (1984) from Chiang Mai (Thailand) obtained very little improvement in digestibility and reduced feed intake in heifers fed urea-ammonia-treated straw. In spite of this the daily gain was similar to that obtained with fresh grass, or grass hay. When fed to dairy cows urea-ammonia-treated straw showed similar DM intake and milk yield as did fresh grass.

Urine is a cheap source of urea and its effectiveness in improving the nutritive value of rice straw was demonstrated by Coxworth and Kullman (1978), Saadullah et al. (1980) and Wanapat et al. (1984). Mahyuddin (1982) showed that the effect of urine-ammonia treatment was influenced by the N-content in the urine, by the amount of urine added to the straw and the time of treatment.

The main problem when considering the use of urine as a source of ammonia for straw treatment is associated with the collection of the urine. Collection of urine from grazing animals is not realistic. For stall fed animals it may be easier to collect the urine, but to make it practical, special arrangements will have to be made in most cases. Simplest would it be to collect the urine from human beings,but it will have to be organized in one way or another. In densely populated areas excreta from man sometimes represent a sanitary problem. If urine could be collected for straw treatment two problems may be solved at the same time.

A system whereby urine is collected in containers added a small amount of H_2SO_4 to trap the ammonia, kill microorganisms, inactivate potential toxic substances and add sulfur for microbial protein synthesis in the rumen might be an alternative.

The urine may then be mixed thoroughly with the straw in a pit or a stack. Here CaO may be added a) to neutralize the acid and thereby release the NH_3 b)to produce heat for acceleration of the reaction between NH_3 and straw, c) to provide an additional source of alkali ($Ca(OH)_2$) and d) to provide Ca as a mineral supplement.

Sodium hydroxide (NaOH)

No doubt wet treatment with NaOH is the most efficient way of improving the nutritive value of straw (Homb, 1984). In Norway "Dip treatment" (Sundstøl, 1981) seems to be a method of great interest for farmers who formerly used the Beckmann-treated straw for their dairy cattle. Experiments with dairy cows published by Randby (1984) showed very high intakes of Dip-treated straw fed together with grass silage and 5-6 kg of concentrate daily (Table 7).

Table 7. Daily feed intake and milk yield in dairy cows fed increasing amounts of Dip-treated straw. Averages of 8 animals (Randby, 1984).

	Year 1981			Year 1982		
	I	II	III	I	II	III
Grass silage, kg DM	8.3	5.6	2.8	8.0	5.5	2.8
Dip-treated straw, kg DM	-	3.0	5.7*	-	3.0	8.3*
Roughage intake per 100 kg live weight	1.6	1.7	1.6	1.6	1.7	2.0
Concentrate, kg DM	5.9	5.9	6.1	6.1	5.9	5.5
Milk yield, kg per day	21.8	21.7	20.6	21.5	21.5	20.6
Milk fat, %	3.62	3.68	3.77	3.74	3.64	3.94
Fat corrected milk,kg per day (4%)	20.6	20.6	19.9	20.5	20.3	20.3

* Straw fed ad libitum.

Digestion trials have shown that the digestibility of organic matter in Dip-treated straw is 70-75% or similar to that of early cut grass silage. Addition of urea and sulfur to the lye solution seems to be a practical way of improving the "protein value" of the treated straw. In a very recent experiment with heifers A.T. Randby (unpublished results, 1984) showed that the animals grew up to 840 g daily on a diet based on Dip-treated straw (ad lib.) plus 1 kg concentrate mixture.

Table 8. Intake and performance of heifers fed Dip-treated straw with and without urea in the lye solution (A.T. Randby, unpublished results, 1984).

	With urea	Without urea
Dip treated straw, kg DM.d^{-1} (ad lib.)	5.9(1.49)*	5.6(1.44)*
Concentrate mixture, kg. d^{-1}	1.1	0.6
Herring meal, mixture, kg.d^{-1}	-	0.4
Daily gain (55 days), g	840	760
Base excess in venous blood, m mol^{-1}	+5.2	+4.9

* per 100 kg live weight.

Compensating the urea in the straw by 0, 4 kg herring meal had no beneficial effect on intake and growth rate in the heifers.

Garmo (1984) confirmed earlier findings that a ripening period is necessary to allow the NaOH to react with the straw and to obtain optimal results of the treatment (Table 9). If the ripening period is too long,all the alkali may be neutralized and fermentation processes may start, especially if the storage temperature is high.

Table 9. The excess NaOH* and in vitro organic matter digestibility of barley straw Dip treated at room temperature (17-20°C) for up to 7 days (Garmo, 1984).

	Days of storage ("ripening")				
	Untreated	0	2	4	7
Excess NaOH, g	-	9.5	7.3	5.5	2.6
IVOMD, %	32.6	49.9	54.1	54.9	58.3

* Titrateable NaOH per kg wet straw (100 g straw extracted in 1l water)

N.P. Kjos and F. Sundstøl (unpublished results, 1984) studied the influence of weather damage on the effect of Dip-treatment of barley oat and wheat straw (Table 10).

Table 10. Organic matter digestibility of good quality straw and weather damaged straw determined in sheep (N.P. Kjos and F. Sundstøl, unpublished results, 1984).

Straw of	Treatment	Good quality straw	Weather damaged straw
Barley	Untreated	54.9	50.7
	Dip-treated	69.1	69.9
Oat	Untreated	58.7	56.0
	Dip-treated	71.9	70.9
Wheat	Untreated	50.6	46.2
	Dip-treated	70.9	69.5

It is interesting to note that regardless of the digestibility of untreated straw the Dip-treated straw has an organic matter digestibility of around 70%. This is in agreement with earlier findings that sodium hydroxide treatment seems to even out differences in the initial material (Mwakatundu and Owen, 1974).

Other chemicals

Calcium hydroxide ($Ca(OH)_2$) is an alkali which has been included in a great number of straw treatment studies in the past (Owen et al., 1984). The main reason is that it is one of the cheapest chemicals one can get for this purpose. Another reason may be that Ca at the same time is a mineral necessary for normal body function and production. Because of higher molecular weight and lower solubility more $Ca(OH)_2$ is needed than that of stronger alkalis e.g. NaOH.

Garmo (1984) working with barley straw, found an in vitro organic matter digestibility (IVOMD)of 55.1% when ensiling with 3% NaOH. A combination of 3% NaOH and 5.5% $Ca(OH)_2$ on DM basis improved the digestibility to 59.5. Calcium hydroxide alone at 11.1% of DM resulted in a IVOMD of 50.6% compared with 31.4%for untreated straw (which was unusually low). Increasing the treatment period from 60 to 120 days resulted in a 3 percentage unit increase in IVOMD of $Ca(OH)_2$-treated straw. Increasing the temperature from 50°C to 20°C had a much great effect increasing the IVOMD of $Ca(OH)_2$ -treated straw from 45.2 to 56.1%.

Since Ca0 often is cheaper than $Ca(OH)_2$ it may be more economical. Another advantage of calcium oxide is that if powder is dusted on wet straw, heat is developed when Ca0 reacts with H_2O to form $Ca(OH)_2$. This heat may enhance the alkali treatment of the straw.

In Australia Djajanegara et al. (1984) obtained encouraging results with wheat straw soaked in a $Ca(OH)_2$ suspension for 24 hours and thereafter dried at 55°C for another 24 hours. Table 11 shows some results from the experiment.

Table 11. Intake and digestibility of untreated and $Ca(OH)_2$-treated straw-based diets by sheep offered ad libitum (Djajanegara et al., 1984).

	Untreated straw	Straw soaked in a $Ca(OH)_2$ suspension
Organic matter intake, $g.d^{-1}$	398	685
Organic matter digestibility, %	54.1	61.9
Live weight change, $g.d^{-1}$	-140	-40

In spite of a reasonably high digestibility, the $Ca(OH)_2$-treated wheat straw failed to maintain the live weight of the sheep.

Table 12. Intake and digestibility in lambs fed chopped barley straw ensiled with lime and urea (Zaman, 1983, cited by Owen, 1984).

$Ca(OH)_2$, g. $kg^{-1}DM$	0		30	60	60
Urea, g. $kg^{-1}DM$	0	30	30	30	60
Intake, g $OM.kg^{-1}$ $W.d^{-1}$	10.9	11.5	12.1	13.4	14.2
Digestibility of straw OM,%	50.8	48.8	55.4	64.6	66.0

In England Zaman from Bangladesh showed a clear positive effect of combining $Ca(OH)_2$ and urea (Table 12). Ensiling the straw for 60 days with 3% urea and 6% $Ca(OH)_2$ improved the feed intake and increased the digestibility of organic matter by 14 percentage units. This is an area which merits further investigation.

Hydrogen peroxide (H_2O_2) has also been tried as agent for straw treatment (see Owen et al., 1984). In a recent investigation Kerley et al. (1984) suspended crop residues in distilled water added

1% H_2O_2 and NaOH to bring the suspension to pH 11.5. After 16 hours incubation the material was rinsed and dried in a vacuum oven at 50°C. As shown in Table 13 both rate of disappearance and extent of disappearance in sacco increased considerably as a result of the treatment.

Table 13. In sacco rate and extent of dry matter disappearance of certain crop residues treated with alkaline hydrogen peroxide (Kerley et al., 1984).

Crop residue	Rate of disappearance		Extent of disappearance (48 hours)	
	Untreated	Treated	Untreated	Treated
	------ % per hour ------		----------- % ----------	
Corncobs	3.76	6.64	47.7	95.4
Cornstalks	4.34	7.18	59.6	95.6
Wheat straw	2.98	5.96	38.3	88.6

The digestibility of rations containing about 70% wheat straw was improved from 54.8% (untreated) to 80.3% when alkaline peroxide treated straw was used. It may be concluded from the experiments that the improvement obtained by H_2O_2-treatment is substantial. The economic feasibility and practical applicability remains, however, to be seen.

<u>Sulfur dioxide</u> (SO_2) has also proved to be effective in some recent investigations (Ben-Ghedalia and Miron, 1983/84). It seems, however, that quite a bit of research remains to be done before a practical method for SO_2 is found (see also Ibrahim and Pearce, 1983).

Justification for chemical treatment of low quality roughages

The fact that more than 10,000 Norwegian farmers have used sodium hydroxide-treated and ammonia-treated straw as a substantial part of the ration for many years indicate that chemical treatment of straw for feeding of farm animals may be both practical and economical. This does not imply, however, that straw treatment is practical and economical everywhere.

There are a number of conditions influencing the feasibility of straw treatment. Some of these conditions are of permanent nature and some are changeable. In the latter case it may be possible to make the impossible possible. An economical evaluation of the results would often be desirable when reports from feeding trials are published. Potts (1982) has discussed economic aspects to be considered when research results on by-product utilization are applied. A few examples of economic assessment of results will be given.

From the experiments with ammonia treatment of straw in Egypt Creek et al. (1983) concluded that each ton of ammonia used for treatment of straw would save at least 7 tons of concentrate feeds. When ammonia-treated straw was fed with low levels of supplements the saving could rise as high as 11 tons. Furthermore an ammonia treatment programme would almost certainly have much lower investment and operating costs than the proposal to establish factories.

Estimates made in United Kingdom were not so convincing in favour of the ammonia treatment, although,total feed costs were slightly lower for the ammonia-treated straw (Owen et al., 1984). In this case the digestibility of the treated straw was only 56.9%,7.5 percentage units higher than that of untreated straw.

Promma et al. (1984)made an economic evaluation of their experiment with urea-ammonia-treated rice straw to cross bred dairy cattle in Thailand. They concluded that feeding of urea-ammonia-treated straw during the dry season showed a positive economic result. Average net profit obtained from milk sale from groups fed on treated rice straw plus concentrates was 1.94 Baht/kg milk or 523.8 Baht/animal / month.

Based on a survey from two districts in Sri Lanka Ibrahim et al. (1983) concluded that there was no alternative other than to use straw based diets to solve the drought period feed problem. Of the farmers 80-90% were willing to accept innovations as regard to improving straw quality. In developing or recommending new technology for the farmers the main requirements should be :

a) the technology should be simple
b) no machinery should be involved
c) chemicals should be freely available at a normal price
d) should not require much labour
e) should easily fit into the farmers normal routine.

Straw and other crop residues are normally low in nitrogen, hence nitrogen or protein should be added to cover the animals' protein requirement. If the energetic value as well as the protein value of these feedstuffs can be improved for instance by urea-ammonia treatment, this should be a good reason for doing it.

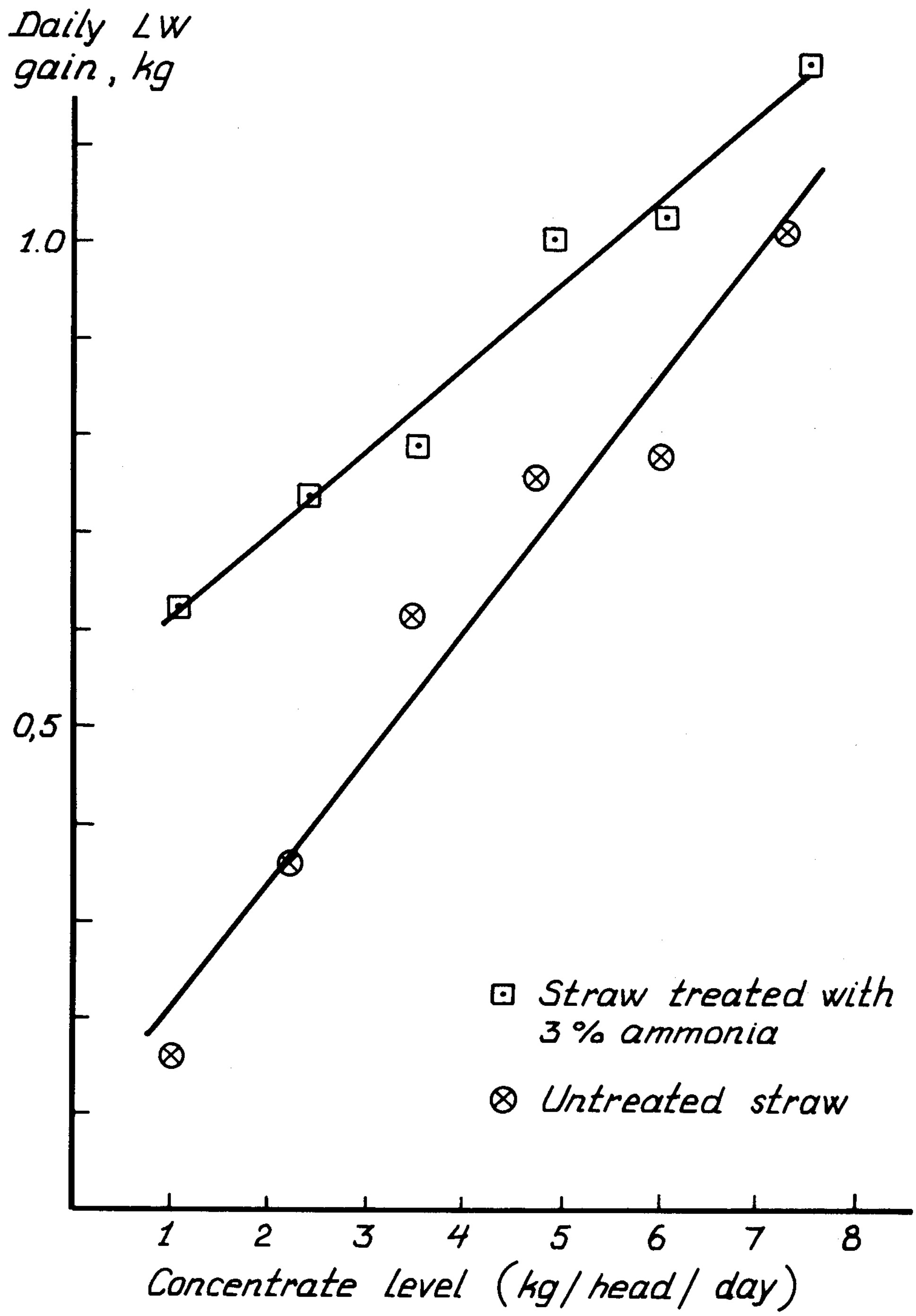
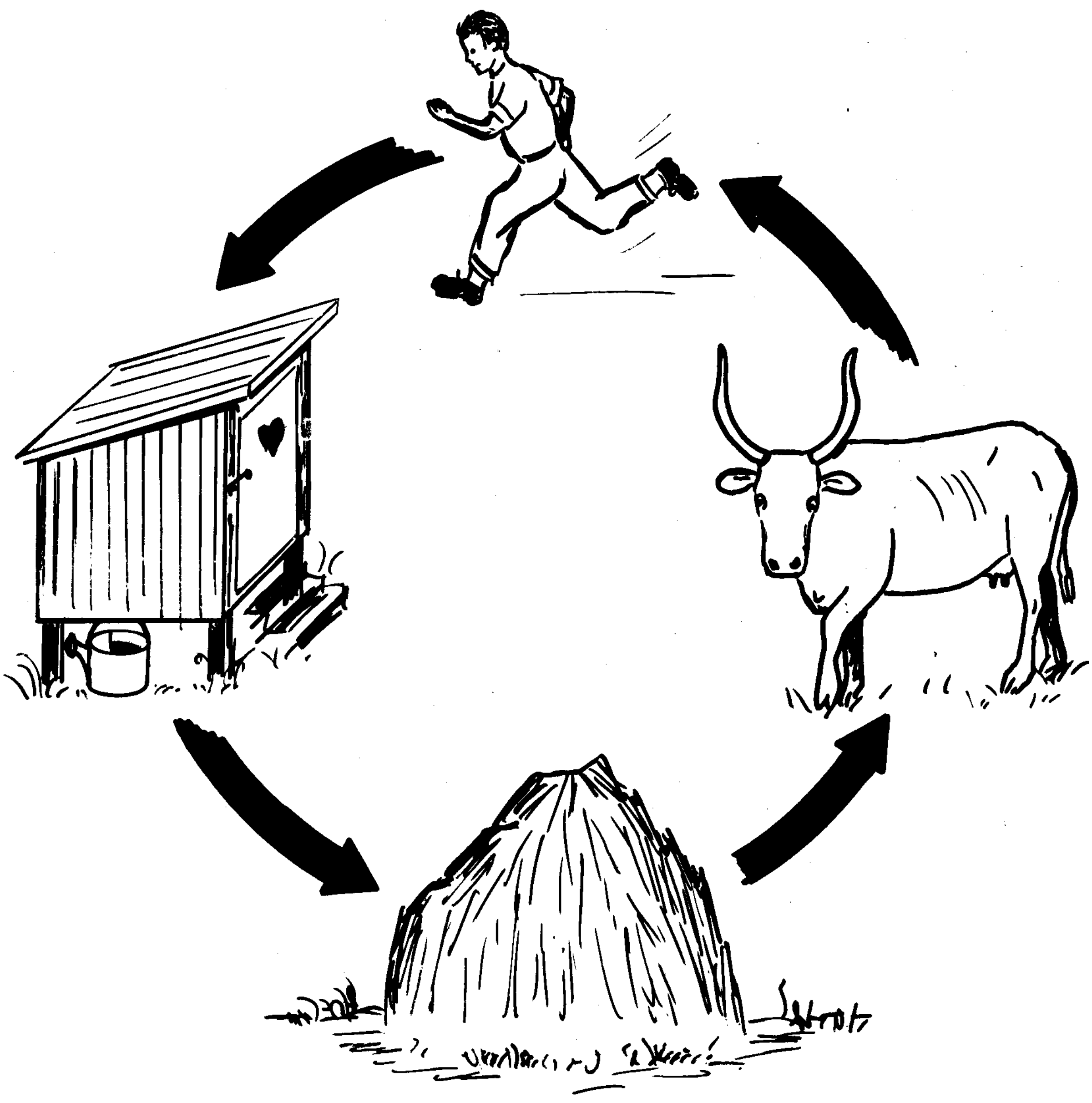


FIGURE 1. THE EFFECT OF AMMONIA TREATMENT OF RICE STRAW AND CONCENTRATE LEVEL ON THE DAILY GAIN OF STEERS (CREEK ET AL. 1983).

"THE URINE CYCLE"



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IMPROVING RICE STRAW QUALITY AS RUMINANT FEED BY UREA-TREATMENT IN THAILAND

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SUMMARY

Rice straw's nutritional quality has been shown to be improved by treating with a cheap source of ammonia such as urea(fertilizer grade, 46% N) in terms of crude protein content, digestibility and voluntary intake by ruminants such as water buffaloes,sheep dairy cattle and native cattle. It is comparable to untreated straw with supplements when fed alone. Reproductive performance of buffalo cows fed on urea treated rice straw was observed to be normal. However, the significant increases in weight gain of suckling calves on urea treatment were observed. Nevertheless, research approach on this avenue should be extensively investigated with special reference to the relevance of small farmers in the developing countries.

Key words : rice straw, urea-treatment, ruminants.

INTRODUCTION

Throughout the rice growing areas of the tropical and the subtropical regions,rice straw tremendously abounds as a by-product biomass and has been conventionally utilized as a vital feed resource for ruminants during the scarce season of forages in many parts of the developing countries. Within the small farming context, it is with no exception from the farmers' point of view that rice straw can be a good source of feed, although it contains high level of structural carbohydrate, minimal amount of crude protein and below recommended level of essential minerals, as has been extensively reviewed by many researchers (Devendra, 1982; Jackson, 1977). Many treatment methods have been elucidated (Jackson, 1977; Klopfenstein, 1978; Sundstøl and Coxworth, 1984; Sundstøl et al., 1978) for improving the utilization of rice straw by ruminants, however, the most feasible and economical method reckoned to be treatment of urea (Jayasuriya, 1983; Saadullah et al., 1981). Within the scope of this review, it is therefore aimed at summarizing related data which have been conducted in Thailand.

Availability and nutritive value of rice straw

Two types of rice are normally grown in Thailand :glutinous and nonglutinous rice varieties and these could be further classified under photosensitive (wet-season) and non-photosensitive (dry-season) varieties. Table 1, shows the amount of rice produced in each region of Thailand and the straw obtained by using the extraction rate of 1.4 to 1 (straw:grain). Approximately 25 million tons of straw is left over as a by-product annually. The actual level of utilization as ruminant feed can not be estimated, however, it is justified from field observations that most of the straw has been saved and stored to be fed to ruminants, particularly in the rain-fed area during the dry and rice planting periods.

A comparison between non-glutinous and glutinous rice varieties was made by Cheva-Isarakul and Cheva-Isarakul (1984), it is found that only crude protein and acid-detergent lignin (ADL)contents were statistically different, RD 10 and RD 7 being highest in crude protein (CP) and lowest in ADL, respectively (Table 2). When grouped, the non-glutinous varieties tended to be higher in nutritive value by having lower ADL and higher metabolizable energy ($P < 0.05$)(Table 3). Furthermore, dry season varieties of either glutinous/ non-glutinous rice contained higher CP ($P < 0.05$) (Table 4), heavier fertilization could be a possible causing factor.

Table 1. Rice production and estimated quantity of rice straw in Thailand.

Region	Rice production (1,000 ton)					Straw (1,000 ton)[1]				
Variety	1977-78	1978-79	1979-80	1980-81	1981-82	1977-78	1978-79	1979-80	1980-81	1981-82
Central										
Wet-season	4,013	4,132	3,659	3,872	4,010	5,618	5,785	5,123	5,421	5,614
Dry-season	1,338	1,927	958	1,672	1,750	1,873	2,698	1,341	2,341	2,450
North										
Wet-season	3,550	4,771	4,266	4,663	5,259	4,970	6,679	5,972	6,528	7,363
Dry-season	142	240	199	197	191	199	336	167	276	267
Northeast										
Wet-season	3,538	5,261	5,635	5,748	5,390	4,953	7,365	7,889	8,047	7,546
Dry-season	18	65	26	62	34	25	91	36	87	48
South										
Wet-season	1,234	1,042	1,086	1,122	1,099	1,728	1,459	1,520	1,571	1,539
Dry-season	88	31	8	32	43	123	43	11	45	60
Total in country										
Wet-season	12,335	15,206	14,649	15,405	15,758	17,269	21,228	20,509	21,567	22,061
Dry-season	1,586	2,264	1,111	1,963	2,017	2,220	3,170	1,555	2,748	2,824
Total	13,921	17,470	15,760	17,368	17,775	19,489	24,458	22,064	24,315	24,885

Dept. of Agric. Econ. of Thailand (1983).

[1] Extraction rate of 1.4 : 1 (straw : grain).

Table 2. Chemical composition, in vitro organic matter digestibility (IVOMD) and energy content of 7 main rice varieties grown in northern Thailand.

Item	Glutinous rice				Non-glutinous rice		
	Sanpatong[1]	RD 6[1]	RD 6[1]	RD 10[2]	Mali[1]	RD 1[2]	RD 7[2]
	% d.m.						
OM	82.2	82.6	81.3	81.1	83.0	80.8	81.2
CP	3.6	3.4[d]	3.8[cd]	5.1[a]	3.4[d]	4.2[bc]	4.6[ad]
NDF	74.5	73.0	73.6	75.3	73.1	74.1	73.5
ADF	53.8	52.8	53.0	55.6	52.9	53.6	52.5
ADL	5.1	4.8[a]	4.8[a]	4.9[a]	4.8[a]	4.6[ab]	4.2[b]
IVOMD	45.1	46.7	47.0	48.8	46.9	48.3	50.7
DE, MJ/Kg DM	7.4	7.5	7.2	7.5	7.8	7.5	7.8
ME, MJ/Kg DM	5.7	5.9	5.4	6.0	6.0	5.9	6.1

[abcd] Significant difference ($P < 0.05$) between variety means are indicated by different superscripts.

[1] Wet-season rice variety.

[2] Dry-season rice variety.

Table 3. Chemical composition, IVDMD and energy content of glutinous and non-glutinous rice (dry basis).

Item	Glutinous	Non-glutinous
OM, %	81.8	81.7
CP, %	4.0	4.1
NDF, %	74.1	73.6
ADF, %	53.8	53.0
ADL, %	4.9[a]	4.5[b]
IVOMD, %	46.9	48.6
DE, MJ/Kg DM	7.4[a]	7.7[b]
ME, MJ/Kg DM	5.8	6.0

[ab] Different superscripts in the same row are significantly different ($P < 0.05$)

Table 4. Chemical composition, IVDMD and energy content of wet and dry season glutinous rice and non-glutinous rice (dry basis).

Item	Glutinous		Non-glutinous	
	Wet season VS	Dry season	Wet season VS	Dry season
OM, %	83.7	81.1	83.0	81.0
CP, %	3.6[a]	5.1[b]	3.4[a]	4.4[b]
NDF, %	73.7	75.3	73.1	73.8
ADF, %	53.2	55.6	52.9	53.0
ADL, %	4.9	4.9	4.8	4.4
IVOMD, %	46.3	48.8	46.9	49.5
DE, MJ/Kg DM	7.4	7.5	7.8	7.6
ME, MJ/Kg DM	5.7	6.0	6.0	6.0

[ab] Different superscripts in the same row within rice group (glutinous/ non-glutincous) are significantly different ($P < 0.05$).

Factors affecting urea-ensiled rice straw quality

Treatment of urea can be simply prepared by sprinkling solution of urea (46% N) onto the straw and ensiled under covers for appropriate period of time, under this condition ammonia from urea could be liberated from the action of urease enzyme present in the straw and released by natural microorganisms adhered on the serface of the straw. Ammonium hydroxide formed is believed to react to the straw and ammonia present helps to maintain the favourable condition for better quality and longer storage period of the straw.

Storage time and level of urea

Result from one of the preliminary laboratory examination (Wanapat et al., 1983) demonstrated that ensiling rice straw with 5% urea (w/w) using 1:1 straw: water and stored for 3 weeks increased in vitro dry matter digestibility by 8% and CP by 3.5% units. Acid-detergent lignin was also decreased (Table 5). Another experiment (Table 6), which compared different level of urea, addition of meanure and storage time on chemical compositions and IVDMD of rice straw.Significant changes were CP and IVDMD percentages, highest increases were due to treatment of 5% urea at week 3 of ensiling and addition of fresh chicken manure did not show a significant increase of IVDMD. Treating straw with urine at 1:1 also increased CP and IVDMD of the straw. Urine as an ammonia source, therefore, renders more attention. Table 7, result also confirms previous findings on percentage of CP and IVDMD increases. Ensiling with urea did not change the major mineral concentrations of the straw (Wanapat, 1984).

Effect of level of urea used on intake and digestibility

It is reported by Wongsrikeao and Wanapat (1984)that buffalo heifers fed 6% urea treated rice straw (UTS) had a significant higher intake and weight gain than the group fed 3% treated straw (Table 8). Higher ADF digestion coefficients may help to explain higher intake.

Table 5. The effects of storage time on in vitro dry matter digestibility (IVDMD), crude protein (CP), acid detergent fibre (ADF), acid detergent lignin (ADL) content of straw treated with urea.

Storage time (week)	IVDMD	CP	ADF	ADL
	----------	---------- % d.m.	----------	----------
0	48.0	3.5	50.4	5.2
1	52.4	6.9	47.3	3.9
2	56.8	6.7	47.2	4.5
3	53.7	4.5	49.2	4.7
4	56.2	5.0	51.1	4.4
5	55.0	4.0	51.0	4.7
6	51.1	4.1	51.7	4.2
7	52.4	4.4	54.8	4.4
8	52.9	4.0	51.1	4.5
± SE	0.414	0.044	0.214	0.244

Table 6. Effect of ensiling with urea and/or chicken manure of rice straw on its nutritive value.

Storage time (week)	% Dry matter	Ash	Crude protein(CP)[1]	Cell wall (NDF)	Cellulose	Hemicellulose	Lignin (ADL)	IVDMD
	% d.m.							
Control (T_1)								
1	41.8	15.5	4.2	77.4	27.3	45.8	4.3	46.4
2	44.3	16.9	4.0	75.4	23.4	47.1	4.9	47.1
3	38.4	17.2	4.3	74.6	23.3	47.0	4.3	46.4
4	37.6	16.8	4.9	76.6	28.0	43.5	5.1	45.4
5	38.2	16.9	4.5	75.6	25.9	43.0	5.8	45.3
6	38.9	18.2	4.0	73.9	23.8	43.2	6.8	47.6
$\bar{x} \pm$ SD	39.9±2.39	16.9±.79	4.3±.31	75.6±1.16	25.3±1.89	45.1±1.60	5.2±.8	46.4±3.7
3% Urea (T_2)								
1	40.8	16.0	8.3	76.3	28.7	43.0	4.9	48.6
2	43.1	16.6	9.3	76.8	22.5	48.6	5.7	48.3
3	35.2	16.0	10.9	77.9	25.3	48.3	4.3	47.9
4	36.1	16.8	10.2	75.1	23.9	47.6	3.6	51.8
5	37.8	16.8	9.1	74.9	25.8	44.4	4.7	49.8
6	37.9	17.6	9.6	75.2	24.7	43.2	7.3	50.4
$\bar{x} \pm$ SD	38.5±2.72	16.6±.54	9.6±.82	76.0±1.07	25.2±1.90	45.9±2.37	5.1±1.17	49.5±1.35

Table 6. (continued).

Storage time (week)	% Dry matter	Ash	Crude protein(CP)[1]	Cell wall (NDF)	Cellulose	Hemicellulose	Lignin (ADL)	IVDMD
	-------	-------	-------	------- % d.m.	-------	-------	-------	-------
3% Urea + Manure (T_3)								
1	37.1	17.4	10.5	76.6	27.3	45.7	3.6	49.5
2	41.4	16.3	9.2	76.8	23.2	48.8	4.8	48.6
3	33.1	16.3	10.7	77.9	26.7	46.9	4.3	48.6
4	37.4	16.5	9.4	78.7	28.4	45.4	4.9	50.9
5	40.3	17.8	9.0	74.8	23.4	45.0	6.4	52.7
6	38.5	17.7	10.2	75.6	24.3	44.5	6.8	49.5
$\bar{x} \pm$ SD	38.0±2.65	17.0±.64	9.8±.66	76.7±1.30	25.6±2.00	46.1±1.43	5.1±.12	50.0±1.44
5% Urea (T_4)								
1	47.1	15.6	14.6	75.9	26.5	45.1	4.3	50.6
2	40.3	16.1	20.9	77.1	23.4	49.2	4.5	51.6
3	31.8	15.9	22.6	77.1	24.1	48.9	4.1	53.6
4	32.9	16.6	20.0	78.9	27.6	46.7	4.6	54.4
5	37.1	17.4	18.8	74.6	23.6	46.4	4.6	54.0
6	37.6	18.1	17.2	75.9	25.0	43.7	7.2	54.3
$\bar{x} \pm$ SD	37.8±5.05	16.6±.87	19.0±2.58	76.6±1.33	25.0±1.54	46.7±1.94	4.9±1.05	53.1±1.45

Table 6. (continued).

Storage time (week)	% Dry matter	Ash	Crude protein(CP)[1]	Cell wall (NDF)	Cellulose	Hemicellulose	Lignin (ADL)	IVDMD
	----------	----------	----------	% d.m.	----------	----------	----------	----------
5% Urea + Manure (T_5)								
1	46.8	16.8	14.4	75.7	22.4	48.2	5.1	53.4
2	33.2	18.2	19.5	76.9	22.7	49.4	4.8	52.0
3	32.7	15.8	19.0	79.9	26.7	49.2	4.0	50.8
4	39.4	16.4	16.2	77.5	27.1	46.0	4.4	54.2
5	32.3	17.3	19.8	73.6	22.3	45.7	5.6	55.2
6	33.9	17.0	18.8	74.3	21.6	46.3	6.4	54.5
$\bar{x} \pm$ SD	36.5±5.23	16.9±.74	18.0±1.97	76.3±2.09	23.8±2.21	47.4±1.52	5.1±.78	53.4±1.51
Manure (T_6)								
1	33.2	16.7	5.5	75.5	27.3	44.0	4.2	44.3
2	36.4	17.6	4.8	76.3	24.4	47.8	4.1	44.8
3	36.6	17.1	5.8	77.9	26.5	46.8	4.6	43.5
4	35.0	17.2	6.0	75.9	28.5	43.0	4.2	43.5
5	35.7	16.6	5.3	75.2	24.5	45.3	5.4	46.5
6	35.9	16.8	5.6	76.0	26.6	44.2	5.2	44.0
$\bar{x} \pm$ SD	35.0±1.19	17.0±.34	5.5±.38	76.1±.86	26.3±1.46	45.2±1.66	4.6±.51	44.5 ± 1.03
Urine (T_7)(1:1)[2]	49	28.0	6.9	59.3	21.8	33.9	3.6	58.0
1.5% NaOH (T_8)[3]	23	25.0	4.9	54.3	10.8	38.2	5.3	75.6

1 Analyzed on wet samples.

2 Sample taken at week 3.

3 Sample treated by Dip Method (Sundstøl and Coxworth, 1984).

Table 7. Effect of urea-ensiling of rice straw on its nutritive value.

Treatment	% Dry matter	Ash	Crude protein (CP)[1]	Crude fiber (CF)	Ca	P	Mg	IVDMD[2]	pH
		----------	----------	% d.m.	----------	----------	----------	----------	----------
Untreated rice straw	46.2	17.2	4.2 (13.6)[3]	36.8	.28	.11	.06	46.1	5.7
1% Urea treated	43.6	18.0	7.2 (50.0)	36.4	.26	.11	.06	48.4	7.1
3% Urea treated	44.1	17.2	11.9 (61.9)	37.3	.26	.11	.06	52.4	8.7
5% Urea treated	44.8	17.3	17.7 (64.6)	36.7	.26	.09	.05	55.5	9.0

1 Analyzed on wet samples.

2 In vitro dry matter digestibility.

3 Percents of total nitrogen as ammonia.

Table 8. Voluntary intake by buffaloes of rice straw and urea treated straw.

Item	Untreated rice straw	Urea treated straw	
		3%	6%
Days in experiment, d	54	54	54
Mean liveweight, kg	289	293	297
Daily DM intake, kg	5.87[a]	6.42[a]	7.32[b]
Daily DM intake, % BW	2.03[a]	2.17[a]	2.52[b]
Daily DM intake, g/kg $W^{0.75}$	84[a]	90[a]	104[b]
ADG, g	-130[a] (2)[c]	-50[a] (3)	210[b] (3)

[ab] Values with different superscripts in the same row are significantly different ($P < 0.05$).

[c] Number of buffaloes.

The mean values of packed cell volume (PCV), hemoglobin (HB), red blood cells (RBC), white blood cells (WBC)and plasma protein of the buffaloes in all treatments were in the normal ranges (Table 9). The reproductive performance of buffalo cows fed on urea treated (5%) rice straw (UTS) was investigated. Weight changes of animals fed on UTS during prepartum and postpartum were smaller than those fed on untreated rice straw: 0.61 and 0.57; 0.39 and 0.21 kg/d, respectively. Normal anterior presentations of fetus in all instances were observed during parturition. The average daily gains and weight at day 120 postpartum of the calves were 0.57, 0.37 kg/d and 90.6, 65.6 kg, for the respective treatments (Wongsrikeao and Taesakul, 1985). This may be explained by increases in milk production and its' composition.

The increases in digestibility and intake of the 5% UTS by crossbred dairy steers were also shown by Wanapat et al. (1983b), however, further supplementation with dried cassava chips decreased the mentioned parameters. Significant weight gain of the steers receiving UTS and minerals from a 4-one months trial was also observed (Table 10, 11).

Supplementation of energy and protein sources in urea-treated rice straw based diets

Feeding buffalo steers with urea-treated rice straw(5%) based -diet and a supplemented small amount (200 g/hd/d)of dried cassava leaf (26% CP) (DCL) resulted in higher digestibility and weight gain (Table 13, 14) (Wanapat et al., 1983a). The advantageous effect of supplementation of leucaena and water hyacinth leaf meals was also reported in the digestibility study with water buffaloes (Table 15, 16) (Sriwattanasombat and Wanapat, 1984).

Rubber seed meal (11.3% CP) supplemented to UTS (6%)for sheep resulted satisfactorily in terms of weight gain (Table 17). However, it is noticable that the amount of UTS consumed was also decreased, possibly due in part to the higher level of fiber of rubber seed meal (Tinnimit, 1984).

Table 9. Hematology of buffaloes affected by rice straw and urea treated straw[a].

Item	Untreated rice straw	Urea treated straw	
		3%	6%
PCV, %	33.8	31.7	32.7
Hb, g %	10.9	10.4	10.6
RBC, x $10^6/mm^3$	6.8	5.4	6.0
WBC, x $10^3/mm^3$	9.5	8.9	8.9
Plasma protein, g %	7.2	7.4	7.4

[a] No significant differences among treatments means (P > 0.05).

Table 10. Dry matter intake (DMI) and average daily weight gain (ADG) as affected by the different diets.

Item	Rice straw (C)	Urea-treated rice (UTS) straw	C + Cassava Chip	UTS + Cassava Chip	S.E. ±
Initial wt. kg	253.5	215.6	262.0	251.7	.071
ADG, kg	-0.134^{bc}	0.430^{a}	-0.312^{c}	0.75^{b}	.149
DMI, straw, kg/hd/d	4.97^{b}	6.82^{a}	2.69^{c}	4.82^{b}	.047
DMI straw, % BW/d	1.74^{c}	2.42^{a}	1.36^{d}	2.10^{b}	2.215
DMI straw, g/kg $W^{0.75}$/d	65.4^{c}	95.2^{a}	46.1^{d}	75.7^{b}	.026
DMI (cassava chip, CC), kg/hd/d	-	-	1.34^{a}	1.77^{a}	.026
Total DMI, kg/hd/d	4.97^{b}	6.82^{a}	4.03^{c}	6.59^{a}	.161

[abcd] Within rows, significant differences (P < 0.05) between means are indicated by dissimilar superscripts.

Table 11. Digestion coefficients (%) for dry matter (DMD), crude protein (CPD), ether extract (EED), nitrogen free extract (NFED), crude fibre (CFD), and acid detergent fibre (ADFD) of each diet.

Treatment	DMD	CPD	EED	NFED	CFD	ADFD
C	42.4[ab]	13.9[a]	47.1[a]	40.5[a]	66.4[b]	47.9[a]
UTS	51.5[a]	18.0[a]	43.5[a]	51.1[a]	78.2[a]	54.3[a]
C + cassava chip	36.1[b]	16.1[a]	45.5[a]	41.2[a]	52.1[c]	37.6[b]
UTS + cassava chip	47.7[a]	17.8[a]	44.8[a]	49.7[a]	66.0[b]	48.9[a]
$\pm$ SE	1.62	0.95	2.82	1.83	1.71	1.36

[abc] Within rows, significant differences ($P < 0.05$) between means are indicated by dissimilar superscripts.

Table 12. The performance of dairy heifers given untreated rice straw, treated rice straw, grass hay, grass silage and fresh grass.

Parameter	Untreated rice	Treated rice straw	Grass hay	Grass silage	Fresh grass
Int. wt., kg	173.4	170.2	170.1	168.3	166.2
ADG, g	79.4[b]	431[a]	433[a]	299[c]	401[a]
Dry matter intake, kg/hd/d, roughage	4.33[b]	3.59[a]	2.76[c]	0.93[d]	2.77[c]
Dry matter intake, kg/hd/d, concentrate	1.32	1.32	1.32	1.32	1.32
Dry matter intake kg/hd/d,	5.65[b]	4.91[a]	4.08[c]	2.25[d]	4.09[c]
total, % BW	3.20	2.53	2.11	1.22	2.18
F/G	75.8[b]	11.2[a]	9.4[a]	7.5[a]	10.2[a]

[abcd] Within row, means with different superscripts are significantly different ($P < 0.05$).

Table 13. Effect of treatments on apparent digestibility (%) of rations using insoluble ash as indicator.

Item	RS	UTS	UTS + DCL	± SE
DM	49.5[a]	58.4[b]	58.5[b]	1.64
OM	57.6[a]	64.6[b]	66.3[b]	1.53
GE	54.1[a]	63.1[b]	65.5[b]	1.46
ADF	49.7[a]	58.9[b]	58.6[b]	1.70
CP	-9.9[a]	24.6[b]	27.1[c]	3.51

[abc] Means within the same row with different superscripts are significantly ($P < 0.05$).

Table 14. Dry matter intake of straw and weight change by water buffalo steers.

Item	RS	UTS	UTS + DCL
Average body wt. kg	259[a]	248[a]	252.7[a]
Daily dry matter intake, kg	4.77[a]	6.14[b]	5.52[c]
Daily dry matter intake, % BW	1.84[a]	2.47[b]	2.18[c]
Daily dry matter intake, g/kg $W^{0.75}$	75.1[a]	98.1[b]	88.7[c]
ADG, g	-383[a]	136[a]	182[a]

[abc] Means within the same row with different superscripts are significantly different ($P < 0.05$).

Table 15. Voluntary feed intake of buffaloes consumed urea-treated rice straw based rations and supplemented with leucaena and/or water hyacinth leaf meals.

Item	Ration[c]			
	1	2	3	4
Daily dry matter intake				
kg	5.6^{a}	6.2^{b}	6.2^{b}	5.8^{ab}
% BW	2.0^{a}	2.2^{a}	2.2^{a}	2.1^{a}
Organic matter intake				
kg	4.7^{a}	5.1^{b}	5.2^{b}	4.8^{ab}
% BW	1.7^{a}	1.8^{a}	1.8^{a}	1.8^{a}

[ab] Within rows, significant differences ($P < 0.05$) between means are indicated by dissimilar superscripts.

[c] 1 = Urea-treated rice straw ad lib.

2 = Urea-treated rice straw + 250 g leucaena meal (LM).

3 = Urea-treated rice straw + 310 g water hyacinth leaf meal (WHL).

4 = Urea-treated rice straw + 125 g LM + 155 g WHL.

Table 16. Apparent digestibility coefficients of the nutrients in the rations by using total collection method and AIA as an internal indicator.

Item	Ration 1	2	3	4	$\bar{X} \pm SE$
Dry matter					
Total collection	51.4[a]	55.0[b]	58.4[c]	57.9[bc]	55.7±3.2
AIA	51.7[a]	56.2[b]	56.6[b]	56.8[b]	55.3±2.4
Organic matter					
Total collection	59.7[a]	62.9[ab]	65.7[b]	65.3[b]	63.4±2.7
AIA	59.8[a]	64.0[b]	64.2[b]	64.2[b]	63.1±2.1
Crude protein					
Total collection	1.3[a]	15.6[b]	22.2[b]	20.4[b]	14.8±9.4
AIA	4.8[a]	16.4[b]	19.3[b]	15.4[b]	13.9±6.3
Gross energy					
Total collection	52.5[a]	57.4[a]	60.2[b]	59.7[ab]	57.4±3.5
AIA	53.6[a]	58.2[b]	58.2[b]	58.2[b]	57.1±2.3
Acid-detergent fiber					
Total collection	51.7[a]	54.8[b]	58.3[c]	57.7[bc]	55.7±3.0
AIA	52.3[a]	56.3[b]	56.6[b]	56.4[b]	55.4±2.1
Acid-detergent lignin					
Total collection	7.3[a]	9.8[a]	12.3[a]	10.1[a]	9.9±2.0
AIA	4.5[a]	13.6[b]	9.1[ab]	7.9[ab]	8.8±3.7

[abc] Within rows, significant differences ($P < 0.01$) between means are indicated by dissimilar superscripts.

Table 17. Performance of sheep fed with straw and rubber seed meal.

Parameter	Ration		
	Rice straw + Rubber seed meal	Urea-treated rice straw	Urea-treated rice straw + Rubber seed meal
Init. wt., kg	12.80	11.95	13.03
Final wt., kg	12.51	13.05	15.25
ADG, g/hd/d	-9.6	36.5	74.0
Roughage DMI, g/hd/d	58.8	324.8	216.2
Conc. DMI, g/hd/d	410.1	-	519.5
Total DMI, g/hd/d	448.9	324.8	735.7
DMI, % BW/d	3.54	2.60	5.20
CP intake, g/hd/d	47.5	16.1	69.4

Average daily gain of 360 g/hd/d was obtained from a 6-month feeding trial by growing water buffalo yearlings fed only urea-treated rice straw. The straw was prepared by ensiling for 3 weeks with solution containing molasses (5% w/w), urea (6% w/w)and water at 1:1 ratio. Supplementation of other sources such as sunnhemp hay,verano stylo hay slightly increased ADG of the buffaloes (Table 18)(Rengsirikul et al., 1984).

A 120-d feeding trial by Wanapat et al. (1984) using growing native cattle and buffalo steers. Treatments including untreated rice straw, urea-treated rice straw (5%), urea-treated rice straw and water hyacinth (3:1) and urea-treated rice straw and water hyacinth (1:1), all ensiled for at least 3 weeks. The group fed UTS had a slight average daily gain and the highest gain was found in the group fed urea-treated rice straw and water hyacinth (3:1). Digestibility of nutrients were also improved by urea treatment and even more pronounced by treatments with water hyacinth. Water hyacinth can be a potential good source of fodder whereever available (Table 19).

Economics of feeding urea-treated rice straw

Data related to this topic has been scarce, though, considered of great importance. A study conducted by Promma et al.(1984) looking at the economics of feeding dairy cattle with different types of roughage including UTS (6%), was conducted. Milk production (4% FCM), milk fat, milk protein were not different. BUN, blood NH_3 and ruminal pH were also reported to be in the normal ranges. It was found that feeding UTS to dairy cows was the most economical of all (Table 20 and 21).

Cheva-Isarakul and Potikanond(1984)(Table22) compared urea treated (6%) rice straw without supplements to untreated rice straw with dried leucaena leaf as a supplement (0.5 kg/hd/d) when fed to growing Holstein Friesian bulls for 91 days. All animals received concentrate (16% CP) in addition at 1 kg/hd/d. Intakes of straw, average

Table 18. Effect of supplements of feeding urea treated rice straw for buffaloes.

Item	Untreated straw(s)	S + Verano stylo hay	S + chicken litter (15%) + molasses(5%)	S + Sunnhemp hay (2:1)	Urea-treated straw (6%) + molasses (5%)
No. animal	6	6	6	6	6
Initial wt, kg	201.5	212.2	224.0	200.3	195.8
Exp. period, mth	6	6	6	6	6
ADG, g/d	63.9^{a}	82.4^{b}	84.3^{b}	159.3^{c}	359.8^{d}

^{abcd} Means on the same row with different superscripts are significantly different ($P < 0.05$).

Table 19. Voluntary dry matter intake (DMI), weight change and digestibility of some nutrients in native cattle (CT) and water buffaloes (BF).

Item	C		$\bar{X}$	UTS		$\bar{X}$	TSW 1		$\bar{X}$	TSW 2		$\bar{X}$
	CT	BF		CT	BF		CT	BF		CT	BF	
Intake												
DMI, kg/d	3.03	4.21	3.61^{a}	3.24	4.75	3.97^{b}	3.30	6.24	4.74^{c}	3.49	5.05	4.26^{b}
DMI, g/kg $W^{.75}$/d	86.6	78.8	82.7^{a}	88.6	88.2	88.4^{ac}	86.8	111.1	99.0^{b}	95.8	90.4	93.1^{c}
Weight change, g/d	-34	-182	-108^{a}	7	79	43^{b}	133	232	182^{c}	23	329	176^{c}
Digestibility, %												
Dry matter	44.0	50.2	47.1^{a}	51.6	51.9	56.7^{b}	56.4	51.8	54.1^{b}	64.3	65.0	64.7^{c}
Crude protein	20.7	23.4	22.0^{a}	23.8	28.6	26.2^{ab}	29.3	28.8	29.0^{b}	45.7	59.6	48.2^{c}
Acid-detergent fiber	41.7	43.2	42.5^{a}	47.9	47.4	47.6^{b}	49.2	54.9	52.0^{c}	58.2	61.6	59.9^{d}

[abcd] Means on the same row with different superscripts are significantly different ($P < 0.05$).

C = control

UTS = Urea treated straw (5%)

TSW 1 = Urea treated straw and water hyacinth (3:1, DM basis)

TSW 2 = Urea treated straw and water hyacinth (1:1, DM basis).

Table 19. (continued).

Item	Animal difference		Significance
	CT	BF	
Intake,			
DMI, kg/d	3.26	5.06	xxx
DMI, g/kg $W^{.75}$/d	89.4	92.1	n.s.
Weight change, g/d	32	114	
Digestibility, %			
DM	54.1	54.7	n.s.
CP	29.9	32.8	n.s.
ADF	50.7	50.4	n.s.

xxx $P < .001$

n.s. = non significant

Table 20. The performance of milk cows given fresh grass, fresh grass + urea treated rice straw and urea treated rice straw.[1]

Parameter	Fresh grass	Fresh grass + treated straw	Treated rice straw
Dry matter intake (roughage),			
kg/hd/d	5.88	7.37	5.93
Dry matter intake (concentrates),			
kg/hd/d	4.40	4.40	4.40
Total dry matter intake,			
kg/hd/d	10.28	11.77	10.33
Milk production, 4% FCM,			
kg/hd/30 d	176.1	268.4	269.9
kg/hd/d	9.2	8.9	9.0
Milk fat, kg/hd/30 d	11.2	10.85	11.7
Fat, %	3.08	3.28	3.25
Milk protein, kg/hd/30 d	8.51	8.77	8.78
Protein, %	3.08	3.28	3.25
Blood urea nitrogen, mg %	8.0	8.5	8.0
Blood ammonia, µg %	660	667	660
Ruminal pH	6.5	6.6	6.6

[1] No significant differences among treatment means ($P > 0.05$).

Table 21. The economic results of milk cows given fresh grass, fresh grass + treated rice straw and treated rice straw.

Parameter	Fresh grass	Fresh grass + treated straw	Treated rice straw
Variable cost, Baht/100 kg milk			
labour, feeds, antibiotic, instruments, A.I., 13% interest, etc.	438.24	408.94	357.74
Stable cost, Baht/100 kg milk			
land, barn, cow, tools, 13% interest, etc.	85.85	85.85	85.85
Total operation cost, Baht/kg milk	5.24	4.95	4.44
Average milk yield, kg/hd/d	9.2	8.9	9.0
Milk price, Baht/kg	6.36	6.36	6.36
Net income, Baht/hd/d	10.30	12.69	17.46

Table 22. Economics of feeding untreated rice straw (RS) with leucaena leaf and urea-treated rice straw (UTS) by growing Holstein Friesian bulls for 91 days.

Item	UTS (6%)	RS + leucaena leaf
Total straw intake, kg/d	186.5	164
Leucaena leaf, kg/d	-	45.5
Concentrate, kg/d	91	91
Total cost, Baht/hd	475.9	477.8
Total weight gain, kg/hd	38.4	44
Feed cost/gain, Baht/kg	12.4	10.9

daily gain and cost/unit gain were similar between groups. It could be summarized that when leucaena leaf is not available, farmers can optionally feed urea-treated rice straw to animals with similar results, provided urea treatment is practically acceptable.

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FACTORS AFFECTING UREA-AMMONIA TREATMENT

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SUMMARY

Effectiveness of urea-treatment of rice straw depends on various factors : quality of straw, concentration of urea, amount of water added and the duration of storage.

Key words : urea-treatemnt, rice straw, ruminants.

INTRODUCTION

In the past few years a considerable amount of research has been carried out on the use of urea-ammonia treatment to upgrade the nutritive value of rice straw. Asian scientists have made a major contribution to the bulk of the information available on various aspects of this treatment. Of the various chemicals available to improve the nutritive value of straw, the use of urea seems to be most appropriate due to its low price, availability at farm level and also because Asian farmers are familiar with this chemical.

It is evident from the information available in literature that urea-ammonia treatment generally increases the digestibility,crude protein content and intake. As a result the animal performances are higher fed on treated straw than on untreated straw. But, the efficiency of treatment i.e. the response to feeding treated straw to a large extent depends on factors such as : initial quality of straw, concentration of urea used, amount of water used,duration or storage: open, semi-closed or closed (airtight).

As these factors are crucial in determining the efficiency of treatment, an attempt is made in this paper to : review the information available, to fill gaps in knowledge with our experimental findings, many of which are not yet published.

Initial quality of straw

Straw quality can be influenced by factors such as :variety, cultural practices : fertilizer, water regime, agro-chemicals, height of cutting, post harvest practices : threshing, storage.

The farmers cultural practices and choice of varieties are likely to be determined by the grain yield parameters. He is unlikely to change cultural practices in order to obtain higher quality straw. Only matters like height of cutting and storage may be relatively easy to change. When discussing yield of straw it is important to distinguish between 'harvested straw' and straw 'left uncut' in the field. The latter is generally referred to as "stubble" and its quantity (kg/ha) depends on the height of cutting. Although no separate estimates are available on straw : stubble rations from other countries, our (Sri Lanka) figures yield a ration of 1:1::1. This is a higher estimate of straw + stubble than the generally accepted 1:1 ratio of straw to grain.

Unlike other cereal straw,the stem component of rice straw seems to have lower silica content and higher digestibility than leaves (Jackson, 1978; Winugroho, 1981). If this is the case, one would expect two things :

(a) the lower the height of cut, the better the quality of harvested straw

(b) due to the low content of silica in the stubble it would respond better to treatment.

The value of this statement deserves however to be tested a bit more.

Table 1 summarises some in vivo digestibility data on initial straw quality and the responses (digestibility and intake) achieved to urea-ammonia treatment. From the trials in Sri Lanka it is clear that the digestibility of untreated straw could range from 43 to 51% and when treated with 4% urea the increase in digestibility units could range from 5 to 1 units.

Table 1. Summary of in vivo data on response to urea-ammonia treatment.

	Dry matter digestibility		Dry matter intake	
	Untreated	Treated	Untreated	Treated
	---------- % --------		------- % BW ------	
Thailand (Wongsrikeao and Wanapat, 1984)	43	55	2.0	2.5
Sri Lanka (Straw Utilization Project, unpublished data)				
Trial 1	51	62	1.0	2.0
Trial 2 (3 x 3 x 3)	45	50	2.7	3.3
Trial 3 (Galpokuna)	47	54	2.4	2.9
Trial 4 (Navaratne)	43	48	1.7	1.8

A similar variation is shown in their corresponding intakes. We should stress here that high variabilities within straw are found and even animal effects should not be excluded without further experiments.

Table 2 shows the response of six varieties of straw and stubble to 4% urea-ammonia treatment. Statistical analysis still has to be done but the overall response of stubble to treatment is nearly twice as compared to straw. Would this mean that the response one would expect to treatment will depend on the height of cutting of the matured rice plant?.

Table 2. Effect of urea-ammonia treatment on the IVOMD of different varieties of straw and stubble (SUP unpublished).

Variety	Straw				Stubble			
	Untreated		Treated		Untreated		Treated	
	CP	IVOMD	IVOMD	% improved	CP	IVOMD	IVOMD	% improved
	----- % -----				---- % ----			
BG 11-11	5.2	43.5	45.2	104	5.1	28.0	30.8	110
BG 34-8	5.2	47.8	52.6	110	5.8	44.9	52.4	117
BG 400-1	5.2	34.7	41.5	120	4.8	34.2	49.9	146
BG 94-1	5.4	35.5	44.8	126	5.9	32.6	48.0	147
BG 276-5	5.1	49.2	51.6	105	4.4	37.9	45.1	119
H 4	4.8	36.3	45.6	126	5.6	28.2	51.0	181
Mean	5.15	41.2	46.9	115	5.27	34.3	46.2	137
SD	0.197	6.5		10.1	0.599	6.4	7.96	27

Concentration of urea

Table 3 summarises the responses (in vivo DMD and intake) achieved with different concentration of urea. Although the increases in digestibility is marginal when more than 4% urea was used, in some experiments the intake has continued to increase with increase in level of urea. Although the data presented in Table 4 is preliminary, a similar trend is evident. It is important to note that the cost of urea is the major cost (30-60%) in treating straw with urea. As such an increase from 4% level to 6% will further considerably increase the cost.

Table 3. Summary of response to level of urea.

Source	Digestibility							Dry matter intake (g/kg $W^{.75}$)						
	Level of urea							Level of urea						
	0	3	4	5	6	8	10	0	3	4	5	6	8	10
Wongsrikeao and Wanapat (1981)	43	53	-	-	55	-	-	2*	2.2*	-	-	2.5*	-	-
Gadre and Jackson (1980)														
Wheat straw-cattle-4 weeks treated	43	-	43	-	-	-	-	70	-	107	-	-	-	-
Jayasuriya (1980)														
Rice straw-Buffalo calves 4 weeks treated	31	-	62	-	-	-	-	69	-	95	-	-	-	-
Dolberg et al. (1980)														
Rice straw	-	41	51	-	52	-	-	-	-	33	-	42	-	-
Jayasuriya and Perera (1981)														
4 weeks treated	-	-	53	-	-	57	-	-	-	40	-	-	51	-
Saadullah et al. (1981)														
Rice straw	45	-	-	46	-	-	-	46	-	-	61	-	-	-

* % BW.

Table 4. Effect of level of urea on urea-ammonia treatment-SUP-Preliminary data.

	Untreated straw	Level of urea (g/100 g DM)		
		2	4	6
Dry matter digestibility	43	43	48	47
Dry matter intake, (kg/100 kg BW	4.0	4.0	3.7	4.0
Digestible dry matter intake, kg/100 kg BW	1.7	1.7	1.8	1.9

Concerns about toxicity of higher levels of urea are correctly expressed even though one should realize that the intake of urea or NH_3 through straw is a slow process evenly spread over the day. SUP has fed 6% urea sprayed straw to cattle which were partly starved. Results seem to indicate that intake of straw and LWG is decreased considerably but no direct toxic effects are observed. (SUP trials, Leelawardene, Tharmaraj and De Rond).

Amount of water or water/straw ratio

Although a 1:1 water/straw ratio is generally accepted there is little or no scientific evidence to support this. Water is required as a 'vehicle' for the chemical and the reactions, also for soaking and swelling. Hence, the following aspects merits consideration.

(a) Minimum quantity of water is essential for the chemical reaction. Urea mixed with airdry straw in its pellet form remains undissolved for several months (personal observation, Ibrahim).

(b) Excess water would lead to leaching of the soluble components present in the straw, and it has been observed (SUB trials, Tharmaraj) on several occasions that if more water is used than straw (exceeding 1:1 ratio) the straw cannot absorb the water. As a result the straw in the bottom part of the pit is over soaked and becomes unsuitable for feeding due to the rapid development of mould.

(c) During the dry season when the need for straw feeding really arises one cannot expect to obtain large amounts of water from the wells.

(d) The effort of carrying water in large quantities (100 litres for 100 kg of straw) is quite considerable. Often the well is distant from the stable and place of treatment.

(e) Moisture content of the final treated product has an influence on the presence or absence of mould (Verma, 1982). Verma concluded that at around 50% moisture content the incidence of mould is very low.

In a recent trial conducted by the S.U.P., straw/water rations of 1:0.3, 1:0.6, 1:1 and 1:1.3 were tested. Increasing the amount of water used from 1:0.3 to 1:1, digestibility increases upto 6 percentage units could be achieved, but the digestible dry matter intakes (kg/100 kg BW) remained at 1.3 kg. Its worth mentioning that in straw treated with 30% and 130% water levels, mould growth (different types of moulds!) was observed. S.U.P. is repeating this trial to confirm the above findings.

Duration or storage of treated material

Most of the information available on the aspect of duration of treatment is based on in vitro experiments. In vitro work indicate improvements in digestibility even after 3 weeks of storage, but unfortunately limited information is available on in vivo responses. Hossain and Rahman (1981) treated straw with 5% urea and stored in pits for 2 or 3 weeks. The DMD of untreated and those treated and stored for 2 or 3 weeks were 49, 63 and 62 respectively. They also

Table 5. Effect of quantity of water used on urea-ammonia treatment.

	Untreated straw	Level of water (%)			
		30 1:0.3	60 1:0.6	100 1:1	130 1:1.3
Dry matter digestibility	51	56	58	62	-
Intake					
- Dry matter, kg/100 kg BW	1.7	2.3	2.2	2.1	1.7
- Digestible dry matter, kg/100 kg BW	.9	1.3	1.3	1.3	-

Source : Straw Utilization Project - Preliminary data.

Table 6. Effect of duration on urea-ammonia treatment.

	Untreated straw	7 days storage	20 days storage
Dry matter digestibility, %	51	58	59
Intake			
- Dry matter, kg/100 kg BW	1.7	2.1	2.0
- Digestible dry matter, kg/100 kg BW	0.9	1.2	1.2

Source : SUP, Preliminary data.

reported that there was no increase in straw dry matter intakes (3.1 kg/100 kg BW for both treated groups as compared to 2.6 for untreated). Some of the earlier trials conducted by S.U.P. on duration of treatment is summarised in Table 7. It is evident from this table that 9 days treatment time is not much inferior to 21 days and also 3 days are similar to 9 days of treatment.

In a recent trial (4% urea) conducted by the SUP(Table 6), 7 days duration was compared with 20 days duration and the responses in digestibility and intake achieved are similar to that reported by Hossain and Rahman.

Table 7. Effect of duration of treatment on production characteristics.

	Duration of treatment (days)	Straw dry matter intake (kg/100 kg BW)	Liveweight gain g/day
Kumarasuntheram et al. 1984	27	2.9	213
(Local bulls)	9	3.0	307
Perdok et al., 1982	29	2.9	310
(Local bulls)	9	3.0	282
SUP unpublished	9	3.3	240
(crossbred bulls)	3	3.1	223
Niraviya			

Storage of treated materials (type of pit)

As the chemical agent involved in bringing about improvement in Nutritive value is ammonia/ammonium hydroxide every effort should be made to achieve airtight conditions. Ibrahim et al. (1983) studied the different forms of storing treated material and also used different materials to provide airtightness. Their data show clearly the advantages of an airlight system.

Basically the treated material could be stored in a heap (stack) or in a pit. Feeding trials conducted by the SUP have indicated that if larger heaps (ca 1 MT) are used, complete airtightness may not be necessary particularly if the straw is treated for a short duration of around 9-10 days.

At present the 2 types of storage systems which have a fair amount of acceptance by the farmers are :

(a) System used in Thailand : treating 1-2 MT of straw and covering with polythene.

(b) System used in Sri Lanka : pit method.

Pits could be made of mud, polythene or brick and cement and top covered with polythene.

CONCLUSION

It is clear from the above discussion that the above listed factors play a role in determining the efficiency of treatment. Hence, due attention has been given to these factors in developing system of urea-ammonia treatment at farm level. The picture starts becoming pretty complete and although more work can be done, for practical purposes it can be said that a fairly well proven system can be offered to the farmers.

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TREATMENT OF CROP-RESIDUES AS ANIMAL FEEDS IN JAPAN

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SUMMARY

Treatment and utilization of rice straw and rice hulls in Japan are reviewed. Many experiments indicate that rice straw and hulls are poor quality roughages in their natural states. There are some limiting factors about the chemical composition of rice straw and hulls that are evidently different from most other roughages. The shortcomings of rice straw and hulls in their natural states as animal feeds are its low nitrogen content,high insoluble ash content, low digestibility and poor palatability.

Several experiments indicate a very strong possibility that nutritive values of these materials could be markedly improved by mechanical treatment, ensilage or chemical treatment with alkali, which have been developed in Japan.

Voluntary intake of rice straw by ruminants was extremely low compared with those of other roughages due to a low palatability and a high content of infermentable materials. Several methods for improving the palatability of rice straw were investigated by making rice straw silage with apple pomace or by soaking with palatable solution and juice of ladino clover.

The ammonia treatment for rice straw and hulls improve the nutritive values of these materials. The nitrogen contents and digestibilities of rice straw and hulls increased after ammoniation. The rumen microbial protein synthesized during the incubation period was higher in ammonia treated rice straw and hulls compared with those of original materials. The comsumption of rice straw by sheep increased when the rice straw was treated with ammo-

nia. The ammonia treatment could have chemical and physical effect on the cell wall structure of these materials, which in turn improve the nutritive values.

The sodium hydroxide treatment of rice straw prepared mechanically has been developed and shown promise in improving the nutritive values of rice straw. In a dry process or spraying method, the penetration of sodium hydroxide solution into straw tissue was extremely reduced by lowering the moisture content of the straw. However, it could be increased by pressing after addition of the solution and by splitting rice straw mechanically. The quality of treated straw prepared mechanically in the industrial plant was examined by checking pH value, residual alkali, in vitro digestibility, changes in chemical composition and animal feeding trials. The alkali spraying treatment was considered to be effective for the enhancement of the nutritive value of rice straw and its technique was almost completely established

Key words : crop residues, treatment, ruminants.

INTRODUCTION

Rice straw and rice hulls are abundant by-products of the rice production in Japan, and the problem of disposal of these materials has plagued the rice industry for recent years. The utilization of both by-products for livestock feeding has been actively thought for dissolving the shortage of forage sources because most ruminants in Japan were being fed under the condition of shortage of roughage.

The potential use of rice straw and hulls as animal feeds is particularly worthy of consideration in view of fact that ruminants are uniquely adapted to utilize the cellulose and hemicellulose in high fibrous materials. However, even though rice straw and hulls contain enough cellulose and hemicellulose to make them source of energy for ruminants, these materials are poor quality feeds in their natural states, because they have serious shortcomings of low nitrogen content, low digestibility and poor palatability.

The attempt of improving the nutritive values of rice straw as a source of feed nutrient in Japan may have been sparked with Iwata's observations (Iwata, 1930 and 1931). These experiments demonstrated that the method of rice straw disintegration by soaking the rice straws in 1% milk of lime for 2 days increased twice net energy compared with that of untreated rice straw. Much information has been given on soaking method in the long history of this method but the method has not been put into practical use because of its technical defects. Some years ago, with the advent of low cost of grain and high cost of treatment of rice straw, researches were concentrated on treating and discharging rice straw and hulls for disposal rather than use of animal feed. That approach seems to be unsound due to a cause of air pollution as burning and detrimental effects to rice production.

A research on improving nutritive values of rice by-products is currently needed to prevent air pollution from disposal to dissolve the shortage of roughage in Japan by improving existing technology and developing new methods for treatment and utilization of these materials.

Nutritive value of rice straw and hulls

Nutritive value of roughages is multifaceted, but is conventionally classified into several components;chemical composition, digestibility and feed consumption.

The availability of nutrients in rice straw is essentially determined by chemical composition of rice straw. Protein deficiency and a high fibrous content are thought to be the chief limiting factors in the utilization rice straw as a feed for ruminants(Table 1). The high ash content of rice straw is also a serious disadvantage of its utilization as a feed (Smith et al., 1971. Van Soest and Jone,

Table 1. Chemical composition of rice straw and hulls.

NDF	ADF	Cellu-lose	Lignin	Silica	Crude protein	Crude fat	Crude fiber	NFE	Ash
% d.m.									
Rice straw (1)									
73.6	44.6	29.8	7.3	-	4.8	1.6	32.6	47.3	13.7
Rice straw (2)									
59.4	-	34.8	13.4	12.9	4.6	1.7	27.4	49.1	17.2
Rice hulls (1)									
79.3	59.8	34.5	-	-	3.7	0.8	41.9	27.0	17.1

(1) Itoh et al. (1975).

(2) Toyokawa (1978).

1968). The ash content of rice straw is about 16% on dry matter basis, two-third of which is silica (Table 1).

Voluntary intake of rice straw was extremely low compared with other roughages (Table 2). These might be due to a low palatability and a high content of infermentable materials. The production of volatile fatty acids in the rumen of sheep fed rice straw alone was also very low.

As plants age, they tend to become more mature and generally decline in nutritive value (Kamstra et al., 1958). Such changes are due to altered chemical composition involving increased fibrous materials, crude silica and decreased crude protein. However, rice straw should be collected in mature stage as rice plant is cultivated to harvest the seed. The nutritive value of rice straw, therefore, could not be improved by harvesting a proper stage of maturity.

Table 2. Voluntary intake of rice straw and alfalfa hay and the production of volatile fatty acids (VFA) in the rumen of sheep.

	Roughage	
	Rice straw	Alfalfa hay
Voluntary intake, g/day	381	1,501
VFA production, mM/l	45.5	125.4

Toyokawa, 1973.

Treatment of rice straw and hulls

Several types of treatment used to increase the nutritive value of rice straw and hulls have been developed in Japan which include mechanical treatment, anaerobic fermentation or ensilage and treatment with various chemicals.

Mechanical treatment of rice straw and hulls

As mentioned above,the low availability of rice straw and hulls is mainly related to the extent of lignification of cell wall. Recent works have been attempted to improve the nutritive value of these materials by mechanical treatment for breaking highly rigid cell wall structure (Togamura et al., 1983; Itoh et al.,1983). The mechanical treatment of screw press grinding followed by expanding or explosion markedly decreased cell wall constituents of rice straw and hulls while the treatment grinding alone did not affect the content of cell wall constituents. Data on in vitro digestibilities showed that these treatments improve the nutritive values of these materials (Table 3).

Table 3. Effect of mechanical screw press alone (Press), screw press followed by expanding (Expand.) and explosion (Explo.) treatment of rice straw and hulls on in vitro organic matter digestibility.

	Original	Treatment		
		Press.	Expand.	Explo.
	%			
Rice straw (1)	43.7	-	-	75.0
Rice hulls (1)	5.4	-	-	25.7
Rice hulls (2)	8.9	11.8	32.3	-

(1) Togamura et al. (1983).
(2) Itoh et al. (1983).

Ensiling and soaking treatment of rice straw

The main defect of rice straw used as a feeding stuff is an insufficient intake for the nutritional demand of livestock. It is, therefore, desirable that the method of improving palatability of rice straw should be established.

Rice straw was ensiled with apply pomace which are rich in soluble carbohydrate (Toyokawa et al., 1977). The quality of rice straw silage was improved by the addition of apple pomace; the content of lactic acid of silage increased and the pH value of silage decreased compared with those of rice straw silage. The dry matter intake of rice straw silage with apple pomace by wethers was significantly increased compared with that of rice straw itself.

The rice straw soaked with juice of ladino clover was fed to the wethers to determine the increased effect of voluntary intake of rice straw (Toyokawa, 1978). The results showed that the daily dry matter intake of soaked rice straw with the juice increased 130%

of that of original rice straw. Rice straw was soaked with the solution tasting sweet (sugar) bitter (quinin dihydrochloride), salt (sodium chloride) and sour (acetic acid), and the preference test was conducted when each soaked and unsoaked rice straw fed to wethers(Toyokawa and Tsubomatsu, 1977). In the case of sugar solution, the average proportion of soaked straw intake to the total intake of straw was more than 90% at the sugar concentration above 2.5 g/100 ml. The dry matter intake of soaked rice straw with 10%sugar solution was 1.8 times as much as that of untreated rice straw. These results indicate that the sweetness of sugar improves the taste of rice straw.

Chemical treatment of rice straw and rice hulls

Ammonia treatment

The primary aim of ammonia treatment in the past was to increase the non-protein nitrogen content of low quality roughages rather than to increase the overall digestibility. But recent researches have been attempted to improve the overall availability of these low quality roughages (Waiss et al., 1972).

The effects of ammonia treatment of rice straw and hulls on chemical composition, in vitro digestibility and chemical and physical changes of cell wall were summarized in Table 4.

Nitrogen contents of ammoniated rice straw and hulls were tripled compared with those of these original materials (Itoh et al., 1975). Neutral detergent fiber (NDF) content was decreased by ammonia treatment, but acid detergent fiber (ADF) which consists of cellulose and lignin was not affected. Nitrogen contents of fibrous materials (NDF, ADF and CF) were also increased after ammoniation(Itoh et al., 1979 and 1981B).

The rumen microbial nitrogen (N) synthesized during the 24 hr incubation period from the adsorbed N of rice straw and hulls treated with ammonia was determined (Terashima et al., 1981B). The

Table 4. Effect of ammonia treatment of rice straw and rice hulls on chemical composition, in vitro digestibility and chemical and physical characteristics of cell wall.

Chemical composition		
	Total nitrogen	Increase
	Nitrogen in fibrous materials	Increase
	Cell contents	Increase
	NDF	Decrease
	ADF	No change
In vitro digestibility		
	Whole	Increase
	Cell contents	Increase
	NDF	Increase
	ADF	No change
Chemical and physical characteristics of cell wall		
	Hemicellulose degradation	Increase
	Free carboxyl group	Increase
	Fiber saturation point	Increase

MICROBIAL N contents of the treated rice straw and hulls in the medium were higher than those of both original materials, suggesting that the ammoniated materials stimulate the rumen microbial activity (Table 5). The rates of the microbial N derived from the absorbed N to the total N of microbial protein synthesized during incubation was 24% for rice straw and 20% for rice hulls. These results indicated that the adsorbed N originated from added ammonia was certainly utilized by rumen microbes as well as other N sources.

The digestion and feeding trials by sheep were conducted of rice straw treated with ammonia to determine the effect on the

Table 5. Microbial N synthesized during the 24 hr incubation period from the absorbed N of rice straw and rice hulls treated with ammonia.

	Rice straw		Rice hulls	
	Original	Ammonia	Original	Ammonia
	(mg/100 ml medium)			
Total microbial N	27.7	42.5	24.2	27.2
Synthesized microbial N during incubation period	7.9	22.7	4.4	7.4
Microbial N derived from the absorbed N		5.5		1.5
(% of synthesized N)		(24)		(20)

intake and digestibility of rice straw ration with concentrate (Terashima et al., 1981A). The consumption and digestibility of ammoniated straw were higher than those of original straw (Table 6). These results indicate that ammonia treatment for rice straw improves the intake and digestibility of the low quality roughage.

The ammonia treatment for rice straw and hulls affected on the structure of tissues especially parenchyma and further on that of sclerenchyma and the outer layer covered with lignin and silica (Itoh et al., 1981A). To reveal the effect of ammonia treatment of rice straw and hulls on chemical and physical structure, free carboxyl group content and fiber saturation point (FSP) were determined on treated materials (Terashima et al., 1984). Ammonia treatment slightly increased free carboxyl group content of rice straw. The FSP defined as the amount of water contained within the water saturated cell wall was increased after ammoniation. These results suggest that ammonia treatment could increase the size and number of porous bodies in the cell wall.

Table 6. Daily dry matter consumption and digestibility of rice straw and ammoniated straw ration with concentrate by sheep.

	Ration	
	Original	Ammonia
Total dry matter intake[1], g/kg.BW$^{.75}$	58.1	72.1
Straw dry matter intake[1], g/kg.BW$^{.75}$	26.7	40.8
Dry matter digestibility[2], %	69.3	73.6
Nitrogen balance, g/day[2]	2.2	2.7

[1] Concentrate was fed at 1.5% of body weight and rice straw was fed ad libitum.

[2] The ration formulated at constant rate of straw and concentrate was provided.

Sodium hydroxide treatment

Two methods of sodium hydroxide treatment, alkali soaking and alkali spraying, have been developed for improving the nutritive value of low quality roughages. In the spraying method, two major problems must be solved before straw sprayed with alkali are utilized for feeding. One of them is a technical problem on the preparation of sprayed straw, especially the necessity of establishment of an optimum condition for the alkaline reaction to increase, and the other is a problem on physiological influence of residual alkali on livestock (Nakashima, 1979).

The penetration of sodium hydroxide solution into straw issues was very low when the moisture contents of straw was lowered. It could be increased by pressing after addition of the solution and by splitting rice straw. The moisture content appropriate for the preparation was about 22%and the process of pressing and splitting was an essential step (Nakashima, 1979). The optimum level of sodium hydroxide for treatment was estimated by an increase in digestibility of straw and the amount of residual alkali. It was about 6%. The conditions of rumen (pH, VFA concentration and bacterial population), mineral balance and blood acid-base status were examined in sheep fed a ration containing alkali treated rice straw to determine the effect of residual alkali in treated straw. The amount of Na intake ($g/BW^{.75}/day$) which would not disturb livestock physiologically was estimated to be 1.20 g. The effect of an experimental ration containing 22-25% rice straw treated with 6-8% sodium hydroxide on the lactation of dairy cows and the fattening of beef cattle was determined and this effect was compared with that of potato pulp. All parameters showed that the alkali treated rice straw had almost the same nutritive value of potato pulp.

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IMPROVEMENTS IN THE FEED VALUE OF RICE STRAW BY FERMENTATION WITH FILAMENTOUS FUNGI

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SUMMARY

The tests reported here are part of an extended research project supported by the International Development Research Centre of Canada. These tests employed five strains of filamentous fungi selected from a screening program involving approximately 200 isolates mostly obtained from Thailand. The five isolates were selected because they gave the highest in vitro digestibilities and protein contents for fermented straw and because they gave negative results in toxicity tests with rats. The five isolates were grown in triplicate, aseptic, 100 g fermentations using rice straw and rice straw mixed with 30% water hyacinth or sugar cane bagasse, to determine the effect of various parameters on the in vitro digestibility and protein content of the fermentation substrates. Results showed that 80% moisture was optimum for growth and that cutting or milling of the straw was unnecessary. Two strains of fungi which performed badly in the preliminary tests were replaced by new isolates selected in a continued screening program. Pathogenicity tests with the fungal isolates were negative as were toxicity tests with them and their fermentation substrates. Nitrogen supplementation of 1% to 2% was detrimental for growth of all the isolates tested, and the form of the added nitrogen (urea or nitrogen salts or a mixture of the two) influenced the amount of inhibition. The highest digestibility and protein content obtained on nitrogen supplemented rice straw were 49% and 12.6%, respectively. A preliminary aseptic, 4 kg (d.w.)

fermentation using commercially prepared fungal inoculum of *Pleurotus florida* gave an in vitro digestibility of approximately 46% and a protein content of approximately 7%. With 30% water hyacinth addition, these values improved to 47% and 11.5%, respectively. Similar aseptic fermentations are underway.

Key words : rice straw, biological treatment, ruminants.

INTRODUCTION

Phase one of this project culminated with the selection of five strains of filamentous fungi for pilot-scale tests on increasing the ruminant feed value of rice straw by solid substrate fermentation (Table 1). These five strains were selected after screening tests on approximately 200 strains mostly collected from environmental sources in Thailand. They were selected because they gave the highest digestibilities and protein contents in test fermentations. The results of this work are to be published in detail in the September 1984 issue of the J. Sci Soc. Thailand (Meevootisom et al.,1984). That report includes a complete list of the filamentous fungi in our collection as of June 1983. The characteristics of these organisms will be listed in the publication and the strains will be offered to Thai scientists interested in using them for various studies. For example, one study already completed has used fungi from our collection for the successful fermentation of water hyacinth as a fish food (Srisodsuk, 1983).

The overall objectives of this project are to develop a simple, inexpensive, rural farm process to raise the digestibility of rice straw from 40% to 70% and to raise the protein content from 4% to 12% while limiting the substrate weight loss to not more than 20%.

Table 1. Growth of the top five isolates at various temperatures as determined by colony diameter on agar medium. Figures are the mean of three replicates. The maximum diameter for each isolate is underlined.

Isolate #	Name	28°C	37°C	40°C
56	Cladosporium	1.25	T	D
133	Pleurotus florida	4.85	1.45	D
135	Pleurotus ostreatus	3.35	1.20	D
226	Agonomycete	7.50	7.10	7.90
233	Geotrichum	6.90	8.05	4.90

Note : T = tolerant; D = died.

The initial screening phase of this project involved 5 g sterile rice straw cultures. This report covers a second phase of the project consisting of aseptic 100 g fermentations as the first step in scaling up to septic 4 kg and eventually 500 or 1000 kg fermentations. The relevant research is scheduled over 3 years and is being carried out through cooperation between the Microbiology Department, Faculty of Science, Mahidol University, and the Livestock Production Department of the Ministry of Agriculture.

MATERIALS AND METHODS

Fungal strains employed were from the stock culture collection of the Microbiology Department, Mahidol University and, unless otherwise indicated, they were isolated from local natural sources. Isolates 100, 133 and 135 were obtained from MIRCEN Bangkok; isolates 138, 141, 142, 144 and 147 were kindly provided by Dr.Napha Lotong and Ms.Sawitri Limtong of Kasetsart University (all local isolates); isolate 352 was kindly provided by Dr.Ian Reid of NRC Canada; and isolates 362 and 363 were obtained from the CBS culture collection Baarn, Netherlands.

All cultures were maintained as refrigerated malt extract agar (MEA) slants transferred every four months (Meevootisom et al., 1984). Before inoculation onto rice straw,stocks were subcultured on fresh MEA plates for one week. Five 10 mm plugs of agar taken from the colony front on such plates served as the inoculum for 5 g cultures of sterile rice straw cut to 2 cm lengths and wetted with mineral salts as previously reported(Meevootisom et al., 1984). These 5g cultures served as inoculum for the 100 g cultures after 2 to 3 weeks growth.

Fermentations on the 100 g scale were carried out using plastic bag incubators(Meevootisom et al., 1984) as modified from Lothong (Lotong and Suwanarit,1983). Before autoclaving, mineral salt solution(Meevootisom et al., 1984) were added to the bags containing the straw. After autoclaving, the bags were cooled and then inoculated with a 5 g starter culture. All fermentations were carried out for three weeks at ambient temperature (approximately 30 $\pm$ 5 C). The cultures were then dried in an oven at approximately 55 C for one to two days before the substrate was weighed and milled to 20 mesh in a Wiley ED-5 cutting mill. These milled samples were stored in ziplock plastic bags from which 100 mg samples were removed for various analytical test. True protein was measured using ninhydrin and in vitro digestibility assays were carried out using an enzyme assay following Abe et al. (1972).

RESULTS AND DISCUSSION

Moisture content, particle size and mixing

With initial 100 g tests, growth of all the isolates tested was poor at 70% moisture (the content employed with smaller scale fermentations in Phase I) and initial moisture was raised to 80% for all subsequent tests. In addition, the preliminary tests showed that no mixing during fermentation resulted in excessive drying which stopped growth on the edges of the substrate, particularly in the region close to the incubator closure. Therefore, all subsequent fermentations were mixed at weekly intervals during the 3 weeks fermentation period (i.e., 2 mixings excluding the initial one during inoculation).

The dry weight losses, protein contents and digestibilities for the various substrate configurations are given in Table 2. As can be seen, the weight loss was generally greatest with the 2 mm straw lengths but not significantly different between the 2 cm and 10 cm lengths. This test was originally intended to demonstrate whether there would be aeration constraints imposed by small particle sizes. With respect to protein contents and digestibilities, they were not greatly different given the range of experimental error and the different weight losses recorded.

The results showed that 10 cm straw lengths are satisfactory for fermentation piles and we interpret this to mean that it will not be necessary to chop the straw for large scale fermentation - a distinct advantage when considering the economics of future use. One surprising outcome during these tests was the loss of ability of isolate 266 to grow on rice straw. This persisted upon succeeding trials even though the isolate continued to grow well on maintenance culture medium. The isolate must have lost some critical but unstable enzymatic activity during subculture, a phenomenon not uncommon in mold maintenance. This strain has now been dropped from the test schedule and replaced by *Dichomitus squalens* (isolate 362) obtained from the Centraalbureau voor Schimmelcultures. This organism has been reported to increase the digestibility of wheat straw substantially (Zadrazil and Brunnert, 1982).

Toxicity and Pathogenecity tests

Toxicity tests for isolates 56, 133, 135 and 233 alone were

Table 2. Substrate parameters after three weeks fermentation using different rice straw particle sizes.

Isolate #	Rice straw sizes											
	2 mm lengths				2 cm lengths				10 cm lengths			
	% wt loss	% true protein	%crude protein	DMD	% wt loss	%true protein	%crude protein	DMD	% wt loss	%true protein	%crude protein	DMD
56	21	2.4	5.1	33	22	2.8	5.8	34	20	2.1	4.5	33
133	35	3.5	7.4	46	25	2.7	5.7	42	23	2.4	5.1	38
135	31	3.0	6.3	38	20	2.6	5.4	41	20	2.4	5.1	33
233	20	1.6	3.4	33	22	2.8	5.8	35	17	2.3	4.8	34
Control	0	1.9	4.0	40	0	1.9	4.0	40	0	1.9	4.0	40

negative. So also were tests with their three-week fermentation substrates on rice straw (RS) only, on RS plus bagasse and on RS plus water hyacinth. Also negative were the pathogenicity tests with these fungi by both the injection and oral routes. Toxicity tests with more recent isolates, 380, 386 and 388, showed that isolate 388 alone was toxic.

Inoculum sizes

Weight losses and protein contents of substrates from 3-week fermentations with various inoculum sizes are given in Table 3. A minimum inoculum of 1% appears to be acceptable in most cases, when considering weight loss as a measure of growth. In addition, the protein content achieved with higher inoculum was either less or not significantly different for the 1% inoculum trials. These data mean that a pre-fermentation of 5 kg will be necessary for a large batch of 500 kg or 1000 kg of straw, since it is not feasible to distribute inoculum in 5 kg quantities. The results of this test are compatible with our experience in other fermentations.

Table 3. Substrate parameters after three weeks fermentation using 10 cm rice straw lengths with different inoculum sizes.

Isolate #	Inoculum sizes								
	One percent			Five percent			Ten percent		
	% wt loss	%true protein	%crude protein	%wt loss	%true protein	%crude protein	%wt loss	%true protein	%crude protein
56	16	2.6	5.5	13	2.5	5.3	20	2.1	4.4
133	26	3.1	6.5	22	3.1	6.5	23	2.4	5.1
135	15	2.6	5.5	11	2.4	5.0	20	2.4	5.1
233	13	2.4	5.0	15	2.6	5.5	17	2.3	4.8
Control	0	1.9	4.0	0	1.9	4.0	0	1.9	4.0

Admixtures

In tests on admixtures of water hyacinth or bagasse with rice straw, 10% inoculum was used. The tests gave the weight loss, protein content and digestibility data shown in Table 4. These indicate that, except for isolate 56, substrate admixtures did not effectively change growth for the isolates. Addition of bagasse did not affect protein content but addition of water hyacinth did and this is not entirely accounted for by the protein content of the water hyacinth itself. Thus, if available, it would seem to improve the fermentation. This may result from its ability to hold large quantities of water or to its possession of some unknown nutrient factor. The low growth of isolate 56 is puzzling and the reason for the effect is under study. With respect to digestibility tests, the results tend to be somewhat variable but what can be seen is that 133 and 135 are the best organisms of the group. Bagasse addition reduced digestibility as would be expected.

The tests show that isolates 133, 135 and 233 are adaptable for a range of substrates but that isolate 56 is not.

Rescreening of selected Phase I isolates

Phase I isolates which grew well on straw were regrown on that substrate at 2 cm lengths and 5 g substrate. Weight loss in the substrate was determined as an index of suitability for growth on that substrate and digestibility assays were carried out to determine whether any of the isolates had a potential for use in the feed improvement test. The results of those isolates that gave a weight loss of 10% or more are shown in Table 5. Some notable isolates were 90, 148 and 199. These isolates will be further examined as part of the continued screening element of the project.

Table 4. Substrate weight losses with 30% additions to rice straw of bagasse and water hyacinth.

Isolate #	Addition											
	None				Bagasse				Water hyacinth			
	% wt loss	%true protein	%crude protein	DMD	%wt loss	%true protein	%crude protein	DMD	%wt loss	%true protein	%crude protein	DMD
56	20	2.1	4.0	33	8	2.3	4.9	25	8	3.1	6.5	32
133	23	2.4	4.5	38	22	2.6	5.4	43	23	3.9	8.2	41
135	20	2.4	5.1	33	17	2.4	5.1	37	17	3.7	7.8	54
233	17	2.3	5.1	34	21	2.4	5.1	31	15	2.9	6.0	33
Control	0	1.9	4.0	40	0	1.7	3.7	33	0	2.2	4.6	39

Table 5. Results from retrials of Phase I isolates on 2 cm rice straw lengths. Only those isolates which gave weight losses of 9% or higher are included since the others can be considered to have grown too poorly to be competitive in a non-sterile fermentation.

Isolate #	% wt loss	DMD	Isolate #	% wt loss	DMD
11	10	36	150	9	37
22	10	39	151	13	32
24	12	ND	160	10	34
48	12	34	161	23	ND
49	9	36	163	27	34
53	9	37	164	10	ND
74	11	ND	165	9	39
80	15	38	169	18	26
90	17	51	171	12	38
100	10	43	177	10	33
113	12	38	179	10	34
134	14	ND	186	11	40
138	12	32	199	19	47
141	10	33	202	26	ND
142	12	37	207	27	39
144	11	39	208	17	33
147	12	32	220	9	31
148	14	46	347	9	35

New isolates

One minor element of Phase II is the continued screening of new local isolates and of strains obtained from culture collections. The newly acquired isolates during Year 1 are listed in Table 6 along with test data concerning them. Some of these isolates are of particular interest. Isolates 386 and 388 are to be discussed further below. Isolates 377, 379 and 380 (all *Chrysosporium's*) will be examined on the 100 g scale with nitrogen supplements as part of the continued screening element of the project.

Advance 4 kg fermentation

The second year of Phase II is initially concerned with 4 kg non-sterile fermentations of rice straw. In order to gain some advance experience with these, we prepared some fermentations using commercially available *Pluerotus florida* (# 133) inoculum. It may be especially relavant since inoculum for this fungus is currently available at low cost (4 baht/400 g fresh weight) and is widely distributed. Our tests for nitrogen supplementation with *P. ostreatus*, a related species, grown on water hyacinth alone showed that maximum possible nitrogen addition was 1.75% before growth inhibitory effects were seen (i.e., equivalent to approximately 3.8% urea or 5% ammonium nitrate addition). However, urea addition alone gave poor growth with *P. ostreatus* and a ratio of urea nitrogen to ammonium nitrogen of 3:2 was found to be optimum. Following these results, an advance trial fermentation on 4 kg rice straw was attempted under septic conditions using addition of 40 g potassium dihydrogen phosphate, 60 g urea, 86 g ammonium sulfate and 16 l water. After soaking for several hours, the piles were inoculated with commercial inoculum(400 g fresh weight or about 150 g dry weight per pile),and the course of the fermentation was followed compared to a control pile of unsupplemented but wetted rice straw. An additional test using rice straw supplemented with 30% water hyacinth was carried out, also with and without nutrient supplements.

The temperature in the piles without nitrogen supplementation remained near ambient for the three weeks of fermentation while that of the supplemented piles rose to 40°C by the 5th day of cultivation before gradually declining again to ambient. Growth of *P. florida* was poor in all the tests, while the two tests with nitrogen supplementation showed heavy fruiting by a species of *Coprinus* by day 10, indicating that the fungus had been growing in the pile for some period before then. This fungus has been taken into the collection (# 386) along with a species of *Chaetomium* (# 388)which was also common in the nitrogen supplemented piles but not in the unsupplemented piles. Both of these fungi have been tested for optimum growth temperature. Both grew optimally at 37°C while *Coprinus* died and *Chaetomium* was tolerant at 45°C. Results of the analytical tests are shown in Table 7.

Table 7. Substrate parameters for advance 4 kg fermentations after three weeks cultivation on uncut rice straw using commercially available inoculum of *Pleurotus ostreatus*.

Substrate	% wt loss	% true protein	% crude protein	DMD
RS	18	2.0	4.2	38
RS + WH	20	3.2	6.7	41
RS + N	24	3.3	6.9	46
RS + N + WH	25	5.5	11.5	47
Dry RS	0	1.9	4.0	40

Note : RS = rice straw; WH = addition water hyacinth;
N = addition of Urea:ammonium sulfate (3:2) mix (1% N).

Table 6. Data on new isolates acquired since the end of Phase I.

Isolate #	Name	% wt loss	PO activity	Cell Azure	DMD
348	Galerina	17	+	1.4	37
350	Lepiota	16	-	1.3	35
352	Merulius tremulosus (NRC Canada)	15	+	X	43
353	Sclerotium	17	+	0.1	38
354	Psathyrella	ND	+	ND	ND
355	Lepiota	12	+	0.7	32
356	Chlorophyllum	4	+	1.2	35
358	Chrysosporium	26	+	X	42
360	Trichoderma	19	+	X	51
361	Trichoderma	15	-	1.4	48
362	Dichomitus squalens (CBS)	40	+	X	52
363	Sporotrichum pulverulentum (CBS)	10	+	1.4	31
364	Trichoderma	13	-	1.5	35
365	Pithomyces	15	-	1.3	33
366	Coprinus	10	+	1.4	37
367	Agonomycete	8	-	1.4	40
368	Lycoperdon	13	+	0.4	34
369	Aphyllophorales	13	+	X	43
370	Gliocladium	10	-	1.2	39
372	Gliomastix	11	-	0.8	41
373	Phoma	14	+	1.0	35
375	Aspergillus	2	-	0.5	36
376	Chrysosporium	28	+	X	43
377	Chrysosporium	19	+	X	49
379	Chrysosporium	36	+	1.4	51
380	Chrysosporium	24	+	X	49
386	Coprinus	12	+	1.6	42
388	Chaetomium	15	-	1.0	42
389-397	Tests underway				

Note : X = decolorized the dye; ND = not done.

The reason for the poor growth of *Pleurotus* in these trials is unclear, since the fungus grew well in our sterile rice straw cultures and in our non-sterile water hyacinth cultures. We suspect that the commercial inoculum used may have been inferior in some way.

Nitrogen supplementation trials

Some nitrogen supplementation tests are summarized in Table 8 for diameters of colonies on agar media. These show that the most tolerant of the original top 5 isolates was *Geotrichum* 233. The other isolates were much more sensitive, particularly to unmixed nitrogen sources. Among the new isolates, *Coprinus* (386) and *Chaetomium* (388) are particularly interesting in their tolerance to high urea, since this is the cheapest available nitrogen source.

Rice straw nitrogen supplementation trials

Based on an evaluation of the data from the trials outlined in the preceding sections, nitrogen supplementation trials were carried out in triplicate 100 g fermentations using isolates 133, 135, 233, 362, 386, 388 and 390. Also tested was a mixed inoculum of 386/388 since this was the combination of isolates found on the 4 kg advance fermentations. The moisture content used was 80%, rice straw lengths were 10 cm and inoculum was approximately 5%. Nitrogen supplements were tailored to suit the preferences of the inoculated isolates as determined in the agar plate trials described in the preceding section. Various addition protocols were used including immediate and delayed additions. The results and the protocols used are summarized in Table 9. Figures given are the average percentages of 3 replicates.

The results were very encouraging. Isolate 133 (*Pleurotus florida*) gave a sizable increase in protein and digestibility with Treatment 1 and this was matched or bettered by isolate 386 (*Coprinus*) or a mixture of 386 and 388 (*Chaetomium*) in Treatment 5 and 6. In

Isolate #	Name	Opt. Temp.	Place/ Year	Mea	Nitrogen					
					1.3%			2.3%		
					Ur	Am	Ur/Am	Ur	Am	Ur/Am
56	Cladosporium	28	Bkk/81	3.55	0.13	0.91	–	0.13	0.66	–
90	Sporotrichum	37	SWD/81	8.70	–	–	+	–	–	–
133	Pleurotus florida	28	Mir/81	6.48	0.10	–	0.10	–	–	–
135	Pleurotus ostrea-tus	28	Mir/81	3.77	+	–	+	–	–	–
148	Auricularia	ND	Bkk/81	8.70	–	–	0.85	–	–	–
226	Agonomycete	40	Bkk/82	7.78	ND	–	0.83	ND	–	–
233	Geotrichum	37	Bkk/82	8.30	1.63	1.25	4.11	–	–	1.55
362	Dichomitus squalens	28	CBS/83	8.30	–	–	0.46	–	–	–
380	Chrysosporium	37	Bkk/84	8.70	–	2.24	3.35	–	–	–
386	Coprinus	37	Bkk/84	7.83	2.20	–	1.38	1.26	–	0.94
388	Chaetomium	37	Bkk/84	2.53	2.30	0.60	2.20	1.70	–	1.69
390	Humicola	45	Chu/84	8.30	1.26	0.75	4.23	0.50		3.99

Note : – = no growth; ND = not done

Table 9. Substrate parameters after three-week fermentations of rice straw with various nitrogen addition treatments with various fungal isolates.

Isolate	Treatment 1				Treatment 2				Treatment 3			
#	% wt loss	%true protein	%crude protein	DMD	% wt loss	%true protein	%crude protein	DMD	%wt loss	%true protein	%crude protein	DMD
133	32	4.6	9.7	49	29	4.8	10.1	44	23	2.0	4.2	42
135	26	3.4	7.1	42	33	4.2	8.8	42	23	1.9	4.0	41
233									33	2.9	6.1	40
362	26	3.9	8.2	45	29	4.4	9.2	44	18	2.5	5.3	41
386												
388												
390									19	1.9	4.0	31
386/388												

Table 9. (continued).

Isolate #	Treatment 4 % wt loss	Treatment 4 %true protein	Treatment 4 %crude protein	Treatment 4 DMD	Treatment 5 %wt loss	Treatment 5 %true protein	Treatment 5 %crude protein	Treatment 5 DMD	Treatment 6 %wt loss	Treatment 6 %true protein	Treatment 6 %crude protein	Treatment 6 DMD
133												
135												
233	28	3.4	7.1	40								
362												
386					42	4.6	9.7	49	44	5.6	11.8	47
388					29	4.5	9.5	46	35	6.0	12.6	43
390	14	1.9	4.0	33								
386/388					44	4.9	10.3	48	39	5.0	10.5	49
Control	0	1.9	4.0	40								

Treatment 1 = Ammonium salts plus urea (2:3) after 1.5 weeks initial fermentation (Total 1% N)

Treatment 2 = Ammonium salts plus urea (2:3) from the start of fermentation (Total 1% N)

Treatment 3 = Ammonium salts plus urea (2:3) in two 1% N additions (Total 2% N)

Treatment 4 = Ammonium salts plus urea (2:3) from the start (Total 2% N)

Treatment 5 = Urea from the start (Total 2% N)

Treatment 6 = Urea in two 1% N additions (Total 2% N).

particular, isolate 386 came very close to the project target protein content of 12% in Treatment 6.

All of these isolates gave weight losses exceeding that set in the target (20%) and this may be considered a detrimental characteristic. Also, the increase in digestibility was only 1/3 towards to target of 70%. However, we feel that both these parameters may be brought closer to the goals by reducing the fermentation time. Concurrent with the first of the septic 4 kg tests underway, growth kinetics tests are being carried out to choose the optimum fermentation times for isolates 133, 380 and 386.

Organisms chosen for study in Year 2 of Phase II

Upon final evaluation of all the analytical data in Year 1, isolates 133 (*Pleurotus florida*), 380 (*Chrysosporium*) and 386 (*Coprinus*) have been chosen for non-sterile 4 kg fermentations in Year 2. These organisms gave digestibilities and protein contents closest to those targeted by using the fermentation substrates and protocols employed. Since isolates 380 and 386 have been only recently acquired, safety tests for them are still underway. These organisms have an advantage over *Pleurotus* in that their growth rates and their optimum growth temperatures are higher than those of Pleurotus. This would allow a reduction in the fermentation time required and, in turn, a reduction in the probability of contamination from extraneous environmental sources. The reduced turnover time would also allow for a smaller fermentation pile (much easier handling).

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FORAGE SUPPLEMENTS : POTENTIAL VALUE IN FEEDING SYSTEMS BASED ON CROP RESIDUES AND AGRO-INDUSTRIAL BY-PRODUCTS IN SOUTH EAST ASIA

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SUMMARY

The justification for increasing the use of crop residues and agro-industrial by-products in associated with their abundant availability and need to improve the low level of production in ruminants. In Asia and the Pacific region alone, the annual production of crop residues and agro-industrial by-products is estimated to be 1298 x 10^6 m tons, of which about 83.1% are roughage materials from both field and plantation crops. There exist two strategies for developing efficient feeding systems using these fibrous feed materials. One strategy is to utilise these intact and in situ, involving practical methods that are realistic of small farm situations. The second alternative strategy is to upgrade the nutritive value by some form of processing and/ or treatment. However, the latter can only be acceptable if the value of the response is higher than the associated costs of processing and treatments. With both strategies, but especially the first, there exist a variety of forage supplements that are potentially valuable to ruminants. This value is reflected in terms of utilisation with reference to cassava leaves (*Manihot esculenta* Crantz), gliricidia (*Gliricidia maculta*) and leucaena (*Leucaena leucocephala*) as supplements in the diet. The beneficial effects of feeding the fresh forages to the animal include *inter alia* increased ME intake, increased N intake, improved palatability, increased availability of minerals and vitamins, improved rumen function and a laxative influence on the alimentary system. An important attendent advantage is lowered cost of feeding due to a reduced dependence on purchased energy and protein supplements. The op-

portunities for intensifying the use of forage supplements in feeding systems based on crop residues and agro-industrial by-products merits more attention.

Key workds : Forage supplements, crop residues, agro-industrial by-products, feeding systems, ruminants, utilisation.

INTRODUCTION

It is widely recognised that the main limiting factor affecting high performance in animals, consistent with economic production, is the availability and quality of the feeds. In cognisance of this, considerable attention has been given in recent years to examine all avenues of efficient feed utilisation that can directly benefit animals. While this has concerned the total feed resources, with ruminants, there has been considerable focus on ways and means to increasing the use of the crop residues and agro-industrial by-products that are available in generally large quantities in most parts of the tropics. The justification for doing so is principally associated with the fact that while large quantities of these crop residues and agro-industrial by-products do exist,and of which often, a large proportion is wasted and underutilised. Of even greater significance concerning utilisation are such obvious advantages as reduced dependence on alternative feeds, reduced cost of feeding, greater offtakes in terms of meat, milk, fibre and skins and enhanced expansion of components of the animal industry in the context of more complete utilisation of the available feed resources. With reference to fibrous feeds and expecially low quality roughages, the ability of ruminant animals (buffaloes, cattle, goats and sheep)to utilise these effectively implies that there exist considerable opportunities for maximising the contribution from these animals.

In the search for more efficient feeding systems using the crop residues and agro-industrial by-products, all research and deve-

.opment programmes have followed one of two principal strategies. One strategy is to develope feeding systems that can use the crop residues and agro-industrial by-products intact and in situ. In this case, diets are formulated using the feeds intact without any treatment in a manner which will be acceptable to the animals as well as having the capacity to promote some degree of production response in terms of meat or milk. A major advantage of this approach in that it overcomes problems of cost of handling, transportation, storage and localised pollution.

The second alternative strategy is to upgrade the nutritive quality of the material through the use of physical(wetting, cutting, chopping and grinding), chemical (alkalis or acids) or biological (microbial growth) techniques. Grinding and pelleting for example, have been shown to give a net increase in the metabolisable energy (ME) intake of straw (Carmona and Greenhalgh, 1972; Jayasuria, 1979). With alkalis, there is now considerable evidence that these enhance the nutritive value of crop residues, for example as NH_3 (Sundstøl, Coxworth and Mowat, 1978; Khan and Davis, 1981), clacium hydroxide (Nath, Sahai and Kehar, 1969; Devendra, 1979),sodium hydroxide (Jayasuria et al., 1981; Kategile, 1982) or combination of these such as urea and lime (Saadullah, Haque and Dolberg, 1982). Doyle (1982)has recently discussed the options for the treatment of fibrous residues. However, the justification for processing and or treatment is dependent on feasibility, economic justification, practical benefits and applicability to small farm situations in terms of increased animal response that is distinctly profitable (Devendra, 1984).

With either of these strategies,there is one aspect of utilisation that has not been seriously considered in the past. This concerns the potential value of various forages, especially the proteinacous ones, which are commonly found throughout the humid tropics. This paper discusses the potential value of forage supplements, focusses on the more inportant examples of these and prospects for increasing their utilisation in feeding systems based on crop residues and agro-industrial by-products to stimulate increased productivity from ruminants.

Availability of crop residues and agro-industrial by-products

It is appropriate to keep in perspective the types and quantities of crop residues and agro-industrial by-products that are produced in the Asian and Pacific region. It has been estimated, based on F.A.O. (1982) statistics, that the annual production of there is 1298 x 10^6 tons (Table 1) from both field and tree crops. Of these, the fibrous feedstuffs accounted for about 83.1% of the total production. It is relevant to point out that about 91% and 30% of the total world production of rice and wheat straw came from Asia.

Many of these feeds are traditionally used while others can be classified as non-conventional (Devendra, 1985). All of them however are potentially very useful.

Forage supplements

There exist a variety of forage supplements throughout Asia. These are traditionally used by farmers in feeding systems for ruminants. However, the benefits of their use in diets based on crop residues and agro-industrial by-products have been inadequately investigated. The rationale for their use is associated with the following advantages :

(i) Availability on the farm
(ii) Easy accessibility
(iii) Provide variety in the diet
(iv) Ensure appetite and reduce the requirement for other supplements
(vi) Reduce the requirement for purchased concentrates
(vii) Act as a protein reserve during periods of feed scarcity. Leucaena for example is able to resist dehydration during droughts. The wood can also be used as fuel.

Table 1. Availability of crop residues and agro-industrial by-products from field and tree crops in Asia and the Pacific.

Crops		Crop residue or by-product	Production (10^6 m tons)	As % of World Production
I. Field Crops				
Castor	i.	Castor meal	0.3	60.9
Cassava	i.	Cassava leaves	5.9	38.0
	ii.	Cassava waste	28.0	38.0
Cotton	i.	Cotton seed meal	8.0	43.8
Groundnut	i.	Groundnut meal	6.4	62.3
Linseed	i.	Linseed meal	0.4	20.9
Maize	i.	Germ meal	15.0	19.4
	ii.	Stover	64.0	19.4
Rapeseed	i.	Bran	2.4	55.1
	ii.	Meal	4.8	55.1
Rice	i.	Broken	16.8	90.7
	ii.	Bran	37.4	90.7
	iii.	Husk	59.8	90.7
	iv.	Straw	373.7	90.7
Sesame	i.	Sesame cake	0.8	67.3
Sorghum	i.	Stover	13.5	29.3
Soya bean	i.	Soya bean meal	7.3	10.8
Sugar cane	i.	Bagasse	48.6	41.2
	ii.	Green tops	63.0	41.2
	iii.	Molasses	12.6	41.2
Wheat	i.	Bran	14.6	30.3
	ii.	Straw	145.7	30.3
II. Tree Crops				
Cocoa	i.	Pod husks	0.1	6.4
Coconut	i.	Coconut cake	12.4	89.6
Oil Palm	i.	Palm press fibre	304.8	50.4

Table 1. (continued).

Crops	Crop residue or by-product	Production (10^6 m tons)	As % of World Production
	ii. Palm kernel meal	50.8	50.4
	iii. Palm oil mill effluent (dry)	0.9	50.4
Rubber	i. Rubber seed meal	0.3	-
		1298.3	-

F.A.O. (1982).

Some of the more important forages that are widely used are cassava (*Manihot esculenta* Crantz) in Malaysia, gliricidia (*Gliricidia maculata*) in Sri Lanka, Leucaena (*Leucaena leucocephala*) in the Philippines and sesbania or turi (*Sesbania grandiflora*) in Indonesia. This list is by no means complete as there as several other examples. These include *incerlalia* leaves from acacia (*Acacia arabica*), banana (*Musa spp.*), jackfruit (*Artocarpus heterophyllus*), pigeon pea(*Cajanus cajan*) neem (*Azadirachta indica*), sweet potato vines(*Ipomoea batatas*) and water hyacinth (*Eichornia crassipes*).

Table 2 presents the approximate chemical composition of the more important forage sources. Cassava, leucaena and sesbania leaves in particular have a relatively high content of crude protein and appreciable amounts of Ca. Leucaena is also an important sources of S (0.03-0.5%) which is essential for the synthesis of sulphur containing amino acids like methionine.

Utilisation

Ensuring high animal response is primarily dependent on maximising dry matter intakes (DMI), which implies consumption of a

Table 2. Chemical composition of the more important forages commonly used (% dry matter basis).

Constituent	Cassava leaves	Gliricidia leaves	Leucaena leaves	Leucaena leaves plus stems plus pods	Sesbania leaves
Dry matter	21.1	25.0	30.0	30.1	17.0
Crude protein (N x 6.25)	17.8	14.7	22.0	17.4	25.1
Crude fibre	14.8	19.9	19.6	30.5	17.5
Ether extract	7.9	5.4	6.9	3.8	4.7
Ash	6.3	4.7	4.4	4.6	7.6
Nitrogen-free extract	53.2	55.3	47.2	43.6	45.0
GE (MJ/Kg)	20.71	23.08	22.18	32.59	21.84
Ca	0.87	0.46	0.55	0.30	1.29
Mg	0.32	0.17	0.34	0.71	-
P	0.26	0.14	0.13	0.14	0.41
Cell wall (%)	29.5	31.5	31.2	34.6	30.4

high proportion of the feed that is offered. Assuming that there are no shortages, the digestibility of the feed (digestible organic matter, DOM) and the efficiency with which the proportion consumed is converted to useful animal products (meat and milk) are important aspects.

It is relevant to note in this context that for the maintenance of adult ruminants, the characteristics desirable in the feed are :

1) Crude protein level which is above 6-7%
2) Dry matter digestibility of about 50-55%, and
3) DMI response of the order of 1.7% of body weight.

Associated with these considerations, it is also essential to take note of the proposals of Preston and Leng (1981) that the following nutritional factors merit attention in order of priority:

1) Fermentable energy
2) Fermentable nitrogen
3) Micronutrients (especially S, P and B vitamins)
4) Roughage (for adequate rumen function)
5) Bypass protein
6) Bypass energy.

Clearly, if high DMI and ME intakes are to be achieved, and therefore also high performance in animals, a first essential obviously is to provide feeds that are attractive and acceptable in diets. Most low quality fibrous residues such as cereal straw, bagasse and palm press fibre have limitations, especially low protein content. This curtails voluntary feed intake, and is also influenced by poor palatability and bulkiness of the fibrous feeds.

Thus, if these crop residues are to be used more effectively and converted to useful animal products, the base feed needs to be improved and or fed with supplement in suitable combinations that are both acceptable as well as of benefit to ruminants. It is now appropriate to consider examples of how this can be achieved using low quality fibrous crop residues such as is found in several parts of the South East Asian region.

Cassava leaves (*M. esculenta* Crantz)

Cassava leaves (*M. esculenta* Crantz) are an excellent source of dietary protein. The leaves are palatable and are commonly fed to small ruminants. The protein appears to be relatively more soluble (Meyreles, MacLeod and Preston, 1977). Depending on the variety used, the content of HCN could be a problem. However, when the "sweet" as opposed to "bitter" varieties and used, the problem of toxicity is overcome. In any case, farmers traditionally harvest the forage the day before it is fed and sun dry it. This reduces the content of HCN and also renders the protein less easily degradable.

The significance of dietary cassava leaves in diets with rice straw substituted at about 34% level is shown in the data in table 3. It can be seen that the effect of adding cassava leaves was to increase DMI by about 34-37%, which was associated with statistically significant ($P < 0.05$) differences in organic matter, crude protein, crude fibre digestibilities and N retention.

Table 3. Intake and digestibility of long or chopped rice straw (RS) supplemented with or without cassava leaves.

Parameter	Long RS	Chopped RS	Long RS + CL	Chopped RS + CL
Fresh intake, g/day	626.4a	633.6a	1692.0b	1640.9b
DMI/$Kg^{0.75}$, g/day	50.7a	49.7a	70.1b	67.4b
DMI as,% body weight	2.6a	2.3a	3.2b	3.1b
DM digestibility,	46.4a	41.3a	53.0a	49.8a
OM digestibility,	51.1a	47.2a	61.4b	54.2a
CP digestibility,	18.3a	31.4b	64.7c	62.4c
Energy digestibility,	48.4a	42.4a	55.5a	51.1a
N retention as,% of intake	-43.3a	22.8b	58.4b	43.6c

+ Cassava leaves

[abc] Means on the same columns with different superscripts differ ($P < 0.05$).

Devendra (1983).

Support for these findings comes from the results of feeding trials using untreated and urea-ammonia treated straw supplemented with cassava leaves in Indonesia (Table 4). The inclusion of up to 50% cassava leaves with treated or untreated rice straw while stimulating increased weight gain, was not statistically different between treatments over 9 and 13 week experimental durations. It follows that the inclusion of cassava leaves to untreated rice straw is obviously cheaper than that of treated straw. It was concluded that grinding and urea-ammonia treatment of rice straw enabled goats to maintain weight. However, the inclusion of cassava leaf in diets with untreated and treated rice straw enable pelleting of the feeds and for the goats to gain weight.

Table 4. Effect of feeding untreated and urea-ammonia treated grand rice straw on the average daily gain of young goats.

Treatment[+]	Live weight gain, g/day	
	9 weeks	13 weeks
75 URS : 25 CL	53[a]	45[a]
50 URS : 50 CL	91[b]	92[b]
75 TRS : 25 CL	93[b]	84[b]
50 TRS : 50 CL	105[b]	101[b]
100 TRS	11[c]	27[a]
SE	10.3	10.4

+ URS - Untreated rice straw, TRS - Treated rice straw, CL - Cassava leaves.

[abc] Means on the same columns with different superscripts differ ($P < 0.05$).

Winugroho and Chaniago (1983).

Gliricidia leaves (*Gliricidia maculata*)

Gliricidia leaves are traditionally used extensively to feed all ruminants in Sri Lanka. Recently several studies have been reported on their value when fed to both cattle and also buffaloes. Table 5 summarises the results of one of the studies.

Supplementation with coconut cake significantly increased both milk yield and milk fat yield ($P < 0.05$), whereas tree legume leaves did not affect both components. In an earlier study however, Perdox et al. (1982), reported results with the same herd in the previous year indicating that supplements of 1600 g gliricidia (DM/cow/day) increased milk and milk fat yields. However with milk yield, leucaena supplementation was as good as supplementing with copra cake, and since the latter has to be purchased, feeding leucaena is presumably cheaper. Supplementing the treated straw with gliricidia or leucaena in addition to coconut cake did not have any significant effect on milk yield and milk fat yields.

An economic analysis of the profit margins due to treatments indicated (Table 5) that supplements of tree legumes marginally improved milk and milk fat yields, but was considerably improved by supplementation with 7 kg coconut cake.

Leucaena leaves

Another example of the value of leguminous forage, in this case leucaena leaves, is shown in balance trials with sheep, where increasing levels of leucaena forage were substituted for rice straw (Table 6). DMI, crude protein and energy digestibilities and N retention were all improved. The increase in ME intake on account of leucaena supplementation ranged from 16.2% with the 10% inclusion to 86.2% for the 50% leucaena leaf inclusion. Figure 1 illustrates the relationship in terms of ME intake in untreated rice straw diets substituted with increasing leaves of leucaena forage and the effect on N retention. The optimum level of leucaena was 40%. Leucaena forage

Table 5. The effect of feeding urea-ammonia treated straw with supplements to lactating surti buffaloes.

Parameter	TRS	Treatment[+]				
		TRS + G (212 CP)[++]	TRS + L (251 CP)	TRS + CC (191 CP)	TRS + G + CC (406 CP)	TRS + L + CC (448 CP)
Milk yield, kg/day	2.41a	2.60a	2.73ab	3.09ac	3.18 c	3.36c
Milk fat yield, g/day	221a	242a	238a	311b	319b	325b
Milk fat percentage,	9.18	9.34	8.71	10.08	10.03	9.65
Margin over costs (S.L.- RS)	4.07	5.19	4.57	8.34	8.52	8.53

\+ TRS -Urea-ammonia treated rice straw; G - gliricidia; L - Leucaena; CC - Coconut cake

++ Amount of crude protein provided

abc Means on the same row with different superscripts differ ($P < 0.05$).

Adapted from Perdok et al. (1983).

Table 6. Intake and digestibility of chopped rice straw (RS) supplemented with varying levels of leucaena leaves.

Parameter	RS (control)	RS + 10% L[++]	RS + 20% L	RS + 30% L	RS + 40% L	RS + 50% L	RS + 60% L
Fresh intake, g/day	741.3a	890.7ab	967.7ab	1158.7ab	1446.0bc	1475.7bc	1300.7bc
DMI/$kg^{0.75}$, g/day	59.9a	58.9a	53.2a	59.9a	68.5b	70.7b	59.9a
DMI as,% body weight	2.7a	2.6a	2.6a	2.8a	3.1a	3.1a	2.7a
DM digestibility,	42.4a	48.5b	46.7b	49.5b	50.5b	53.2c	49.6b
OM digestibility,	50.9a	51.3a	49.5a	52.5b	53.3b	55.5b	52.4b
CP digestibility,	19.7a	40.5b	47.2c	49.6c	52.0c	66.2d	50.5c
Energy digestibility,	40.4a	46.4b	46.3b	52.1c	51.5c	54.7c	46.2b
N retention,as % of intake	-0.1a	20.2b	16.4b	23.6b	31.5c	27.5c	30.8c

++ RS - rice straw, L - leucaena leaves.

[abc] Means on the same row with different superscripts differ ($P < 0.05$).

Devendra (1983).

has also been used as a protein supplement in sugar cane based diets for cattle (Alvarez and Preston, 1976).

In order to assess the comparative value of different forages, a balance study was also completed using sheep fed either cassava leaves (C), leucaena leaves (L) leucaena leaves plus stems plus pods (LSP) or gliricidia leaves (G). Each of these forages was used to substitute 30% of untreated rice straw. Table 7 summarises the results. There were statistically significant differences in organic matter and crude protein digestibilities ($P < 0.05$). In terms of crude protein digestibility and N retention, leucaena leaves was first, followed by cassava leaves, leucaena leaves plus stems plus pods and finally gliricidia leaves. Substituting rice straw with these forages increased the ME intake by 62.7, 67.4, 31.3 and 62.0% respectively. The higher N retention is consistent with the finding in Indonesia, where it has been shown that supplementing leucaena at 0.7kg DM/head/dry increased microbial protein synthesis from 14 to 32 mg/100 ml hr and rumen NH_3 levels from 9 to 12 mg/100 ml. Increasing leucaena to 1.5 kg DM/head/dry reduced microbial protein synthesis to 25 mg/100 ml/hr (Hendratno, 1982).

These results indicated that leucaena and cassava leaves are more important than leucaena forage (leaves + stem + pods) or gliricida. A relatively higher N content is implicated, which is an important consideration when these leaves are put to much greater use in practical diets. Recent studies in Mexico on the effect of tropical forages on rumen function and flow of nutrients to the proxunal duodenum in cattle showed that leucaena forage produced higher N flows than sweet potato, cassava banana or sugarcane leaves (Jodoy and Elliott, 1981). The forage protein was either material eseaping rumen degredation or microbial protein due to greater synthesis stimulated by the amino acids present in leucaena. It is also of interest to note that U Ter Mueller et al. (1979) for reported that the biological value of leucaena protein was high and which supported similar growth rates to groundnut cake (Hulman Own and Preston, 1978).

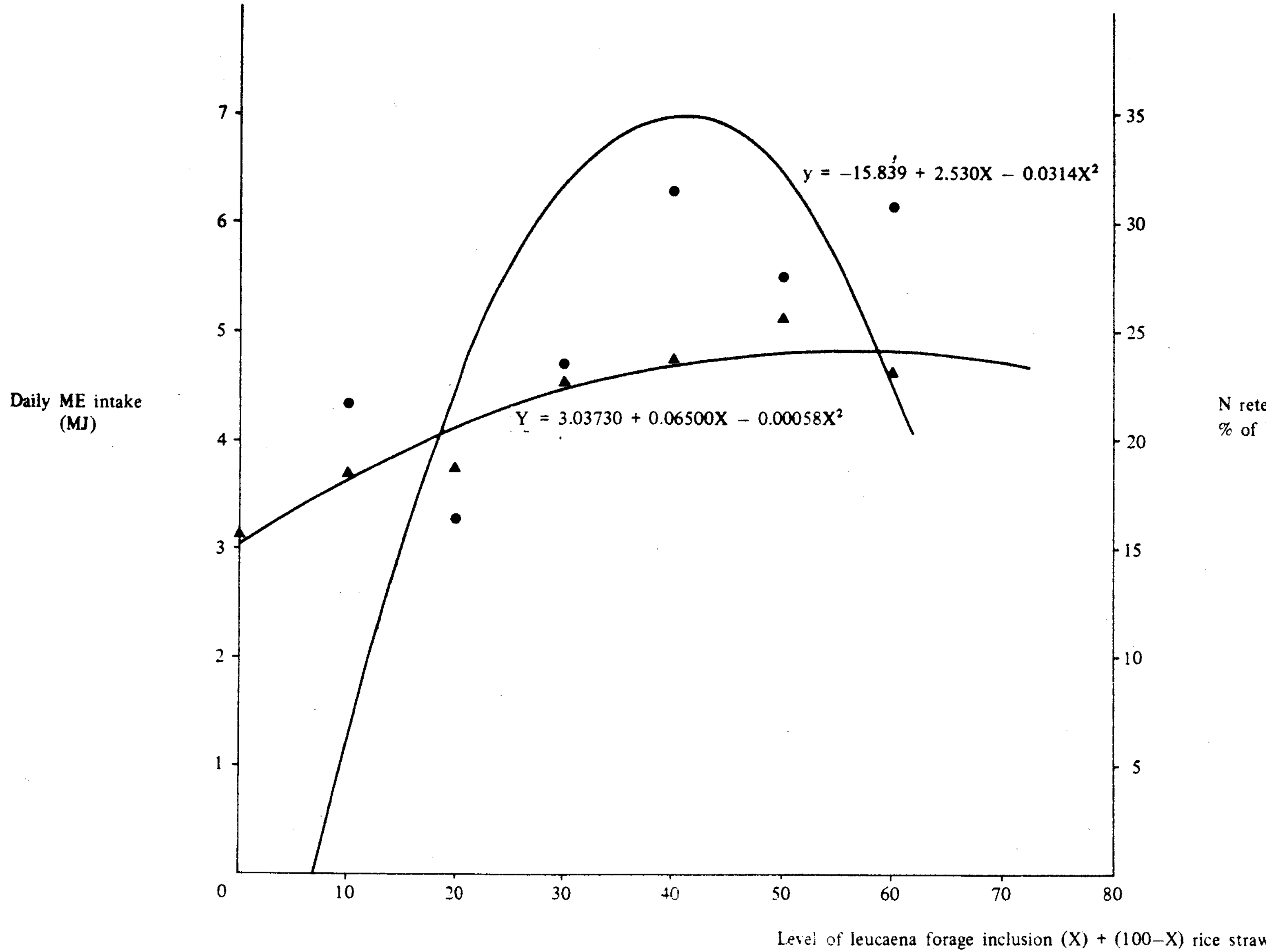

Figure 1. Trends in the intake of ME and N retention in sheep with increasing level of dietary leucaena forage

Table 7. Intake and digestibility of chopped rice straw (RS) supplemented with either cassava leaves (CL), leucaena leaves (L), leucaena leaves plus stems plus pods (LSP) or gliricidia leaves (GL).

Parameter	RS+CL	RS+L	RS+LSP	RS+GL
Fresh intake, g/day	1556.8a	1408.6a	1414.5a	1414.3a
DMI/kg$^{0.75}$, g/day	65.9a	69.7a	64.7a	64.1a
DMI, as % body weight,	3.0a	3.2a	3.0a	2.7a
DM digestibility,	53.5a	49.2a	48.0a	47.6a
OM digestibility,	60.5a	56.9b	55.4b	55.4b
CP digestibility,	49.7a	50.4a	44.3a	31.6b
Energy digestibility,	54.7a	52.6a	45.7a	48.9a
N retention, as % of intake,	162a	34.8b	39c	92d

[abcd] Means on the same row with different superscripts differ ($P < 0.05$).

In the Philippines, leucaena leaves have been fed with rice straw and/or dried poultry manure to crossbred dairy heifers and the results are summarised in Table 8. There were no differences between treatments in dairy live weight gain, but final live weights were different.

Considering the feed costs, diet one was more expensive than diets two, three or four in the commercial system when leucaena had to be purchased as a dried meal. On the other hand if it can be easily cultivated at little or no cost in the backyard system, the cost of feeding diets one, two and three involving leucaena is substantially reduced. This is reflected in the cost/kg gain in the backyard system of 4.61, 4.42 and 4.26 P for diets one, two and three compared to 10.33 P for diet four which used up to 65% concentrates.

Table 8. Effect of feeding rice straw diets supplemented with leucaena leucocephala and/or dried poultry manure to crossbred dairy heifers in the Philippines.

Parameter	Treatments 1	2	3	4
Average daily gain, kg	0.58a	0.44a	0.53a	0.50a
Feed efficiency, kg	15.6a	25.2a	15.2a	11.9a
Final weight, kg	307a	241b	258b	272ab
Daily feed costs, P				
Commercial+	8.41a	3.98b	4.89c	5.33c
Backyard++	2.63d	1.90a	2.22a	5.09b

Treatments : 1 - 35% rice straw + 45% leucaena + 25% concentrates

2 - 35% rice straw + 30% leucaena + 15% dried poultry manure + 20% concentrates

3 - 35% rice straw, 22.5% leucaena, 22.5% dried poultry manure + 20% concentrates

4 - 35% rice straw + 65% concentrates.

abc Means on the same row with different superscripts differ ($P < 0.05$).

\+ 15 cows

++ 2-3 cows

Adapted from Trung et al. (1983).

An important advantage concerned with forage supplementation is the increased availability of minerals for the animal. In the trial referred to where four types of forages were used at the 30% level with rice straw (Table 7), the corresponding mineral balance is presented in Table 9 compared to a control diet where only chopped rice straw is fed. It is obvious that forage supplementation significantly offected the availability of Ca, Mg and P. Moran, Satoto and Dawson (1982)also reported similar results for leucaena supplementation to diets for buffaloes and cattle in Indonesia.

Several studies have been reported on the utilisation of leucaena forage in Thailand. Veerasilp (1981) reported that a mixture of 1:2 fresh leucaena and gliricidia in a rice straw diet fed to sheep maintained body weight whereas feeding either forage alone produced live weight loss. Snitwong et al. (1983) fed dehydrated sugar cane tops with or without fresh leucaena leaves to young buffaloes and recorded a daily gain of 0.70 kg compared to 0.23 kg for the unsupplemented group, reflecting again the benefit due to increased energy and protein intakes. Promma et al. (1984) reported positive production responses in crossbred Holstein-Friesian dairy cattle fed urea treated rice straw and leucaena. Cheva-Izarakul and Potikanond (1984) compared feeding urea treated rice straw versus untreated straw plus leucaena leaves and reported growth responses of 0.48 kg and 0.42 kg/day, emphasising the value of leucaena.

Other forage examples

Although specific examples of the more widely used forages have been cited to demonstrate potential value, many other types of forages have also been used. These include banana leaves (*Musa spp.*) feed with rice straw and concentrates to Red Sindhi bulls (Gupta, Singh and Gupta, 1966) which was associated with in-

Table 9. The effect of feeding rice straw (RS) supplemented with either cassava leaves (CL), leucaena leaves (L), leucaena leaves plus stems plus pods (LSP) or gliricidia leaves (GL) on mineral balance.

Parameter	Treatments				
	RS (Control)	RS+ CL	RS+ L	RS+ LSP	RS+ GL
Ca retention, as % of intake	5.4ab	27.4b	22.9a	7.8a	21.2c
Mg retention, as % of intake	19.1a	30.2b	30.4b	26.2b	33.4b
P retention as, % of intake	-ve	65.3a	56.8b	38.2c	39.4c

[abc] Means on the same row with different superscripts differ ($P < 0.05$).

creased DMI, jackfruit leaves (*A. heterophyllus*) to goats (Devasia, Thomas and Nandakumaran, 1976), pigeon pea forage to Zebu cattle (Schaaffhausen, 1965) sun hemp leaves to sheep (Balaraman and Venkatakrishnan, 1974), sweet potato forage to cattle(Fernandez,Ffoulkes and Preston, 1979; Meyreles, Rowe and Preston, 1979) and water hyacinth (*Eithornia crossipes*) to cattle and buffaloes in Thailand (Wanapat, Sriwattanasombat and Chanthai, 1983) and Bangladesh (Hamid, Haque and Saadullah, 1984).

Effects of the supplemental forage

The beneficial effects of using supplemental forages are associated with several advantages in the animal. Precise reasons for these beneficial effects are not entirely clear and need to be investigated more thoroughlly. Present knowledge suggests however, that the following aspects are involved and associated with the process of utilisation :

Palatability

Palatability is enhanced by the presence of the forage supplements, especially if these are fed fresh and green. Also, feeding forages fresh and green overcomes problems of cost of drying, transportation storage and processing.

Energy intake

There is an increased ME intake. This is the result of a direct effect on feed intake which may or may not be associated with digestibility. Moran, Satoto and Dawson (1982) found for example, that while there was a response to leucaena supplementation, ME intake with or without leucaena were similar. In other situations both in intake and digestibility are improved (Devendra, 1983).

Nitrogen utilisation

There is simultaneously an increased N intake. This is achieved by a higher N content in the supplemental forage which assists in the intake of the basal feed, when both are mixed. With such forages as leucaena and gliricidia, higher N intake and utilisation appear to be associated with the presence of tannins. It is significant to note that although plant tannins are toxic to microorganisms and animals, there is no evidence that forage tannins have an effect on ruminants (McLeod, 1974). Tannins are also known to reduce protein digestibility.But this is not always the case depending on whether they are hydrolisable or condensed.

There is evidence that tannins may have a protein protection function. Since protein solubility and rate of flow of digesta are two major factors influencing degredation in the rumen and the quantity of dietary protein that passes intact to the abomasum (Annison, 1956; Kempton, Nolan and Leng, 1977), protein solubility is an important criteria of quality. This point is evident in table 10 where seven protein sources were used to assess degredation in the rumen and solubility using the acid-pepsin technique (to simulate post-rumen digestion). It was found that of the feeds used, only spent tea leaf, fish meal, cassava leaf, gliricidia leaf meal and ipil-ipil leaf meal had a solubility in the rumen of 40%. With acid pepsin solubility, gliricidia, leucaena and cassava leaf meals only had values of 44.7 to 69.1% compared to over 85% for fish meal, coconut oil meal and sesame oil meal.

Table 10. The solubility of some protein feeds in the rumen and in acid-pepsin solution.

Feed	Crude protein content (%)	Solubility in the rumen at 8 hr (%)	Acid pepsin solubility at 8 hr (%)
Spent tea leaf	34.8	12.3	38.4
Cassava leaf meal	29.1	26.8	44.7
Gliricidia leaf meal	23.4	31.2	66.5
Fish meal	37.9	37.6	69.1
Leucaena leaf meal	33.0	40.2	86.1
Rubber seed meal	12.1	44.5	86.4
Coconut oil meal	24.7	50.8	87.7

Adapted from Jayasuriya, Wijeyatunge and Perera (1982).

The availability of increased N to the animal, consequent to the beneficial effect of including forages in the diet is also consistent with the findings reported in Indonesia (Hendratno, 1982) and Malaysia (Devendra, 1983).

Minerals and vitamins

Forage supplements are also a useful source of macro and micro minerals and vitamins.

Digestive system

Since the beneficial effects of forage supplementation are found with both low quality base feeds (Meyreles, Rowe and Preston, 19 ; Devendra, 1983; Wanapat, Sriwattanasombat and Chanthai, 1983) and also feeds of higher quality such as molasses (Salais, Sutherland and Wilson, 1977), it is logical to conclude that there are beneficial effects in the rumen digestive system. It is not clear exactly what these are, but are obviously concerned with rumen movement, rate of digestion and absorption of the end products of digestion.

Laxative influence

Green forages have a laxative influence on the alimentary tract. Good rumen function is achieved when good quality forage supplements are used, resulting in the end products of digestion of acetic, propionc and butyric acids. High contents of acetic and buthric acids are energetically inefficient, and situations that favour a shift towards more propionic acid production and glucose precursors is desirable.

Continuing effort

The beneficial effects of using supplemental forage sources in diets based on crop residues and agro-industrial by-products apparent in the studies reported, and the limited work that has been done in this direction suggest that much more effort is necessary. The opportunities for doing so are enormous and are justified by the following considerations :

i) Low inherent productivity in ruminants due to reduced DMI; supplemental forages this situation and therefore improve performance considerably.

ii) Various types of forages are commonly found in most farms and can therefore be put to effective and immediate use with crop residues and agro-industrial by-products that are also available.

iii) Decreased cost of feeding is apparent due to a reduced dependence on purchased energy and protein supplements.

The strategy of using corp residues and agro-industrial by-product intact with supplemental forage supplements and/or limited concentrates, therefore has some merit. It is especially advantageous if the alternatively strategy of some form of processing and/or treatment is either impractical or is uneconomic.

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UTILIZATION OF TREE LEGUMES WITH CROP RESIDUES AS ANIMAL FEEDS IN THAILAND

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SUMMARY

Information is reported on tree legumes that are widely grown in Thailand with potential value as protein supplements in the rations consisting of low quality, fibrous crop residues. These are recommended as alternatives to other methods of improving the nutritive value of crop residues. Valuable tree legumes are Leucaena, Sesbania, Gliricidia, Erythrina and Pigeon pea. Chemical analyses of the plants and their effects on animal performance are briefly discussed.

Key Words : tree legumes, crop residues, protein supplements.

INTRODUCTION

According to the statistics for the agriculture (Cent. for Agric. Stat., 1982), there are about 10 million ruminants in Thailand. They are expected to grow at 1.1%/yr for the period of the 5th national five year economic and social development plan. Particular emphasis is placed on the promotion of dairy production which is progressing in several areas. Considerable funds has also been invested for vaccine production to control the animal diseases, particularly the foot and mouth disease. In 1985, also the national animal health and production institute is to be established.

All these events should lead to an increase in the ruminant population which will also need increased feeds. Unfortunately, because of the monsoonal climatic zone which is usually covered with trees and forest, Thailand is not well blessed with natural grasslands that could support greater number of the ruminants. According to the agricultural statistics (Center. Agric. Stat., 1982), there are approximately 0.66 million ha of natural grazing land. With shifting cultivation practice for decades, particularly in the north, areas under imperata expanding. Gibson (1977) reported that there were approximately 2500 sq.km. of imperata in the hilly areas of the north. Studies by Falvey (1979) had shown that green leaf desmodium could be used successfully to improve the imperata areas on the highland areas. But, because of the water shade, coupled with the rough terrain and being in the remote areas, does not seem appropriate at the present time to invest sizeable funds to develop such areas into production pastures. On the other hand, the development of the valuable arable land into permanent pasture would not be an easy job either. This is because the agriculture in Thailand is crop-dominant and characterized by small holding size. Unless involved in dairy farming, the farmers would not be happy to grow pasture for their stocks. Therefore, a productive large size pastures of the temperate types is still an illusion to the small farmers in this country.

With the recent advances in farming systems,however, it should be possible to introduce crop-livestock integration into village areas and pastures could be incorporated into the system. Gibson (1984) has shown that by this innovation dairy farmers in the ley farming project in Khon Kaen province did well in having legume pastures on the crop farms adopting the ley farming practice. In this system crop residues could play a very important role in providing a feed source for the animals. Also, tree legumes should be an integral part of the forage program in the system. It is a useful source of protein.

Crop residues

The important crops produced in Thailand are rice, corn, cassava, sugarcane, pineapple, pulse and oil crops, rubber and fruit trees. These crops have produced an enormous amount of residues which are considered very high potential feed sources complementary to the natural fodder available in limited quantity. As far as the available amount and the present utilization are concerned, rice straw is considered to be the most important feed source for village or small livestock farmers. It is estimated that approximately 18.6 million tons of rice straw were produced in 1982 (Khajarern, 1984). The second top by-product is sugarcane tops with an annual yield of about 7.3 million tons. This is underutilized due to isolated production and the farm mechanization. The majority of the by-products are therefore left on the farms and burnt, although an appreciable quantity are dehydrated and exported to Japan.

Khajarern (1984) has brought together all the available information regarding the kinds of crop-residues, their production and utilization as animal feeds. Although many kinds of residues are produced, only rice straw is widely used, particularly during the dry period when no green feeds are available. This paper will consider rice straw and to a lesser extent with sugarcane tops with particular emphasis on their uses in combination with tree legumes, as a protein supplement, which is considered to be one alternative to improve the nutritive value of crop residues. Rice straw is low in nutrients and digestibility and contains high fibre. The protein contents may range from 1.9 to 4.2%. In the case of cane tops this may be in the range of 5.5 to 7.7% (Table 1). Both feeds do not supply adequate nutrients required by animals and thus weight losses have observed in a number of cases when they are used as a sole diet. The decrease in body weight was from 0.008 to 0.260 kg/h/day (Anucha, 1983; Snitwongs, 1983; Intaramongkol, 1978; Suriyajantratong, 1984).

Table 1. Chemical composition of some crop residues in Thailand (% on dry basis).

Crop-residues	Moisture	CP	EE	CF	Ash	NFE	ADF	NDF	NDS	lignin	Source
Rice straw	7.3	3.8	2.1	30.5	15.68	40.8	52.9	70.3	29.7	4.0	Dept. of Live-stock
Rice straw, treated	7.6	6.5	1.5	32.5	16.8	35.1	57.8	68.3	31.7	4.8	Suriyajantratong
Rice straw	-	4.2	0.9	27.5	15.2	47.3	-	-	-	-	(cited by Khajarern, 1984)
Rice straw	16.9	2.4	1.6	29.2	14.5	36.2	-	-	-	-	Holm, (Chiangmai)
Rice straw (treated)	16.3	2.3	1.1	38.6	8.7	33.0	-	-	-	-	Holm, NaOH treated
Rice straw	5.3	2.0	-	-	-	-	52.2	75.4	-	4.7	Wanapat, (1984)
Sugar cane tops	-	6.4	1.7	33.9	7.6	50.4	-		-	-	Khajarern, (1984
Sugar cane tops	10.0	7.8	2.2	32.0	4.9	43.5	43.5	67.5	-	5.8	Dept. of Live-stock
Sugar cane tops	3.6	5.5	1.7	34.0	7.9	47.3	-	-	-	-	Dehydrated for export
Bagasse	8.1	3.3	3.8	34.7	4.6	45.5	50.3	70.8	29.2	9.0	Pelleted

To get full benefit from these kinds of by-products as animal feed there are techniques for improving their nutritive values. These could be done by chemical treatment or by microbial fermentation. Treatment with urea and ensiling technique is widely used among the dairy farms. Promma (1983), were Wanapat and Chanthai (1982), Wanapat et al. (1982ab) the pioneers in this field for Thailand and extension bulletins on this subject are available.

The microbial fermentation method was initiated in recent year at the Faculty of Science, Mahidol University obtaining a fund support from IDRC. 350 strains of fungi are isolated and tested for their efficiency to digest rice straw. Out of the above number three strains have been chosen e.g. *Pleurotus*, *Caprinus* and *Chaetomium*. Large scale fermentation tests are underway (Meevudhisom, 1984).

Tree legume fodders

The other method of utilizing fibrous residues which seems to be more practical as far as the small farmers are concerned is to use legume leaves as a supplement. Tree legume seems to offer high potential for this purpose. Factors that would favour this approach are the high protein content, drought resistance and less care. Also, there are several varieties to choose from which are already widely grown along the fences of the homesteads. The following species are widely grown in Thailand either on the farm land or along the fences: *Leucaena leucocephala*, *Gliricidia maculata*, *Sesbania glandiflora*, *Samanea saman*, *Acacia auriculaeformis*, Pigeon pea (*Cajanus cajan*) and *Erythrina*. Of these, however, Leucaena and Gliricidia have been the most widely researched. Chiangmai University has initiated a research project on tree fodder.

Nutrients and some toxic substances in tree legumes

The leaves of several tree legumes contain high protein content and it could range from 13% in the *Erythrina* to 23.4% in the *Sesbania* leaves (Table 2). Protein contents are generally variable among the various strains and is only affected by location.

Toxic substances in tree legumes should be taken into account when considering the use of the plants for animal feeds. Farmers should be educated and made aware of these. The most common toxic substances found in fodder legume leaves are mimosine hedrocyanic acid (HCN) and nitrate. Mimosine is an amino acid found in leucaena leaves and young pods. This and its derivatives could be harmful to animals if taken excessively and for a prolonged period. Mimosine contents of the leucaena varieties growing in Thailand have been examined by Udorn et al., (1982). Young leaves have higher mimosine than the fully mature ones (Table 3). On the average the young leaves contain 7.1% while only 3.9% have been reported in the older leaves. Symptomps of mimosine toxicity in cattle were observed in Thailand in a feeding trial in 1981 carried out by the Office of Northeast Livestock Development Project. In this experiment high level of leucaena leaves, (50% of the diet), was fed to weaners receiving 40% rice straw and 10% rice bran. Normal growth was observed from the first to seven month after the start of the experiment. Signs of mimosine toxicity was observed at the eighth month (Table 4). Mimosine has been known to breakdown in the rumen to its derivative (DHP) an other toxic agent, which acts on the thyroid gland to interfere with the production of hormone thyroxine, and thus, impairing the health of the animals (Jones, 1981). In Thailand we have tested this on a group of cows receiving 50% of fresh leucaena leaves in a normal grass diet. The cows were fed for two months and urine collected and tested for the DHP. Urine samples were tested at Davies laboratory in Australia. UHP test

Table 2. Chemical composition of some tree legumes in Thailand* (% on dry basis).

Leumes	Mois-ture	CP	EE	CF	Ash	NFE	ADF	NDF	NDS	Lignin	Ca mg/100 g	P mg/100 g	HCN mg/100 g	NO_3 ppm
Pigeon pea	7.4	18.0	8.6	21.1	6.9	38.0	33.1	37.2	62.8	15.2	914.1	143.2	3.8	3.0
Acacia auriculaeformis	5.1	14.4	4.8	24.7	3.7	47.3	33.6	43.2	56.8	17.7	-	-	4.0	2.2
Caesalpinia	6.1	20.4	9.6	11.6	5.8	46.5	18.4	22.6	77.4	5.1	-	-	4.0	12.1
Delonix	3.3	17.1	7.1	12.9	7.6	52.1	28.9	35.7	64.3	16.0	-	-	3.8	5.1
Gliricidia	13.7	22.9	5.6	14.9	11.4	31.4	27.5	27.2	72.8	12.7	-	-	4.0	124
Erythrina	9.9	13.3	9.4	16.3	11.9	40.3	26.4	28.1	71.9	5.4	-	-	1.5	84
Sesbania	7.3	23.5	6.3	6.1	13.8	38.1	15.4	15.9	84.1	4.5	-	-	-	-
Leucaena, Local	11.9	18.7	10.8	8.2	9.9	40.4	-	-	-	-	2672.5	118.2	-	-
Leucaena, Australia	11.4	19.9	12.4	6.8	10.6	38.9	-	-	-	-	2631.1	121.9	-	-
Leucaena, Ivory coast	11.3	21.2	11.9	7.4	9.7	38.6	-	-	-	-	2615.5	123.3	-	-
Leucaena, El-Salvador	11.5	21.2	10.9	7.5	9.8	38.9	-	-	-	-	2314.1	117.3	-	-
Leucaena, New Guinea 64	11.1	20.6	10.5	8.7	9.4	39.7	-	-	-	-	2423.5	122.7	-	-
Leucaena, New Guinea 71	11.6	20.3	11.8	7.3	10.4	38.7	-	-	-	-	2714.6	117.8	-	-
Leucaena, Taiwan	11.3	17.7	9.7	7.8	11.9	41.6	-	-	-	-	3628.4	105.4	-	-
Leucaena, Columbia	11.4	20.1	7.4	8.0	8.6	44.5	-	-	-	-	2508.1	145.8	-	-
Leucaena meal**	6.1	17.6	-	-	13.4	-	-	-	-	-	1.07	0.43	-	-
Samanea saman	10.5	22.4	5.6	25.2	3.3	33.1	32.1	36.9	63.0	16.1	302.2	178.1	-	-
Samanea pods	10.9	16.7	2.9	10.6	3.3	55.5	-	-	-	-	235.9	132.8	-	-

* Department of livestock (1967).

** Sriwatanasombat et al. (1984).

Table 3. Mimosine contents of leucaena leaves samples from Pakchong and Roi-Et (%).

Varieties	Young leaves					Mature leaves				
	months					months				
	Feb.	Apr.	Jun.	Aug.	$\bar{x}$	Feb.	Apr.	Jun.	Aug.	$\bar{x}$
Salvador type K_8-Australia	6.93	9.55	5.78	8.74	7.75	2.04	6.21	3.76	4.79	4.20
Salvador type K_8-Hawaii	11.22	8.72	7.83	9.11	9.22	2.63	3.84	4.19	6.67	4.33
Salvador type K_{28}	3.65	9.28	6.99	7.70	6.90	1.57	5.59	4.08	4.42	3.91
Salvador type K_{67}	9.31	6.29	7.99	6.69	7.57	4.90	3.98	4.61	4.50	4.49
K_{156}	3.39	5.0	5.84	6.67	5.22	1.87	3.51	4.03	4.33	3.43
cv. Peru	6.35	5.69	6.95	7.24	6.55	2.98	3.40	3.75	5.78	3.97
cv. Cunningham	2.51	7.82	8.70	8.00	6.75	1.26	1.34	5.07	4.47	3.03
Peruvain	5.48	6.78	7.76	7.72	6.93	1.81	3.34	4.83	4.79	3.69
Ivorycoast	7.83	7.53	6.85	6.41	7.15	3.46	4.38	4.39	4.28	4.12
Average	6.29	7.40	7.18	7.58	7.11	2.50	3.95	4.30	4.89	3.91

Udorn et al. (1982).

Table 4. Effect of high level leucaena leaves on the performance of yearling cattle.

Feeding redients	Group I	Group II	Group III
Rice straw, %	40	40	1 kg/h/day
Concentrate, %	60	-	-
Leucaena leaf, fresh, %	-	50	1 kg/h/day
Rice bran, %	-	10	-
No. of animals	5	5	5
Duration, days	232	232	232
Initial weight, kg.	117.4	123.6	116.6
Daily weight gain, kg/h	0.643	0.431	0.431
Condition of animals at 8th month period	normal	sign of toxicity	normal

* Office of Livestock Development (1981).

have shown negative results indicating that there appear to have rumen microorganisms capable of detoxifying the DHP. Another test with yearling buffaloes receiving up to 60% leucaena leaf meal also have shown negative results and the animals have performed(Snitwong, 1983). HCN and nitrate are known to be present in a number of tree legumes but with appreciable quantity except in *Erythrina* (Table 2). Although analysis shows low level of the toxic substances, care should be taken not to feed an excessive amount af leaves containing these.

Leaves of sesbania (*S. grandiflora*) are relished by cattle but they also contain HCN. It has does been reported that mature seeds contain canavarine, and amino acid, which acts as an antimetabolite to arginine (NAS, 1979). In the case of *Mimosa pilgra*, a shrub type mimosa, no reports are available about the toxic effects to animals, but feeding the dried leaves as a supplement to rice straw in rations for buffaloes have not produced satisfactory results compared with the feeds of pure rice straw (Pisoot et al., 1983); less weight loss was observed in the group receiving higher levels of dried leaves (Table 5). It is possible that the leaves may contain some undesirable substances or that the intake of the leaves is still too low to supply adequate protein, although the content is high in protein (Table 2). Furthur investigations are clearly necessary.

Table 5. **Effects of dried leaves (DL)** on the performance of buffaloes during the dry period .

Parameters	Treatments			
	6 kg rice straw	5 kg RS + 1 kg DL	4 kg RS + 1 kg DL	3 kg RS + 3 kg DL
No. of animals, hd	2	2	2	2
Duration, days	123	123	123	123
Initial wt.,kg	152.0	211.0	219.5	166.5
Daily weight gain, kg/h/day	-0.19	-0.10	-0.11	-0.01
Total feed intake, kg/h/day	5.1	5.6	5.7	5.4
Mimosa leaves, kg/h/day	0	0.93	1.70	2.57

Pisoot et al. (1983)., RS = rice straw; DL = dried mimosa leaves.

With sheep, Vearasilp (1981) has shown that, feeding up to 400 g/hd/day, gave no weight loss when supplementing rice straw feed during the dry season.

Palatability of some tree legumes and animal performance

There are marked differences in the palatability of the leaves from tree legumes grown in Thailand. Among the four kinds of tree legumes that have been tested,Leucaena and Acacia are most palatable, the intakes of fresh leaves of both being 11.6 and 12.0 kg/head/day respectively (Manidool, 1983). Intakes of *Delonix* and

Samanea are very low, being only 0.41 and 0.88 kg fresh leaves per-head per day, indicating the low palatability of both (Table 6).During the test period at Pakchong, animals in the *Delonix* group did not take any feed for two days and were then removed from the trial. The rest of the animals ate the leaves but lost their appetite. In the case of *Samanea* leaves, the cattle exhibited a selective behaviour and browsed only on the young pinnae at the first two days but later got accustomed to the older leaves. Both *Delonix* and *Samanea* leaves have relatively high lignin contents (Table 2) and this could affect the nutritive value of both species.

Table 6. Intake of tree legume leaves by cattle and goats .

Tree legumes	Fresh wt.(kg/h/day)	% DM
Cattle		
Caesalpinia	0.41	35.6
Samanea	0.88	37.2
Leucaena	11.60	28.9
Acacia	12.00	38.5
Goat		
Leucaena	1.34	27.8
Acacia	0.63	39.1

Manidool (1984).

Ripe *Samanea* pods are well relished by the cattle and buffaloes. They are sweet in taste, have a high protein content when in green stage (Table 2) and could be a good feed supplement during the dry season. According to Anucha (1983) the supplement of *Acacia* pods (Samanea) at the levels of 1-5 kg/h/day to rice straw feed could either maintain or increase the body weight of cattle(Table 7). He also noted that scouring occurred in the group fed pods which was

Table 7. Effects of *Acacia* pods (Samanea) supplement on the performance of cattle fed on rice straw .

Parameters	Rice straw plus			
	0 kg Samanea	1 kg Samanea	2 kg Samanea	5 kg Samanea
Initial wt. (kg)	103.3	112.6	103.6	109.3
Average daily weight gain, kg/head/day	-0.06	0.06	0.10	0.04
DM intake, kg/head/day	3.2	2.87	3.89	5.46
Duration, days	113	113	113	113

Anucha (1983).

observed in the first two weeks of feeding. The symptoms ceased later with no ill effects. It should be noted also that the ripe seeds of *Samanea* is big and very hard, the thick coats of which are resistant to ruminal digestion. The use of *Samanea* pods may be limited by the seed characteristics.

Erythrina subumbrans

Erythrina leaves are fairly rich in protein, low in lignin and very palatable, particularly in the broad leaf type. At Satoon Forage Crop Station, mature cattle,recorded an average intake of 14 kg green leaves per head per day for a period of a week. Feeding trial have as yet to be done but in some areas in the south a number of farmers grow *Erythrina* along the fences and have some experience with the tree. The leaves are collected and fed to the cattle when they return to the barns in the evening. I have seen one dairy farm near Bandung in Indonesia where *Erythrina* with Napier grass interplanted between rows of the trees. This farm raises 120 head of dairy cows and the *Erythrina* leaves form a very good fodder supplement. The management provides for one lung is to be left on the tree for each lopping during the dry season to ensure the good regrowth of the plants. There are several kinds of *Erythrina* e.g. the variegata type for ornamental; the narrow leaf for nursing crop and, to some extent, young leaves are for human food; and the broad leaf type. The later is more productive and better used for fodder purpose. It is leafy and easy to establish by cutting. One striking feature is the ability to produce some amount of leaves during the dry season. Nitis (1984) has shown that *Erythrina* tree still provides an average of 14% of total leaves from legume tree fodder (Table 8) during 6.0-7.5 month dry period.

Table 8. Amount of tree legume leaves (% of total fodder) available for goats during the dry period in various locations in Indonesia .

Tree legume	No. of dry months				
	1.5-3	3.4-5	4.5-6	6-7.5	7.5-9
Erythrina	9.9	7.0	13.4	14.0	0
Cariandra	0	0	2.1	2.6	0
Leucaena	2.8	2.0	2.3	2.8	35.4
Sesbania	1.8	9.7	1.8	2.2	2.4

Nitis (1984).

It is recommended to that up to 4 kg green leaf per day for a mature cow can be fed. This limit will avoid nitrate poisoning. The leaves of *Erythrina* contain fair amount of nitrate (Table 2).

Acacia auriculaeformis

This is an other interesting tree legume that deserves thourough investigation. It is a fast growing tree that has a very wide ranges of adaptation. It grows well in soils that limits the growth of leucaena. The leaves are well relished by goats and cattle. On average the leaves contain 14.4% protein, 17.7% lignin, 2.31 ppm nitrate and 3.06 mg % HCN (Table 2). The intake of the leaves by both goats and cattle are low (Table 6). Observations at the goat station in Pattani has shown that feeding Acacia leaves as a sole diet for **two** weeks caused diarrhaea. The animals lost weight and the hind quarter became weak. Feeding about 200 gm of fresh leaves every day as a supplement fodder,did not affect the health of the animals. This practice has under gone for years. The preference of this species by the station was because of the poor soils on the station.

The regrowth or coppicing of *Acacia* trees is relatively slow if the trees are cut very low or if all branches are defoliated. The lopping of the leaves should, therefore, be done lightly and infrequently if the continuance supply of green leaves are expected. In Pattani area, young leaves are attacked by insect belonging to *Anomala* group which occurs during October through November. *Acacia* is widely grown in Thailand but not for fodder purpose. Considering the acceptance of the cattle and goat coupled with it's excellent adaptation and growth, it should also receive close study for fodder purpose.

Sesbania glandiflora

This species is grown in Thailand as a food crop; the flowers are eaten by humans. As a fodder it is used in some dairy farms. They are grown along the fences but not as a fence line as with leucaena. The leaves have a high protein content and palatability. The nitrate content is fair. At Pakchong Station it has been shown that it has, on the average, 62.7% DDM and a DM intake of 478.8 g/hd/day (Table 9). The sheep which were fed with *Sesbania* leaves as a sole diet for 14 days lost weight by 1.63 kg (Tinakorn, 1982).

Table 9. Intake and digestibility of *S. glandiflora* leaves in sheep .

Sheep No.	Intake (gm/day)	DDM+ (%)	TDN++ (%)	VI (gm/day)
1	405.8	66.0	57.6	34.2
2	701.1	62.9	53.4	51.5
3	499.5	62.8	53.7	35.8
4	146.5	61.6	53.4	33.1
5	601.2	53.7	52.0	55.1
6	348.6	68.9	59.1	31.0
AVE	478.8	62.7	54.8	40.1

Tinakorn (1982). Report: Pakchong forage crop station.

\+ DDM-Digestible dry matter

++ TDN-Total digestible nutrients.

No data exists about its feeding to cattle but because of the high protein content of the leaves, it is recommended to limit the use at 4 kg fresh leaves for a mature cow for supplementing to other fodder or fibrous feeds.

Gliricidia sepium

The leaves of this species produce good quality feeds which could be used as a protein source in rations containing high fibrous matters. Analysis has shown that pure leaves contain upto 22.5% protein (Table 2). Compared to *Leucaena* and *Erythrina* leaves, *Gliricidia* has lower palatability but the cattle accept it eventually. In Thailand it is not as widely-grown as *Leucaena* and *Sesbania*, but is being promoted in backyard pasture programmes. Vearasilp (1981) reported that a mixture of fresh of *Leucaena* and *Gliricidia* leaves in the ratio of 1:2. Fed as a supplement to rice straw, equivalent to 50.2 g/DM/head/day improved the nutrition level of the sheep. The animals receiving such rations maintained body weights compared to those animals receiving only *Leucaena* or *Gliricidia* as a supplement which lost 13-15 g/head/day. DM intake and digestibility of *Gliricidia* leaves were lower than in *Leucaena* leaves. DM intake and digestibility of *Gliricidia* were 465.4 g/head/day and 51.0% respectively while those for *Leucaena* were, respectively, 510.9 g/head/day and 57.9%.

Leucaena leucocephala

The plant is known in Thailand as "Kratin". It is believed to have been introduced into this country some 500 years ago via India or Kampuchea (Manidool, 1982). It becomes naturalized and widely spread from the coastal areas to 800 meters in the highland of the north. It is used both as human food and as an animal feed. Other uses are live fences and fuel source. The giant varieties are being utilized for forestry purpose. As an animal feed the main product is leafmeal, but recently it has gained popularity as a fodder crop, particular for the backyard pasture development. It has very high nutritive value (Table 2) and is very palatable. During the last three years large amount of seeds were produced by the Department of Livestock for distribution to small farmers and for sale for those who are interested in large scale leafmeal production. Mimosine toxicity has also been observed in Thailand (Table 4), when yearling cattle were fed with an excessive amount of leucaena leaf for prolonged period. Boonlom and Nirandorn (1984) have reported the results of a feeding trial to compare the effects of supplementing leucaena leaves in the rice straw ration on the performance of growing cattle. This supplemented ration gave a similar results, in terms of an average weight gain. An average daily gain of 0.480kg/h/day was obtained for the leucaena leaf supplement group compared to a gain of 0.420 kg/h/day from the urea-treated rice straw group(Table 10). The benefit of using leucaena leaves as a supplement was also shown by another experiment carried out by the Office of Northeast Livestock Development Project in which 1 kg each of green leaves and rice straw

Table 10. Performance of growing cattle fed diets containing untreated rice straw and leucaena leaves compared to urea-treated rice straw .

Parameter	Group I treated straw	Group II straw + leucaena leaves
No. of animals	8	8
Initial body wt., kg	90.7	91.2
Live wt. gain, kg/head/day	38.4	44.0
Average weight gain, kg/head	0.42	0.48
Total DM intake, kg/d	2.91	3.15
DM concentrate, kg/d	0.96	0.96
DM roughage, kg/d	1.95	2.19

Boonlom and Nirandorn (1984).

was fed to yearling cattle as a supplement to a traditional feeds obtained by village grazing practice. The supplement gave very satisfactory results in terms of daily weight gain and the economic viewpoint. The average daily gain was 0.431 kg/head/day compared to the gain of 0.643 but with 60% concentrate containing ration (Table 4).

Experiment has also shown that leucaena leaves could be used satisfactorily with dried sugar cane tops. Snitwong (1983) conducted a feeding trial to compare the performance of the young buffaloes receiving dehydrated sugarcane tops with or without fresh leucaena leaves supplement. An average daily gain of 0.700 kg/head/day was recorded for the supplemented group as compared to 0.230 kg/head/day for the control group which received pure dehydrated sugarcane tops (Table 11).

Table 11. The performance of buffaloes fed on dehydrated sugarcane tops with and without leucaena leaf as protein supplement

Parameter	Diets	
	Sugarcane tops	Sugarcane tops plus leucaena
Initial wt., kg	220.2	210.0
Average daily gain, kg/head	0.23	0.70
DM intake, kg/d	5.19	8.3
DM cane tops, kg	5.19	4.5
DM leucaena, kg	-	3.8

Snitwongs (1983).

In another experiment, Snitwong (1983) used high levels of leucaena leafmeal (up to 60%),as a protein source in combination with 1% urea in a ration containing 34% cassava chips. The buffaloes gave an average daily gain of 0.480 kg/head/day (Table 12). DHP tests in the urine showned negative results and no abnormality in the size of thyroid gland was observed. This indicated that buffalo could tolerate high level of leucaena leafmeal.

Although leucaena is widely grown in Thailand, there are some limitation. In acid soils, for instance, poor growth is obtained. Soil pH should be raised to near neutral in reaction if good growth is expected. In the acid soils, particularly in a sandy condition, Al toxicity is usually encountered and there-by affecting the growth of the plants. Table 13 shows the effects of acid soils and high Al content on the yields of leucaena grown in sandy soil area in the south. Low pH and high Al content in soils decrease the forage yields of leucaena very significantly.

Table 12. Performance of buffaloes fed on rice straw with leucaena leaf meal and concentrate supplement

Feed ingredients	Control	40% LM	50% LM	60% LM
Cassava chips	47	45	43.5	34
Soybean cake	18	5	-	-
Leaf meal	0	40	50	60
Rice bran	20	-	-	-
Corn meal	15	9	5	5
Urea	-	1	1.5	1
CP, %	13.2	13.4	13.8	13.7
Mimosine, %	0	1.28	1.60	1.92
Performance				
No. of buffaloes	5	5	5	5
Duration, day	120	120	120	120
Initial wt., kg	317.3	316.9	342.6	326.5
Average dairy weight gain, kg/head	0.62	0.48	0.39	0.48
Feed intake, kg/head/day	8.09	9.02	9.20	9.02
DHP test, urine	negative	negative	negative	negative
Wt. of thyroid gland, g	37	25	25	31

Snitwong (1983).

LM = Leucaena leaf meal.

Table 13. Effects of lime and fertilizers on the yields of Leucaena on Banthon soil *

Treatments	pH	Al (ppm)	DM yield (kg/ha) 1st year	DM yield (kg/ha) 2nd year	Average
Control	4.96	27.4	166.3	146.3	156.3
Organic soil, 1875 kg	4.23	-	168.1	71.6	119.8
Lime, 2500 kg	7.13	1.37	2,070.0	2,086.3	2,078.1
Npk_{375} + Lime	6.61	-	4,609.4	3,480.6	4,045.0
Npk_{375} kg	4.78	10.27	1,941.3	1,078.1	1,510.0

Narativas Forage Crop Station (1980).

*Banthon soil series : Coastal area of south Thailand;
Sandy,
Hard pan below, 80-120 cm;
CEC 3-3.6 me/100 gm;
P 3 ppm,
and K 61 ppm.

CONCLUSIONS

The uses of tree legumes in conjunction with the fibrous residues as animal feeds in Thailand has very good prospects particularly for small farmers and village cattle. At present research on the utilization of leucaena is more extensive than other tree legumes, but there is good opportunity for considering the other varieties, particularly on the problem soils which shall support only some adapted species. Also, problem of toxicity in some varieties should receive detailed investigations. The results from a number of researchers in Thailand indicate that it is advantageous to supplement-suitable legume leaves to fibrous residues as animal feeds, but these results have not widely disseminated to farmers. Efforts, therefore, should be made to disseminate the principles and technique of utilizing the tree legume leaves. This could be done through extension and training programmes so that the farmers could learn and appreciate the value of tree legumes as animal feeds. Also, agronomic studies should be strenghtenned to select the suitable species and seek ways to increase the yields of fodder portion of tree legume.

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SUPPLEMENTATION OF UREA-TREATED RICE STRAW

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SUMMARY

The paper discusses supplementation of (urea-ammonia treated) rice straw with special reference to research results in Sri Lanka by the Straw Utilization Project. The case for supplementation considers differences between tropical and temperate countries, the needs of farmers, principles of nutrition and interactions between straw type and concentrate level. Both type as well as level of supplements affect the interaction. It is suggested that work on supplements, green leaves as well as concentrates, is intensified.

Key words : urea-ammonia treated rice straw, supplementation, concentrates.

INTRODUCTION

The shortcomings of straw as a ruminant **feedstuff** are well-known and can be summarized as :

- low digestibility (DC)
- low crude protein levels (CP)
- imbalanced mineral contents

A low voluntary feed intake (VFI) is often associated with straw. A dry matter intake (DMI) of upto 3 kg straw/100 kg BW,it is very much the question whether we can speak of a low intake (see Table 1). It seems more appropriate to speak of a relatively low VFI, rela-

Table 1. Cost of feeding (Rs/day/animal) to animals of 50% production and 100% production.

Item	Assumptions*					
	O	I	II	III	IV	V
Milk						
4 lts/day (50%)	2.75	3.19	3.02	2.87	2.40	3.40
8 lts/day (100%)	5.05	5.05	5.18	5.05	5.05	6.07
Liveweight gain						
250 g/day (50%)	1.86	not	1.96	1.86	1.65	2.36
500 g/day(100%)	5.00	calculated	7.15	3.33	7.15	7.84

* The numbers refer to different assumptions (feeding values, DMI's, etc.) for which rations have been calculated in table 10 of SUP 1984b).

ting such to the required nutrients and the absorbed nutrients from straw even at high VFI.

Nutrient intake from a feed can be read as :

VFI x Feed quality (DC, CP, minerals, etc.).

The resultant low intake of nutrients from straw is mainly due to low digestible nutrient concentration in the straw. This problem can be overcome through different avenues :

- treatment of the straw (chemical, physical, biological)
- supplementation of the straw based ration with concentrates or good quality roughages (legumes, young grass)
- a combination of treatment and supplementation.

The choice between these avenues is essentially an economic choice (Straw Utilisation Project, 1984b. Schiere et al., 1984). Progress has been made regarding the methods of treatment of straw (Ibrahim,

1983) and the use of ammonia (NH_3) has been widely reported (Sundstøl et al. 1978). In India, Bangladesh and Thailand, and especially in Sri Lanka, the use of urea is being explored (Perdok et al., 1982; Pathirana, 1983; Jayasuriya et al., 1984; Schiere and Ibrahim, 1984). The principals of straw treatment have been dealt with in other publications and will be left out of discussion(Straw Utilization Project 1983a, 1984a).

It is well established that urea treatment does definitely increase the feeding value of straw due to relatively higher digestibility and a consistant increase of DMI due to treatment. The extra N-supply is also an important advantage of urea treatment of straw. It can therefore safely be said that treatment reduces the need for concentrates. Nevertheless concentrates are still needed :

- for higher production levels
- to balance specific deficiencies
- if not enough straw is available
- because concentrate supplementation may be cheaper than urea treated straw to attain the same level of production.

A few elaborate papers on principles and supplementation of fibrous residues have recently come available(Preston and Leng, 1984; Verma and Jackson, 1984). This paper will discuss some research results applying to supplementation found in Sri Lanka by the Straw Utilization Project (SUP). Considerations presented below are relevant for the SUP because of its attempt to compound rations and compare their prices. If any catalytical effects or unexpected interactions frequently occur, the ration calculation based on additive models may become a useless effort and the prediction of results will become much more complex. Papers like Preston (1983) and others indicate that animal production responses may be difficult to predict from conventional analysis. The relevance of these so called catalytic or associative effects should be established before discarding the use of conventional ration calculations in situations of tropically applied animal nutrition.

Supplementation: Differences between tropical and temperate countries

Tropical animal husbandry and nutrition differs from temperate animal nutrition because of different feed qualities. It also operates under different economic conditions (Jackson, 1981). Roughages are generally inferior in the tropical compared with temperate areas, (digestibility, crude protein, ready available carbohydrates). Concentrates are also generally of inferior quality partly because the good qualities are exported or fed to monogastrics. Quality refers to aspects like fat residues in press cakes,fibre residues and high ash contents in products like rice bran, etc. Moreover the variety of concentrate feeds available at the farm level of often much less than in the tropics. Less variety could mean a higher incidence of specific deficiencies. It should be said that inferior feed quality may partly go unnoticed by lower requirements of often less productive animals.

Supplementation : A farmer's point of view

Economics of small farmer enterprises in the tropics are complicated. It is suffice to mention a few examples.

High production is not necessarily profitable productions. Table 1 shows how in a theoretical example it can be much cheaper for a farmer to have two animals each gaining 250 g/day than 1 animal gaining 500 g, because of the law of diminishing returns. On an international scale one can also see that a country like New Zealand with medium producing diary animals on relatively cheap feed is better off than Europe where cows are yielding much higher with more expensive feeds.

Many animal scientists are worried about animals losing weight in the dry season. Alternatives are proposed as to how to let the animals maintain bodyweight. For the farmer it may be more expensive to maintain liveweight(there may simply not be enough feed) than to let the animals lose weight and regain in periods of cheap feed. the Australian ranching industry applies the latter principal.

Besides reluctance (tradition, prices) from the farmers to buy unknown feeds (like molasses, fishmeal) especially if the national infrastructure is often not well enough developed to ensure a steady supply of these feeds. The starting point should be the present farmers situation and not too much reliance should be placed on what could happen if molasses would be imported, if the farmer would plant gliricidia etc.

Guaranteed and/or stable and/or high prices are an exception. Small farmers will therefore aim at secure though low incomes rather than invest in feed, breed, etc. for high production but often uneconomic returns. Often the main aim of keeping animals is as an insurance or savings account.

Farmers have only limited land to spare for planting "high yielding" grass or leucaena and Gliricidia. Yields of green feed from these sources are often disappointingly low and go at the expense of the farmers emergency crop of manioc or cash crop of beans, fruits, bananas, etc.

A farmer does not care about feed conversion rates as long as the balance of his enterprise is at a maximum. Too often the animal scientist tends to get excited at high production forgetting the cost and benefit relevant for the farmer. If feed conversion is used as a ratio between feed used per produce then it should be realized that also dung, draught etc. are to be counted as produce.

National (macro)economic considerations often do not coincide with farmers (micro) economic reasoning.

Whereas for a western farmer single products count : milk or meat, for tropical farmers often a conglomerate of produces are relevant: milk, meat, draught, dairy, insurance, dung, etc.

Supplementation : A nutritionist's point of view

Because the SUP is linked closely to the extension, the need is felt to do ration calculation. This is to assess costs of different feed combinations and compare the usefullness of treating rice straw versus non treating, (SUP, 1984b; Schiere et al., 1984). Therefore the SUP is obviously interested in predicting responses to feeding practices. Preston (1983) suggests that the use of conventional feed analyses is limited. Words like bypass protein and catalytic feeding are common place. Possible reasons for "unpredictable" responses can be that :

Supplementation in ruminants can affect both the metabolism of the body but also the metabolism of the rumen. Providing the rumen with limiting nutrients (N, energy, S, P) can cause a sudden increase in the digestibility of the ration as shown by many(Figure 1). The magnitude of rumen stimulation is however yet to be determined and also the range at which rumen supplementation can affect the rumen metabolism and digestibility. It is likely in our view that this "stimulation" or catalytic action will mainly take place at low levels of supplementation. It should also be remembered that some feed components can have depressing effects on rumen fermentation : e.g. highly soluble carbohydrate or high fat rations. The feed industry has long learned to live with rules like: rice bran less than 30%, fishmeal at least 5% etc.

Specific deficient nutrients may be supplied to the body like amino acids or minerals. In our idea the concept of "bypass protein" or "slowly degradable protein"is not clear enough to claim specific and predictable effects.

If only concentrations in feeds are measured and dry matter intakes are not considered expressed per unit liveweight, predictions are likely to be false.

The experience of SUP is that work with poor quality roughages and heterogenous cattle gives highly variable results. Interpretation of data should give the proper place to the important term "experimental error".

We will hereunder review some areas of prediction which are most relevant for ration calculation.

Interactions between straw type and concentrate level (Non-linear responses)

Basic assumption to do ration calculation is additivity of feed values. If the response to supplementation is not additive,unpredictable and even different between types of roughage, then the ration calculation based on additive models is in trouble. There are two arguments for the response curves of treated straw (TS) and untreated straw (US) to converge (Figure 2).

- When the concentrate levels are 100%, then there is no difference anymore between the TS and the US ration.(This argument leads to a predictable interaction and should not worry us).
- If part of the treatment effect is stimulation or rumen fermentation the relative advantage of TS over US gets lost at higher levels of supplementation because the US ration will receive its rumen stimulant from the supplement. (This leads probably to less predictable interactions and should worry us).

In analysing these interaction it is necessary to specify the type of supplement and the level of feeding. Our data range include upto 40% supplement in the ration. We have not yet analysed the data per specific supplement in detail but no unpredictable effects occur at the levels used in SUP trials. Both converging as well as diverging effects are found, but not of extreme magnitude. The existence of an interaction does not have to worry us if it can be mathematically predicted. Effects like those found by Saadullah, 1984 (Table 2) are much more "problematic for the additive models"because they are difficult to predict : first an initial high increase and after that no response. Can this be explained by taking the approach of the additive ration calculation or differences in dry mat-

Table 2. Liveweight gain, intake of calves (LW_i approx. 50 kg) fed treated straw and different levels of fishmeal.

	Level of fishmeal, g/day						
	0	50	100	150	200	250	SE_m
Liveweight gain,g/d	57[a]	198[b]	197[b]	205[b]	192[b]	215[b]	40
g CP/100 g LWG[1/]		21	42	61	89	95	
	Milk powder						
	0	15	25	50	150	200	
Liveweight gain,g/d	80[a]	142[b]	151[b]	203[c]	206[c]	95[a]	16
g CP/100 g LWG[1/]		15	21	24	71	400	

1/ Assuming 60% CP in fishmeal and 30% CP in milk powder. According to table 1 the CP required/100 g LWG ranges approximately from 30-40 g for this class of animals, taking 0 g fishmeal as a reference.

Source : Saadullah (1984).

ter intake? Linear responses to fishmeal additions as in Table 2 can be explained quite well from feed requirement tables 3 1 milks(4% fat) requires 87 g CP (Table 4)and this can perfectly be what fishmeal contributed to that ration. There is no clear need in this case to suspect special effects of fishmeal. Figures 3, 4, 5 and 6 show production responses with generally not very disquieting interactions between type of basal ration (untreated or treated straw) and level of concentrate. Supplementation goes upto about 30-40% of the total ration.

Voluntary feed intake (VFI)

The intake of basal roughage (VFI_r) decreases when the intake of concentrate (VFI_c) increase. Total voluntary intake (VFI_t)

Table 3. Nutrient requirements for growing-finishing steer calves and yearlings (daily nutrients per animal).

Live weight (kg)	Daily live weight gain (kg)	Minimum DMI (kg/an)	kg/100 kg LW	Roughage (%)	CP (kg)	TDN (kg)	Required per 100 g LWC*	
							CP (kg)	TDN (kg)
100	0	2.1	2.1	100	0.180	1.21	-	-
	0.5	2.9	2.9	70-80	0.360	1.8	0.036	0.12
	0.7	2.7	2.7	50-60	0.400	2.0	0.031	0.11
150	0	2.8	1.9	100	0.230	1.6	-	-
	0.5	4.0	2.7	70-80	0.440	2.5	0.042	0.180
	0.7	3.9	2.6	50-60	0.490	2.7	0.037	0.157
200	0	3.5	1.8	100	0.300	1.9	-	-
	0.5	5.8	2.9	80-90	0.570	3.4	0.054	0.300
	0.7	5.7	2.9	70-80	0.610	3.6	0.044	0.242
300	0	4.7	1.6	100	0.40	2.6	-	-
	0.9	8.1	2.7	55-65	0.81	5.4	0.045	0.311

* Calculated from extra CP/TDN requirement per 100 g gain above maintenance.

Source : Adapted from NAS (1976).

Table 4. Daily nutrient requirements of lactating and pregnant cows.

Live weight (kg)	TDN (kg)	CP (g)
Maintenance of mature lactating cows		
350	2.85	341
400	3.15	373
450	3.44	403
500	3.72	432
Milk production-nutrients per kg milk of different fat percentages		
(% fat)		
3.0	.282	77
4.0	.326	87
5.0	.365	98
6.0	.410	108

Source : Adapted from NAS (1978).

generally increases. Some workers have indicated that increases of VFI_r are possible when specific supplements are fed. We have gone through our intake data and find a general decrease in VFI_r of approximately 0.3-0.5 kg/kg supplement. The correlation is not high but only in one instance was an increase of VFI_r reported(Figure 7). The levels of supplement range approximately from 0-40% supplement in the rations and the supplements range from commercial dairy concentrates (rice bran, coconut cake, fish meal) to green forage gliricidia or leucaena. An analysis of the cluster of points is underway but as yet not very promising. Virtually no increase in VFI_r was found and Fugures 8, 9 and 10 support that statement. Many others have shown associative effects i.e. the increase of digestibility of the roughage due to addition of a concentrate (Saadullah, 1984). SUP has indications of its own to such effects (Figure 1) but even in that case VFI_r did not increase due to supplement addition (Figure 9).

The only case in which VFI_r has consistently increased through supplementation was with urea addition. The increase is limited to urea directly sprayed as 2% solution on the straw without reaction taking place (SS). The increase is more consistent and more pronounced if urea is sprayed and real treatment takes place. The effect of urea spraying of straw on VFI_r seems to depend on the urea concentration used. The decrease of VFI_r after supplementation is similar for TS and US (Figure 8 and 10).

Specific nutrient components in relation to the use of(urea-treated) straw

Although it may not be perfect to use the classical feed analysis approach, SUP will do this mainly due to an absence of a well accepted alternative approach.

Energy :

It is probably an over simplification to use TDN or ME as a measure of energy. It may be necessary to distinguish between types of energy supplies the body has :

- from fibre
- from ready available carbohydrates
- from fat (here not further discussed).

Leng and Preston often stress the importance of glucogenic precursors. Others from Europe (Van Es, 1984) do not agree on the lack of glucose. Part of the argument can probably be avoided if the production levels and feeds are specified and which may cause glucose shortages. Tropical feeds may be more glucose-deficient than temperate feeds, although tropical production levels are less demanding. The matter becomes important to ration calculation when the glucose precursor shortage require special starch sources. If that were necessary, it would be nice if practical standards could be evolved like : for each kg of straw so many kg of starch is necessary. A single measurement like TDN is in such a case not enough to predict the feeding value of a feed but quite helpful.SUP has one indication of a glucose precursor shortage (Table 6)in lactating buffaloes. Rice bran supplement for growing bulls showed no catalytic response (unpublished work Niraviya, 1984a)which indicates no specific need for starch like substances.

Protein :

The basic question is whether TS is protein deficient for low to medium production. Good quality protein like fishmeal is difficult to obtain in Sri Lanka and when used it showed no spectacular response : 100 g fishmeal extra gave 100 g extra LWG with no increase in VFI_r or even in VFI_t. (Perdok et al., 1982). No spectacular responses to protein feeding on TS were found in a fattening experiment (Niraviya, 1984a) and further addition of CP in the form of *Gliricidia* did not increase milk yield of dairy buffaloes (Table 5)as compared to the same amount of protein from rice bran including easy available energy.

Table 5. Effect on milk production of crossbred cows in Bangladesh of supplementing urea-treated rice straw with fishmeal ($\bar{x} \pm$ SD).

Fishmeal (g/day)	Liveweight (kg)	Intake (kg/day)	Milk yield (kg/day)	kg fishmeal/ltr milk[1/]
0	315±4	8.3±0.1	5.8±0.5	
100	321±2	8.3±0.1	6.3±0.6	0.097
200	321±2	8.5±0.5	7.6±0.5	(approx. 50-60 g CP)
300	325±2	8.6±0.2	8.6±0.7	

1/ Calculated as a linear regression from the data in the first and in the fourth column.

Source : Mannan et al. (1984, cited by Saadullah, 1984).

Table 6. The effeçt of ricebran supplementation and an isonitrogenous level of gliricidia on the milk production of Surti buffaloes.

Ricebran level kg DM/100 kg BW	Milk production (l/day)	Fat percentage %	Milk fat production (g/day)+
.37	2.75	8.11^{b*}	223.0
.69	3.30	7.04^{a}	232.3
.37+ .21 *Gliricidia*	2.53	8.25^{b}	209.0

\+ No significant differences ($P > 0.10$) in milk fat production.

* Significant differences ($P < 0.05$) are indicated by dissimilar super scripts a, b.

Source : Van Der Hoek et al. (1983).

The point that needs to be to stressed is that to our impression the value of NPN-CP in TS should not be underestimated. Apart from the above quoted absence of "spectacular" responses to CP additions to TS it is worth mentioning that positive live weight gain were only possible on TS (Ghebrehiwet et al. 1984; Niraviya, 1984b). Saadullah (1984) also found that animals gained on TS without fishmeal supplement. In one case the live weight gain was around zero but this referred to an open straw heap from which quite a bit N will have escaped, (Tharmaraj et al. 1984). CP values of 5-7% obtained in laboratories after drying do no justice to the CP value of TS. Recalculation of the data of Jayasuriya and Perera (1983)shows that after 2 hours the CP value (= N x 6.25) of TS is still around 9-11%. Recent yet unpublished work points in the same direction. This applies to unaerated TS. A specific and possibly important virtue of NPN on straw is that it becomes slowly and steadily available in contrast to NPN on concentrate. As yet SUP sees no reason for aeration of TS prior to feeding.

Fat :

This component is merely mentioned here because common (Sri Lanka) feeds like coconut cake and rice bran can have fairly high fat contents. Here again it may be necessary to specify to types of fats : liquid, solid saturated or unsaturated. Specific fatty acids are said to be essential also for the rumen metabolism,but excess fat may be harmful especially on the cellulolitic activity of the rumen bugs.

Minerals :

Many small cattle farmers do not even feed common salt and mineral deficiencies generally show up at a long term. Nevertheless the mineral deficiencies will be real. More attention to this aspect is justified as work moves away from methods of treatment.

CONCLUSION

Although straw treatment reduces the need for concentrates, there are a number of reasons to intensify the work on supplements (green leaves as well as concentrates). This is especially relevant since the work on practical urea treatment methods seems to draw to an end. If straw is fed untreated the need for work on supplementation is even more important.

Work on supplementation should take into account fact that basal raw materials in the tropics are generally inferior (indirect effects of climate, exports of better quality feeds). Also, the production levels of animals in the tropics are generally lower and less specialized. Research with relevant levels and types of supplement requires a good understanding of the farmers situation. Often micro economics is not the same as macro economics and high productions are not necessarily profitable productions. In order to predict feeding values of feeds or rations much more work is yet necessary. Voluntary feed intake measurements are of paramount importance plus the establishment of response curves and quantification of interactions. Though catalytic responses are known,the general picture seems to be that additivity exists. Harmful or particularly useful levels of certain concentrates should be established in the future. The main problem of straw is not its low intake but the low intake of nutrients due to low nutrient concentration.

Tropical roughages may be deficient in glucose precursors although the production level needs to be specified. Protein values of urea treated straw should not be understimated. Specific effects of fats and minerals should be studied. With hard work, perseverance and common sense,it should be possible to predict feeding values of tropical feeds. Feed formulation must not be an aim in itself but it can be a help to develop economic rations as long as they are applicable to the surroundings.

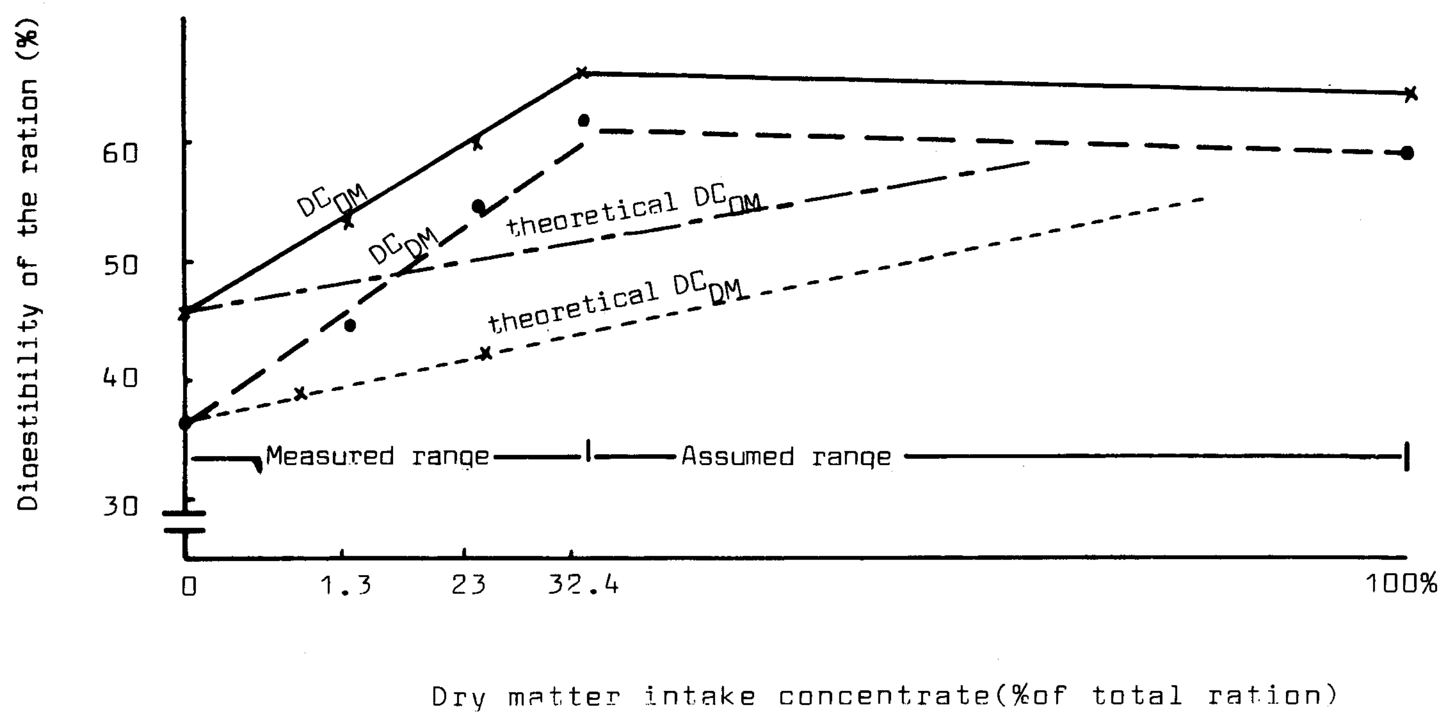
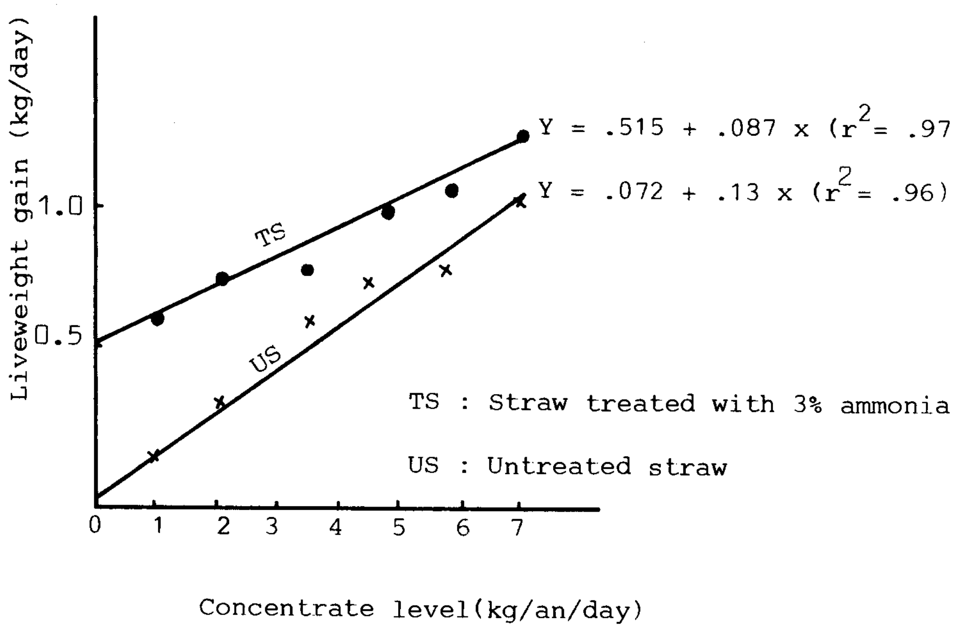


Figure 1. Effect of addition of a commercial dairy concentrate on the **total** digestibility (DC) of the ration of treated straw and that concentrate.

Note: DC_{DM} and DC_{OM} beyond 32.4% concentrate are assumed values.
Especially values near 100% are academic only.

Source: Compiled from Kumarasuntharam (1984), Leelawardene and Van Nes (1984).



Source : Creek et al. (1983)

Figure 2. Response of liveweight gain to level of concentrate fed as a supplement to rice straw.

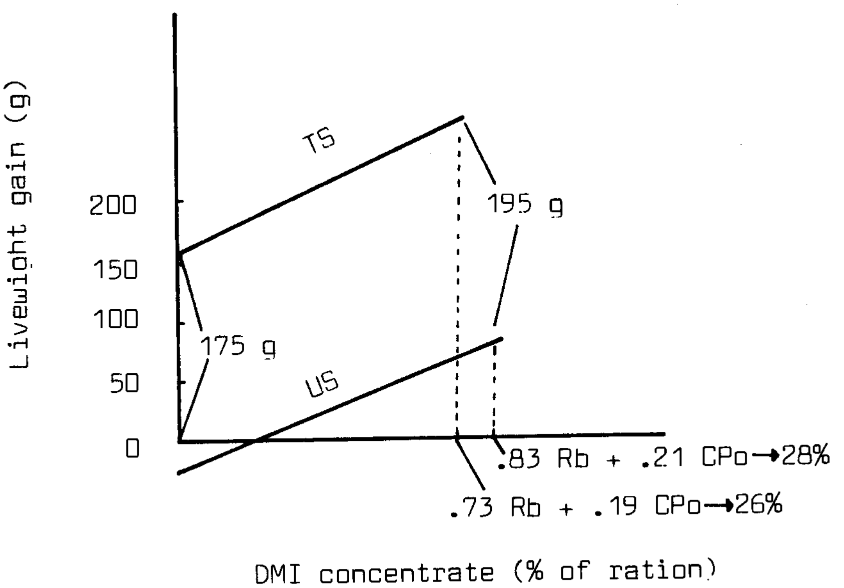


Figure 3; Liveweight gain on treated straw (TS) and untreated straw (US) with and without concentrate supplement (Niraviya ,1984)

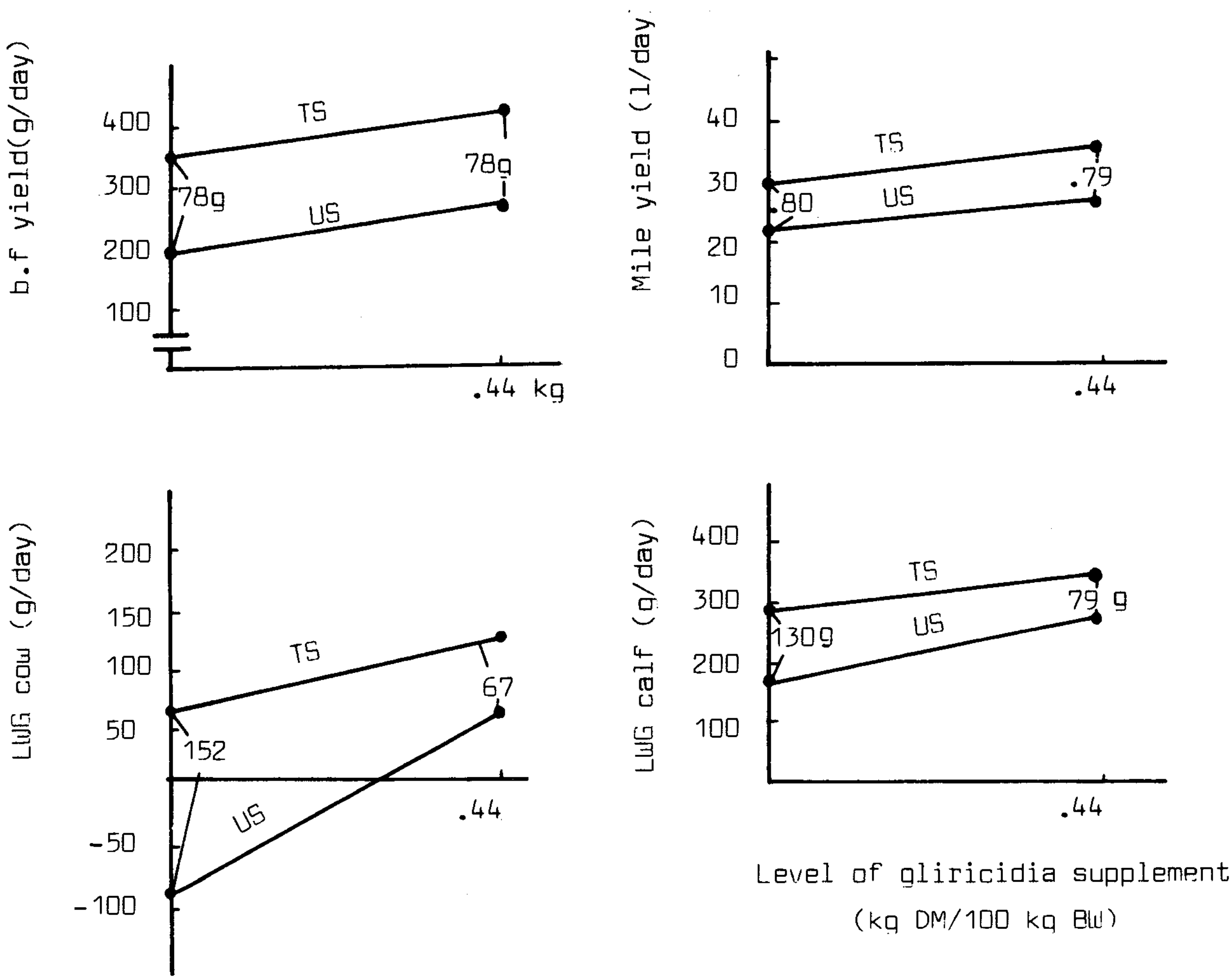


Figure 4. Response of Gir cattle to supplementation of straw (TS) untreated straw (US) with gliricidia.

Source: Perdok et al.(1982)

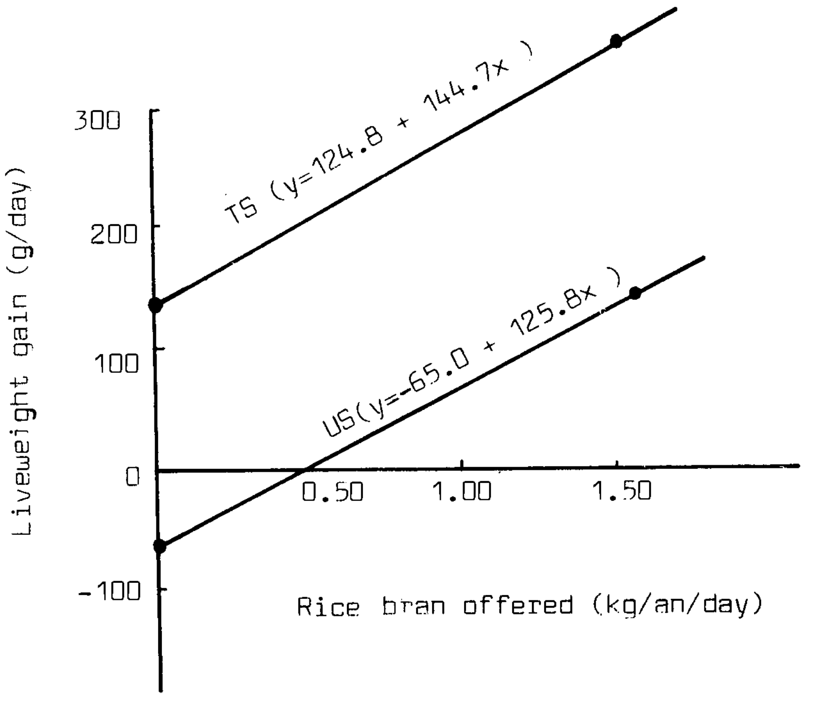


Figure 5: Effect of liveweight gain by adding rice bran to a ration of treated straw (TS) or untreated straw (US).

Source: Ghebrehiwet et al.(1984)

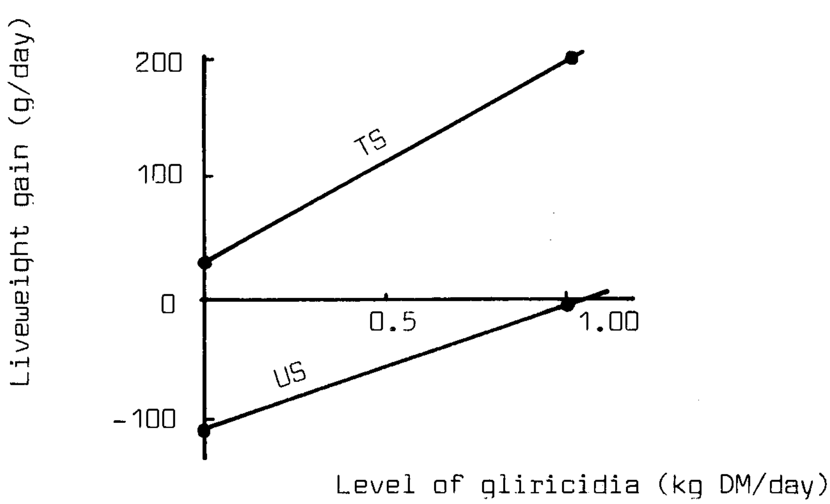


Figure 6: Effect of gliricedia addition on the liveweight of young bulls fed either treated straw (TS) or untreated straw (US)

Source: Tharmaraj et al.(1984)

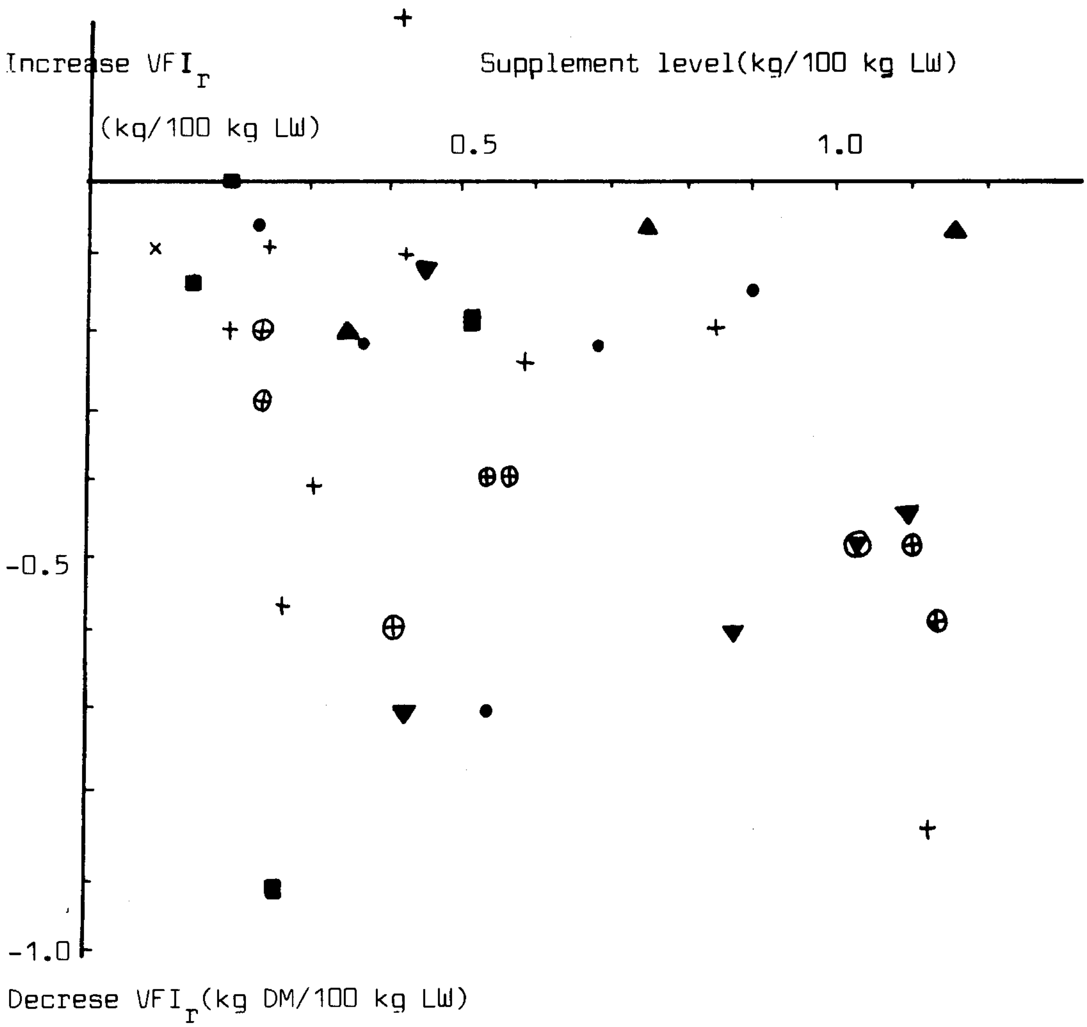


Figure 7: Effect of VFI_c on VFI_r

Note: Explanations to the signs are:

+ =Gliricidia	× =Fish meal
● =Rice bran	▼ =Rice bran + Coconut poonac
■ =Coconut poonac	◆ =Rice bran + Fish meal
▲ =Morlac +	o =With untreated straw

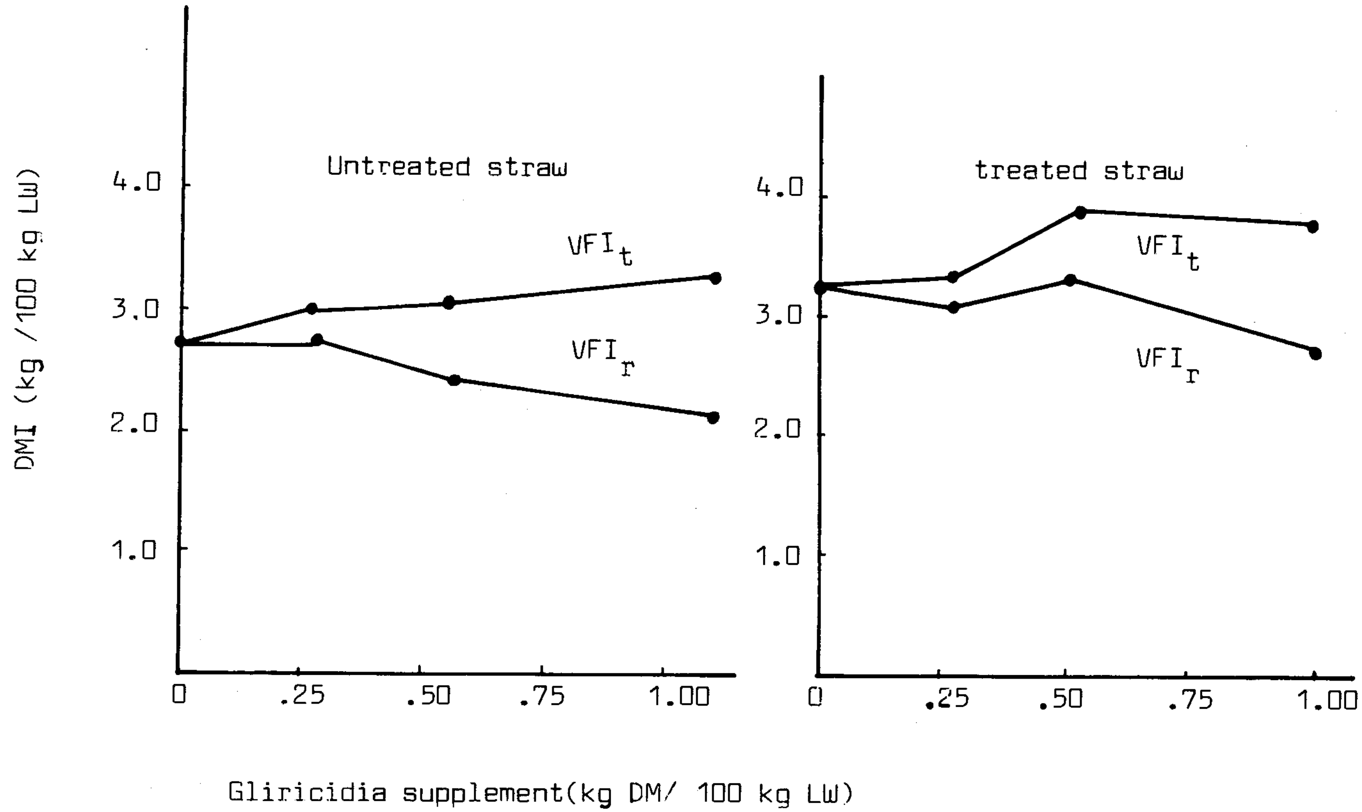


Figure 8: Effect of Gliricidia supplement on VFI_r and VFI_t

(Tharmaraj et al. 1984)

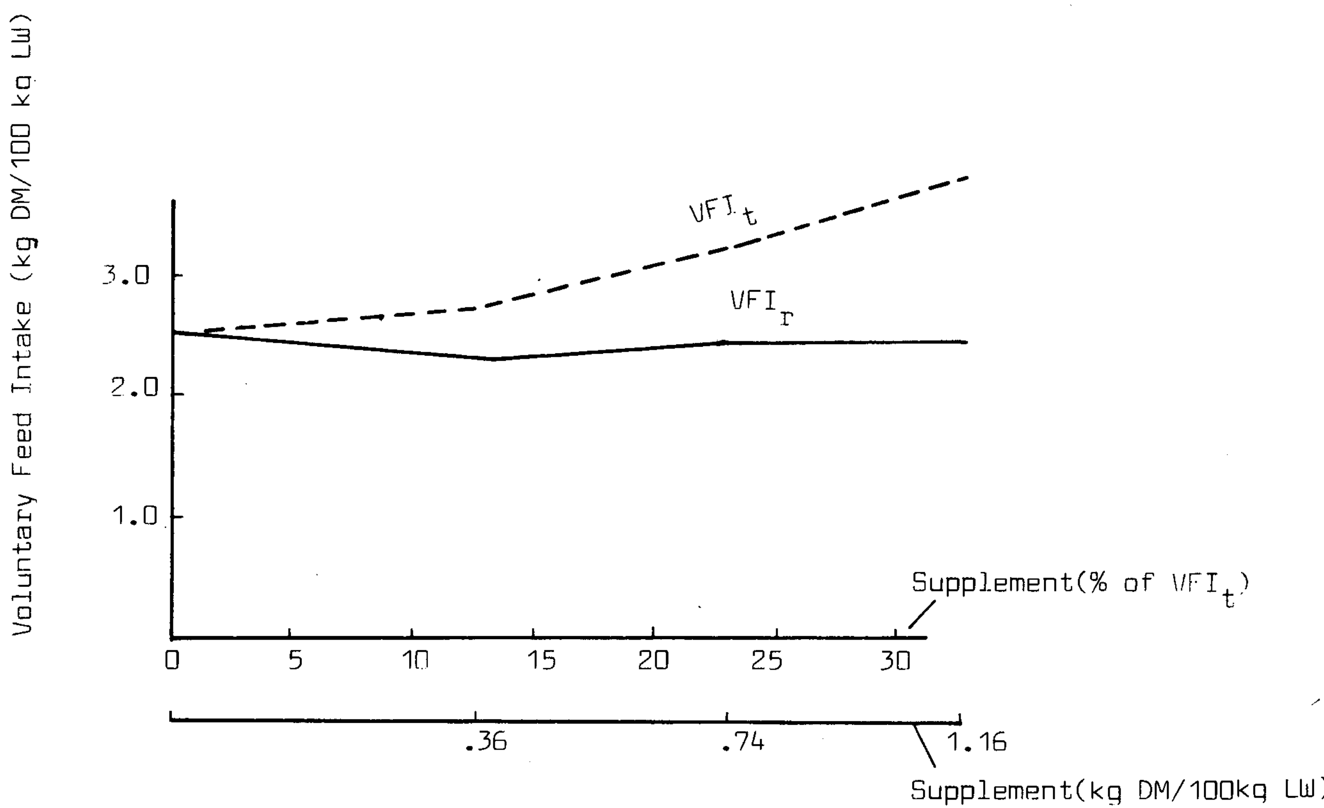
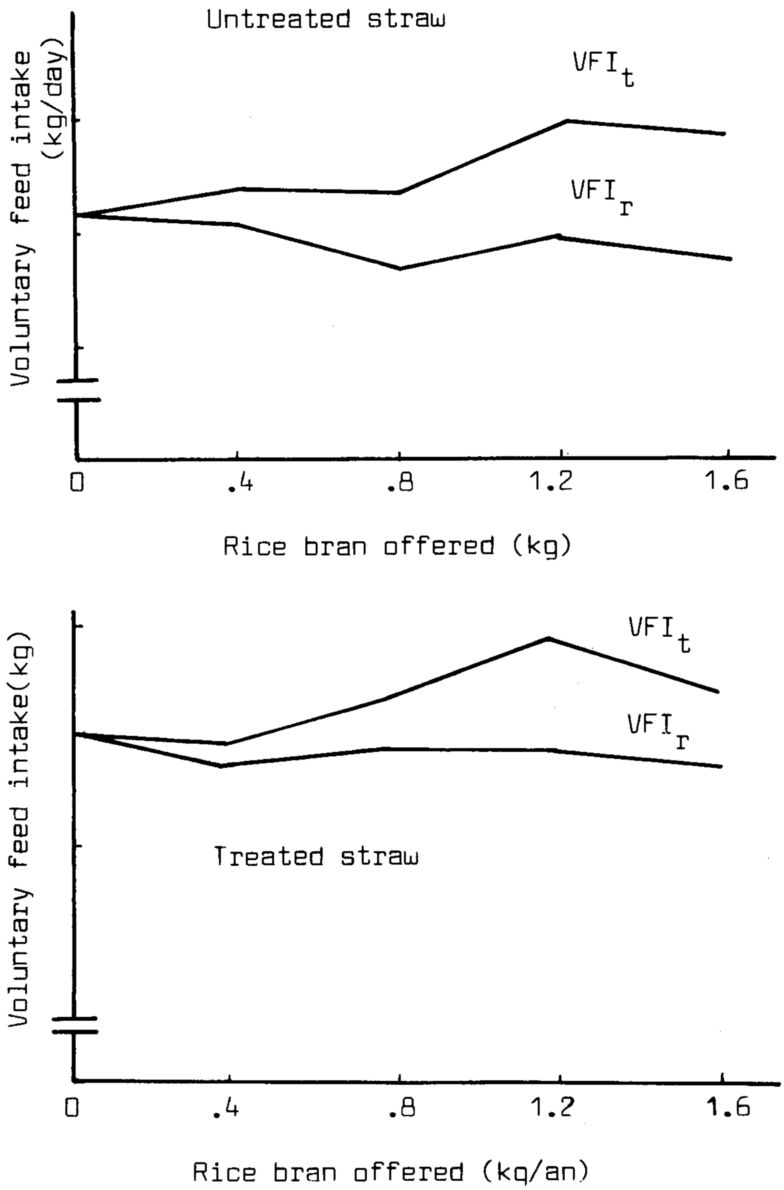


Figure 9: Effect of commercial dairy concentrate intake (VFI_c) on intake of treated straw (VFI_r) and total intake (VFI_t)

source: Kumarasuntharam(1984)



Fiqure 10. Straw voluntary Intake (VFI_r) as affected by increasinq levels of rice bran

Source : Gebrehiwet et al.(1984)

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PRODUCTION RESPONSES OF LACTATING COWS FED UREA-TREATED RICE STRAW COMPARED TO UNTREATED RICE STRAW SUPPLEMENTED WITH LEUCAENA LEAVES

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SUMMARY

Six cross-bred Holstein-Friesian Lactating cows were used to investigate milk production and milk composition response when fed 4% or 6% urea treated rice straw or untreated rice straw plus leucaena leaves for 84 days. Rice straw was treated with urea solution (6% or 4% + 100% water, w/w) and stored for at least three weeks. The treated rice straw was aerated until no odour of ammonia could be noticed. Supplemented sundried leucaena leaves were supplied in a fixed amount (1.5 kg/d) on an ad lib. diet of untreated rice straw. There were no significant differences in dry matter intake between groups fed 6% urea-treated straw (11.23 kg/d), 4% urea-treated straw (10.7 kg/d) or untreated straw plus leucaena leaves (11.12 kg/d). No significant differences between treatment mean were also found for milk production and milk composition : 8.8 kg FCM/d, 8.4 kg FCM/d and 8.5 kg FCM/d respectively, 3.7%, 3.7% and 3.4% milk fat respectively and 3.5%, 3.5%, 3.4% milk protein respectively.

Key words : urea-treated rice straw, leucaena leaves, production, Holstein-Friesian lactating cows.

INTRODUCTION

Crops residues from agricultural operations are extremely large in relation to primary products in South-East Asia. Many attempts have been intensified to this region to make better use of main crop residues. Rice straw, represents the main by-product in

Thailand and always form the main roughage supply for cattle and buffalos during the dry season.

Parameters of production are reported to decrease, if rice straw forms the main component of the ration (LBS Chiangmai, 1979) and remains unchanged by supplementing straw rations by concentrates (Promma et al.,1982). Treatment of rice straw with urea has been shown to increase voluntary dry matter intake (Promma et al.,1982; Wanapat et al., 1982). Feeding urea treated rice straw could maintain weight of dairy heifers (Promma et al., 1982), Sahiwal heifers (Perdock et al., 1982) and growing steers (Wanapat et al., 1982). Positive production responses in buffaloes were recorded with diets containing urea treated rice straw (Perdock et al., 1982) and in cross-bred lactating cows (Promma et al., 1984; Rengsirikul and Chairatanayuth, 1984).

Treatment of rice straw with urea has been done by using 4% urea(Perdock et al., 1982) or 5% urea (Saadullah et al., 1982; Verma et al., 1982; Wanapat et al., 1982) or 6% urea (Promma et al., 1982; Rengsirikul and Chairatanayuth, 1984). Similar results have been reported elsewhere and confirmed that treatment of rice straw with urea seem to be the most practical method in South-East Asia.

Supplementation of rice straw with leucaena leaves for dairy bull calves was investigated by Cheva-Isarakul and Potikanond(1984). Dry matter intake, weight gains and feed conversion were similar to group being offered urea treated rice straw, when fed with concentrates. Consequently, this method may be useful in areas where leucaena leaves are available.

This experiment was carried out to investigate the production responses of Thai-crossbred : Holstein-Friesian lactating cows on urea treated rice straw compared to untreated rice straw supplemented with leucaena leaves, and to compare it is economic terms with the results of lactating cows being offered 4% urea treated straw, 6% urea treated straw and untreated straw supplemented with leucaena leaves in completion with concentrates.

MATERIALS AND METHODS

Urea treatment of rice straw

All rice straw is treated with 4% or 6% urea and 100% water w/w. Sheets of plastic are spread and have to overlap to provide an adequate seal against the floor surface. Rice straw is spreaded uniformly over the plastic bottom. Part of the quantity of water was sprinkled over the straw using a sprinkling can. The rest was used to dissolves urea (4% or 6% of urea) and the solution was sprinkled over the straw again. The next layer is treated in the same way, until the stack contains the required quantity (500-100 kg). The stack is sealed off by using plastic sheets overlapping each other. Covering sheets are folded at its bottom and pushed under the ground sheet. Shading is done by using used gunny bags, palm leaves or bundles of straw. The straw heap is stored for at least 3 weeks. All treated rice straw needs to be aerated until no adour of ammonia can be noticed.

This experiment was conducted at Chiangmai Livestock Breeding Station, Thailand, throughout the dry season of 1984. 6 crossbred Holstein Friesian lactating cows were selected 1 week after second calving, with similar blood, body weight,milk production/day and similar milk production in first lactation period. All lactating cows were dewormed and randomly allocated in a balanced design for three periods of 28 days. The three different treatments were :

1. 6% urea treated rice straw (ad libitum) + concentrate (ration).

2. 4% urea treated rice straw (ad libitum) + concentrate (ration).

3. Untreated rice straw (ad libitum) + dry leucaena leaves (1.5 kg/h/d)+ concentrate (ration).

Concentrates were prepared based on 12% digestible protein and 70% TDN respectively. All lactating cows were given concentrates twice a day before milking. Milking was done by milking machine at 0500 hours and 1500 hours. The feed intake of roughages and concentrates were measured daily. Milk samples were analysed in a milk laboratory weekly throughout the experimental period. The body weight of cows were measured at the end of each period. All lactating cows were adequately supplied with minerals and water.

The examination of feeding effects and the comparison of treatment means were done by using analysis of variance and orthogonal comparisons as described by Chantalakhana (1980).

RESULTS AND DISCUSSION

Straw treatment method

Treatment of rice straw with 6% urea has been done in Thailand by Promma et al., since 1979. Six percent of urea was used to ensure an adequate amount of ammonia as some of ammonia will escape between plastic layer. The small scale experiment with different levels of urea by Promma and Panichayakarn (1983) showed that total fixed nitrogen and dry matter digestibility of 4% urea treated aerated rice straw was similar to the 6% urea treated rice straw ($P > 0.01$) (Table 1). Total untreated ammonia in fresh 10% urea treated straw was higher than those of 8%, 6% and 4% urea treated rice straw respectively. Consequently, 4% urea (w/w of straw) may be sufficient for rice straw treatment in warm climate. Similar results with 4% urea treatment have been reported by Jayasuriya (1980) and Jayasuriya and Perera (1982).

The chemical composition of feeds used were shown in table 2. The results of urea treatment increased organic matter digestibility from 49.0 to 54.2 (6% urea treated straw) and from 49.0 to 53.9 (4% urea treated straw). The average increase in crude protein was 5.1% units (6% urea treated straw) and 1.5% unit (4% urea treated straw). Crude protein content of 4% in urea treated

Table 1. Effect of urea level on fixed nitrogen, untreated ammonia and dry matter digestibility of treated rice straw at 21 days ensiling period.

Parameter	Concentration of urea, %			
	4	6	8	10
Fixed nitrogen, %	1.056[a]	1.320[a]	0.830[b]	0.770[b]
Untreated ammonia, %	1.57[a]	1.51[a]	1.80[b]	2.63[b]
IVDMD, %	45.2[a]	43.5[a]	46.5[a]	43.5[a]

Promma and Panichayakarn (1983).

[ab] Means on the same row with different superscripts differ ($P < 0.05$).

Table 2. Chemical composition of feeds used in feeding trial for lactating cows.

Feed	Percent of dry matter						
	DM	ASH	EE	CF	CP	NFE	IVDOM
Concentrate mix	88.5	8.3	7.9	17.1	14.2	41.0	-
Untreated rice straw	91.1	14.6	2.8	38.4	2.6	32.6	49.0
6% urea treated rice straw	95.3	15.4	3.5	40.9	7.7	27.8	54.2
4% urea treated rice straw	96.9	15.3	3.2	41.2	4.1	33.1	53.9
Leucaena leaves	90.0	8.0	4.4	15.1	23.0	39.5	57.3

aerated rice straw was slightly lower than 6% urea treated aerated rice straw. This may be due to lower concentration of ammonia in 4% urea treated straw heap as some of ammonia could escape between plastic layers. Consequently 4% urea treatment requires carefully sealing off or in the other hand, 4% urea treated rice straw should be fed without aeration. Feeding 4% urea treated unaerated rice straw has been done and reported by Jayasuriya, 1980; Jayasuriya and Perera, 1982; Perdock et al., 1982;Ibbrahim, 1984. Feeding un aerated treated rice straw could protect nitrogen loss by some 25% (Jayasuriya and Perera, 1982).

Lactating cows performance

Total voluntary intake of each diet; roughage dry matter intake weight change, milk production and milk composition are summarized in Table 3.

There were no significant differences in dry roughage intake between groups being fed 6% urea treated straw (7.20 kg/d),4% urea treated straw (6.8 kg/d) and untreated straw plus leucaena leaves (7.0 kg/d), or 1.98, 1.86 and 1.95% BW/d or 86.6, 81.4 and 84.8 g/kg $W^{0.75}$/d respectively. Total dry roughage intake in group-fed untreated rice straw plus leucaena leaves was similar to those given urea treated rice. This may be due to the feeding regime which all supplemented leucaena leaves was given 1 hour prior to the untreated rice straw feeding (0800 hours),or the supplementation of legume leaves could increase feed intake (Lane, 1982; Sriwattanasombat and Wanapat, 1984). Nevertheless, dried leucaena leaves were used only in one fixed ration (1.5 kg/h/d or 1.35 kg DM/h/d). More trials are needed to determine the most appropriate ratio of leucaena leaves and rice straw.

Live weight change was similar in all treatments. Most cows were able to gain weight particularly after having passed peak production. Lactating cows being offered untreated rice straw plus leucaena leaves tended to have slightly lower weight gain(71.8

Table 3. The performance of lactating cow given 6% urea treated rice straw, 4% urea treated rice straw and untreated rice straw plus leucaena leaves.

Parameter	6% urea treated straw	4% urea treated straw	Untreated straw + L
Roughage dry matter intake,			
kg/hd/day	7.2[a]	6.8[a]	7.0[a]
g/kg $W^{0.75}$/day	86.6	81.4	84.8
% BW	1.98	1.86	1.95
Concentrates dry matter intake,			
kg/hd/day	4.03[a]	3.9[a]	4.12[a]
Total dry matter intake,			
kg/hd/day	11.23	10.7	11.12
Feed efficiency, kg feed/kg			
FCM milk	1.28	1.27	1.31
Milk production (4% FCM),			
kg/hd/28 days	245.0[a]	234.9[a]	236.0[a]
kg/hd/day	8.8	8.4	8.5
Milk fat, kg/hd/28 days	9.4[a]	9.2[a]	8.9[a]
Average fat, %	3.7	3.7	3.4
Milk protein, kg/hd/28 days	9.03[a]	8.62[a]	8.9[a]
Average protein, %	3.5	3.5	3.4
Weight changes, g/day	+96.4[f]	+96.3[f]	+71.8[f]

[a]No significant differences (P > .25) were observed.

g m/d) while cows being fed 6% urea treated straw or 4% urea treated straw showed similar weight gain (96.4 gm/d and 96.3 gm/d respectively).

The lower weight gain may be due to an inappropriate ratio of untreated rice straw and leucaena leaves or insufficient digestible energy. However, there were no significant differences between treatment means.

Differences in average milk production expressed as 4%FCM/hd/d or 4% FCM/hd/period were not significant for cows being fed 6% urea treated straw (8.8 kg/hd/d or 245 kg/hd/period),4% urea treated straw (8.4 kg/hd/d or 235 kg/hd/period)and untreated straw plus leucaena leaves (8.5 kg/hd/d or 237 kg/hd/period). The cows being offered 4% urea treated straw tended to be slightly lower in milk production. This may be due to a lower crude protein content of 4% urea treated aerated straw compared to 6% urea treated straw (Table 2) or lower roughage dry matter intake and lower total feed in take. However, lactating cows being offered 4% urea treated straw showed a minimum feed efficiency (See Table 3).

Differences in milk composition expressed as average percentage of fat and protein in milk or fat and protein production per period were not significant for cows being fed 6%urea treated straw, 4% urea treated straw and untreated straw plus leucaena leaves. The animal being offered untreated straw plus leucaena leaves tended to show slightly lower milk fat production. This may be due to the feeding regime or the ratio of untreated straw and leucaena leaves supplementing by concentrates,could not meet the proper requirement.

Economic evaluation

There were no significant differences in average net profit obtained from milk sale for cows being fed 6% urea treated straw (12.9 B/h/d or 575.4 B/h/month), 4% urea treated straw (19.15 B/h/d

Table 4. Economic evaluation of lactating cows fed 6% urea treated rice straw, 4% urea treated rice straw and untreated rice straw plus leucaena leaves.

Parameter	6% urea treated straw	4% urea treated straw	Untreated straw + L
Variable cost (฿/100 kg milk) : labour, feeds, antibiotic instrument, A.I., 13% interest etc.	336.3	326.3	331.7
Stable cost (฿/100 kg milk) land, barn , cows, tools, 13% interest, etc.	86.0	86.0	86.0
Total operation cost,			
฿/100 kg milk	422.3	412.3	417.7
฿/kg milk	4.22	4.12	4.18
Average milk yield, kg/hd/day	8.8	8.4	8.5
Milk price, ฿/kg	6.4	6.4	6.4
Net income, ฿/hd/d	19.20[a]	19.15[a]	17.26[a]
฿/hd/month	575.4	574.5	517.8

[a] No-significant difference (P > .25) was observed.

or 574.5 B/h/month) and untreated straw plus leucaena leaves (17.3 B/h/d or 517.8 B/h/month) (See Table 4). Average net profit obtained for lactating cows being fed urea treated rice straw was similar to those reported by Promma et al., (1984). However, it can be considered from table 4 that while the cost of the diet containing leucaena leaves tended to be the lowest, average net profit obtained showed some particular trend. This was due to the increase of variable cost, of which 57% was used for concentrates, in cows being offered untreated rice straw, while cows being offered 6% urea treated straw or 4% urea treated straw required 53.4% and 55.5% respectively.

CONCLUSION

Feeding 6% urea treated rice straw can increase liveweight gain and animal milk production, the cows condition and production can be well maintained during the dry as well as during the rainy season (Froemert, 1983).

Feeding 4% urea treated rice straw could maintain cow's conditions and production as well as 6% urea, treated rice straw.Further alternative methods for lactating cows feeding,may requires non-aerated urea treated rice straw.

The supplementation of untreated rice straw with leucaena leaves could provide nutrients as well as 6% or 4% urea treated rice straw. However, the combination of untreated rice straw and leucaena leaves should be considered for further experiments.

The relevance to the use of each diet depends on many factors : quantity of crop residue and supplementary diets and their availability, cost of operation and profitability, practicability of the method and the acceptance among the farmers.

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SUPPLEMENTING UREA-TREATED RICE STRAW FOR NATIVE CATTLE IN BANGLADESH

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SUMMARY

Two feeding experiments with native cattle were conducted for a period of 120 days in Bangladesh. The calves were fed ammoniated rice straw (urea-treated) supplemented with varying levels of fishmeal (0-250 g in Experiemnt A and 0-150 g in Experiment B) The dry matter and organic matter intake during the experimental period as per cent of live weight varied from 2.5 to 2.8 and 2.0 to 2.3 in Experiment A, and 3.5 to 3.8 and 2.8 to 3.1 in Experiment B, respectively. Lower intakes during the experimental period in Experiment A might be due to the lower initial weight of the calves compared to that of animals in Experiment B and also to differences in the environmental temperature in which the Experiments were conducted. There was little effect on feed intake in per cent of live weight when supplementing low levels of fishmeal with ammoniated rice straw-based diets for ruminants.

The fishmeal supplemented group showed a significant live weight gain ($P < 0.01$) compared to the group fed basal diet of urea-treated (ammoniated) rice straw without fishmeal. Feeding high levels of ammoniated rice straw (90-92%) required 50 g of fishmeal to ensure optimal animal performance.

Key words :Urea-treated rice straw, fish meal, native cattle.

INTRODUCTION

As in all other rice growing countries in Asia, rice straw contributes more than 80-90% of the total available feed for livestock. Straw is fad in addition to weeds, roadside grasses, aquatic plants and limited quantities of agro-industry by-products such as bran, oilcakes and molasses. The quantities of feedstuffs available in Bangladesh are shown in Table 1. The table suggests that approximately 2 kg of straw dry matter and only 0.08 kg of concentrates are available to cattle per head per day.

The concentrates are used not only for ruminants but also for poultry and fish. Under prevailing conditions the formulation of conventional, balanced rations is difficult, because of the limitations in feedstuffs available. The alternative is importation but is obviously undesirable in Bangladesh context.

Table 1. Major feeds available for ruminants in Bangladesh.

Feedstuff	Production (Dry matter) 000 tons	Availability (kg/head of cattle/day)
Rice straw	14,955	
Wheat straw	264	
Total	15,219	2.01
Grasses	1,219	0.20
Concentrate :		
Oilcakes	168	0.02
Rice bran	697	0.06
Sugarcane tops	192	0.03
Fodder crops (misc.)	81	0.01
Molasses	10	0.001

World Bank (1982).

The strategy therefore is to use the limited amounts of feed supplements oilcakes, animal by-products, aquatic plants or tree leaves in such a way that the utilization of fibrous crop residues, is maximised. This is important since very little land is available for the production of fodder or cereals exclusively for livestock.

Straw has low digestibility and nitrogen content. The intake by ruminants is also low. Improvement in digestibility, nitrogen content and higher intake can be achieved through the treating straw with urea as a source of ammonia(Dolberg et al.,1981; Saadullah et al., 1980 and 1981; Verma et al., 1982; Jaiswal et al., 1984 and Perdock et al., 1982). It has been observed by Saadullah et al. (1980a and 1981), Haque et al., (1983). Ørskov (1981), Khan and Davis (1981) and Chauhan (1982) that animals fed poor quality roughages, even when treated with urea (ammonia), need supplementary true protein to make efficient use of the energy available from the treated straw. The combined results of earlier experiments (Saadullah et al., 1981a; 1981b) suggest that a concentrate of supplement less than 0.5 kg/day/calf to a urea-treated basal straw diet significantly improved both feed utilization and daily rate of gain ($P < 0.01$). It was also observed that daily rate of gain for the control group and the group receiving 150 gm fishmeal with increasing levels of rice bran were 143, 357, 354 and 335 g/day respectively. For the groups receiving 300 g oilcake instead of 150 g fishmeal with increasing levels of rice bran, the daily gains were 188, 252 and 235 g/day. It was concluded from the above studies that a small supplement of relatively undegraded protein to the rumen was an essential supplement to urea-treated rice fed to calves.

The objective of the results of experiments reported here was to determine the level of supplemented protein required to develop a response curve when fed with rice straw ammoniated through urea by native growing cattle in Bangladesh.

MATERIAL AND METHODS

Experimental Animals

Local Bangladeshi male calves of approximately more than one year of age and similar live weights were used in feeding experiments A and B. The calves were purchased from the local market and were of unknown pedigree. It was not possible to record the exact age of the calves.

Days on Experiment

The experiment lasted for 120 days and excluded a 15 day preliminary period.

Group of Calves

Thirty-six and 25 male calves were used in experiment A and B, respectively. Experiment A involved 2-six treatments and experiment B five treatments;each group in each experiment used six and five cattle each respectively and were allocated randomly. The groups were randomly placed on the different experimental diets.

Preliminary period and Animal Health

Before collecting the experimental data, an initial adjustment period of three weeks was allowed for the calves to adapt to the experimental diets and housing contions. Faeces from each calf was examined for internal parasites and drugs were administered, where necessary. The calves were penned in loose housing systems in groups of six and five in experiment A and experiment B, respectively.

Experimental Diet

Rice straw ammoniated by means of urea formed the basal diet for the different groups in experiments A and B. Treated straw was fed ad libitum and offered twice a day in two equal amounts at 0700 and 1600 hrs. Fishmeal was also fed to the calves in the morning followed by water hyacinth before giving straw and after removal of leftovers from the feeding trough. This practice was followed to ensure complete ingestion of fishmeal or water hyacinth. Dry straw was treated with 5% urea based on the quantity of sundried straw. The urea was dissolved in an amount of water equivalent to the quantity of sundried straw. Na_2SO_4 at the rate of 0.35% of straw added to the urea solution before spraying it over the straw. The urea solution treated straw was stored for seven days in the earthen pit or bamboo basket and fed to the experimental animals. The straw was chopped to a length of 5-8 cm before being offered to the calves. It should also be noted that these experiments were conducted in two different seasons viz, one in the summer and the other one in the winter.

Feed Intake

Weekly straw intake of the different groups was recorded.

Live weight

The calves in experiments A and B were weighed on two consecutive days at the beginning of the experiment, after the adjustment period of three weeks. They were then weighed twice weekly on two consecutive days and the mean was taken as the weight of the calf for that week.

Statistical Analysis

The results were analysed by analysis of variance and Duncan's multiple range test for significance.

RESULT AND DISCUSSION

Feed Intake

The daily dry and organic matter intake of the calves are shown in Table 2 and 3 from experiments A and B. A higher average dry matter and organic matter intake was observed with the calves of experiment B as compared to that of experiment A and is probably be due to the higher initial live weight of the calves of this experiment. A trend towards a small increase in dry matter intake of the basal diet was seen with increasing levels of fishmeal. This difference in dry matter and organic matter intake was narrowed when the intake was related to live weight. The intake in percent of body weight in these experiments is in good agreement with the findings of Saadullah et al. (1982, 1983), Mould et al. (1982), Perdock et al. (1982) and Hamid et al. (1984), Jaiswal et al. (1984) reported a straw dry matter intake of 3.5-4.0% and 1.9-2.8% on rice straw ammoniated through urea and untreated rice straw diets respectively, with or without supplementation of fishmeal or cotton seed cake. Smith et al. (1980) found a lower dry matter intake of 1.4-1.9% of live weight in exotic breeds of cattle fed a ration of untreated barely straw supplemented with soybean or fishmeal.

Live weight gains and feed conversion

The daily live weight gains and feed conversion of calves in experiments A and B are illustrated in Figure 1. It will be seen that little benefit was shown in live weight gains in cattle gives supplements beyond 50 g per day to the basal diet. This results suggested that the supplementation of 50 g of fishmeal to the basal diet of experiment A was the optimal level for higher live weight gains and feed efficiency. The basal diet group without fishmeal were able to show moderate live weight gains of 57 and 80 g/day both in experiment A and experiment B respectively. Supplementation of the basal diet in experiments A and B with 15, 25, 50, 100, 150, 200 and 250 g of fishmeal enabled the calves to grow faster than the group fed the basal diet of urea-treated straw indicating that supplements removed major nutritional limitations imposed by the basal diet.

Table 2. Dry matter intake, live weight gain and feed conversion of the experimental calves (Experiment A).

Attribute	Treatments (g fish meal)						SE of means
	1	2	3	4	5	6	
	0 g	50 g	100 g	150 g	200 g	250 g	
Initial live weight , kg	48.5	52.5	51.5	52.6	51.1	52.0	
Final live weight, kg	57.3	83.0	81.8	83.5	81.0	85.2	
Daily DM intake, kg	1.4	1.7	1.8	1.7	1.8	1.9	
Daily OM intake, kg	1.1	1.3	1.4	1.4	1.5	1.5	
DM intake in % of BW	2.8	2.5	2.6	2.6	2.7	2.8	
ADG, g	57a	198b	197b	205b	192b	215b	40
Feed conversion, kg	25	9	9	8	9	9	

ab Values with in the same line with different subscripts differ ($P < 0.05$).

Table 3. Dry matter intake, live weight gain and feed conversion of the experimental calves.

Attribute	Treatments (g of fish meal)					SE of means
	1 0 g	2 15 g	3 25 g	4 50 g	5 150 g	
Initial live weight, kg	55.0	55.2	55.0	56.4	56.8	
Final live weight, kg	64.6	71.8	73.0	81.8	81.8	
Daily DM intake, kg	2.1	2.2	2.2	2.3	2.5	
Daily DM intake, % BW	3.5	3.6	3.6	3.4	3.5	
Daily OM intake, kg	1.7	1.8	1.8	1.8	2.0	
ADG, g	80a	142b	151b	203c	206c	16
Feed conversion	26	15	15	11	12	

^{abc}Values with in the same line with different subscripts differ ($P < 0.01$).

The initial dramatic response to 15 g of fishmeal supplementation to the basal diet was significant ($P < 0.01$) and is not easily explained. According to Ørskov (1984), approximately 2% of the daily live weight gain is nitrogen. The difference in daily gain between the control and the group receiving 15 g of fishmeal was 62 g live weight gain. This was equavalent to 1.24 g (62 x 0.02 N) or 7.8 g of crude protein gained the animal body daily. But the dietary protein intakes in this group were 8.3 g. On the basis of the outflow rate of 4.4% and a protein degradability of 59% at 16 hours of incubation, this group received only 3.3 g of crude protein post-ruminally. Thus the input of crude protein was smaller than the output of 7.8 g of crude protein. It is very difficult to accept that the response on live weight gain was due to the effect of undegraded protein from fishmeal. This dramatic response on live weight gain due to fishmeal supplementation of the basal diet may not be attributed to the protein supplement,but some unknown 'factor' might have contributed to it by enhancing the better utilization of fermented products for production purposes. Hovell et al. (1976) suggested that the presence of unknown 'factors' in the concentrate diet, which allow efficient utilization of acetate, presumably by aiding its conversion to lipids via fatty acids, may play a part. Mould et al. (1982) reported that the digestible dry matter intake and live weight gain were 2.79 and 0.29 kg/day in calves fed untreated rice straw and a supplement of fishmeal and 2.9 and 0.38 kg/day for calves fed urea- treated rice straw and the same amounts of fishmeal. They also observed that the digestibility of dry matter was 65% and 64%with untreated straw failed to contribute in live weight gain to the extent of that on urea-treated diets. Smith et al. (1980) also observed that digestibility of poor quality roughages,either supplemented with urea or fishmeal, was more or less the same, but fishmeal supplemented rations resulted in significantly higher live weight gains as compared to those of animals given urea supplement. The live weight gains observed with calves fed urea-treated straw with water hyacinth and with or without fishmeal supplement were not unexpected in view of the findings of Saadullah et al. (1982, 1983), Hamid et al.(1984), Verma et al. (1982), Perdok et al. (1982) and Jaiswal et al. (1984). However, the daily rate of gain in those experiments were higher than the findings of the present study, but the feed conversion ratio was were low from 18-24 with urea-treated straw to 8-10(kg dry matter per kg live weight gain) with urea treated straw supplemented with 50-100 grams of fishmeal. The comparable data for exotic breeds and small cattle fed high levels of straw were shown in Table 4. To compare the small-sized cattle like the native cattle of Bangladesh with exotic breeds in terms of daily live weight gain may not give a true picture (Dolberg, 1981). To be meaningful, figures must be related to the size of animals. Large animals have to grow faster than small animals to obtain the same efficiency. In spite of a growth rate of 594 and 650 g/day at initial live weights of 255 and 297 kg, respectively, the larger breeds were not more efficient converters than the small animals (53 and 56 kg) 198 and 203 g/day with a feed conversion ratio of 9 and 11 in the present experiments A and B (Table 4).

Table 4. Comparison of live weight gain (LWG) and feed conversion (FCR) of different types of cattle fed high level of straw.

Breed of animals and country	No. of animals in Expt.	Experi- ment period (days)	Initial L.W. (kg)	LWG (g/day)	FCR	Diets on DM basis	Reference
Steer, USA	24	109	205	650	9	72% straw	Lesoing et al.(1981)
Steer, USA	20	114	297	650	15	78% straw	Lesoing et al.(1981)
Hereford X Angus, USA	30	175	255	294	18	72% straw	Garret et al.(1975)
Kedah-Kelantan Malaysian	6	518	73	275	14	100% Napier	Devendra and Lee(1975)
Local Bangladeshi	18	84	57	110	16	99% straw	Saadullah et al.(1981)
Local Bangladeshi	24	106	68	377	8	85% straw	Saadullah et al.(1982)
Local Bangladeshi	42	154	53	198	9	92% straw	Saadullah(present study)
Local Bangladeshi	42	119	56	203	11	90% straw	Saadullah(present study)

N.B. In all cases straw was treated with urea.

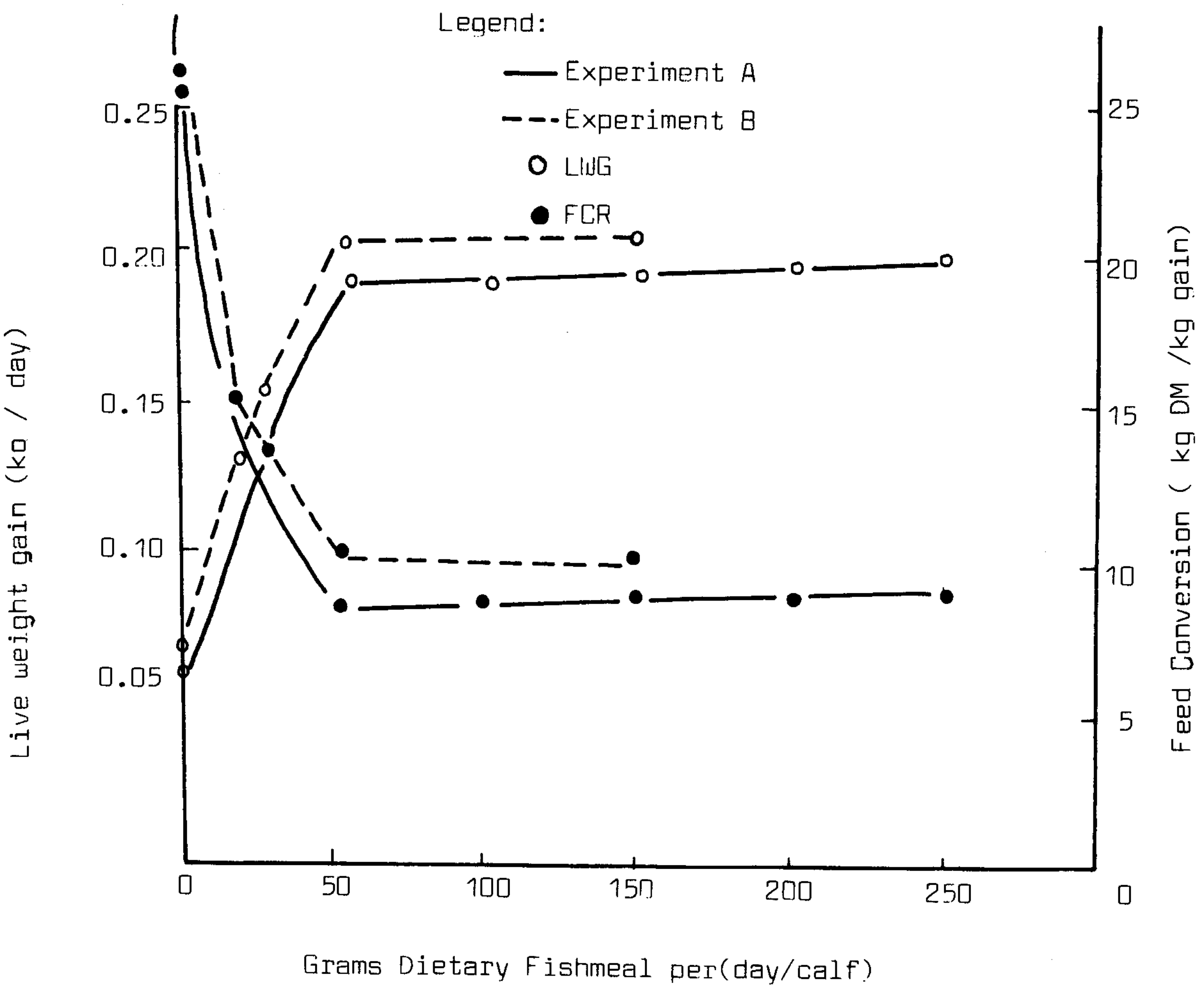

Figure 1. Effect on live weight gain (LWG) and Feed Conversion (FCR) as function of dietary Fishmeal.

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FEEDING UREA-TREATED RICE STRAW TO LACTATING BUFFALO COWS

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SUMMARY

The influence of four experimental diets: untreated rice straw (UTS), UTS + rice bran (RB), UTS + ipil-ipil leaf meal (ILM) and UTS + RB + RB + ILM given to pregnant and lactating buffalo cows, on body weight, heigh at withers and heart girth of new born calves, monthly weight changes of suckling calves and reproduction parameters of the cows were investigated. No significant differences (P > 0.05) were found among experimental diets.

Key words : urea-treated rice straw, buffalo cows, calves, reproduction, body weight.

INTRODUCTION

Rice straw is the largest fibrous crop residue available for feeding of livestock. It is low in available energy, nitrogen, minerals and vitamins. Its utilization is limited by low voluntary intake. When it is fed alone it cannot sustain effective animal production. Improvement in digestibility and intake of this straw has been achieved by supplementary feeding to provide nitrogen, minerals, vitamins etc. for optimum rumen function. Ensiling rice straw with urea improves the voluntary intake and nutritive values of the straw supplementation of urea treated with *Leucaena leucocephala* for dairy cows increases milk production.

Thai buffaloes are of the swamp type and the milk production is low. Feeding of urea treated rice straw to this buffalo during pregnancy or lactation could affect reproduction, milk production and growth of their calves. Informations on these parameters were investigated.

MATERIALS AND METHODS

Buffalo cows

Sixteen pregnant buffalo cows were given four kinds of diets, four animals/diet, 60 days before calving. The animals were continuously fed the same feed postcalving. The animals were kept individually in a stall.

Experimental diets

The four experimental diets were :

1. Urea treated rice straw (UTS)
2. UTS + 500 g rice bran/animal/day (RB)
3. UTS + 1% body weight of ipil-ipil leaf meal/animal/day(ILM)
4. UTS + RB + ILM

Feeding

Urea-treated rice straw was given to the animals twice a day, at 9.00 a.m. and 3.00 p.m. Supplementation of RS, ILM and RS + ILM were given in the afternoon. Water and minerals were available at all times.

Buffalo calves

Birth weights, height at withers and heart girth of the calves were recorded within 24 hours. The calves were weighed monthly from birth to the fourth month and were separated from their dams for a night before weighing. Calves were dewormed within seven days and repeated again 30 days after the first deworming. Calves were allowed to suckle and live with their dams.

Preparation of urea-treated rice straw

Urea treated rice straw was prepared as described by Wongsrikeao and Wanapat (1984). UTS were ensiled for three weeks before feeding to the animals.

Reproduction parameters

Disappearance of corpus luteum (CL) and the involution of uterus were identified by rectal palpation. Occurrence of postpartum estrus was detected by the presence of vaginal mucus and the assistance of vesestomized bull.

RESULTS AND DISCUSSION

Birth weights, heights and heart girths of the calves

Average birth weigh, height at withers and heart girth of new born calves of buffaloes fed UTS, UTS + RB, UTS + ILM and UTS + RB + ILM were not different (P > 0.05) and are shown in Table 1.

Table 1. Birth weights, heights and heart girths of new born calves of buffalo fed UTS with or without supplement.

Diet for buffalo cows	Calves		
	Birth weight (kg)	Height at withers (cm)	Heart girth (cm)
UTS	25.5	65.50	72.30
UTS + RB	24.0	66.44	69.62
UTS + ILM	24.75	67.25	71.50
UTS + RB + ILM	26.26	68.70	72.14

The results indicated that feeding UTS with or without supplementation to late pregnant buffalo cows did not affect birth weight, height at withers and heart girth of calves. Difficulties in parturition had never been encountered in this study. Average birth weight, height at withers and heart girth of buffalo calves in Thailand have been reported. Under management at the Surin Buffalo Breeding Centre, improved pasture was available for grazing most of the time, except during extremely dry periods (late February to early May) when hay and/or silage was given to the animals in supplement to grazing. The average birth weight of male calves were 28.6 kg, as compared to 26.9 kg of the females (Chantalakhana et al., 1983a). The mean weight, height at withers heart girth and the length of body of buffalo calves at the Surin Livestock Station born during the years 1957 to 1975 were 26.6 cm, 68.9 cm, 67.3 cm for female; 68.8 cm for male and 69.2 cm for female; 52.5 cm for male and 51.4 cm for female calves, respectively (Chantalakhana et al. 1977). At the Suratthani Livestock Station, the birth weight was 32.8 kg for male calve and 31.9 kg for female calves (Pongphairoj and Chaidet, 1979). Harber (1981) reported the birth weights were on the average 28.8 $\pm$ 6.6 kg and 28.8 $\pm$ 5.4 for the male and female calves in eight villages of the Northeast of Thailand. The weight of the calves in this study was a little bit lower than those that have been mentioned above and could be due to variation of parity, season, climatic factors genetic factors and management.

Body weight change and growth character of suckling buffalo calves

The average monthly weights from birth to four months of suckling calves of lactating cows fed UTS, UTS + RB, UTS + ILM and UTS + RB + ILM were 74.3 kg, 74.8 kg, 75.3 kg and 77.8 kg with an average daily gain of 0.40 kg, 0.42 kg, 0.42 kg and 0.43 kg respectively.

Table 2. Means of monthly weights from birth to four months of suckling buffalo calves of lactating buffalo cows fed UTS with or without supplementation.

Age (m)	Diets			
	UTS	UTS + RB	UTS + ILM	UTS + RB + ILM
Birth	25.5	24.0	24.75	26.26
1	37.72	36.42	39.24	40.42
2	49.32	50.06	54.61	55.10
3	62.84	63.25	63.60	65.46
4	74.32	74.80	75.26	77.84
Average daily gains, kg	0.40	0.42	0.42	0.43

Monthly weight changes of buffalo calves among groups were not different ($P > 0.05$). Supplementation of UTS with RB or ILM or a combination of RB and ILM to lactating buffalo cows showed the same growth pattern as feeding UTS. However, combined RB and ILM feeding was better than the rest. There are two issues to be considered. Firstly level of supplement is not high enough to affect the growth of the calves. Secondly, there is the genetic make up of buffalo cows. Thai buffaloes are meat type and the milk yield is low. However, UTS increased milk production in dairy cows were reported by Khan and Davis (1981), Promma et al. (1984) and Rengsirikul and Chairatanayuth (1984). Chantalakhana et al. (1983b)has determined the growth pattern of Thai swamp buffalo. The birth weights were 28.0 kg and 28.2 kg in the male and the female, . respectively. The month weights at four months age for the respective sexes were 75.51 kg and 79.27 kg.

Reproduction parameters of buffalo cows post calving

Reproduction parameters of buffalo cows postcalving affected by feeding UTS, UTS + RB, UTS + ILM and UTS + RB + ILM are shown in Table 3. Disappearance of corpus luteum, involution of uterus and occurrence of first postpartum estrus were found to be not significant ($P > 0.05$). CL disappearance were 2.75, 3.0, 2.5 and 2.5 days; involution of uterus was 30.5, 29.25, 31.25 and 31.00 days; first postpartum estrus was 116, 114, 114 and 112 days for cows fed UTS, UTS + RB, UTS + ILM, UTS + RB + ILM, respectively. The results indicate that feeding of UTS with or without supplement did not enhance the involution of uterus and postpartum estrus. This could be due to the effect of suckling. It has been known that suckling prolongs the occurrence of post partum estrus.

Table 3. Reproduction parameters of buffalo cows fed UTS with and without supplement at postcalving.

Reproduction parameters	Diets			
	UTS	UTS + RB	UTS + ILM	UTS + RB + ILM
CL disappearance	2.75	3.0	2.5	2.5
(days)	(1-5)	(1-5)	(1-6)	(1-5)
Involution of uterus	30.5	29.25	31.25	31.00
(days)	(26-38)	(25-34)	(27-40)	(25-36)
First postpartum	116	114	114	112
estrus (days)	(72 136)	(68-138)	(71-140)	(74-132)

CONCLUSION

UTS can be used to feed the buffalo during late pregnancy and during lactation. Supplementation of UTS with rice bran or ipil-ipil leaf meal showed the same results as UTS alone.

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PRACTICAL ASPECTS OF UREA-AMMONIA TREATMENT OF RICE STRAW AT FARM LEVEL

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SUMMARY

The paper discusses practical aspects of urea-ammonia treatment of rice straw at the farm level based on experiences in Sri Lanka. The inputs include straw, urea, water, a balance, urea measurement cup, water bucket/watering can, pit and polythene cover. Farmers are sensitive to issues such as palatability and acceptability, loose motion, work load, neighbours opinion and extension and economic aspects like quick returns, butterfat content and milk yield.

Key words : urea-ammonia treated rice straw, practice aspects, problems farmers.

INTRODUCTION

The Straw Utilization Project in Sri Lanka is actively involved in finding methods of incorporating rice straw in ruminant rations. Deficiencies of straw as a feed, can be overcome profitably in some cases by urea ammonia treatment. A variety of "treatment" approaches is available :

US - untreated straw i.e. intact straw without any treatment

SS - sprayed straw, i.e. straw sprinkled with a solution of urea (2 kg urea/100 l water/100 kg straw) and fed immediately. No reaction takes place, only supplementation of straw with nitrogen is effectuated.

TS - treated straw i.e. straw sprinkled with a solution of urea (4 kg urea/100 l water/100 kg straw). After sprinkling this straw is left to "react" for some time either uncovered (TS_o), covered with bags, leaves etc. (TS_{scl}) or completely airtight (TS_{cl}).

Except for the US the other methods require inputs and the TS also requires a structure to keep the straw i.e.the treatment pit. Methods of treatment and costs are elaborated in publications of the Straw Utilization Project (SUP, 1983a; SUP, 1983d). Figure 1 is a graphic presentation of the (dis) advantages of the different methods.

The urea concentration, water dilution and duration of treatment, as well as pit design etc. to be applied in urea ammonia treatment of rice straw is not solely determined by the technical experimental data from laboratory and large scale feeding trial. Practical aspects like price, availability of urea, water, straw, building materials, farmers skills, etc.as well as returns to be expected from the "investment"are deciding whether the farmer accepts the message. Problems like mould, crows picking the polythene,scarcity of other available feeds, "sio-ecological" environment,etc. are difficult to express in monetary terms. The paper discusses some of the complex matters experienced during a few years field work in Sri Lanka. A list the common questions and answer on straw feeding specific to Sri Lanka has been published and widely circulated as extention material.

Availability of inputs

The urea ammonia treatment method used by SUP is very simple and the following inputs are required: straw, urea, water, and petty equipment (SUP, 1983a).

Straw : is not an abundant feed resource. It's transport is usually costly and unpractical. Straw quality may also be a problem. Inadequate storage may lead to moulds. Sri Lanka has recently experienced one season which was so dry that no straw was even produced and another season with so much rain that both paddy grain and straw were drowned.

Urea : is claimed to be widely available. However we have found that it is mainly available in the planting season and less in the dry season. Micro-and macro economic prices have to be studied.

Water : is a scarce resource in the dry season. Water is also heavy to carry (100 kg water per 100 kg straw) and on small farms it usually does not come from a tap and a rubber hose.

Other inputs : a balance, urea measurement cup,water bucket/ watering can, pit, polythene cover. Some of these are items which a farmer rarely owns (Figure 2).

Can these items by provided to the farmer at a subsidised rate or can these be issued and deducted from the milk bills.

Pit construction

SUP recomends treatment under airtight conditions and the choice of method of sealing is left to the farmer giving alternatives like :

- mud walls : (does the area have good mud for wall building?)
- polythene and covered with urea bags (is polythene cheap, are urea bags easily available, bags tend to give threads which may cause problems when ingested).
- brick and mud or cement (what is price of bricks and cement, quality of mud, local customs).
- bamboo baskets (Bangladesh) : (price and availability of bamboo).
- pit in the ground : (ground water or rainwater may cause problems, walls will fall in, protection needed, much sand in feed).

Whether or not a roof is necessary depends on the rainfall in the periods when the pit is used. If polythene cover is used a roof may not be necessary even in a rainy area. In a dry area at least shade is necessary to avoid excessive radiation on the polythene. Some old straw and coconut leaves may be enough to protect it from the sun. In some areas crows may completely tear open the polythene, requiring extra protection of the pit.

Feeding practices and issues, farmers points of view

Farmers are generally reluctant to accept new methods. Acceptance is affected by problems like :

Palatibility/acceptability : The animals should easily accept the feed. Our experience except in a few odd cases is that most of the animals accept and eat readily after 1-3 days. Some take longer than 1-3 weeks especially since the farmer is reluctant to let his (or her) animal go off feed to force it consuming treated straw. Usually in such circumstances real feed scarcity is not yet experienced.

Loose motion : In some cases animals fed TS may have thinner dung than on US and farmers do not like this. Incorrect rumours tend to spread, like lowered fertility in cows and risks of toxicity on TS which impede the acceptance.

Work load : Many farmers have found that by treating straw once a week, there is labour saving as the time spent in cutting scarce grass every day. Collecting feed is often (but not always) a womens job. Figure 3 shows how the treatment is done once a week.

Heighbours opinion : Certain emotional reluctance of farmers who have always correctly considered straw as a bad feed will take some time to change. Not only have farmers of some areas in

Sri Lanka been reluctant to accept the idea of feeding straw, also extension, teaching, research and political "staff" often have had some difficulties in accepting new methods even though feeding straw as such is not new. SUP has even gone to the extent of advertising in the newspaper (Figure 3).

Extension : Considerable effort is spent in preparing material, training farmers as well as leaflets for extensionists and non-farmers (Annex 1).

Economical aspects

Prices and availability of straw, urea, building materials, etc. are all components of cost. These need to be considered from the farmers point of view.

Quick returns : The farmer is one who expects quick returns. One could easily demonstrate the production responses of feeding treated straw with dairy animals within one week. Extra income from dairy produce will also be paid back on such a short term. Production responses are well proven from our experiences in Sri Lanka. Possible extra liveweight gains or extra draught power will be more difficult to translate in money. It should be remembered that even in countries like Australia it is a common practice to let the animals lose weight in periods of feed scarcity and let them gain again in periods of affluent, cheap feed.

Butterfat content or lacto desimeter reading : In Sri Lanka the milk is usually priced according to butter fat content. If there is an increase in butter fat by feeding TS, the farmer is easily convinced. The increase in BF with feeding TS is another thing which is helping acceptance of the farmers. In those areas where the lactometer is the only test,responses in butter fat will not be useful to the farmer. In rare cases butter fat fell after TS feeding, and it is not sure whether this is consistent.

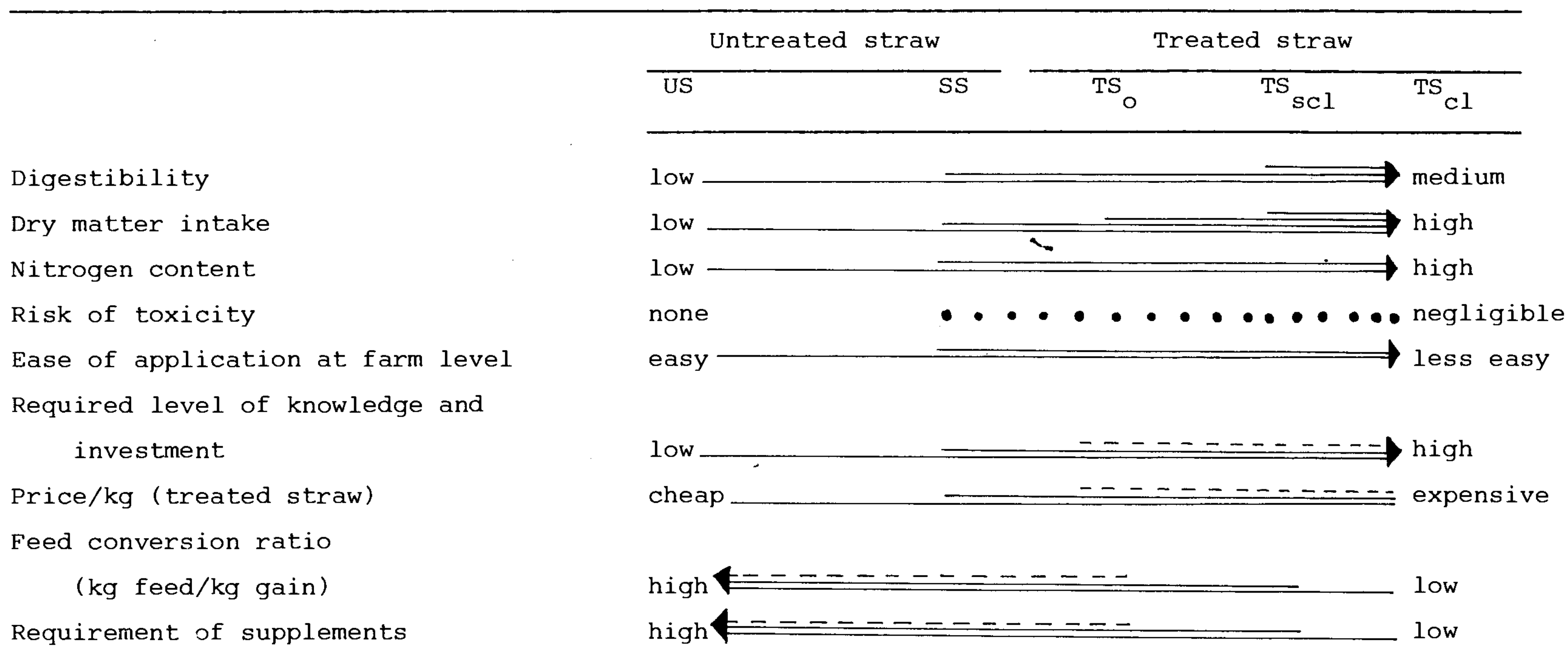
Milk yield : If increased milk yield after feeding TS can be shown, a extension is very easy. This is often the case when the farmer has been feeding both too little and too bad quality"rubble" (very low quality roughage) to his animals and when he switches to TS. Some of our farmers do get such responses. These responses will spread the message around. It is advantageous therefore to start with farmers who have potentially good producing animals which are fed on very poor quality feed.

Treating straw and/or supplementing straw

The insufficient intake of nutrients from straw can be overcome by increasing the straw quality (treating or spraying) or by supplementing with concentrates. The choice between these two alternative is essentially an economic one. The SUP has approached this issue in several ways which requires a few simplifications but shows clearly that straw treatment is not the most economical approach in all cases (SUP, 1984b). Rations were calculated using either US, SS or TS, supplementing upto a required level depending on nutrient requirement of the particular type of production. It can be seen clearly from Table 1 that only higher production of milk and live weight gain of the treatment of straw is economical. Assumptions like potential intake feeding values used, additivity and absence of interactions, etc. are presently a subject of research by SUP. It should well be remembered that these calculations apply to a specific set of assumptions within Sri Lanka. The basic approach applies to other countries but the results have to be calculated for each country and socio-ecological area separately.

CONCLUSION

Many factors are involved in the acceptability of straw extension. The message of feeding straw instead of burning is rather universal (Figure 3). Whether to treat, to spray or to supplement is not so easily answered and has to be worked out for each situation separately. How to treat may also differ from area to area. Aspects like availability of straw, urea, water, other feeds, building materials, type of animals and level of production need special attention. From preliminary experiences in Sri Lanka, farmers from certain regions and conditions are eager to accept the message. This is a hopeful sign for farmers in feed-starved areas, extensionists, researchers and policy makers.



US - untreated straw

SS - straw supplemented with 2% urea sprayed on the straw

TS_o - straw treated without cover; open system

TS_{scl} - straw treated and not airtight covered; semi-open system

TS_{cl} - straw treated under airtight conditions; closed system.

Figure 1. Graphic presentation of advantages and disadvantages of the different urea ammonia treatment systems.

Table 1. Calculating rations.

Production level	Cheapest ration		Medium price		Expensive ration	
	kg[1]	Rs[2]	kg	Rs	kg	Rs
Maint (350 kg LW)	7.0 US	0.83	7.3 SS	1.46	6.3 TS	2.53
	0.8 RB		no supplement		no supplement	
4 l milk	7.0 US	2.75	7.3 SS	2.87	9.2 TS	3.68
(350 kg LW)	4.0 RB		2.3 RB		no supplement	
8 l milk	9.8 TS	5.05	7.4 SS	6.50	5.8 US	12.37
(350 kg LW)	1.9 RB		4.0 RB		4.0 RB	
			0.6 CPo		2.4 CPo	
250 g gain	4.2 SS	1.89	5.6 TS	2.33	4.0 US	3.58
(200 kg LW)	1.7 RB		0.1 RB		2.3 RB	
					0.5 CPo	
500 g gain	4.2 TS	5.00	3.3 US	7.16	3.4 US	7.35
(200 kg LW)	2.3 RB		2.3 RB		2.3 RB	
	0.5 CPo		1.4 CPo		1.3 CPo	
Medium work	7.4 SS	2.25	7.0 US	2.51	7.8 TS	3.11
(350 kg LW)	1.2 RB		3.6 RB		no supplement	
Heavy work	7.4 SS	3.14	9.8 TS	3.91	7.0 US	4.15
(350 kg LW)	2.8 RB		no supplement		4.0 RB	
					0.4 CPo	

1. Ration in which 7.3 US)
0.8 RB) means : 7.3 kg US + 0.8 RB covers the daily requirements.

2. This is the feed cost (Rs/day/animal) if the ration as mentioned in the earlier column is being fed.

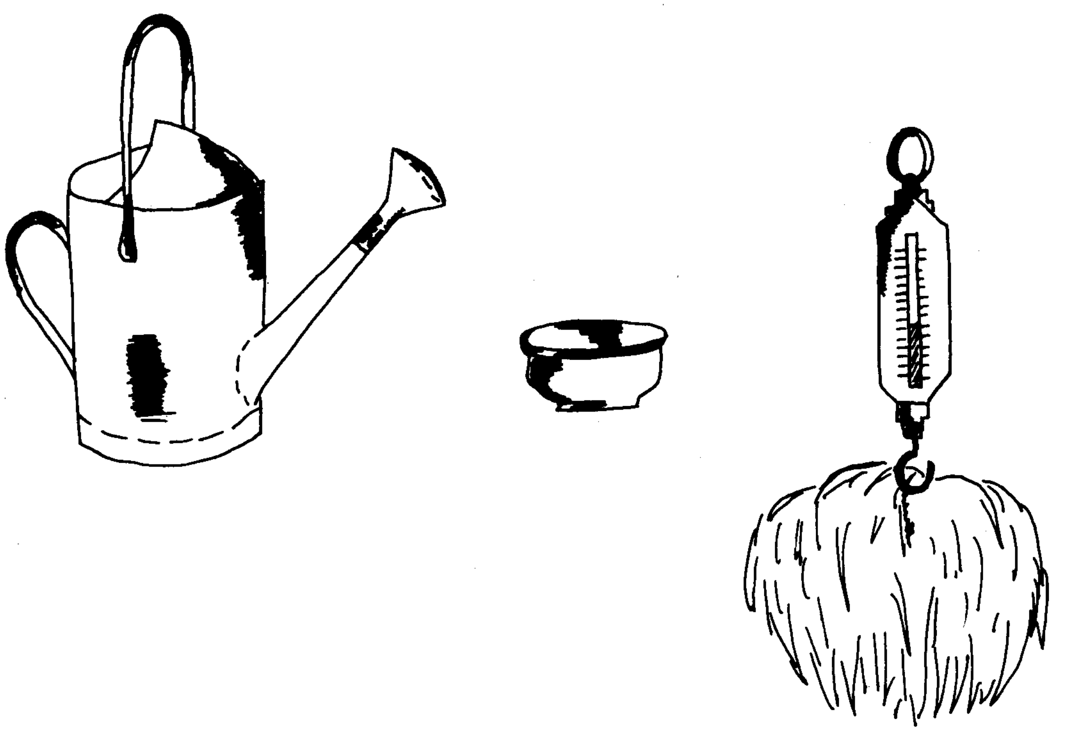


Figure 2:Equipment necessary for straw treatment on farm scale.

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THE USE OF AGRICULTURAL WASTE BY-PRODUCTS SUPPLEMENTED WITH LEUCAENA LEAVES FOR GROWING GOATS

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SUMMARY

A study was conducted using agricultural waste by-products supplemented with leucaena leaves for growing goats for 60 days at Karang-Malang, Yogyakarta. Sixteen male Kacang cross-bred goats of one year of age with an average body weight of 13.2 kg were used in a completed randomised design and given four treatment groups with four goats, each in individual cages. Treatments one, two and three (I, II and III) consisted of such agricultural waste by-products as corn stalks, sorghum stalks and sugarcane tops, respectively; each ration was added with peanut vines and cassava tops supplemented with leucaena leaves. Treatment IV consisted of Napier grass and concentrate (coconut meal : rice bran = 3:1). The average daily live weight gains of groups I, II, III and IV were 56.3; 55.0; 50.0 and 40.4 g, dry matter consumption were 78.5; 74.8; 67.3 and 42.8 g $W^{0.75}$ kg average digestible protein consumption per gram body weight gain of goats were 1.2; 1.0; 1.1 and 0.9 g, and average TDN consumption per gram body weight gain were 6.2; 5.1; 5.8 and 6.5 g, respectively. In a seperate study, $T_{\frac{1}{2}}$ values of peanut vines, cassava tops, corn stalks, sugarcane tops and sorghum stalks were 38, 50,70, 128 and 130 hours respectively.

Key words : agricultural waste by-products, leucaena leaves, Napier grass, growing goats.

INTRODUCTION

Indonesia is an agrarian country with abundant supplies of agricultural waste by-products which support ruminants, especially in densely populated areas such as Java and Bali. It has been estimated that agricultural waste by-products will supply 4.2 millions animal units which is about 60% of the whole animal units in the Islands. Furthermore, it is known that one hectare of cultivated land could produce 3.8 tons dry-matter of sugarcane tops or 0.9 tons dry-matter of cassava tops or 2.1 tons dry-matter of peanut vines or 2.9 tons dry-matter of corn stalks or 2.6 tons dry-matter of sorghum stalks (Sukanto-Lebdosukoyo, 1982).

MATERIALS AND METHODS

The study was a completely randomized design and conducted for 60 days at Karang-Malang, Faculty of Animal Husbandry, Gadjah Mada University, Yogyakarta, Indonesia,at an altitude of 113 m above sea level average annual rainfall of 2000 mm, and average daily ambient temperature of 28°C.

Sixteen male crossbred Kacang goats of six month of age weighing 13.2 ± 1.2 kg were kept in individual cages and devided into four groups of four animals in each group, namely group I, II, III and IV. Treatments 1, 2, and 3 consisted mainly of agricultural waste by-products like corn stalks (*Zeamais*) sorghum stalks (*Sorghum vulgare*) and sugarcane tops (*Saccharum officinarum*),respectively. The three rations were added with peanut vines (*Arachis hypogeae*) and cassava tops (*Manihot utilissima*) and supplemented with leucaena leaves (*Leucaena leucocephala*). Treatment 4 consisted of Napier grass (*Pennisetum purpureum*) and concentrate feeds coconut meal (*Cocos nucifera*) : rice bran (*Oryza sativa*) in the ratio 3:1. Each feed ingredient and concentrate feed was given seperately.Drinking water was supplied ad libitum.

In the pre-study period, the cages were disinfected with *Creoline*, the goats were bathed with *Asuntol* and treated with *Rintal*.

Proximate analyses of feeds were carried out according to AOAC procedures (1965). Digestible crude protein (DCP) and Total Digestible Nutrients (TDN) of Napier grass and concentrate were calculated according to Hari-Hartadi et al. (1980), DCP and TDN of agricultural waste by-products were calculated according to Soedomo-Reksohadiprodjo (1982).

A seperate study was also conducted using the method of Leng (1980) to measure the $T_{\frac{1}{2}}$ of individual the agricultural waste by-products.

RESULTS

Daily feed dry-matter intakes were at a range of 42.8 to 78.5 g/$W^{0.75}$ kg, Kearl (1982) stated that growing goats consumed 47.4 to 78.5 g dry-matter/$W^{0.75}$ kg (Table 2).

Digestible crude protein consumed for gram body weight gain were in the range of 0.9 to 1.2 g, Kearl (1982) stated that the values were in the range 0.5 to 0.7 g (Table 2).

Energy (TDN) for gram body weight gain were in the range 5.1 to 5.9 g, Kearl (1982) stated that the value were in the range of 4.8 to 6.2 g TDN (Table 2).

The average daily gain of the goats were at a range of 40.4 to 56.3 gram compared to those reported by Kearl (1982) with values with a range of 50.0 to 60.0 g (Table 2).

The study showed that agricultural waste by-products supplemented with leucaena leaves could be used as animal feeds and would give reasonable goats production.

In situ study showed that peanut vines ($T_{\frac{1}{2}}$ = 38 hr) was grouped as a low quality agricultural waste by-product, whilst cassava tops ($T_{\frac{1}{2}}$ = 50 hr), corn stalks ($T_{\frac{1}{2}}$ = 70 hr), sugarcane tops ($T_{\frac{1}{2}}$ = 128 hr) and sorghum stalks ($T_{\frac{1}{2}}$ = 130 hr) were grouped as very low quality agricultural waste by-products(Preston,1983). Table 3 presents these results.

Table 1. Composition and $T_{\frac{1}{2}}$ of feed ingredients (% DM basis).

Ingredients	CP	EE	CF	NFE	DCP	TDN	$T_{\frac{1}{2}}$ (h)
Corn stalks	7.9	1.6	27.6	53.0	4.6	44.4	70
Sorghum stalks	5.7	2.1	30.9	49.5	1.4	31.1	130
Sugarcane tops	5.4	1.3	28.4	53.8	1.7	42.0	128
Peanut vines	14.9	1.5	26.9	45.0	11.5	58.1	38
Cassava tops	23.4	6.3	26.1	35.2	12.4	40.0	50
Leucaena leaves	26.4	4.5	9.7	44.2	13.1	68.9	-
Napier grass	10.5	3.3	29.8	37.8	6.4	47.2	-
Concentrate :							
(Coconut meal :							
rice bran = 3:1)	16.8	12.4	14.2	49.5	12.5	79.9	-

Table 2. Intake and response of goats to treatments.

Item	Treatments			
	I	II	III	IV
Dry-matter consumption, g/day/goat				
corn stalks[1/]	135	-	-	-
sorghum stalks[1/]	-	136	-	-
sugarcane tops[1/]	-	-	118	-
peanut vines[1/]	162	189	148	-
cassava tops[1/]	136	143	147	-
leucaena leaves[1/]	112	93	143	-
Napier grass[1/]	-	-	-	186
Concentrate	-	-	-	145
Daily gain, g/day	56.3	55.0	50.0	40.4
Digestible crude protein consumption per gram body weight gain, g	1.2	1.0	1.1	0.9
TDN consumption per gram body weight gain, g	6.2	5.1	5.8	6.5
Feed dry-matter consumption per kg metabolic body weight, g/day	78.5	74.8	67.3	42.8

1/ chopped

Table 3. Percentage dry-matter remaining in the rumen of goats and $T_{½}$ values.

Ingredient	Percentage dry-matter remaining (h)					$T_{½}$ (h)
	4	8	12	24	48	
Corn stalks	92.26	88.01	86.47	69.97	62.84	70
Peanut vines	88.18	80.19	78.39	63.56	41.55	38
Sugarcane tops	96.57	95.37	94.53	90.72	75.58	128
Sorghum stalks	89.42	82.32	80.41	74.64	72.36	130
Cassava tops	81.27	68.63	66.31	55.46	53.33	50

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UTILISATION OF BREWERY BY-PRODUCTS FOR BEEF CATTLE IN JAPAN

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SUMMARY

The experiment reports the utilization of industrial by-product, distillers soluble as cattle feed. Twelve Holstein castrated male cattle wighing about 270 kg were divided into two treatment groups in confined lots for 11 months. Treatment one had, 9.1% barley distillers soluble (BDS)and 13.2% distiller grain and treatment two had 10.6% distillers grain in the dry matter. The average final body weight were 652.8 kg and 699.7 kg, and the average daily gain were 1.20 kg and 1.25 kg respectively. These results indicated that distillers soluble and grain can be used as protein feeds for beef cattle. It was found that 9% distillers soluble and 13% of dry weight of distillers grain could be used on dry matter basis of 9% of total feed.

Key words : brewery by-products, utilisation, Holstein cattle.

INTRODUCTION

In order to increase cash income,farmers have to do beef to a maximum the production costs of beef cattle, especially to decrease feed cost, which is the main proportion of production cost. One of the methods to decrease feed cost is the utilization of agricultural and industrial by-products. In Japan, there is limited report that barley distillers soluble (BDS) can be fed to cattle with the exception of the report by Kawashima et al.(1982). There are some reports concerning BDS utilization in USA (Hatch et al., 1972; Chen et al.,1977; Waller Klopemtem and Poos, 1980).

was under 5% of total feed. The experiment was conducted to explore more efficient utilization of distillers soluble.

MATERIALS AND METHODS

Twelve Holstein castrated male cattle weighing about 270 kg were divided into two treatment groups of six animals each. The animals were confined in each lot and given the feeds as shown in Table 1 and 2. In treatment one, BDS and distillers grain made from whisky distilley were fed and, in treatment two, distillers grains produced from whisky distilley and low quality concentrate ration were given to cattle. The cluration was about 11 months. Body weight, body length and height were measured every month and blood samples were collected from the jugular vein three times during the fattening period. Glucose, urea, triglyceride and mineral concentration in serum were analyzed using the spectrophotometer and atomic absorption spectrophotometer.

Carcass characteristics were also evaluated including autopsy of the rumen, the abomasum and the liver at slaughter.

RESULTS AND DISCUSSION

As shown in Table 3, daily body weight gains were 1.20 kg and 1.25 kg for the two treatments and were better comparing the performance data of dairy steer in Japan (Livestock Industry Japan, 1982). The lower daily gain in treatment 1 might be due to the decrease in appetite since BDS was too fermented.

Table 4 represents feed consumption and feed efficiency. The feed efficiency in both experiments were good and there was no large differences between treatments.

Carcass characteristics are shown in Table 5. Dressing percentage and meat quality were good in comparison to the carcass

Table 1. Feed consumption by cattle (treatment 1, kg/day).

Ingredients	Months										
	0.6	2	3	4	5	6	7	8	9	10	11
Distillers grain	5.2	6.5	6.9	6.9	6.6	6.8	4.2	4.4	4.5	4.0	3.4
BDS	0.8	1.5	1.9	2.3	2.5	2.8	2.2	2.4	2.5	2.0	1.4
Cracked corn	1.0	1.9	2.4	2.9	3.2	3.4	4.0	4.4	4.5	3.8	3.1
Milo	0.8	1.5	1.9	2.3	2.6	2.8	3.4	3.7	3.8	3.3	2.7
Others (including wheat bran)	2.7	1.2	1.5	1.7	2.0	2.1	1.7	1.8	2.0	1.5	1.1
Crushed barley										2.7	3.0
Rice straw	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Total	12.0	14.1	16.1	17.6	18.4	19.4	17.0	18.2	18.8	18.8	16.2
DCP	0.70	0.82	0.97	1.06	1.14	1.25	1.11	1.21	1.24	1.25	1.05
TDN	5.0	5.5	6.7	7.7	8.4	9.2	9.0	9.8	9.9	10.5	9.1
Ca	0.04	0.05	0.06	0.07	0.08	0.09	0.08	0.08	0.08	0.07	0.05
P	0.03	0.04	0.05	0.05	0.06	0.07	0.06	0.06	0.06	0.06	0.05

Table 2. Feed consumption by cattle (treatment two, kg/day).

Ingredients	Months										
	1	2	3	4	5	6	7	8	9	10	11
Distillers grain	8.0	8.3	8.3	8.3	8.3	5.0	3.0	3.0	2.0	2.0	2.0
Complete feed	3.0	3.3	3.3	3.3	3.3	3.3	2.0	2.0	2.0	2.0	2.0
Cracked corn				1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0
Crushed barley			1.1	1.0	1.5	2.0	3.0	3.5	3.5	3.5	4.0
Others (including wheat bran)	2.1	3.3	3.5	5.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Rice straw	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Total	14.7	16.5	17.8	20.2	21.7	18.9	17.6	18.1	17.1	17.1	17.6
DCP	0.83	0.99	1.09	1.32	1.43	1.32	1.24	1.28	1.24	1.24	1.28
TDN	5.5	6.9	7.8	9.6	10.8	10.6	10.9	11.3	11.1	11.1	11.5
Ca	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
P	0.03	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Table 3. Body weight gain of cattle (kg).

Parameter	Treatment 1	Treatment 2
Fattenning period, days	327	334
Body weight,		
Beginning	259	281
Final	653	700
Gain	394	419
Daily gain	1.20	1.25

Table 4. Feed intake and feed conversion rate in cattle.

Parameter	Treatment 1			Treatment 2		
		% of total feed			% of total feed	
		wet weight	dry weight		wet weight	dry weight
Feed intake, kg/head						
Concentrate	2591	51.0	77.7	3731	68.1	89.4
Distillers grain	1804	35.5	13.2	1749	31.9	10.6
BDS	683	13.5	9.1	-	-	-
Total	5078	100	100	5480	100	100
Rice straw	490	-	-	534	-	-
Feed conversion rate, kg						
DM		8.7			9.8	
DCP		0.89			0.96	
TDN		6.8			7.8	

Table 5. Carcass characteristics of cattle.

Item	Treatment 1 3/	Treatment 2 3/
Body weight, kg		
Before slaughter	630	658
Carcass weight, kg	387	396
Dressing, %	61.5	60.1
Marbling score	1.6	2.3
Carcass grade 1/	4.0	5.3
Back fat thickness, mm 2/	11.5	12.2

1/ Scored; super excellent 10, excellent 8, good 6, middle 4 & average 2.

2/ Measured fat thickness under skin between 5th and 6th rib.

3/ Average of six cattle.

characteristics of dairy steam produced in Japan (Livestock Industry Japan, 1982). Carcass grade was a little better in treatment two. This was also due to the difference of final body weight.

The results of autopsy are presented in Table 6. All cattle had parakeratosis. This morbid change was quite general in cattle given a large amount of concentrate. There was no incidence of urinary calculi. The result was coincident with farmers' observations that the occurrence of urolithiasis was prevented by feeding distillers residue.

The results of serum metabolites are shown in Table 7. Serum glucose concentrations tended to decrease in the finishing period of fattening and might be correlated with the decrease in feed consumption. Serum glucose concentrations were rather higher in treatment two compared with those in treatment one. Although urea

Table 6. Autopsy of cattle.

Characteristic	Treatment 1	Treatment 2
Rumen parakeratosis score1/,3/	2.8	2.0
Liver abscess2/	1	1
Urinary calculi2/	0	0
Ulcer of abomasum1/,3/	0.5	1.5

1/ Degree of morbid change; 0-5.

2/ Number of abnormal animal.

3/ Average of 6 cattle.

concentrations in the serum was high or in the final period of treatment two, the cause was no clear. In both treatments, serum triglycedride concentrations had a significant increase as time passed. The result was agreement with a report by Kitagawa (1983) that serum triglyceride concentrations tended to increase.

The serum phosphorus concentrations in both treatments tended to be higher than. The normal range in blood serum of between 4 mg/100 ml and 7 mg/100 ml. The results might be due to high content of dietary phosphorus.

Selling prices and profit by farmers are shown in Table 8. Meat quality was better in cattle of treatment two than in those of treatment one, while the selling price was adverse. The daily variations of selling price of carcass caused the discrepancy. Since feed cost was lower in treatment one the profit was better in this treatment.

It was concluded that distillers soluble and grain, was a useful protein feed for beef cattle. Feeding with 13% of distillers

Table 7. Serum metablite concentrations in cattle.

Month after the beginning of exp.	Treatment 1[1/]			Treatment 2[1/]		
	3	6	10	3	6	10
Glucose (mg/100 ml)	61.5	60.8	47.9	75.7	70.5	56.4
± SD	13.7	5.5	13.4	16.6	7.9	5.7
Urea (mg/100 ml)	12.6	11.3	12.7	13.3[a]	12.9[a]	20.7[b]
± SD	1.1	1.7	2.3	0.9	2.0	1.9
Triglyceride (mg/100 ml)	9.4[a]	15.4[b]	26.6[c]	8.4[a]	12.9[ab]	18.9[b]
± SD	4.3	4.0	4.5	3.4	4.1	2.1
Minerals (mg/100 ml)						
Ca	9.56	9.25	9.75	9.71	9.29	9.18
± SD	0.17	0.30	0.31	0.34	0.21	0.23
P	8.07	7.42	7.12	7.89	7.29	6.78
± SD	0.60	0.82	0.40	0.23	0.50	0.41
Mg	2.12	2.21	2.46	2.15	2.36	2.14
± SD	0.25	0.18	0.20	0.06	0.11	0.12
Na	331[a]	333[a]	383[b]	331	330	328
_ SD	10	10	18	10	8	17
K	19.8	17.9	19.4	18.8	17.0	19.6
± SD	2.3	0.9	1.3	2.4	0.9	1.9

1/ Average ± SD of six cattle

a, b, c : $p < 0.05$

Table 8. Economic analysis.

Characteristic	Treatment 1[1/]	Treatment 2[1/]
Selling price (yen)	514,689	502,395
Purchasing price of calf (yen)	164,724	178,716
Feed cost (yen)		
Concentrate ration	142,309	185,758
Distillers grain	19,844	19,239
BDS	11,475	-
Rice straw	12,250	13,350
Mineral mixture	7,164	2,250
Total	193,042	220,597
Profit[2/] (yen)	156,923	103,082

1/ Average yen of six cattle 1 $ = 250 ¥

2/ Profit = Selling price - Purchasing price of calf - Feed cost.

grain and 9% of BDS on the dry matter basis and reduced the feed cost. Mixing BDS with distillers grain might be a excellent method because of the improved appetite.

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RUBBER SEED MEAL AND OIL PALM MEAL FOR LIVESTOCK FEEDING IN THAILAND

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SUMMARY

In Thailand, rubber seed cake (RSC) with shells in abundant but rubber kernel cake (RKC) is only available in certain places. RSC and RKC contain approximately 14% and 29% CP (DM basis). Both residues contain high proportions of essential amino acids especially lysine but small amount of methionine. 10-20%RKC and 20-30% RSC can be added to the rations of growing - finishing pigs. Fattening pigs (60-90 kg) can use 35% RSC in the diet. For broilers, 10% RSC in the diet is profitable. Oil palm meal contains 8% CP whereas oil palm seed meal contains 12% CP (DM basis). Crossbred yearling heifers fed with 50% oil palm meal gained 660 g/day whereas those fed with 50% basal corn diet gained only 650 g/day. Feed cost per kg weight gain for heifers on oil palm diets was much lower than that on the corn diet. However, 10-40% oil palm seed meal fed to broilers did not give satisfactory weight gain or a reduction in feed cost.

Key words : rubber seed meal, oil palm meal, feeding, livestock.

INTRODUCTION

Rubber and oil palm by-products have been used for livestock feeding in many countries. Rubber seed cake is a by-product and is the whole seed after oil extracting process. The other portion is rubber kernel cake which is rubber seed meal without shells. Oil palm yields a few feed by-products such as palm press fiber, palm kernel cake, oil palm seed meal,oil palm meal and palm oil sludge. Feed by-products normally found in Thailand are oil palm meal which is whole fruit after oil extraction; oil palm seed meal which contains palm kernel and nut shells, and palm kernel cake which is seed kernel without shells.

Rubber by-products contain some hydrocyanic acid which may be toxic especially monogastric animals. However, rubber and oil palm by-products are a good source of animal feeds in Malaysia, Indonesia, the Philippines, Sri Lankg, Thailand and other countries. This paper reviews the suitability and results of using these by-products for animal production.

Utilization of rubber residues

Rubber seed cake sometimes called rubber seed meal is composed of the shell and kernel. It contains approximately 6-9% moisture, 13-16% crude protein, 6-8% ether extract, 36-46% crude fibre, 2.5-4% ash, 29-32% NFE, 4390-5116 kcal GE/kg, 0.11-0.91% Ca,0.24-0.34% P and 20 mg HCN/kg of the dry matter. The chemical composition of rubber kernel cake on dry matter basis was 29% crude protein,13% ether extract, 9% crude fiber, 5% ash, 4713 kcal GE/kg, 0.28% Ca, 0.57%P and 17 mg HCN/kg of dry matter. In addition, rubber seed cake with or without shells contains high proportions of lysine, arginine, valine, threonine,tryptophan and other essential amino acids but is rather low in methionine. Another problem in using rubber seed residues is hydrocyanic acid which at high levels will affect feed intake and growth rate of monogastric animals.

In Thailand rubber seed cake (RSC)with shell and rubber kernel cake (RKC) are available for animal feeding but the former is more abundant. Vearasilp et al. (1977) reported two experiments with pigs using rubber kernel cake and rubber seed cake with shell (Tables 1 and 2).

Table 1. Effect of rubber kernel cake on growth of fattening pigs (35-100 kg)1/

Description	Experimental diets2/				
	Control	10% RKC	20% RKC	25% RKC	28% RKC
Rubber kernel cake (RKC), %	0	10	20	25	28
Chemical composition3/					
Crude protein, %	16.01	16.02	16.02	16.02	16.05
Digestible energy, kcal/kg	3341	3350	3387	3456	3458
Cyanide, mg/kg	0	1.8	3.5	4.4	5.0
Animal performance4/					
Feed intake, g/d	1855^{a}	2297^{b}	2228^{b}	1981^{a}	2062^{ab}
Average daily gain, g	512^{ab}	640^{c}	602^{bc}	495^{a}	478^{a}
Feed conversion ratio	3.75^{ab}	3.59^{a}	3.75^{ab}	4.02^{bc}	4.33^{c}

1/ From Vearasilp et al. (1977).

2/ Other ingredients were fish meal, soybean oil meal, ground corn, rice bran, ground oyster shell, vitamin-mineral mix, steamed bone meal, fat.

3/ Calculated, as-fed basis.

4/ Values in the same row with different superscripts are statistically different ($P < 0.05$).

Table 2. Effect of rubber seed cake with shell on growth of fattening pigs (35-100 kg[1/]

Discription	Experimental diets[2/]			
	Control	10% RSC	20% RSC	25% RSC
Rubber seed cake with shell (RSC), %	0	10	20	25
Chemical composition[3/]				
Crude protein, %	16.01	16.02	16.02	16.02
Digestible energy, kcal/kg	3341	3318	3318	3372
Cyanide, mg/kg	0	2.0	4.0	5.0
Animal performance				
Feed intake, g/d	1780^{a}	1950^{ab}	2246^{c}	2142^{bc}
Average daily gain, g	418^{a}	445^{a}	542^{b}	430^{a}
Feed conversion ratio	4.29^{a}	4.40^{a}	4.15^{a}	5.02^{a}

1/ From Vearasilp et al. 1977.

2/ Other ingredients were fish meal, soybean oil meal, ground corn, rice bran, steamed bone meal, ground oyster shell, vitamin-mineral mix, ground limestone and fat.

3/ Calculated, as-fed basis.

It was evident that 25% RSC or RKC can be included in the rations of growing and fattening pigs. The animals consumed rubber meal diets readily and animals on 10% RKC consumed the most feed (2297 g/day) whereas those on the control diet consumed only 1855 g/day. The diet containing 10-20% RKC gave the most average daily gain, 640 and 602 g, respectively and body weight gain was decreased with increasing levels of RKC. The increase in body weight gain might be due to available energy, lysine and other essential amino acids in RKC and the decrease in body weight of pigs consuming 25-28% RKC might be due to high levels of hydrocyanic acid and crude fiber in the diets. The animals fed with 20% RSC consumed the most feed (2246 g/day) and showed the highest body weight gain (542 g/day). Again the level of RSC beyond 20% caused a decrease in body weight gain probably due to high level of fibre content and hydrocyanic acid in the diet. The results suggest that rubber kernel cake is superior to rubber seed cake with shells in terms of average daily gain and feed conversion ratio. From these two experiments, it is suggested that 10-20% of RKC and/or 20% RSC with shell in swine diets will give the best results in terms of feed intake, average daily gain and feed efficiency.

Siriwathananukul et al. (1982) conducted a similar experiment with growing and finishing pigs by using RSC at 10, 20 and 30% in the diets (Table 3). They found that the pigs fed with 20-30% RSC in the diets consumed more feed than those on the control or 10% RSC diet. Average daily gain of pigs fed RSC was increased with increasing levels of up to 20% RSC. The pigs fed with 20% RSC gained the most (521 g/day) whereas those on the control diet gained the least (459 g/day). Feed efficiency of pigs fed with 20% RSC was also better than the control-fed group. The result of this experiment is in agreement with that of Vearasilp et al. (1977). Siriwathananukul et al. (1982) concluded that for pigs weighing 15-35 kg and 35-90 kg, 10-20% RSC and 20-30% could be included in the diet.

Table 3. Effect of rubber seed cake with shell on growth of growing and fattening pigs (15-90 kg)[1/]

Description	Experimental diets[2/]			
	Control	10% RSC	20% RSC	30% RSC
Rubber seed cake with shell, %	0	10	20	30
Chemical composition[3/]				
Crude protein, %	16.02	16.01	16.01	16.01
Crude fiber, %	2.99	5.49	8.80	12.39
Digestible energy, kcal/kg	3409	3354	3350	3345
Cyanide, mg/kg	0	15	30	45
Animal performance				
Feed intake, g/d	1450	1430	1600	1520
Average daily gain, g	459^{a}	479^{ab}	521^{b}	501^{ab}
Feed conversion ratio	3.16	2.99	3.07	3.04
Backfat, cm	2.67	2.82	2.56	2.71

1/ From Siriwathananukul et al. (1982).

2/ Other ingredients were fish meal, soybean oil meal, corn, broken rice, rice bran, ground oyster shell, vitamin-mineral mix, and fat.

3/ Calculated, as-fed basis.

Tinnimit and Pralomkarn (1984) conducted another experiment with fattening pigs by using RSC with shell, rice bran, broken rice and concentrated premix (Table 4).

Table 4. Effect of rubber seed cake with shell on growth of fattening pigs (60-90 kg)[1/]

Description	Experimental diets[2/]			
	Control	15% RSC	25% RSC	35% RSC
Rubber seed cake with shell, %	0	15	25	35
Chemical composition				
Crude protein, %[3/]	13.20	13.30	13.34	13.38
Crude protein, %[4/]	12.02	11.70	12.20	11.06
Ether extract, %[4/]	9.53	6.82	8.20	9.64
Crude fiber, %[4/]	4.68	8.97	11.34	16.21
Animal performance				
Feed intake, g/d	2220	2320	2380	2730
Average daily gain, g	435	436	459	511
Feed conversion ratio	5.12	5.31	5.24	5.30
Backfat, cm	1.85	1.75	1.90	1.93

1/ From Tinnimit and Pralomkarn (1984).

2/ Other ingredients were rice bran, broken rice and concentrated premix (36% CP).

3/ Calculated, as-fed basis.

4/ By analysis, as-fed basis.

Increasing the level of RSC (15-35%) to diets for fattening pigs increased intake. The animals on 35% RSC consumed the most feed (2730 g/day)whereas those fed with the control diet consumed only 2220 g/day. In the same manner, pigs fed with 35% RSC gained the most (511 g/day)compared to the control diet(435 g/day). Feed conversion ratio and backfat test were not significantly different. It was concluded that 35% RSC can be included in the diet of fattening pigs about two monghs before marketing.

Rubber seed cake with shell can also be used in broiler ration. Sripongpun et al. (1983)used 5, 10, 20 and 40% RSC in diets for broiler (Table 5).

The chickens consumed the diets readily. Body weight gains of chickens for all treatments were similar. Feed efficiencies of broilers fed with 20-40% RSC were also lower than the control or the group consuming 5-10% RSC. This is probably due to high level of crude fiber and low energy in the two diets. As regards the cost of feed per kg of weight gain, the chickens on 10% RSC showed the least cost followed by 5% RSC and control diets. It was concluded that for broiler production, 20% RSC was suitable while 10% RSC gave the best results in terms of body weight gain and feed cost per kg weight gain.

Utilization of oil palm residues

Oil palm meal is a residue after oil extraction of whole fruits. This product contains approximately 13% moisture and 8% crude protein, 8% ether extract, 35% crude fiber, 5% ash and 44% nitrogen-free extract on the dry matter basis. Tesprasith (1983) fed crossbred heifers (Holstein x Red Sindhi) weighing about 180 kg with rice straw ad libitum and a limited amount of basal corn diet or 50% oil palm meal in the diet (Table 6). When 50% of oil palm meal was used to replace corn in the diet, crude protein of the mixture was slightly lower than that of the corn diet. Nitrogen-

Table 5. Effect of rubber seed cake with shell on growth of broilers (1-49 days)1/

Description	Experimental diets2/				
	Control	5% RSC	10% RSC	20% RSC	40% RSC
Rubber seed cake with shell, %	0	5	10	20	40
Chemical composition3/					
Crude protein, %	23.11	23.07	23.73	23.56	23.36
Crude fiber, %	3.30	5.50	6.80	11.80	19.60
Ether extract, %	4.34	4.54	4.65	4.87	5.39
NFE, %	51.89	50.37	48.73	44.37	37.47
HCN, mg/kg4/	0	1.25	2.50	5.00	10.00
Animal performance					
Feed intake, kg/bird	3.45	3.53	3.53	3.72	4.33
Body weight gain, kg	1.67	1.67	1.67	1.61	1.58
Average daily gain, g	34	34	34	33	32
Feed conversion ratio	2.07[a]	2.12[a]	2.11[a]	2.31[b]	2.75[c]
Feed cost/kg gain (Baht)	13.10	13.00	12.68	13.14	13.92

1/ From Sripongpun et al. (1983).

2/ Other ingredients were ground corn, fish meal, soybean oil meal, bone meal, salt and vitamin premix.

3/ By analysis, as-fed basis.

4/ Calculated, as-fed basis.

Table 6. Effect of oil palm meal on growth of growing crossbred heifers (180-220 kg)[1/]

Description	Corn diet	Oil palm diet
Oil palm meal[2/]	0	50
Corn	50	0
Rice bran	25	25
Soybean oil meal	23	23
Bone meal	1	1
Salt	1	1
Chemical composition[3/]		
Crude protein, %	14.87	13.56
Ether extract, %	4.55	10.66
Crude fiber, %	6.42	19.56
Ash, %	4.55	7.55
Nitrogen-free extract, %	57.77	36.92
Animal performance		
Concentrate intake, kg/d	1.74	1.76
Average daily gain, g	650	660
Cost of conc./kg gain (Baht)	11.40	7.87

1/ From Tesprasith (1983).

2/ Oil palm meal was obtained from whole fruit and contained 12.82% moisture, 7.08% CP, 6.91% EE, 30.51% CF, 4.55% ash, 38.49% NFE.

3/ By analysis, as-fed basis.

crude fiber and ash were much higher than those of corn diet. In spite of these differences, average daily gain of heifers consuming 50% oil palm meal was 660 g whereas those consuming 50% corn diet gained only 550 g/d. This indicates that the amount of crude protein (13.6%) was sufficient to support normal growth while ether extract and crude fiber were supplemental sources of energy besides that obtained from nitrogen-free extract. Since oil palm meal was still very cheap, therefore, the cost of concentrate mixture per kg weight gain for oil palm diet was significantly cheaper than the corn diet. Therefore, up to 50% of oil palm meal was suitable.

Palm kernel is another by-product feed in Thailand. At present, oil palm seed meal (nut shell plus palm kernel)is available for animal feeding. This product contains approximately 8% moisture, 11% crude protein, 10% ether extract, 27% crude fiber,3% ash, 41% nitrogen-free extract, 0.18% Ca and 0.40% P on an as-fed basis. Prolomkarn et al. (1983) conducted an experiment with broilers using 10, 20, 30 and 40% oil palm seed meal in the diets. The results of this experiment (Table 7) indicate that when oil palm seed meal was added to the diet from 20-40% while maintaining similar amounts of crude protein,crude fiber was greatly increased whereas nitrogen-free extract or available energy was greatly decreased. This resulted in a higher feed intake for the chickens consuming 10-40% oil palm seed meal. The average daily gain of chickens fed with control diet was 35 g whereas the gain of those fed with oil palm seed meal was less than this and decreased with increasing levels of oil palm seed meal in the diet. The dressing percentage for the control group was 70.63% whereas that of all other groups fed with oil palm seed meal was 2-5% lower. Feed cost per kg weight gain for all groups fed with oil palm seed meal was not convincing or the use of this product might not be economical because of low weight gain caused by low energy intake and high fiber content in the diets.

Table 7. Effect of oil palm seed meal on growth of broilers (1-56 days)[1/]

Description	Experimental diets[2/]				
	Control	10% OPSM	20% OPSM	30% OPSM	40% OPSM
Oil palm seed meal, %	0	10	20	30	40
Chemical composition[3/]					
Crude protein, %	21.95	22.70	22.87	23.32	23.06
Crude fiber, %	3.14	6.12	10.72	14.84	20.02
Ether extract, %	3.51	3.26	3.34	4.28	4.34
NFE, %	55.35	52.23	47.36	39.48	37.14
Animal performance					
Feed intake, kg/bird	4.42	4.54	4.49	4.81	5.24
Body weight gain, kg	1.94	1.90	1.82	1.81	1.80
Average daily gain, g	35	34	33	32	32
Feed conversion ratio	2.28^{a}	2.40^{a}	2.47^{ab}	2.65^{bc}	2.9^{c}
Feed cost/kg gain	12.91	13.01	12.69	13.09	13.64
Dressing percentage	70.63^{a}	68.91^{b}	69.04^{ab}	68.10^{b}	65.31^{c}

1/ From Pralomkarn et al. (1983).

2/ Oil palm seed meal was a mixture of palm kernel cake and nut shell. Other ingredients were corn, fish meal, soybean oil meal, bone meal, salt and vitamin premix.

3/ By analysis, as-fed basis.

CONCLUSIONS AND SUGGESTIONS

Rubber and oil palm by-product feeds can be successfully used in livestock feeding and the following guidelines may be followed :

a. 10-20% of rubber kernel cake for growing- finishing pigs (35-100 kg).
b. up to 20% of rubber seed cake with shells for 15-35 kg pigs.
c. 20-30% of rubber seed cake with shells for 35-90 kg pigs.
d. up to 35% of rubber seed cake with shells for 60-90 kg pigs.
e. up to 20% of rubber seed cake with shells can be included in broiler rations but 10% of rubber seed cake give the best results.
f. up to 50% of oil palm meal (whole fruit) for growing cattle.
g. 20% of oil palm seed meal (nut shells plus kernel)can be included in diet for young broilers and 30% for older broilers.

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THE CAUSAL EFFECT OF LANDHOLDING ON CATTLEHOLDING

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SUMMARY

Changes in the landholding pattern of 317 households of a village in Noakhali District, Bangladesh were studied over a period of five years together with the effect any changes might have had on cattle holding. It was found that there had been a considerable turnover in landholding, resulting in less landless households and more small farms. This in turn influenced the cattle population. The number of bullocks decreased from 171 to 144, young stock from 96 to 91, whereas the number of cows increased from 96 to 166. This drastic increase in cows, but fall in bullock numbers is largely explained by more holdings having less than two acres, as an increasing number of cows are used for work on such holdings. This study does not support the common notion that increasing cropping intensity with irrigation necessitates stronger animals. Timeliness appears more important for the farmer, i.e. that he can make his own decisions about when he should cultivate, when he has his own animals, although they are small. Given the traditional cropping pattern of Bangladesh, it estimated that the increased number of cattle kept by holdings smaller than two acres is putting increasing pressure on feed resource other than crop residues, derived mainly from village common land.

Key workds : Landholding, households, cattle, farmers.

INTRODUCTION

It is widely acknowledged that cattle are important for Draft power in traditional Asian agriculture. However the factors causing changes within the herd at village and national (aggregate) level are less well understood. Size of landholding was earlier shown to have a clear effect on the type of animal skept by Lasson (1981a) in four villages in Noakhali District, Bangladesh.

The present study was a follow-up on the first basic survey,undertaken with the objective of studying firstly the changes that had taken place in landholding patterns in one village, over the period 1978 to 1984, and secondly,the effect any changes might have had on the composition of the cattle herd of the village.

MATERIALS AND METHODS

The data used for the analyses in this paper relates to the previous socio-economic study 1 of the Hasanpur Village (Lasson, 1981b; Dolberg, 1982). To assess the changes some new data were gathered in the middle of 1984. The basic survey was a total sample survey of four villages in the Noakhali District. The survey was contered on the socio-economic aspects of village structures and was broad in scope. The basic survey included records of livestock. This gave the basis for relating livestock holding to other socio-economic characteristics (Lasson, 1981b).

In 1980 the sizes of the adult cattle in Hasanpur were measured by Dolberg (1982). To obtain the 1983-84 data, the same assistant who made the 1980 measurements was hired to the job. The data were collected in July 1984.

They include household recording of :

1) Land holdings in 1983 (November-December).
2) No. of bullocks.
3) No. of cows.
4) No. of young stock.

It was noted that the number of shallow tube wells in the village had gone up from one in 1980 to 15 in 1984, there increase cropping intensity. More than 60% of the land is estimated to be used for a winter rice crop.

Landholding refers to the cultivated acreage, not the owned acreage. The amon season falls during the monsocn period and is the dominant cropping season. This explains why the amon season 1983 was chosen.

The period 1979-1984 sow changes in the population composition of the households. The population increased but concerned the same families. Four new households were established in the period, but these were not included in the survey.

The data treatment was for the basic survey made at RECKU, Copenhagen. For the analyses in this paper computer runs were made at RECAU, Arhus, Denmark.

RESULTS

Changes in Landholding

Changes in the landholding pattern between 1978 and 1983 are presented in Table 1. 159 households had no land in 1978 and 98 are still landless in 1983. 26 households cultivated between 0-0.5, 21 between 0.5-1.0, 11 between 1.0-2.0 and three households between 2.0-3.0 acres. There was no cultivation of land above three acres. Of the 137 households without land in 1983, 15 cultivated 0-0.5 acres, 10 between 0.5-1.0, 8 between 1.0-2.0, 4 between 2.0-3.0 and 2 households more than 3 acres in 1978.

Table 1. Changes in the amon season landholding in Hasanpur Village (1978-83).

Landholding (1978)(Ac) \ Landholding (1983)	No land	0-0.5*	0.5-1.0	1.0-2.0	2.0-3.0	Over 3.0	Raw total
	acre						
No land	98	26	21	11	3		159
	30.9%	8.2%	6.6%	3.5%	0.9%		50.2%
0-0.5	15	8	10	5	1		39
	4.7%	2.5%	3.2%	1.6%	0.3%		12.3%
0.5-1.0	10	5	6	7	2	1	31
	3.2%	1.6%	1.9%	2.2%	0.6%	0.3%	9.8%
1.0-2.0	8	5	5	15	6	5	44
	2.5%	1.6%	1.6%	4.7%	1.9%	1.6%	13.9%
2.0-3.0	4	3	8	4	1	6	26
	1.3%	0.9%	2.5%	1.3%	0.3%	1.9%	8.2%
Over 3	2	1	2	4	3	6	18
	0.6%	0.3%	0.6%	1.3%	0.9%	1.9%	5.7%
Column	137	48	52	46	16	18	317
Total	43.2%	15.1%	16.4%	14.5%	5.0%	5.7%	100.0%

Raw chi Square = 126.37 with 25 degrees of freedom   Significant = 0.00

Pearson's = 0.54   Significance = 0.00

* It is acknowledged that the intervals used in the tables are not mutually exclusive, but in the actual analyses this problem has been taken care of.

Combining the information from the two years (1978 and 1983), it was found that the total number of landless reduced from 159 to 137, i.e. from 50.2 to 43.2% of all households.

This is due to an increasing number of households cultivating land in the category 0-1 acres of land; compared to 1978, there was an increase of 30 households.

There was no change in the number of households larger than 3 acres and was 18 in 1978 and 1983. However, there has been considerable mobility within the groups as only six of the 18 households from 1978 remain in this category. 12 households acquired more land and 12 households have lost land. Among these, two were completely land less in 1983. On the other hand no landless households have been able to acquire more than three acres. 11 of 12 households getting more land had between one to three acres in 1978. There was a fall from 26 to 16 households for the 2.0-3.0 ac category.

The over pattern showed that land has become distributed over more households and that there has been a considerable turnover. A more detailed analysis of the data showed that only 101 out of 317 households had not experienced any change over the period studied.

Livestock population

Information on the total number of bullocks, cows and calves is provided in Table 2.

There was a fall in the number of bullocks from 171 to 144, a drastic increase in the number of cows from 96 to 166, whereas the number of young stock is almost unchanged (96 to 91). The total the number of cattle increased from 365 to 401.

Relationship between landholding and type of cattle kept

The relationship between size of holding and the type of cattle kept in 1979 and 1984 is given in Table 3.

Table 2. No. of cattle in Hasanpur Village (1979-1984).

Category	1979	1984	Difference
Bullocks	171	144	-27
Cows	96	166	+70
Young stocks	96	91	-5
Total	363	401	+38

Table 3. Relationship between landholding and cattle holding (1979-1984).

Type of animals	Bullocks		Cows		Young stock		No. of holdings	
Landholding(Ac)	1979	1984	1979	1984	1979	1984	1979	1984
No. land	17	0	13	10	14	15	159	137
0-0.5	10	4	20	28	11	11	39	48
0.5-1.0	24	25	9	43	11	12	31	52
1.0-2.0	51	57	31	49	18	25	44	46
2.0-3.0	39	25	10	16	25	17	26	16
Over 3	30	33	13	20	17	11	18	18
Total	171	144	96	166	96	91	317	317

Bullocks

For bullocks there are two landholding categories of particular interest. Of a total reduction in the number of bullocks from 171 to 144,the number of bullocks kept by the landless and the landholding category 2.0-3.0 acres is of particular interest. These two categories lost 31 bullocks. There was also a loss of six bullocks in the category 0-0.5 acres. This total loss is reduced by a gain of 10 bullocks in the remaining categories, resulting in a combined loss of 27 bullocks.

Cows

There are two landholding categories of particular interest concerning the number of cows. There has been a drastic increase in the number of cows from 9 to 43 in the landholding category 0.5 to 1.0 acres and from 31 to 49 in the category 1.0-2.0 acres. Together these two landholding categories accounted for the additional 52 out of a total of 70 cows over the period 1979 -1984. There was a fall of the number of cows from 13 to 10 cows only in the landless group.

One significant feature in cow keeping was the increase in the number of holdings having two cows. This figure increased from 9 to 33 holdings, reflecting the increased use of cows for draught power.

Young stock

The number of young stock remained the same. When this is compared to the increase in cow number however, there has been a decline in the number of young stock. In 1979, the ratio of cows to young stock was 1:1 (96 against 96). In 1984 this ratio had changed to 1:0.55 (166 against 91). This decline appears to have taken place in the landholding category 0.5-1.0 acres in particular. There has been an increase in cow population from 9 to 43, but the number of young stock is almost constant (11 against 12). A similar trend, although not so marked, was observed in the landholding category 1.0-2.0 acres.

Shift in land and cattle holding

The relationship between the shifts in land and cattle holding was also examinated. Tables 4, 5 and 6 show the relationship between land holding and cattle holding dynamics.

The results are summarized in Table 7.

It can be seen in table 7 that the really big changes in the case of bullocks are caused by either loss or gain of land. Calculations show that 74% of the holdings losing bullocks lost land and 83% of those gaining bullocks gained more land.

Below two acres, cows tend to be used as draft animals. This is reflected in the fact that 51.5% of the total turnover in cows has been in households getting more land, but typically only 0.25-0.50 acres (Table 5). By comparison, the loss of bullocks has taken place in holdings losing more than 1 acre and the gain in households gaining more than 1 acre (Table 4). These findings indicate that the movement of bullocks could be used as an indicator for changes in landholdings.

For calves, the situation is extremely varied and no particular trend was apparent. In economic terms this may be explained by the fact that compared to bullocks and cows, young stock are a much smaller units and are more easily to substituted inrespective of whether this was due to an incremental loss or gain of land/income.

DISCUSSION

There has been a heavy turnover in land since only 101 out of 317 households experienced on change. Of the 101 households 98

Table 4. Relationship between the shift in landholding and the shift in Bullock ownership.

Shift in bullock holding / Shift in landholding (Ac)	-2 Animals	-1 Animal	No Shift	+1 Animal	+2 Animals	+3 Animals	Row total
Lost	17	7	13	5			42
More than 1	5.4%	2.2%	4.1%	1.6%			13.2%
-1 - -0.25	5	1	8		1		15
	1.6%	0.3%	2.5%		0.3%		4.7%
-0.5 - -0.25	3	4	11	1	1		20
	0.9%	1.3%	3.5%	0.3%	0.3%		6.3%
-0.25 - -0	2	1	6	1			10
	0.6%	0.3%	1.9%	0.3%			3.2%
No shift	1	1	99				101
	0.3%	0.3%	31.2%				31.9%
0 - 0.25		2	13	2			17
		0.6%	4.1%	0.6%			5.4%
0.25 - 0.5	1	2	25		2	1	31
	0.3%	0.6%	7.9%		0.6%	0.3%	9.8%
0.5 - 1		4	24	10	4		42
		1.3%	7.6%	3.2%	1.3%		13.2%
Gained	3	4	13	11	8		39
Over 1	0.9%	1.3%	4.1%	3.5%	2.5%		12.3%
Column	32	26	212	30	16	1	317
Total	10.1%	8.2%	66.9%	9.5%	5.0%	0.3%	100.0%

Raw chi square 84.51,40 DF, sign. .00, Pearson's s .42,sign. .00

Table 5. Relationship between shift in landholding and shift in cow ownership.

Shift cow holding / Shift landholding (Ac)	-2 Animals	-1 Animal	No Shift	+1 Animal	+2 Animals	+3 Animals	Row total
Lost		6	22	10	4		42
More than 1		1.9%	6.9%	3.2%	1.3%		13.2%
-1 - -0.5		2	10	2	1		15
		0.6%	3.2%	0.6%	0.3%		4.7%
-0.5 - -0.25		4	12	3	1		20
		1.3%	3.8%	0.9%	0.3%		6.3%
-0.25 - 0		1	9				10
		0.3%	2.8%				3.2%
No shift		3	92	6			101
		0.9%	29.0%	1.9%			31.9%
0 - 0.25		1	12	3	1		17
		0.3%	3.8%	0.9%	0.8%		5.4%
0.25 - 0.5			19	12			31
			6.0%	3.8%			9.8%
0.5 - 1	1	5	19	12	5		42
	0.3%	1.6%	6.4%	3.8%	1.6%		13.2%
Gained	1	2	18	11	6	1	39
Over 1	0.3%	0.6%	5.7%	3.5%	1.9%	0.3%	12.3%
Column	2	24	213	59	18	1	317
Total	0.6%	7.6%	67.2%	18.6%	5.7%	0.3%	100%

Raw chi, square 84.51, sign. .00, Pearson's s .15, sign. .00

Table 6. Relationship between shift in landholding and shift in young stock ownership.

Shift young stock holding / Shift landholding (Ac)	-3 Animals	-2 Animals	-1 Animal	No shift	+1 Animal	+2 Animals	Row Total
Lost	1	4	7	18	11	1	42
More than 1	0.3%	1.3%	2.2%	5.7%	3.5%	0.3%	13.2%
-1 - -0.5			4	8	3		15
			1.3%	2.5%	0.9%		4.7%
-0.5 - -0.25			2	12	5	1	20
			0.6%	3.8%	1.6%	0.3%	6.3%
-0.25 - 0			2	7	1		10
			0.6%	2.2%	0.3%		3.2%
No shift	2		3	91	5		101
	0.6%		0.9%	27.7%	1.6%		31.9%
0 - 0.25		1	1	11	4		17
		0.3%	0.3%	3.5%	1.3%		5.4%
0.25 - 0.5			2	26	3		31
			0.6%	8.2%	0.9%		9.8%
0.5 - 1			8	24	10		42
			2.5%	7.6%	3.2%		13.2%
Gained	1	3	2	18	15		39
Over 1	0.3%	0.9%	0.6%	5.7%	4.7%		12.3%
Column	4	8	31	215	57	2	317
Total	1.3%	2.5%	9.8%	67.8%	18.0%	0.6%	100.0%

Raw chi square 88.69, DF 40, sign. 0.00, Pearson's 0.07, sign. 11.

Table 7. Summary of shift in land and cattle, ownership.

	Animals					
	Loss			Gain		
Loss	Bullocks	:	43.0%	Bullocks	:	7.0%
	Cows	:	10.0%	Cows	:	21.4%
	Young stock	:	21.6%	Young stock	:	20.0%
Gain	Bullocks	:	12.9%	Bullocks	:	34.8%
	Cows	:	9.5%	Cows	:	51.5%
	Young stock	:	20.0%	Young stock	:	26.7%

Note : These calculations are based on the total turnover of animals within each category. Bullocks 155; Cows 126 and Young stock 120.

were landless in both years under study. Thus all households having land have experienced a change. It is noteworthy, that there are more households with access to land in 1983 than in 1978. Land distribution is more even with an increased number of holdings below two acres. A similar observation has been made in India (Raagaard, personal communication). In the present study 12 of 18 farmers having above three acres of landholding in 1978 have lost land. However another 12 have gained so much that the number of farmers having more than three acres of land remains unchanged at 18. Lasson (1981b) found that decreasing farm size leads to an overall larger animal density. It is therefore not surprising that the total number of cattle has gone up from 363 to 401.

Several studies from Bangladesh and India (Vaidyanathan et al. 1979; Raagaard, 1973; Gill, 1981; Lasson, 1981b; Helmrich, 1983; Jabbar, 1983, reported that with smaller farm size (approximately below two acres) female cattle tend to be higher than male cattle in total numbers. It has been argued that this was due to a rational adjustment on the part of farmers. With decreasing size of holding the number of working days are reduced. On the other hand the maintenance cost goes up as the animal has to be fed and looked after every day. In addition to draught power, the cow the produces milk and offspring.

A cow, from this point of view, is therefore a more useful multipurpose animal compared to the bullock, which is a specialist animal providing only draught power. Although this sounds logical no observation have been made with regarded to whether this is, really the case. The other possibility is that the farmer with decreasing farm size chooses the cow simply because it is smaller than the bullock, making more efficient use of resources (Dolberg, 1982). The dramatic increase in cows has not been accompanied by a corresponding increase in young stock. If the cows were used both for draught and milk production a calf would have followed to stimulate milk let down. Proof for the fact that more cows are used for draught is seen in that more are kept in pairs according to the data.

Jabbar (1983) has discussed the influence of draught an reproduction in cows. He concluded that the effect would be negative, and observed that draught cows did not reproduce to the same extent as milking cows. It was evident in the present study that cows kept by the landholding categories 0.5-1.0 and 1.0-2.0 acres do not reproduce, to the same extent as cows in the other landholding brackets (Table 3). Whether the reason is that farmers do not purposely breed working cows or they become infertile due to the additional stress imposed on them by being used for work, is not clear. Given the prevailing system of young, free grazing males serving as bulls (Helmrich, 1983), the latter explanation appears more plausible. The issue needs further work.

There has been a fall in the number of bullocks kept by the landless, so that no bullocks were found in this category by

1984. There may be two explanations for this. One is that the previous bullock keepers have acquired land. The other is that, perhaps, the market for hiring out of bullocks is less lucrative with overall decreasing farm size, i.e. more farms are self-sufficient in draft power. It is also possible that the increase in cropping intensity has left less land available for free grazing.

This study does not support the common notion that increasing cropping intensity with irrigation recessitates stronger animals. Timeliness appears more important for the farmer, i.e. that he can make his own decisions about when he should cultivate, and when he has his own animals. Gill (1981) made a similar observation. Irrigation engineers account for water for soil preparation (Skutch, personal communication). By the same reason, there is a need for more attention to ways of intensifying animal production when irrigation is introduced. The quantity of crop residues will be increased and the need for strong draught animals reduces the tendency towards cow keeping. Both features suggest that possibilities for meat and milk production should be explored.

Shifts in landholding are positively correlated with shifts in bullock ownership. With more land more bullocks are owned and vice versa. The situation for cows and particularly calves is more complex and a considerable element of substitutions is involved.

It is concluded that shifts in landholding strongly influence the pattern of cattle keeping. In the short run the chain of reactions is assumed to be that increasing human population leads to smaller holdings, which in turn leads to a dominance of female over male cattle.

The long-term consequences are more difficult to evaluate. The possible negative implications on fertility will lead to a reduction, ultimately, in cattle numbers,unless the cows that are used for work are infertile and are now kept alive rather than slaughtered. The question is - and it is not answered in the present study-whether the actual number of breeding cows are kept constant or reduced.

In relation to the theme of this workshop, there is a question about whether it is useful to pay attention to crop residues as animal feeds. Farmers of the present study are not asking this question as they have no other choice. Actually crop residues are insufficient as feeds and weeds are also used together with a substantial amount of grass grazed on common land. About one acre of crop residues and weeds are considered to be required to feed one cattle beast under traditional practices in Bangladesh. This is equivalent to providing a 125 kg animal 2.5%dry matter daily or 1,140 kg a year.

In 1979, 63% of all the cattle were kept on holdings with less than two acres. Assuming a weight of 175, 150 and 75 kg for bullocks, cows and young stock, respectively, (Dolberg, 1982), and an intake of 2.5% dry matter per beast daily, it can be calculated on the basis of Table 3 that total daily feed requirements in 1979 were 821 kg dry matter for holdings below two acres. In 1984, 70% of all cattle was kept on holdings below two acres and feed requirements had gone up to 982 kg dry matter or by 20%. This additional requirement might have been met from the additional by - products provided by the increase in cropping intensity due to the introduction of irrigation pumps. Assuming the cropping intensity has remained constant as is the case in many villages in Bangladesh, this development has put an additional pressure on other feed resources such as common land to the tune of 59 tonnes a year. The role of these other feed sources need attention as they are often more important than crop residues for these small holdings.

The growing human population and increasing livestock numbers, increase the use of common land and has lead to deforestation with serious ecological consequences. In addition, fodder including crop residues, is increasingly being used as fuel in Bangladesh

(Helmrich, 1983). This aspect also needs to be considered by animal nutritionists in future programmes dealing with the integration of fodder and fuel production (Preston, 1980).

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PERFORMANCE OF PASTURE GRASSES AND LEGUMES UNDER CASHEW PLANTATION

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SUMMARY

The performance of pasture grasses and pasture legumes under the cashew trees were compared. Signal grass (*Brachiaria brizantha*) showed greater potential as a forage crop either planted purely or in combination with pasture legumes particularly with stylosanthes (*Stylosanthes gracilis*) and centrocema (*Centrocema pubescence*). Among the legumes *stylosanthes* and *centrocema*, showed better capability to survive and grow with the pasture grasses. The 29-day cutting interval of signal grass planted under cashew trees had a higher forage yield compared to that of the 24-day, 19-day and 14-day intervals.

Key words : grass, legumes, performance, cashew plantations.

INTRODUCTION

The World Bank (1980) has estimated that in Asia, as much as 80% of the farmers till less than two hectares of land and the per capita income is way below the poverty line. This and the present practices of monoculture crop production has not helped them the subsistence level of living.

The case for integrated crop/livestock raising lies in the fact that the region has tremendous potential for the development of truly indigenous and self-reliant method of mixed farming to icnrease production and the net income at the farm level.

A survey by 3M International (1979) indicated that there are approximately 5,000 hectares of cashew land in the Philippines. Cashew farmers net an average income of ₱ 500.00 per hectare per year, which is comparatively low or than the proceeds from other agricultural crops grown with the same size of land area.

Salcedo and San Jose (1969), Javier (1975) and Mojica (1979) asserted that the carrying capacity of pasture land can be improved by introducing legumes. They add nitrogen to the soil, provide livestock with forage of high nitrogen value and stay green during the dry season. Escudero (1976) affirmed that the most practical way of improving pasture is to have a balance among grasses and legumes.

The first study was undertaken to determine the performance of pasture grasses and legumes and their combinations when planted under cashew plantation. A subsequent study was conducted to determine the optimum cutback schedule for the promising species of pasture grass identified in the first sutdy.

MATERIALS AND METHODS

Study 1 - Performance of pasture grasses and legumes under cashew plantation (wet season)

Experimental plots of 4 x 4 m were established between seven-year old cashew trees with a spacing of 9 meters between trees. Rootstocks of the grasses were planted at a distance of 50 cm between rows of the grasses at the rate of 4 kg/ha. The pasture grasses planted were Guinea (*Panicum maximum*), signal (*Brachiaria brizantha*), and molasses (*Melinis minutiflora*) and the pasture legumes were stylosanthes (*Stylosanthes gracilis*), centrocema (*Centrocema pubescence*) and mimosa (*Mimosa pudica*)

The experiment was conducted using the randomized complete block in a 3 x 4 factorial design. Herbage yield of the pasture grasses and legumes were harvested at 24-day cutting intervals. Data collection was done for a period of four months.

Study 2 - Frequency of cutback for signal grass (*Brachiaria brizantha*) planted under cashew plantation.

The experiment was conducted to evaluate the herbage yeild of signal grass as affected by the different interval of cutting. Again, 4 x 4 m plots were laid out in-between the cashew trees. The area was thoroughly prepared by plowing, harrowing and removal of weeds. Goat manure was applied in all plots at the rate of 5 tons/ha two weeks before planting the pasture grass.

Rootstocks of signal grass were planted in each plot at 50 cm between rows and hills. Clipping the grass was done **two** months after planting. Subsequent cuttings were based on the four schedules, which served as treatments;

T_1 - every 14th day
T_2 - every 19th day
T_3 - every 24th day
T_4 - every 29th day

The experiment was conducted using the randomized complete block design (RCBD) with four treatments replicated three times. Collection of data lasted for three months.

RESULTS AND DISCUSSIONS

Table 1 shows the average number of tillers of pasture grasses planted with and without pasture legumes 60 days after planting. Molasses grass planted with mimosa had the highest number of tillers per hill (50). The combination of signal grass with centrocema, molasses grass with stylosanthes and signal grass with mimosa produced 35, 30, 28 tillers, respectively. Pure signal grass resulted to an average production of 25 tillers per hill.This

Table 1. Average number of tillers of pasture grasses per hill.

Grasses	Legumes	Average*
Guinea	No legume	12 ef
	Stylosanthes	19 cdef
	Centrocema	16 cdef
	Mimosa	15 def
Signal	No legume	25 bcde
	Stylosanthes	23 bcde
	Centrocema	35 b
	Mimosa	28 bcd
Molasses	No legume	9 f
	Stylosanthes	30 bc
	Centrocema	35 bcde
	Mimosa	50 a

* Averages followed by the same letter are not significantly different at the 1% level.

was significantly higher compared to Guinea grass with 12 tillers and molasses grass with 9 tillers. Molasses grass produced the least number of tillers per hill.

Analysis of variance among grass and legume means and interaction between grasses and legumes showed highly significant differences. These differences might have been due to the growth characteristics of the grasses themselves. Molasses and signal grass grow close to the ground which favours conservation of available soil moisture. This appears to have encouraged the production of more tillers. On the other hand, Guinea grass is an erect growing grass and soil moisture around its base was wanting because of excessive evaporation.

Planting of pasture legumes in-between the grasses had in general, favorably affected the tillering capacities of the grasses although Guinea planted with the tree legumes have comparable number of tillers with Guinea and molasses planted purely. Signal grass planted alone had the highest average number of tillers (25). This was comparable to the number of tillers of those combined with legumes namely, signal-centro, signal-mimosa, molasses-centro and molasses-stylo.

The forage yield of pasture grasses and legumes at 24-day cutting interval is shown in Table 2. Signal grass planted purely had the highest forage yield (40 tons/ha)than pure Guinea and molasses grass (27 and 24 tons/ha., respectively). Signal-stylo, signal-centro, signal-mimosa have a forage yield of 36, 33, and 23 tons per hectare, respectively. Guinea-stylo, guinea-centro and guinea-mimosa combinations have computed forage yield of 28, 31 and 20 tons/ha., respectively, while molasses-stylo, molasses-centro and molasses-mimosa with 24, 14 and 14 tons of forage yield per hectare.

There were no significant differences among legume means and interaction between grasses and legumes. Differences among the grass means could be due to the degree of tolerance of signal and Guinea grass to shading as reported by Santherasegaram (1966).

Table 3 shows the average forage yield of signal grass pasture in tons/ha at different intervals of cutting. The 29-day cutting interval had an average yield of 1.56 tons per hectare. It was followed by the 24-day, 19-day and 14-day cutting intervals with 1.04, 0.83 and 0.82 tons per hectare,respectively.

There were highly significant differences between treatment means. The 29-day cutting interval had significantly outyielded the closer cutting intervals. However, closer appraisal showed that the 14-day and 19-day cutting intervals ended up with higher total forage yield in a longer time frame.

Table 2. Forage yield of pasture grasses and legumes at 24-day cutting interval (tons/ha).

Grasses	Legumes	Average*
Guinea	No legume	27 abc
	Stylosanthes	28 abc
	Centrocema	31 abc
	Mimosa	20 bc
Signal	No legume	40 a
	Stylosanthes	36 ab
	Centrocema	33 ab
	Mimosa	23 abc
Molasses	No legume	24 abc
	Stylosanthes	14 c
	Mimosa	18 bc

* Averages followed by the same letter are not significantly different at the 1% level.

Table 3. Computed forage yield of signal grass pasture at different intervals of cutting (tons/ha).

Treatment	Average
29-day	1.56 a
24-day	1.04 b
19-day	0.83 c
14-day	0.82 c

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EFFECT OF RICE BRAN AND BARLEY ON GROWTH OF RATS

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SUMMARY

The effect of rice polishings and a comparative trial between the parched barley meal and the boiled pearl barley were studied in growing rats. In trial 1, 5, 10 and 15% rice polishings were added to each basal diet. In trial 2, the diets containing 76% parched barley meal and 76% boiled pearl barley were fed mid-age-growing rat. In trial 1, rats in all treatment groups showed no significant differences in growth. In trial 2, parched barley meal group significantly increased daily body weight of rat, while the boiled pearl barley group depressed it ($P < 0.01$). Grain residue which contains moderate amount of dietary fibre and other vitamins and minerals has beneficial effect for early and growing rats.

Key words : rice bran, barley, growth, rat.

INTRODUCTION

The expression of bulky feed as crude fibre(Weende Method) and cell wall constituents (Van Soest, 1963) is also being presently extended to foods by human nutritionists. Fibrous feeds has high in fibre or cellulose occupying a greater volume and has less biological value for simple stomach animal.

The inhibitory effect of high levels of dietary fibre on growth rate of growing-finishing swine has been demonstrated repeatedly (Crampton et al. 1954; Hochstetler et al. 1958; Stevenson et al. 1960). Hochstetler et al. (1958) reported that when oat replaced 20% and 40% of the basal ration, there was a different growth rate. However, when wheat bran replaces 20% and 40% of the basal ration of pigs, they found the decreased daily gain highly significant. This result coincides with the previous results reported by Bahstedt and Fargs (1933) and Forbes and Hamilton (1952). Pond and coworkers (1962) reported that the average daily gain of pig was significantly reduced by the addition of 24.8% corn cobs to either a 10% or 18% protein ration. These workers found that average daily gain was not significantly affected by protein level but was reduced significantly by the addition of 12.4% corn cobs to the ration. Merkel et al. (1958) also have found that the level of crude fibre in the ration was more highly correlated with the results of growth and carcass data than either energy or protein level.

The rat has the ability to utilize cellulose by the gastro intestinal micropopulation and cecum. Johnson et al. (1960) studied the cellulose metabolism in the rat using an isotope technique and reported that 31% of ingested tabacco and soybean cellulose-C^{14} was metabolised.

Rice has high nutritional value, mainly in the layer of bran and the germ which lie under the hull. With only the hulls removed, it becomes brown rice; when milled and polished, it is white rice. Rice yields 70% of its weight as white rice, 20% as bulky hulls that are inedible for man or beast and 10% as bran, germ and polish. Rice bran contains high fat and rancidity can pose problems. It is a good source of thiamine and is high in niacin. Cystine and tryptophan contents are low. The low calcium and high phosphorus contents as phytin are hardly available for chicks and swine.

The world production of rice polishing in 1980 totalled 3,131,060 M/T. The ten leading rice producing countries are: China, Rep. (1,400,000 M/T of rice bran or polishings), India (615,620 M/T), Indonesia (241,180 M/T), Bangladesh (187,690 M/T), Thailand (165,000 M/T), Japan (149,570 M/T), Vietnam (110,000

M/T), Burma (98,000 M/T), Korea (86,000 M/T) and Brazil (78,000 M/T). Rice polishings can supplement 12% of poultry rations, 8% of chick rations, 25-30% of swine rations and 20% of ruminant rations. World production of barley in 1979 totalled 163,456,000 M/T. The ten leading barley producing countries are : The Soviet Union, France, United Kingdom, China, Canada, West Germany, United States, Denmark, Spain and Turkey. Barley is extensively cultivated in South East Asia. In Korea, total production of barley amounts to 584,000 M/T (1979). The production of barley has decreased due to changes in the food con sumption pattern in Korea. Barley grains produce about 64% pot and 36% pearl barley. The production of foods and beverages from barley is almost always linked to the production of animal feeds since the foods and beverages consumed by man are usually produced by milling the whole grain to remove the hull, seed coat,aleurone layer, and embryo. The starchy cooking water from barley has long been used as a broth in invalid diets, to stop diarrhea, and to relieve indigestion.

The present studies were designed to find out the influence of rice bran and the effect of parched barley and boiled pearl barley on growing rats.

MATERIALS AND METHODS

Animals

Female Sprague Dawley rats used in the present experiment were obtained from Department of Food & Nutrition. Seoul National University. In trial 1, six rats, initally weighing 30 g, were randomly assigned one of four different diets supplemented with rice polishings, and were fed ad libitum for eight days. In trial 2, six rats, initially weighing 132-138 g, were randomly assigned one of two diets of parched barley meal and boiled pearl barley, and were fed ad libitum for 11 days. Rats were housed in a polyethylene cages with stainless steel wire floor at 20-23°C. Each rat was weighed individually every day or few days interval.

Diet composition

In trial 1, rice bran replaced 5%, 10%, 20% of the basal diets. The basal diets consisted of 18% protein, 7.5% fat and 7% ash. The fibre contents of the control, 5%, 10% and 20% of rice bran groups were 0.2%, 0.7%, 1.2% and 2.7%, respectively(Table 1). In trial 2, 76% of parched barley meal and 76% of boiled pearl barley were added to each basal diets (Table 2). The fibre contents of parched barley meal and boiled pearl barley groups were 3.2% and 0.6%, respectively.

Comparisons between nutritional groups were conducted by using randomized block design and analysis of variance to determine significant differences among four groups in the trial 1. Student's t-test was used to compare between the two groups in trial 2.

RESULTS AND DISCUSSION

In trial 1, rats supplemented with polished rice bran showed unsignificant differences in body weight increases during the experimental period (Table 3).

However, the 20% rice bran group gained 2.1 g daily while other groups gained 1.7 g, 1.8 g, and 1.6 g in the control, the 5% rice bran group and 10% rice bran group, respectively. It is assumed that rice bran could be supplemented 20% of ration with good results for growing rat. The fibre content of the experimental diets 0.2-2.7% showed no inhibitory effect. High fibre ration reduce protein and fat digestion and interfere with the absorption of minerals and accelerate the flow of food through the digestive tract and bind certain nutrients and carry them into the stool, 18% protein and 7% ash were assumed adequate nutrients for the rice bran experiment.

Table 1. Ingredients used and the chemical composition of experimental diets with different level of rice bran (g/100 g diet).

	Rice bran			
	Control	5%	10%	20%
Ingredients :				
Rice bran 1/	0	5	10	20
Fish meal 2/	35.16	31.94	28.05	22.56
Starch	58.15	56.93	55.38	53.08
Corn oil	2.49	1.93	0.37	0.16
Vitamin & mineral mix 3/	3.70	3.70	3.70	3.70
Salt	0.50	0.50	0.50	0.50
Chemical composition (%) :				
Moisture	10.2	10.1	9.9	9.8
Crude protein	18.0	18.0	18.0	18.0
Ether extract	7.5	7.5	7.5	7.5
Crude fibre	0.2	0.7	1.2	2.7
Nitrogen-free-extract	57.1	56.7	56.4	55.4
Ash	7.0	7.0	7.0	7.0

1/ Particle size of rice bran : 1.3% particle of rice bran passed through 0.149 mm sieve, 10.5% particle remained in 0.149-0.21 mm sieves, 52.3% particle remained in 0.21-0.297 mm sieves, 28.5% particle remained in 0.297-0.5 mm sieves and 7.4% particle remained in 0.5-0.715 mm sieves.
Chemical composition of rice bran : 9.56% moisture, 14.25% crude protein, 20.65% ether extract, 10.28% crude fibre, 35.46% NFE and 9.8% ash.

2/ Chemical composition of fish meal : 13.97% moisture, 51.2% crude protein, 14.25% ether extract, 0.56% crude fibre, 20.02% ash, 4.81% Ca and 2.41% P.

3/ Composition of vitamin and mineral mixture (per gram) : 5,000 IU vitamin A, 1,000 IU vitamin D_3, 2 IU vitamin E, 0.4 mg vitamin K_3, 0.25 mg thiamine, 0.8 mg riboflavin, 0.4 mg vitamin B_6, 0.4 mg niacin, 2 mg Fe, 2 mg Cu, 0.16 mg Zn, 3.6 mg Mn, 0.04 mg Co and 0.08 mg I.

Table 2. Ingredient and composition of experimental diets, trial 2 (%).

Treatments / Ingredients	Parched[1/] barley meal	Pearl[2/] barley boiled
Barley meal	76.0	-
Pearl barley boiled	-	76.0
Casein	14.3	14.3
Corn oil	5.0	5.0
Vitamin & mineral mix[3/]	3.7	3.7
Salt	1.0	1.0
Chemical composition (%) : (D.M. basis)		
Crude protein	21.8	21.2
Ether extract	7.0	6.7
Crude fibre	3.2	0.6
Nitrogen-free-extract	63.0	67.4
Ash	5.0	4.1

1/ Chemical composition of parched barley meal : 12.6% crude protein, 2.6% ether extract, 4.2% crude fibre, 78% NFE, 2.6% ash, 75 mg Ca, 303 mg P, 375 Kcal, 0.16 mg thiamine, 0.09 mg riboflavin, 5.5 mg niacin.

2/ Chemical composition of barley cooked : 11.9% crude protein, 2.3% ether extract, 0.8% crude fibre, 81.9% NFE, 1.0% ash, 395 Kcal, 47 mg Ca, 163 mg P, 0.21 mg thiamine,0.08 mg riboflavin, 2.9 mg niacin.

3/ Compositions of vitamin and mineral mixture are listed in table 1.

Table 3. Effect of rice bran on growth of rat (Trial 1) (g).

Treatment / Day	Control	Rice bran 5%	Rice bran 10%	Rice bran 20%
Initial	30.8 ± 1.46	30.7 ± 0.6	31.2 ± 1.33	31.3 ± 1.77
2nd day	31.6 ± 2.01	31.5 ± 1.21	31.6 ± 3.02	31.8 ± 1.63
3rd day	33.2 ± 2.29	32.4 ± 1.58	31.8 ± 3.30	32.0 ± 1.61
4th day	34.0 ± 1.43	34.3 ± 1.49	33.2 ± 1.87	32.9 ± 1.72
5th day	38.4 ± 2.69	39.4 ± 2.52	36.2 ± 1.21	39.2 ± 3.88
6th day	40.1 ± 2.15	40.6 ± 1.96	37.1 ± 2.00	39.8 ± 2.06
7th day	42.3 ± 2.37	41.4 ± 1.75	42.3 ± 1.87	43.4 ± 2.39
8th day	42.7 ± 2.62	43.1 ± 2.11	42.6 ± 2.32	46.2 ± 2.76
Difference	11.9	12.4	11.4	14.9
Mean daily gain	1.70	1.77	1.63	2.13

Table 4. Effect of parched barley meal and pearl barley boiled on growth of rats (Trial 2) (g).

Treatment / Day	Parched barley meal	Pearl barley boiled
Initial	137.8 ± 3.42	131.7 ± 3.73
2nd day	141.0 ± 3.88	131.4 ± 4.07
4th day	149.6 ± 3.62	137.8 ± 4.87
5th day	158.5 ± 4.28	138.7 ± 3.94
7th day	166.6 ± 4.71	140.1 ± 3.29
8th day	171.9 ± 4.32	141.7 ± 4.01
10th day	181.1 ± 4.58	144.4 ± 4.32
11th day	192.0 ± 4.66	144.9 ± 5.18
Live weight increased	54.1	13.2
Mean daily gain*	5.41^{a}	1.32^{b}

* Different superscripts in the horizontal level means show significant difference between the two treatments ($P < 0.01$).

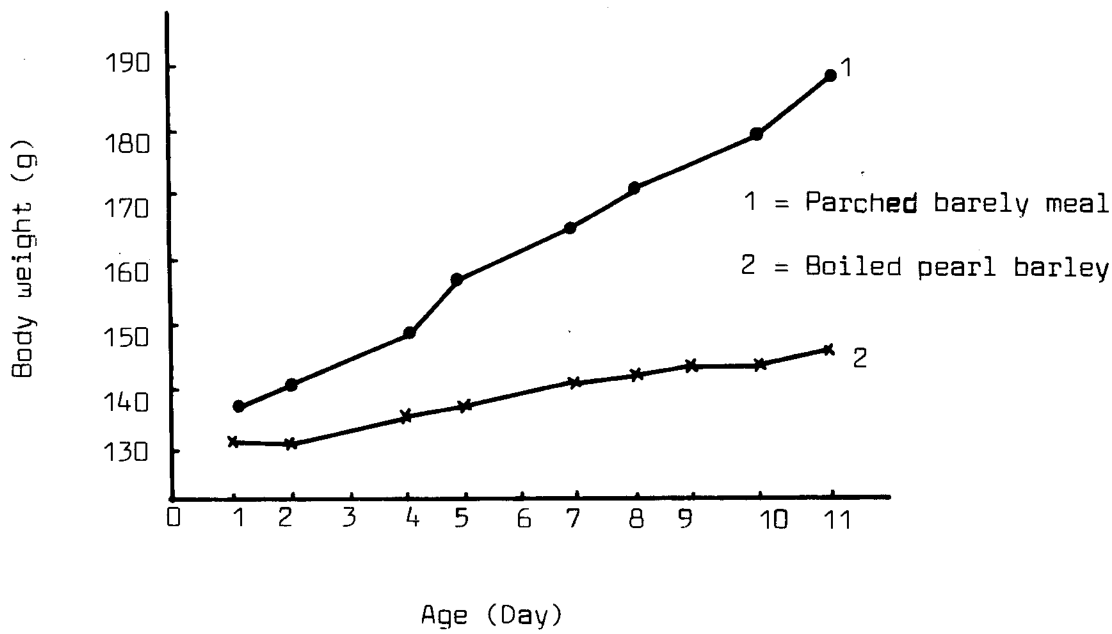

Figure **1.** **Growth** curves of rate fed.

In trial 2, parched barley meal which has been used as a beverage during the summer and an emergency fast food, and pearl barley boiled which has been served as barley-rice meals for the major daily food of Korean were fed to rats to compare daily gains (Figure 1). Parched barley meal group was found superior($P < 0.01$) to the boiled pearl barley group in body weight gain when 76% of both grain was added to the basal diets (Table 2) which contained 3.2% crude fibre in the parched barley group. Both rations contained relatively high levels of protein (21%)and soluble carbohydrates (63-67%). The content of fibre, niacin, calcium and phosphorus in the parched barley meal was higher than the content of those in the boiled pearl barley. From the results of trial 2, it can be concluded that the diet with 76% parched barley meal promoted the growth of rat, while the diet with 76% boiled pearl barley depressed the growth of rats fed high protein (21.2%) and low fibre (0.6%) diet. This finding is a different to the previous report on growing pig fed 13% of corn cob (10% crude fibre).

Grain residues which contain dietary fibre with other nutritious ingredients have beneficial effects for early and growing rats.

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UTILIZATION OF DECAFFEINATED TEA WASTE IN PIGS

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SUMMARY

Decaffeinated Tea Waste (DCTW) at 0, 5, 10 and 15% levels in the diet was fed to weaned Hampshire piglets or eight weeks of age for a period of 140 days. No significant differences were observed in body weight gain, feed consumption, feed conversion, digestibility of nutrients and utilization of nitrogen and minerals. The cost per kg weight gain was found to be lower in groups fed rations containing DCTW. The results indicated that upto 15% DCTW can be safely included in growing and finishing pig rations with distinct economic advantage.

Key words : decaffeinated tea waste, performance, pigs.

INTRODUCTION

Decaffeinated Tea Waste (DCTW)is an industrial waste product of the caffeine factories which is left after the extraction of caffeine from the factory tea waste. Factory tea waste is available as waste in the tea gardens from two varieties of plantation in India namely - *Camellia sinensis* and *Camellia assamica,* the latter is available only in the State of Assam and in the North-Eastern States of India. At present several thousand tonnes of this product are being wasted without any use except using a portion as manure.

DCTW contains about 17.0% crude protein and have no any toxic substances, except a small quantity of tannin (0.4-0.8%) and can be included in broiler rations upto 15% level without any deleterious effect (Konwar et al., 1983). However, no work has been carried out in pigs. Therefore, an attempt has been made to find out the possibilities of using this industrial waste of *Camellia assamica* variety as one of the feed ingredients in pigs. This paper presents the results of this study.

MATERIALS AND METHODS

Decaffeinated Tea Waste was collected from the Caffeine Factory of M/S Assam Pharma and Co. Ltd., Jorhat.

32 (16 male and 16 female) actively growing Hampshire piglets of eight weeks of age were selected. They were randomly divided into four groups of eight (four male and four female) each (Table 1).

Table 1. Distribution of experimental animals.

Blocks	Treatments			
	Gr.I (control)	Gr.II	Gr.III	Gr.IV
Male				
I	16.50	14.50	14.50	14.25
II	12.75	13.50	14.00	14.25
III	12.00	12.50	12.25	11.75
IV	10.50	11.25	11.00	11.50
Average :	12.94 $\pm$ 1.11	12.94 $\pm$ 0.60	12.94 $\pm$ 0.70	12.94 $\pm$ 0.66
Female				
V	14.00	14.25	14.00	14.00
VI	13.75	13.25	13.75	13.75
VII	12.50	12.25	12.25	12.00
VIII	11.50	12.00	11.75	12.00
Average :	12.94 $\pm$ 0.50	12.94 $\pm$ 0.45	12.94 $\pm$ 0.48	12.94 $\pm$ 0.47

Four different treatments were applied at random so that one animal from each of the blocks was under each treatment. The animals were fed separately in individual pens. The treatments Group - 1 (Control) - ration containing conventional concentrate mixture; Group - II - 5%; Group - III - 10% and Group - IV - 15% level of incorporation of DCTW in the concentrate mixtures. Nutrients were supplied at various levels at different stages of growth (NRC, 1973). The experimental rations are presented in Table 2 and chemical composition in Table 3.

Animals were offered feed twice daily and water ad lib. Daily feed consumption were recorded. Live weight was also recorded initially and then at fortnightly intervals. Feed conversion ratio was calculated from the records of the feed consumption and body weight. The cost of the experimental diets and feed consumed per kg gain in weight were calculated. At the end of the experiment a digestibility trial was conducted.

The feeds were analysed for proximate composition according to AOAC (1976). The calcium and phosphorus contents were estimated as per procedures suggested by Talapatra et al. (1940). The data were analysed as per Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

The data on mean body weight gain,feed consumption, feed conversion ratio and cost of feed per kg body weight gain are presented in Table 4. The digestibility coefficients, percent utilization of nitrogen and minerals have presented in Tables 5 and 6 respectively.

It was observed that all the piglets, irrespective of treatments, reached the marketable body weight of 70 kg within the same period. The maximum body weight gain for the period was obtained in group fed control ration (0% DCTW), followed by the groups receiving 5%, 10% and 15% DCTW in order. This indicates

Table 2. Composition of different experimental rations for growing and finishing pigs (%).

Ingredients	Growers				Finishers			
	C	Gr 1	Gr 2	Gr 3	C	Gr 1	Gr 2	Gr 3
Maize	50.0	48.0	48.0	46.0	60.0	58.0	58.0	57.0
Wheat bran	12.0	10.0	6.0	6.0	5.0	5.0	5.0	5.0
Black gram	5.0	6.0	6.0	6.0	4.0	4.0	2.0	2.0
Rice polish	11.0	10.0	10.0	8.0	20.0	18.0	15.0	12.0
Groundnut cake	9.0	8.0	8.0	7.0	2.0	2.0	2.0	2.0
Soyabean meal	5.0	5.0	4.0	4.0	3.0	2.0	2.0	1.0
Fish meal	5.0	5.0	5.0	5.0	3.0	3.0	3.0	3.0
DCTW	0.0	5.0	10.0	15.0	0.0	5.0	10.0	15.0
Min. mixture	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Cost/quintol	236.0	228.0	217.0	209.0	214.0	204.0	195.0	186.0

Additives :- 1. Nuvimine forte @ 500 g/100 kg feed

2. 3-Nitro hoechst @ 50 g/100 kg feed.

Table 3. Chemical composition of experimental rations for growing and finishing pigs (% dry matter basis).

Nutrients	Growers				Finishers			
	C	Gr 1	Gr 2	Gr 3	C	Gr 1	Gr 2	Gr 3
Crude protein	18.0	18.1	18.1	18.0	14.1	14.1	14.1	14.1
Ether extract	7.9	6.4	6.6	6.5	6.1	6.1	5.9	5.9
Crude fibre	4.2	4.7	4.9	5.0	7.1	7.1	7.2	7.3
N.F.E.	59.4	59.9	59.3	59.3	60.5	60.4	60.3	60.3
Total ash	10.6	10.8	11.1	11.1	12.3	12.3	12.6	12.3
Calcium	1.18	1.20	1.21	1.23	1.11	1.13	1.11	1.15
Phosphorus	0.89	0.95	0.95	0.91	0.85	0.88	0.85	0.86

Table 4. Average values of body weight gain, feed consumption, feed conversion ratio and feed cost per kg body weight gain.

Diets	Initial body weight in 56 days (kg)	Final body weight in 196 days (kg)	Total gain in 140 days (kg)	Feed consumption (kg)	Feed/gain ratio	Cost/kg body weight gain (Rs)
Control	12.94	74.88	61.94[a]	234.58[b]	3.79[c]	8.01
Gr 1 (5% DCTW)	12.94	74.56	61.64[a]	235.32[b]	3.82[c]	7.70
Gr 2 (10% DCTW)	12.94	71.10	58.16[a]	233.17[b]	4.01[c]	7.66
Gr 3 (15% DCTW)	12.94	70.69	57.75[a]	230.90[b]	4.00[c]	7.53

[abc]Mean values bearing the same superscripts do not differ significantly ($P > 0.05$).

Table 5. Digestibility coefficients of nutrients in finisher fed different experimental rations (%).

Nutrients	Control	Gr 1	Gr 2	Gr 3
Dry matter	83.81[a]	83.56[a]	84.26[a]	84.33[a]
Crude protein	75.47[b]	75.16[b]	74.69[b]	74.65[b]
Ether extract	76.45[c]	75.89[c]	77.66[c]	78.19[c]
Crude fibre	42.65[d]	41.29[d]	40.97[d]	40.52[d]
N.F.E.	81.81[e]	81.05[e]	82.26[e]	82.34[e]

[abcde] Mean values bearing similar superscripts do not differ significantly ($P > 0.05$).

Table 6 summaries the data on digestibility for individual treatments. No statistically significant differences were found.

Table 6. Percent utilization of nitrogen, calcium and phosphorus by finishers fed different experimental rations (%).

Groups	Nitrogen	Calcium	Phosphorus
Control	67.37[a]	55.67[b]	54.97[c]
Gr 1 (5% DCTW)	67.15[a]	54.60[b]	55.26[c]
Gr 2 (10% DCTW)	65.89[a]	53.27[b]	58.88[c]
Gr 3 (15% DCTW)	64.98[a]	53.18[b]	58.76[c]

[abc] Mean values bearing similar superscripts do not differ significantly ($P > 0.05$).

that body weight gain is progressively decreased as the level of DCTW was on the increase. However, there was no significant difference in weight gains of any of the groups compared to the control. Highest feed consumption was recorded in groups fed 5% DCTW and lowest in 15% DCTW group compared to the control (0% DCTW), the differences were not significant.

Feed conversion ratio in the groups fed control ration and 5% DCTW in their diets was superior to that in the 10% and 15% DCTW groups. Though there are some differences in respect of feed conversion ratio in control and in experimental groups, the differences were not significant. The feed conversion ratio in the experimental groups was slightly affected due to inclusion of DCTW in the experimental rations and the effect was higher as the level of DCTW was on the increase. This effect might be due to the presence of tannins in DCTW which was left after the extraction of caffeine from Factory Tea Waste. Similar observations were also reported by Annon (1982).

The cost of feed per kg live weight gain decreased with the inclusion of DCTW. The cost of the both starter and finisher rations decreased considerably to the extent of Rs. 27.00 and 28.00 per quintol respectively.

The results thus suggested that DCTW can safely be incorporated in growing and finishing pig rations upto the level of 15% without any deleterious effect with distinct economic advantage.

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THE EFFECT OF IONIZATION ON MICE GROWTH AND BREEDING PERFORMANCE

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SUMMARY

At early growing stages the body weight gains of mice anionized were not different from the unionized group. Dietary intake did not significantly affect the body weight of mice(15-17 g). Ionization slightly depressed the growth of mice by 2.4 g, untreated mice switched over the ionization group by 2.3 g as compared with the 3.3 g for the untreated during the four day-feeding period. Plane of nutrition and ionization did not significantly affect the growth of mice when fed high protein and high carbohydrate diets. The Common Ionization Method was appeared statistically superior to the Overnight-Ionization Method. The growth rate of the offspring of mice ionized prior to conception was found to be normal but the number of progeny was considerably high.

Key words : ionization, nutrition, growth,mice.

INTRODUCTION

As long ago as 500 B.C. Aotus,a Greek physician first used electric stimulation for partial medical treatment. In the healthy body the acid-base balance is maintained by buffers, present in the blood rapidly neutralizing food and metabolic acids. When the common acids dissociate into their respective cations and anions, the anionic component may be considered to be the base. Bases are weak or strong depending on their affinity for the hydrogen ion, HCO_3^-, $HPO_4^=$, $H_2PO_4^-$ and protein are relatively strong bases because they have a strong affinity for the hydrogen ion (Knause, 1978; Tadashi, 1979). When anions are dominant in the body, the pH value of blood is maintained in weak alkalinity (7.35-7.4). If cations (Na^{+}, K^{+}, Mg^{++}, Ca^{++}) are dominant pH value of blood shows acidity. There are these symptoms of lethargy,senility and unhealthiness (Krause, 1978).

Anionization charges the body into a weak alkaline blood condition, increase its ability to clean blood, strengthen resistance against disease, cure rheumatism, exudative diathesis and the scrofulous tendency of the body (NRC, 1978; Tadashi, 1979). The recommended ionization technique for humans is shown in Table 1.

Table 1. Some instances of anionizations depending on the symptoms.

Methods / Items	Common method			Overnight method	
	Power	Time	Daily	Power	Time
To improve physical condition	Medium	30 min	Once or twice	Weak	6-9 hrs.
Trouble internal organs	"	"	"	"	"
Trouble nervous system	"	"	"	"	"
Weak heart and system	"	"	"	Not recommended	
Diabates	"	"	"	Weak	6-9 hrs.
Obesity	"	"	"	"	"
Thyroid galand	"	"	"	"	"

Since the growth of mice affected by ionization has been reported hitherto, a study was conducted to assey the effects of anion charging on mice growth and breeding performance during the different growing periods.

MATERIALS AND METHODS

Mice used in the present experiments were obtained from The Je-Ju Animal Health Research Institute, Je-Ju, Korea. Twelve 25 day-old mice weaned at a body weight of 6 g were used until they reached 19 g before puberty (Mindey, 1971) for the anionization studies. Each mouse was weighed individually every day or few days. Mice in the treatment group were housed in polyethylene cages with stainless steel wire floor. The mixed diet was moistened with water and forced to pass through a chopper and dried at 65°C to form pellets. Anion charging was applied by placing cages on a vinyl plate which was charged electrically using an Electrical Ionizing Machine presented by Shin-Jin Electro Medical Instrument Company (1977) (Home-Lator, SJ-104, power : 100 V 50-60Hz, 46 x 30 d 20^{cm}).

The ionization charge was gradually increased from the 0.5 unit (525 volts) on the first day and to 1-1.5 unit (550-600 volts) using the Common Ionizing Method. The body weights were measured individually or on a group basis or at several days interval. The results were treated statistically using the t-test, F-test and factorial analysis for prediction of difference and probable interactions (Snedecor, 1962). Five trials were conducted on follows :-

Trial 1 : Effects of ionization and diet level on body weight.

Weaned mice were acclimatized for ionization for three days before the start of the experiment. The Overnight Method was applied at 0.5 unit (525 volts) for 7 hours ionization. Each mouse was fed ad libitum except for the restricted feeding experiment. The diets used in this trial are shown in Tables 2 and 3.

Table 2. Ingredients and the chemical composition of diet 1.

Basal diet[1/]	80%
Casein	20%
Chemical composition of diet 1	
Crude protein	31.9%
Crude fat	2.77%
Crude fibre	2.70%
Nitrogen free extracts	42.9%
Minerals	1.9%
Metabolizable energy	232 Kcal/100 g

1/ Ingredient and composition of basal diet : 63% corn, 4% wheat bran, 20% soybean oil meal, 11% fish meal, 50 ppm antibiotics and 290 Kcal/100 g metabolizable energy. Chemical composition of basal diet 2:21.57% crude protein. 3.46% ether extracts, 53.64% nitrogen free extracts, 3.38% crude fibre and 2.3% ash.

Table 3. Ingredient and the chemical composition of diet 2.

Basal diet[1/]	83.3%
Dried whole milk[2/]	16.7%
Chemical composition of diet 2	
Crude protein	22.4%
Crude fat	7.3%
Crude fibre	2.8%
Nitrogen free extracts	51.1%
Minerals	1.87%
Metabolizable energy	304 Kcal/100 g

1/ Ingredients of basal diet were similar to diet 1.
2/ Chemical composition of dried whole milk : 4% moisture, 26.5% butter fat, 25.5% protein, 38.2% lactose and 5.8% minerals.

Trial 2 : Effects of switching over from the unionization to ionization or vice versa on body weight of mice near puberty.

Twenty four mice were allocated to three cages with eight in each. Mouse in each treatments was fed the Diet two (Table 3) ad libitum for five days. The Common Method was applied at 1 unit (550 volts) for two 30 minutes daily.

Trial 3 : Effects of ionization and plane of nutrition on body weight of mice.

In this trial 24 mice were allocated to four cages with six in each. Mice were fed ad libitum either a high-protein or a high-carbohydrate diet as in Table 4. The Common Method was applied for ionization for all treatments.

Table 4. Ingredients and chemical composition of diet 3*.

Ingredients	High protein diet (%)	High carbohydrates diet (%)
Basal diet[1/]	70	70
Casein	29	-
Soybean oil	1	3.7
Dextrose	-	26.3
Chemical composition of diet 3		
Crude protein	36.2	15.1
Crude fat	3.4	6.1
Crude fibre	2.4	2.4
Nitrogen free extracts	37.5	61.8
Minerals	1.7	1.6
Metabolizable energy	212 Kcal/100 g	341.3 Kcal/100 g

1/ Ingredient and composition of basal diet were similar to diet 1.

Trial 4 : The Common Method vs The Overnight Method.

Twenty four mice fed ad libitum fed diet one and allocated to three cages. The treatments were the Common Method (two 30 minutes ionization) on six mice. The Overnight Method (seven hour ionization) using six mice and 12 mice control for seven days.

Trial 5 : Breeding performance of mice previously anionized.

Three female mice anionized before conception and an unionized female mouse were mixed with anionized and unionized males respectively. Size of offspring, birth weight and subsequent weights were measured. Diet two was fed ad libitum during the experiment period.

RESULTS AND DISCUSSION

The body weight increases of mice in trial 1 are shown in Tables 5, 6 and 7.

Table 5. Effect of ionization on body weight of mice at post-weaning (Trial 1) (g).

Treatment[+]	Anionization		Unionization	
Day	Body weight	B.W.G.[++]	Body weight	B.W.G.
Initial	6.25		6.32	
5th day	6.68	0.11	6.44	0.03
7th day	7.25	0.29	7.08	0.32
12th day	10.76	0.70	10.50	0.68
Mean daily increase		0.41		0.38

\+ Diet 1

++ B.W.G. : Body weight gain.

The differences of mean body weight gains between the two treatments were 4.5 g and 4.2 g for the ionized and the unionized group, respectively. Immediately after weaning, these ionized mice showd slightly higher growth rates than the unionized group. The differences were not significant.

To find out the possible stimulating effect of ionization on growing mice of 11.5-12.1 g these were fed for 11 days (Table 6).

Table 6. Effect of ionization on growth of mice at mid-growth stage (Trial 1) (g).

Treatment[+]	Anionization		Unionization	
Day	Body weight	B.W.G.[++]	Body weight	B.W.G.
Initial	11.50		12.10	
4th day	12.94	0.48	13.49	0.46
7th day	14.56	0.54	14.67	0.39
9th day	14.95	0.20	14.95	0.14
11th day	16.20	0.63	15.49	0.27
Differences	4.70		3.39	
Mean $\pm S\bar{x}$	0.47 $\pm$ .27		0.34 $\pm$ 0.26	

\+ Diet 2

++ B.W.G. : Body weight gain per day.

Body weight differences were 4.7 g and 3.4 g for the ionization and the unionization groups which were not significant. The mechanism involved in this stimulatory effect of ionization on early growing mice is believed to be due to the alkaline blood keeping the body healthy (Tadashi, 1979). It was observed in the study that the ionized mice were more active than untreated mice.

When the diet was restricted to 2 g daily for four consecutive days, ionized mice lost weight 0.03 g and the unionized group lost 0.36 g. When the diet was increased to 3 g daily, mice gained 2.4 g and 3.3 g in the ionized and the unionized groups, respectively. The levels of dietary allowances did effect significantly ($P < 0.05$).

The growth of mice affected by switching over is shown in table 8.

Table 7. Effects of anionization on daily body weight changes of mice fed different levels of diets (Trial 1) (g).

Treatment[+] / Day \ Diet	Anionization		Unionization	
	2 g daily	3 g daily	2 g daily	3 g daily
Initial	0.046	0.688	0.015	1.006
2nd day	0.320	0.306	0.240	0.454
3rd day	0.110	1.376	-0.410	1.580
4th day	-0.508	0.030	-0.205	0.250
Difference	-0.032	2.4	-0.36	3.29
Mean	-0.008	0.60	-0.09	0.823

\+ Diet 2

Table 8. Effects of switching over from the unionization to ionization on growth of mice of near puberty (Trial 2) (g).

Treatment[+] / Day	Ionization		Unionized-Ionization		Unionization	
	Body weight	B.W.G.[++]	Body weight	B.W.G.	Body weight	B.W.G.
Initial	14.79		15.13		15.34	
2nd day	15.48	0.69	15.91	0.78	16.35	1.01
3rd day	15.78	0.30	15.68	0.23	16.80	0.45
4th day	17.16	1.38	17.27	1.59	18.38	1.58
5th day	17.19	0.03	17.41	0.14	18.63	0.25
Differences	2.4		2.28		3.29	
Mean daily gains ($\bar{X} \pm S\bar{x}$)	0.60 ± 0.36		0.69 ± 0.45		0.82 ± 0.61	

\+ Diet 2

++ B.W.G. : Body gains per day.

Body weight increases were found slightly higher in the unionization at 3.3 g than ionized group at 2.4 g during five-day growing period of mice. The unionized mice switched over to the ionization showed decreased growth rates at 2.3 g which was close to the weight gains of ionized group. Table 8 shows that as mice grew near to maturity, ionization depressed mice growth. The results were however not statistically significance.

A further switching over experiment was carried out in trial 2, and the results are shown in Table 9.

During the four-day growing period, the body weight gains of the ionization switched over to untreated the untreated group switched over to ionization, and in the untreated groups gave 0.75 g, 0.5 g and 1.2 g, respectively, which were not significant. The growth rates of mice near puberty had a steady state growth curve in the ionized group (Table 9). It is assumed that fattening type of body weight increase in mice might be depressed when mice were ionized at near maturity.

Table 10 shows the results of the growth of mice fed high protein diet (36.2% protein, 212 Kcal/100 g ME) and high-carbohydrates diet (15.1% protein, 341.3 Kcal/100 g ME).

There was no significant differences among total body weight gains of mice in the high protein-ionization group(1.9 g), the high-carbohydrates-ionization group (1.8 g),the high-protein-untreated group (2.4 g) and the high carbohydrate - untreated group (1.6 g) during seven-day growing period of mice in trail 3. It was found that protein in diet showed slight resistance against ionization by mice.

The results (Table 11) compare the Common and The Overnight Methods.

Table 9. Effects of switching over to ionization or vice versa on the growth of mice near puberty (Trial 2) (g).

Treatment[+]	Ionized-Union.[++]		Unionized-Ion.[+++]		Unionization	
Day	Body weight	B.W.G.*	Body weight	B.W.G.	Body weight	B.W.G.
Initial	17.16±0.85		18.56±0.42		17.59±1.73	
2nd day	17.27±0.54	0.11	18.27±0.31	-0.29	18.41±1.73	0.82
3rd day	17.35±0.53	0.08	18.85±0.05	0.58	18.15±1.73	-0.26
4th day	17.51±0.46	0.16	18.73±0.18	-0.12	18.62±1.73	0.47
5th day	17.91±0.48	0.40	19.06±0.21	0.33	18.79±1.73	0.17
Difference	0.75		0.5		1.2	
Mean daily gains ($\bar{X} \pm S\bar{x}$)		0.19±0.10		0.13±0.21		0.30±0.25

\+ Diet 2

++ Switch from ionized mice to unionization.

+++ Switch from unionized to ionization.

* Body weight gain.

Table 10. Effects of ionization and feeding high protein and high carbohydrate diets on mice growth (Trial 3) (g).

Treatments[+] / Day	High Prot. Ion.	High CHO Ion.	High Prot. Untreated	High CHO Untreated
Initial	8.41	7.85	7.55	8.64
3rd day	9.45	8.38	8.58	9.44
5th day	10.02	10.09	9.15	9.76
7th day	10.33	9.61	9.99	10.19
Differences	1.92	1.76	2.38	1.55
Mean daily gains ($\bar{X} \pm S\bar{x}$)	0.27 ± 0.21	0.25 ± 0.20	0.34 ± 0.28	0.22 ± 0.19

\+ Diet 3 fed ad libitum.

Table 11. Effects of methods of ionization on mice growth[1/], (Trial 4) (g).

Methods / Day	The Overnight[2/] Method	The Common[3/] Method	Untreated
Initial	12.74	11.46	11.55
2nd day	12.54	11.24	11.07
3rd day	13.05	11.99	11.78
4th day	13.64	13.47	12.37
5th day	14.90	13.74	12.41
6th day	13.41	13.71	12.78
7th day	13.57	14.09	12.92
Differences	0.82^{a}	2.63^{b}	1.37^{ac}
Mean daily gains ($\bar{X} \pm S\bar{x}$)	0.12 ± 0.07	0.37 ± 0.11	0.19 ± 0.04

1/ Diet 1 fed ad libilum.

2/ 7 hour-ionization.

3/ Two 30 minutes-ionization.

Mice gained total body weight during six days at 0.8 g, 2.6 g and 1.4 g in the seven-hour-ionization, the two-30 minutes-ionization and the untreated group, respectively. The Common Method (two-30 minutes-ionization) was found to be superior ($P < 0.01$) to The Overnight Method or untreated group.

To secure breeding ability of mice previously ionized three female mice and one unionized female were bred in trial 5. The number of offsprings and their growth weights are given in Table 12.

Average birth weights were 1.3 g and 0.9 g in the ionized and the unionized, respectively. This result has indicated that the ionization during the growing period of mice did not bring about any detriments in breeding performances and growth of both sexes.

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RECOMMENDATIONS

I. Farm-system surveys preceeding introduction of innovations :

1. It was agreed that more emphasis be given to describing the totality (systems) of farming in a given area before introducing innovations. The pre-evaluation should involve :

   a) Thorough assessment of present feed supplies, both quantitatively and qualitatively, and in different seasons.
   b) gathering information on numbers and types of animals and their productivity levels.
   c) assessing alternative uses of crop residues.
   d) describing land tenure and ownership.
   e) assessing existing government extension services.
   f) projections of future increases or changes in animal production and their economic implications.
   g) assessing the social conditions which may hinder or assist attitudes to innovations; the importance of understanding the hopes and aspirations of the target group must be stressed.

2. When innovations are introduced, it is important that they occur with the co-operation and participation of farmers and extension services.

3. The practical and economic value of upgrading straw should be examined in detail before attempting to introduce the technology to a farming system. In assessing the economic value it is important to consider that treatment of straw usually increases both digestibility and voluntary consumption. The increased intake may be the most important attribute in areas when there is an abundance of underutilized crop residue.

II. Factors affecting nutritive value of straw :

1. There is an urgent need to examine and describe the nutritive

value of different varieties of rice and other cereal straws and stovers. There is also an urgent need to establish effective dialogue between plant breeders and animal production services. Animal research units should be a natural component of large plant research stations.

2. There is need to examine is detail the effects of harvesting method, cutting height, fertilizer treatment, storage methods and other factors on the nutritive value of straws and stovers. Reports of experiments with straw and stovers should include information on variety of material, stage of maturity at harvesting, fertilizer treatment and method of storage.

III. Method of improving poor quality roughages :

1. Several efficient methods for chemical treatment of low quality roughages are available and are well-documented. It is recommended that work on adapting these methods to practical situation, where treatments can be shown to be economic, is given more emphasis.

2. Chemicals for upgrading, which also supply valuable nutrients and act as preservatives (eg. urea) should be given priority. Often preservation of straw will in itself increase feed supply.

3. Naturally-accurring sources of chemicals such as limestone, urine etc., should be considered further.

4. Experience obtained so far has shown that the greatest uptake of chemical treatment of straw occurs when rapid recoupment of costs is achieved eg. milk production.

IV. Supplementation of poor quality roughages.

1. There is need to obtain more information on positive and negative effects of supplementing poor quality roughages with locally-available material. Supplementation at low levels appear to give the greatest effects on animal productivity.

Suggested procedures or guidelines for examination of new crop residues and effects of supplementation will shortly be published in a Manual prepared by FAO/ILCA.

V. Appraisal of impact of innovations :

1. When innovations have been introduced it is important that progress afterwards be monitored for several years. Such work chould usefully be undertaken by short-term student projects. The information and experience so collected would benefit others. This information, of course could also be used to redirect or focus attention on the next constraints to be studied in the systems.

2. Information and results from experiments with crop residues should be made available to other groups concerned, as quickly as possible. This may be achieved through rapid publications in journals, but particularly by distribution of information to network of groups connected with eg. ILCA, IAEA, IFS, IDRC, AFAR Network and other organizations.

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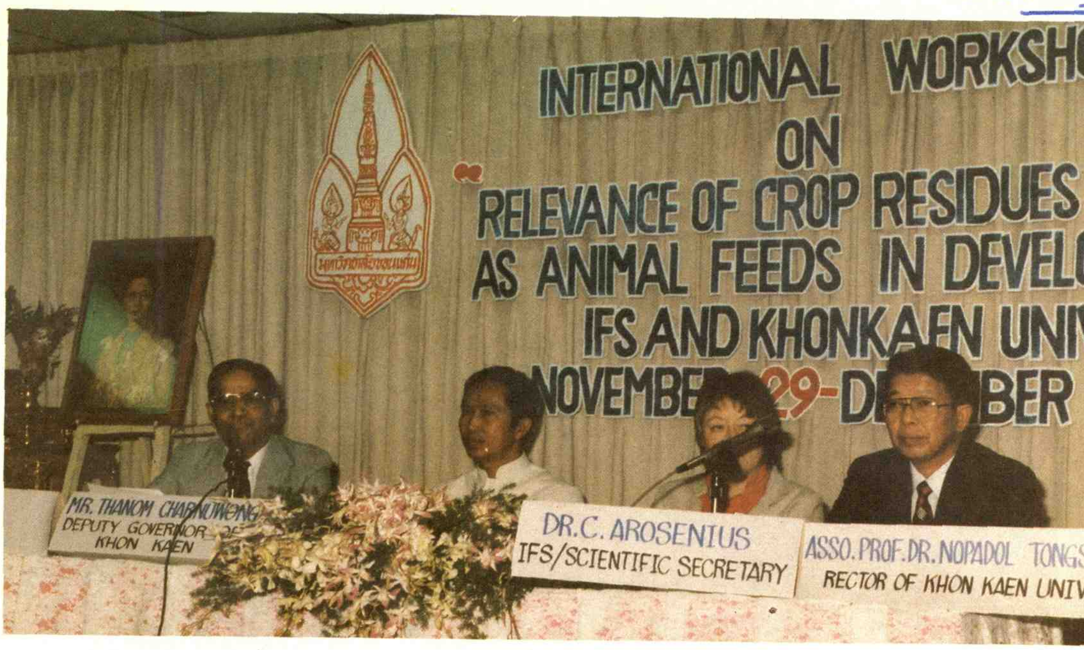
Surendra

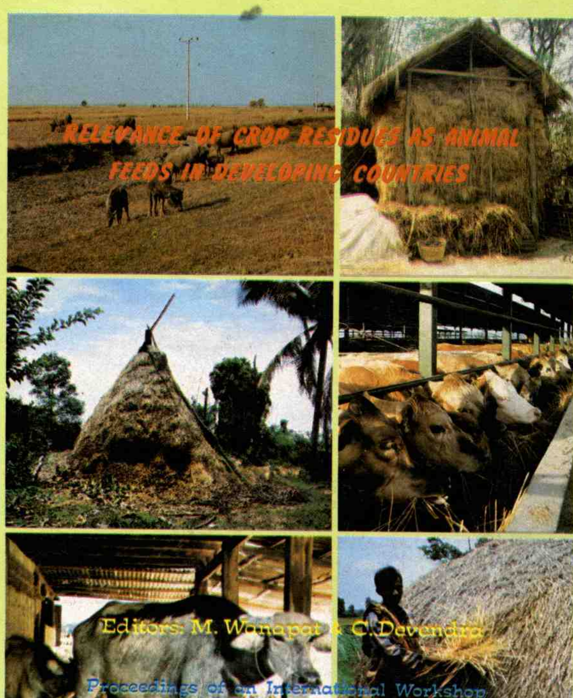


Opening Ceremony : (L to R) B.K. Soni (FAO/APHCA) (Bangkok), Thanom Chanuwong (Deputy Governor of Khon Kaen), Christina Arosenius (IFS Scientific Secretary) and Associate Professor Dr. Nopadol Tongsopit (Rector of Khon Kaen University).

IFS Grantees participated in the Workshop :

Standing : (L to R) A.S.B. Rajaguru (Sri Lanka), Mu-Hwan Lee (Korea), I.M. Nitis (Indonesia), Boonlom Cheva-Isarakul (Thailand), A.Q. Repollor, Jr. (Philippines), Weerasak Wongsrikeao (Thailand), and S. Reksohadiprodjo (Indonesia).

Seating : (L to R) Metha Wanapat (Thailand) (Convener) and Christina Arosenius (Sweden) (IFS Scientific Secretary).



RELEVANCE OF CROP RESIDUES AS ANIMAL FEEDS IN DEVELOPING COUNTRIES

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