POTENTIAL VALUE OF NON-CONVENTIONAL FEEDSTUFFS FOR ANIMALS IN ASIA

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SUMMARY

The utilisation of non-conventional feed resources (NCFR) in Asia is justified by serious feed deficits, rising cost of production, continuing low animal productivity, and inability of the components of the animal industries to meet national targets, especially of animal proteins. Constraints to their more effective utilisation are reviewed in the context of characteristics of these feeds, adequacy and requirements, and priorities for use by animals. It is estimated that from field, plantation and tree crops, approximately 238 X 10^6 tonnes or 46% of non-conventional feeds are produced annually. Of these about 80-93% of the feeds produced are suited for feeding ruminants. Optimum levels of utilising many of the feed ingredients are summarised as a first step to diet formulation, and case studies are cited which demonstrate economic benefits. Limited data is given on deleterious principles in the feeds. The following strategies merit increased future attention : all year round feeding systems, more intenstive use of AIBP and NCFR especially in stall feeding systems, development of complete rations, strategic supplementation, wider use of leguminous forages and urea-molasses block licks. The strategies for promoting expanded and intensive use of NCFR require high emphasis on the utilisation of research results involving large scale on-farm testing of the potentially more important feedstuffs in individual countries. This initiative merits the highest priority in the objective to maximise productivity from, and more efficient use of, the animal genetic resources in Asia.

I. INTRODUCTION

Expanding the utilisation of available feeds, including non-conventional feed resources, represents possibly, the most challenging task concerning components of the animal industries in Asia. The situation is associated with three important reasons. Firstly, there continues to exist serious feed deficits that do not appear to be contained in the face of increasing human and animal population growth.

Secondly, inadequacies in dietary nutrient supply penalise animal performance and do not maximise the production of animal products (meat, milk, eggs, skin and fibre), and between ruminants and non-ruminants, the former are especially inefficient. Thirdly, inability to meet national targets especially of edible animal products, has raised doubts about the efficiency of existing animal production systems and the utilisation of resources used by animals (Devendra 1983). These three reasons justify a specific focus on more efficient use of the available feeds, in the context of feeding and nutrition being the most serious non-genetic factor affecting production.

Several regional meetings have been held in Asia on the subject of available feeds and their utilisation, for example, in Malaysia (1977; 1986; 1987), Indonesia (1981, 1989), Philippines (1980), Bangladesh (1983), Japan (1983), Pakistan (1983), Thailand (1984), Sri Lanka (1986), Japan (1987), India (1988) and Japan (1989). In India, annual meetings are held on the subject through the Indian Council of Agricultural Research (ICAR) supported all Indian Coordinated Research Project on the Utilisation of Agricultural By-products and Industrial Waste Materials for Evolving Economic Rations for Livestock. In addition, regular meetings are held by the Animal Nutrition Society of India (1986). Reference is also made to seven consecutive meetings between 1981-1987 on fibrous agricultural residues sponsored by the International Development Program of Australian Universities and Colleges (see for example Dixon, 1988).

Over the period 1977-1989, including this seminar, these total to about 22 regional meetings, meaning that about one meeting is convened annually. The fact remains however, that the situation with reference to increased productivity from the animal resources has not changed significantly in the context of more intensive, and expanded utilisation of the available feeds. The situation is particularly critical for ruminants (buffaloes, cattle, goats and sheep), whereas for non-ruminants (pigs and poultry) the converse is true in view of the use of mainly imported cereals, fish meal and advanced temperate technology.

The intent in this paper is to focus on the available feeds, review the advances that have been made, and more particularly, emphasise strategies that justify expanded utilisation. The benefits include the likely impact of these strategies on potential increased contribution from the totality of animal resources.

II. ANIMAL RESOURCES

Table 1 sets out the magnitude of the animal resources in the Asia, the percentage in terms of the total world population and the average annual growth rate specific to each species.

The extent of both the ruminant and non-ruminant animal resources are quite enormous. Among ruminants, about 97% of the buffaloes and 56% of the goats are found in Asia in terms of the total world populations of these species, followed by cattle and sheep of 31% and 29% respectively. There also exist sizeable populations of asses, camels, mules and horses, which as percentage of the total world population were 20%, 23% 26% and 37% respectively.

Among non-ruminants, ducks accounted for as much as 63% of the total world population, followed by 49% pigs and 38% chickens. Among ruminants, the goat and buffalo populations were growing at the fastest rate, followed by sheep and cattle. Among non-ruminants, the chicken population is growing the fastest.

It is significant to draw attention to the fact that ruminants (buffaloes, cattle, goats and sheep) are generally more widely reared than non-ruminants and the vast majority of the ruminant populations are in fact, owned by small farmers, landless peasants and labourers. They are renewable resources and have varied functions (Devendra 1983) from food production (meat and milk) to various miscellaneous benefits (security, draught power, fertiliser, fuel, utilisation of coarse crop residues, social values and recreation).

By comparison, pigs and poultry constitute advanced animal industries in many countries in Asia. The main reasons for this are associated with the availability and successful transfer of proven technology in pigs and poultry production, the ease of importing feedstuffs for them, a large and ready market for the products and the rapid turnover of capital investment. The two industries have already assumed industrial proportions and are usually found in urban-fringe areas which an absorb the growing domestic market outlets for the products. In view of the priority on the development of ruminants in most countries in Asia, expanding the use of agro-industrial by-products and non-conventional feed resources will necessarily have to focus more on these species, including their individual characteristics in the quest to increase productivity from them.

III. FEED RESOURCES

(1) Categories

Three main categories of feeds are identifiable : crop residues, agro-industrial by-products (AIBP) and non-conventional feed resources (NCFR). For purposes of this paper, particular emphasis is given to the last category (NCFR).

(2) Non-conventional Feed Resources

NCFR refer to all those feeds that have not been traditionally used in animal feeding and/or are not normally used in commercially produced rations for animals.

Defined in this manner, the NCFR embrace a wide diversity of feeds that are typical of, and abundant in Asia. A feature about these ingredients is that whereas the traditional feeds of crop origin tend to be mainly from annual crops, the NCFR include commonly, a variety of feeds from perennial crops and feeds of animals and industrial origin. In this sense, the NCFR could really be more appropriately termed "new feeds", and this term is in fact being increasingly used.

Thus, the term NCFR has been frequently used to describe such new sources of feedstuffs as palm press fibre (oil palm by-products), single cell proteins, and feed material derived from agro-industrial by-products of plant and animal origin, poor quality cellulosic roughages from farm residues such as stubbles, haulms and vines. Other agro-industrial by-products also exist such as slaughter-house by-products and those from the processing of sugar, cereal grains, citrus fruits and vegetables from the processing of food for human consumption. This list can be extended to derivatives from chemical or microbial processes, as in the production of single cell proteins.

It is not easy however to draw a distinct demarcation between traditional feeds and NCFR. This is because in some countries, such as India and Pakistan, what may now be classified NCFR may in fact be traditional to the extent that it may have been fed for a long time. A case in point concerns wheat straw which is very widely used in both these countries. Additionally, the availability of NCFR, especially of plant origin, is dependent to a large extent on type of crops being cultivated, and the prevalent degree of application of the crop technology.

(3) **Characteristics of NCFR**

The NCFR have a number of characteristics that are worth noting and to keep in perspective :

(i) They are the end products of production and consumption that have not been used, recycled or salvaged.

(ii) They are mainly organic and can be in a solid, slurry or liquid form.

(iii) Their economic value is often less than the cost of their collection and transformation for use, and consequently, they are discharged for wastes.

(iv) The feed crops which generate valuable NCFR are excellent sources of fermentable carbohydrates, eg. cassava and sweet potato and this is an advantage to ruminants because of their ability to utilise inorganic nitrogen.

(v) Fruit wastes such as banana rejects and pineapple pulp by comparison, have sugars which are energically very beneficial.

(vi) Concerning the feeds of crop origin, the majority are bulky, poor quality cellulosic roughages with a high crude fibre and low nitrogen contents, suitable for feeding to ruminants.

(vii) Some of the feeds have deleterious effects on animals, and not enough is known about the nature of the active principles and ways of alleviating the effects.

(viii) They have considerable potential as feed materials, and for some, their value can be increased if there were economically justifiable technology means for converting them into some usable products.

(ix) More information is required on chemical composition, nutritive value, toxic factors and value in feeding systems especially of those feeds for which data are inadequate.

Many of the NCFR are currently designated as wastes, and this is an inaccurate description. They are wastes to the extent that they have not been shown to have an economic value so that if these wastes can be utilised and converted by animals into valuable products for human benefit, they then become new feed materials of importance. Additionally, they can alleviate the existing limited feed resources. Recycling, reprocessing and utilisation of all, or a portion of the wastes, offer the possibility of returning these to beneficial use, as opposed to the traditional methods of disposal and relocation of the same residues. The demonstration of potential value can thus make many of these wastes, new feeds of value and importance. The AIBP and NCFR are of three categories :

(1) Energy rich feeds from bananas, citrus fruits, pineapple, sugar cane an root crops (eg. banana waste and molasses).

(2) Protein supplements such as oilseed cakes and meals, animal by-products, by-products from the food industries and fishmeals (eg. coconut cake and feather meal).

(3) By-products from cereal milling and palm oil refining (eg. rice bran and palm oil mill effluent {POME}).

IV. QUANTITIES OF FEEDS PRODUCED

It is important to quantify the magnitude of NCFR produced. The identification and definition of AIBP and NCFR involve a number of considerations which are worthy of note. They include inter alia :

(1) Quantities and kinds of materials available. This involves the use of statistical data and other sources of information for example, area under the crop, average yield per hectare and extraction rates epcific to individual crops.

(2) Brief physical description (eg. bulky, roughage, slurry, wet or dry).

(3) Characterisation (Energy or protein source and chemical composition).

(4) Location of production.

(5) Seasonality of production.

(6) Present use by animal category.

(7) Alternative uses if any (eg. as a fertiliser).

(8) Potential for processing.

(9) Cost of collection, handling, transportation and processing.

(10) Impact on prevailing and future utilisation.

The distinction between conventional feeds and NCFR varies from country to country. In India and Pakistan, what may be classified as NCFR elsewhere may in fact be traditional and a case in point concerns wheat straw which is very widely used. In the long term, wider use of NCFR would designate many of these as traditional feeds.

Table 2 summarises the availability of NCFR in Asia and the Pacific. From field, plantation and tree crops alone, the total availability of feeds to inlcude AIBP and NCFR is approximately 513 million tonnes. Of this, about 238 X 10^6 tonnes or 46% are considered to be NCFR. Of this, about 80% of the NCFR in field crops and 93% in tree crops are suitable for feeding ruminants. It is stressed that this total availability is thus higher than the figure suggests, as it has not been possible to include calculations of feed derived especially from animal slaughter and the food processing industries. Good examples are slaughter-house by-products (eg. feather meal) and those from the processing sugar, cereal grains, citrus fruits and vegetables for human consumption.

The emphasis on crop production and the concurrent processing of some of the products result in effluents which cause serious pollution problems, eg. pineapple canning wastes, palm oil processing wastes, rubber processing wastes, slaughter-house wastes and distillery wastes. Serious efforts should therefore be made to find effective and economic uses for these residues and wastes, without detriment to the environment.

V. PRIORITIES FOR USE

Table 3 summarises the priorities for using AIBP and NCFR in Asia according to their potential value and importance especially to individual species of animals. It categorises the broad types of feeds, their essential characteristics and the main species which currently utilise them.

VI. ADEQUACY AND REQUIREMENTS : JUSTIFICATION FOR USE

The question of matching potential response in animals by ensuring the requirements of the total animal genetic resources represents a major challenge to animal nutritionists in all countries. The Asian region is unique in that this situation varies from one of acute inadequacy to adequacy in some countries. While all animal species are involved, the problem is more acute for lactating ruminants with their higher demand for more nutrients (Devendra and Wanapat 1985).

The justification for ensuring more complete utilisation of the available crop residues and AIBP including NCFR is associated with low per animal performance, manifesting in such deleterious effects as low growth rates, age at first parturition, interval between parturitions, prolongation of non-productive life and high mortality rates in animal populations.

Perhaps the greatest justification for improving the efficiency of feed utilisation and management systems are the potential improvements feasible. A number of studies demonstrate this and include results in goats (Sachdeva et al. 1974; Devendra 1979), sheep (Soetanto 1986), buffaloes (Putu et al. 1983) and cattle (Devendra and Lee 1975).

More intensive utilisation of the available feeds is also necessary in the face of chronic feed deficit situations that occur annually throughout countries in South Asia.

Table 4 provides the trends in the feed balances in India, between 1970 and 1984. Two major conclusions are apparent. Firstly, feed deficits and the malady of undernutrition was a continuing problem. Secondly, there has been a distinct trend towards a reducing feed deficits despite increased animal populations over the 14 years. This trend is probably reflective of improved feeding systems, more efficient use of the available feeds and increasingly intensive systems of production. Whether in terms of scale and magnitude, these approaches are adequate and can be further improved is a matter of debate. Reddy (1987) has recently pointed out that many NCFR remain to be more widely used in India, implying that there is still scope for reducing the feed deficits.

Table 5 illustrates a parallel situation in Pakistan also for the year 1984. The feed deficits for animals in terms of total digestible nutrients (TDN) and DCP are about 25% and 41% respectively.

VII. CURRENT CONSTRAINTS TO UTILISATION

The NCFR are presently underutilised. This is due to several reasons:

(1) Production is scattered and in some cases, the quality produced is low, especially for processing.

(2) High cost of collection of some of the NCFR eg. rubber seeds.

(3) Non-competitive costs and unremunerative prices.

(4) Tendency to think of some NCFR eg. palm oil mill effluent in terms of disposal, not utilisation.

(5) Processing is difficult and in any case problematical.

(6) Lack of managerial and technical skills to utilise the feeds <u>in situ</u>.

(7) Limitations in the end uses of the produced products.

(8) Uncertainty about the marketability of the end products.

(9) Associated with (5) lack of managerial skills and capital resources for the purchase and operation of suitable technology, or for the study of new appropriate technology.

(10) Small farmers who form the backbone of traditional agriculture have neither the resources and know-how nor the quantities of residues to take individual action.

In addition to these and with specific reference to NCFR utilisation, there are additional major constraints that merit attention :

(1) Availability in terms of time, location, seasonality and storage facilities.

(2) Convertibility with respect to handling, separation, transportation and physical processing of the residues.

(3) Limited knowledge on the composition of the residues, such as proximate components (eg. crude protein, crude fibre and minerals) intake and nutritive value (eg. digestible energy and proteins) which are pertinent to the development of utilisation technology.

(4) Use of the end product in relation to demand, rate of growth of demand, storage and markets.

(5) Inadequate demonstration of potential value in feeding systems both nationally and regionally due to low priority research.

(6) Economic viability of residue utilisation programmes involving

NCFR also needs to be demonstrated.

VIII. UTILISATION

It is not intended to review again, aspects of the utilisation of individual feed ingredients for animals. This is in view of the availability of exhaustive recent reviews on non-conventional feed resources in Asia and the Pacific (Devendra 1985) and rice straw as a feed for ruminants (Doyle, Devendra and Pearce 1986).

Particular attention is drawn to optimum levels of utilisation of individual feeds, since in the formulation of practical balanced diets for feeding individual farm animals, one immediate consideration is the technically optimum level of the feed which can be used to advantage. The question brings to bear the importance of the more fundamental aspects of research on the nutritive value of individual by-products, from chemical analysis, digestibility and balance studies to practical feeding trials that can relate optimum levels of individual by-products to feed efficiency and animal product output.

Table 6 brings together the available information from practical feeding trials where graded levels of 16 non-conventional feedstuffs were used. The identification of optimum levels was based on the results of these studies. Thus, a 30% level of poultry excreta would appear o be optimal for ruminants and 5-10% for poultry. With oil palm by-products, the optimum level of inclusion in ruminant diets is 30-40%. With rubber seed meal, the corresponding level for all species of livestock in India, Malaysia and Sri Lanka appears to be 20%. In India, cows and bulls appear to tolerate an optimum level of 40% sal seed meal.

These optimal levels of inclusion represent an approximation of the amounts that are likely to promote good response in the animals. The levels will be influenced, no doubt, by other ingredients in the diet and by the ability of individual species to utilise these materials. The removal of toxic or deleterious components is of course important in this context.

With specific reference to poultry litter, in recent years, considerable research and development effort has been directed in

Pakistan at increasing the use of poultry litter especially in diets for ruminants. The two principals advantages that have been demonstrated are, firstly, potential increased use of an available feed, and secondly, substantial reduction in the cost of milk production when the diet is formulated from mainly local feeds.

Based on the experience in Pakistan, it is relevant to draw attention to the following issues (Iqbal Shah and Mueller 1983) :

(1) Prior to feeding, poultry litter should be ensiled, stacked, dehydrated or treated with chemical or otherwise, to reduce the microbial count and totally eliminate pathogens;

(2) Poultry litter can be fed to different classes of animals as follows :

(i) Up to 30% DM in the ration (4-6 kg DM/head/day) for high producing dairy cattle. Higher levels of about 45% are possible for brief periods when feeds are in short supply.

(ii) Up to 40% DM in the ration for beef cattle. However, not more than 30% is recommended.

(iii) Up to also 30% DM for fat lambs, but the copper content in poultry litter may limit the level of the litter below 30%.

(3) High energy feed ingredients (eg. molasses, root crops and grains) are necessary when large (25% DM and above of poultry litter) are used to ensure maximum utilisation of the non-protein nitrogenous component of the litter.

(4) Palatability problems are best overcome by ensiling or chemical treatment. Molasses inclusion increases the palatability and intake of the litter. A dust-free ration prevents irritation of the eyes and the respiratory systems,

(5) Adaptation to the feed is important and must be done gradually (3-5 days).

(6) When fed at or about the 20% level, poultry litter usually supplies all the calcium and phosphorous requirements.

(7) The critical constituent of poultry litter is ash which reduces the amount of organic matter in the total ration and adds to the total content of indigestibles.

(8) Poultry litter containing high levels of antibiotics and other anti-microbials and chemotherapeutics should be avoided.

IX. DEMONSTRATION OF ECONOMIC BENEFITS

The final objective in ensuring expanded use of the AIBP and NCFR is high performance in animals and of a type that is demonstrated to be economic. With several crop residues, the importance of seeking an economic advantage has been emphasised (Giaever 1984; Greenhalgh 1984). The high costs of the pretreatments need to be weighed against the beneficial effects, including the extent of the animal response. In simple terms, the significant of the economic aspect is illustrated.

In order to illustrate this important point, two case studies are presented, one from Malaysia on the utilisation of rubber seed meal by poultry, and the second from the Philippines concerning poultry litter.

In the first example in Malaysia, two experiments are cited, both involving rubber seed meal. In both examples, a 20-25% level of rubber seed meal partially replaced soyabean meal for either broiler or egg production, and both diets were compared to control diets which did not have rubber seed meal. The control diets in both cases, as one will expect, were more expensive than those with rubber seed meal. The calculations in Table 7 demonstrate the reduced costs of feeding resulting from the use of rubber seed meal.

The second case study concerns the utilisation of leucaena leaf meal (LLM) and dried poultry litter (DPL) and rice straw-based diets in the Philippines. The life-time performance of 20 crossbred dairy cattle was studied over a four-year period. The results of this study are summarised in Table 8 adapted from Trung et al. 1987.

The results indicated that although there were no treatment effects, except for total solids (per cent), inclusion of LLM and DPL gave satisfactory growth rates (0.40 - 0.46 kg/day) and total milk yields. In particular, the study showed that there were definite economic advantages due to the inclusion of LLM and DPL during both the growth and lactation phases (Table 8). It has been suggested that the combined inclusion of 23% of LLM and 23% of DPL was beneficial. Likewise in Pakistan, Hasnain (1983) has shown how the inclusion of poultry litter decreased feed costs in lactating animals.

X. DELETERIOUS PRINCIPLES

Many NCFR contain substances that are deleterious to animal health. Little is known about the effects of these to the animal body both in the short and long term. One is the presence of HCN or prussic acid in the "bitter" varieties of cassava leaves and stems and in rubber seeds. If these feedstuffs are used without treatment, death may occur in extreme cases. Fortunately, methods are now available to detoxify the HCN.

The second example concerns tannins which are widespread in such feedstuffs as sal seed cake, tamarind seed hulls and sorghum. Ruminants can tolerate a much higher concentration of tannins than rats or chicks. They can inhibit the activity of micro-organisms in the rumen and depress the digestion of protein and fibre. With leucaena forage, there exists the toxic non-amino acid mimosine, which is degraded to another toxic compound, 3-hydroxy-4(1H)pyridone (DHP). The latter is goitrogenic. Other examples include the presence of theobromine caused by fermentation of cocoa pod husks and also a trypsin inhibitor in guar meal. Table 9 provides a summary of various types of toxic principles found in the main AIBP and NCFR. This list is not exhaustive but provides limited information on the approximate contents of the known toxic principles. More information is required on the type and extent of these deleterious principles and especially their effects on animals.

XI. ON-FARM TESTING

Figure 1 demonstrates the steps that can be followed using rice straw as an example of a potentially valuable feed (Devendra, 1987). The steps involve initially, research at the station-level involving the characterisation, assessment of nutritive value and utilisation, pre-treatments (physical, chemical or biological) and supplementation (type and extent of), if this can be justified. It is essential to establish very early in the planning process, a balance between station-level and on-farm research; how the work is going to be undertaken on farm involving farmers, the resources required for the purpose and the duration of the task.

The on-farm work needs to consider the objectives of production, the treatments involved, the precise methodologies that are going to be used to support the work, the measurements to be undertaken, all aspects of the inputs used, the outputs from the experiment, and other issues related to the economic anlaysis of the final results. Adequate animal numbers and replications are essential to ensure statistical validity and to overcome possible problems that are likely to be countered under the field conditions. Sometimes, and depending on the extent of such problems, degress of precision in the conduct of the work may need to be compromised, but not at the expense of enabling statistical analysis of the results. In order to ensure attention to all these aspects as well as smooth conduct of the work, consideration need also be given to how intensively the on-form work will be monitored. Concerning the conduct, procedures and economic analysis of on-farm animal research, attention is drawn to the value of a recent publication on appropriate methods for conducting on-farm animal research, procedures and economic analysis (Amir and Knipscheer, 1989).

The stability and success of on-farm testing also depends to a large extent on minimising risk factors, possible compensation, remuneration in the form of produce from the results, and the enthusiasm of farmers.

With respect to rice straw specifically, and other such potentially important feeds, unfortunately, the situation is that there has been limited and inadequate attention to large scale on-farm testing in the past, with the result that the bulk of the research completed is essentially fundamental and confined to the experiment station level. It is suggested that more conscious and concerted efforts are necessary to extend more widely the value of the results to real farm situations.

There is a great need therefore for improved evaluation of new technologies through on-farm testing and demonstrations. On-farm trials are probably the only accurate assessment of whether new technology packages are acceptable both economically and socially to the farmers as they take into account all of the interacting components unique to small farm systems. They are a means of identifying and addressing the constraints to adoption of new feeding systems, and in many instances in Asia, the importance of such trials which aim to utilise research results far out-weighs the need for further documentation of the effects of supplementation or pretreatments. The final benefits of such work are associated with commercial development with such attendent benefits as increased per animal production, maximum efficiency in feed resource use, reduced pollution, increased farm income and quality of life of especially small farmers (Figure 1).

XII. EXPANDING POTENTIAL UTILISATION

It is appropriate to identify potential examples of AIBP and NCFR which merit particular focus, and which can through interventions, make a significant contribution to improved performance and productivity from the animal resources. Table 10 presents a list of some examples of primary feeds appropriate to individual species by location. Both ruminants and non-ruminants are identified. In the former case, mainly meat animals including the use of the swamp buffaloes for draught and meat production are the species of choice.

Irrespective of the choice of feed and location for successful application, acceptable feeding systems are those that are simple, practical, within the limits of farmer's capacity and resources availability, convincing and consistently reproduceable. The approach at the farm level is to seek optimum rather than maximum performance. Moderate to low levels of animals performance may be biologically inefficient, but could be more economically viable than high levels of performance especially within the limitations of small farm systems. It is equally essential that in order to ensure the utilisation of research results and their impact, that there be large scale on-farm testing of the potentially more important non-conventional feeds involving the participation of farmers.

The following strategies are considered important in the objective to increase productivity from the animal resources through more efficient utilisation of AIBP and NCFR :

(1) All year-round feeding systems.

(2) More intensive use of AIBP and NCFR especially in stall feeding systems.

(3) Development of complete rations.

(4) Strategic supplementation.

(5) Wider use of leguminous forages, and

(6) Urea-molasses block licks.

With all these strategies, the development of more innovative feeding regimes is necessary, to include delivery systems that can promote impact.

XIII. CONCLUSIONS

Expanding the use of non-conventional feed resources in Asia is urgently justified because of feed deficit situations and the rising cost of production. The urgency relates to continuing low animal performance, inadequate utilisation of the available feed ingredients and poor efficiency of existing animal production systems. The strategy to correct this situation calls for more innovative technical application of the information on hand, backed by strong institutional support that can focus more particularly on the primary AIBP and NCFR. In this context, more on-farm animal testing is an important requirement to extend the potential value of these feedstuffs.

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TABLE 1

ANIMAL RESOURCES IN ASIA (FAO, 1986)

	Species	Population (10^6)	As % of total world population (%)	Annual rate of growing (1975-1985, %)
I.	Ruminants			
	Buffaloes	134.2	97.1	1.2
	Cattle	387.7	30.5	0.7
	Goats	275.9	56.1	1.4
	Sheep	321.6	28.1	1.0
	Asses	20.1	49.6	-ve
	Camels	4.0	23.0	-ve
	Horses	17.3	26.6	2.2
	Mules	5.6	37.1	12.9
II.	Non-Ruminants			
	Chickens'	2244.0	30.0	5.8
	Ducks'	103.0	62.8	1.3
	Pigs	3.6	46.0	1.5

' Million heads

TABLE 2

PRIORITIES FOR THE UTILISATION BY ANIMALS OF AGRO-INDUSTRIAL BY-PRODUCTS (AIBP) AND NON-CONVENTIONAL FEED RESOURCES (NCFR) IN ASIA

	Feed source	Characteristics	Species
1.	Energy and protein (eg. rice bran, coconut cake, soyabean meal, poultry litter)	High energy High protein	Pigs, poultry, ducks, lactating ruminants
2.	Good quality crop residues (eg. cassava leaves)	High protein High energy	Pigs, ducks, lactating ruminants and use as supplements in meat animals
3.	Medium quality crop residues (eg. sweet potato vines)	Medium protein	Pigs, ruminants (meat and milk), camels and donkeys
4.	Low quality crop residues (eg. cereal straws and bagasse)	Low protein Very fibrous	Ruminants (meat and draught), camels and donkeys

Notes : 1) The reference to AIBP includes crop residues
2) Ruminants refer to buffaloes, cattle, goats and sheep

TABLE 3

THE AVAILABILITY OF NON-CONVENTIONAL FEED RESOURCES IN ASIA AND THE PACIFIC

(Devendra, 1985)

Category	Availability (10^6 t)
Field crops	230.3
Tree crops	7.4
Total	237.7[+]

[+] Represents 46.3% of the total availability from field and plantation crops

TABLE 4

TRENDS IN FEED BALANCES IN INDIA
(Adapted from Reddy, 1987)

Nutrient	1970			1984		
	Availability[a]	Requirement[b]	% Deficit	Availability	Requirement	% Deficit
Energy (10^7 Mcal ME)	6162.8	9877.9	37.6	7399.4	10933.5	32.5
DCP (10^4 mt)	113.2	297.8	61.9	135.1	344.0	54.0

[a] ME - Metabolisable energy; DCP - Digestible crude protein
[b] Of herbivores (buffaloes, cattle, goats, sheep, asses, yaks and chauri) and non-ruminants (poultry and pigs)

TABLE 5

FEED AVAILABILITY AND REQUIREMENTS IN PAKISTAN IN 1984

Principal feed source	Availability (10^3 mt)[a]		Total Requirements[b] (10^3 mt)	
	TDN	DCP	TDN	DCP
Crop residues and agro-industries by-products	8359.9	947.5	-	-
Fodder crops	18059.5	692.8	-	-
Grasses[c]	11200.0	700.0	-	-
TOTAL	37619.4	2340.3	50096	3951
% Deficit	-	-	24.9	40.7

[a] TDN - Total digestible nutrients; DCP - Digestible crude protein
[b] Of ruminants : buffaloes, cattle, goats and sheep
[c] From canals, banks, road sides, orchards, flood plains and rangelands

TABLE 6

OPTIMUM LEVEL OF UTILISATION OF SOME IMPORTANT NON-CONVENTIONAL FEEDS IN DIETS FOR FARM ANIMALS IN ASIA

Non-conventional feedstuffs	Species	Location	Optimum level of inclusion in the diet (%)	Reference
I. **ANIMALS**				
1. Blood meal	Pigs	Malaysia	3	Hew & Devendra,1977
2. Poultry excreta	Poultry	Malaysia	5-10	Ng & Hutagalung,1974
	Poultry	India	15	Ann. Rpt. I.C.A.R., 1983
	Sheep	Malaysia	20-30	Devendra, 1976b
	Cows	Thailand	30	Tinnimit, 1977
II. **PLANTS**				
3. Cocoa				
- Cocoa pods husk	Sheep	Malaysia	30	Devendra, 1977b
4. Mango				
- Mango seed kernel	Calves	India	20	Patel & Patel, 1971
	Bullocks	India	40	Patel _et al_. 1972
	Cows	India	10	Ann. Rpt, I.C.A.R. 1983
5. Oil palm				
- Palm oil mill effluent	Sheep	Malaysia	40	Devendra & Muthurajah, 1976
- Palm press fibre	Sheep	Malaysia	30	Devendra & Muthurajah, 1976
- Palm oil solids	Poultry & pigs	Malaysia	10-15	Devendra _et al_. 1982
6. Pineapple				
- Pineapple bran	Poultry	Malaysia	15	Ng & Hutagalung, 1974
7. Rice				
- Rice husk	Sheep	Malaysia	5	Devendra, 1977a
8. Rubber				
- Rubber seed meal	Pigs	Malaysia	20	Ong & Yeong, 1977
	Poultry	Sri Lanka	20	Buvanendran & Siriwardene, 1970
	Poultry	Sri Lanka	20	Rajaguru, 1973
	Calves & cows	India	20	Ann. Rpt. I.C.A.R. 1975-76
	Calves	India	30	Ann. Rpt. I.C.A.R. 1983
	Cows	India	25	Ann. Rpt. I.C.A.R. 1983

cont'd ...

Non-conventional feedstuffs	Species	Location	Optimum level of inclusion in the diet (%)	Reference
Rubber				
- Rubber seed meal	Pigs	Malaysia	20	Ong & Yeong, 1977
	Poultry	Sri Lanka	20	Buvanendran & Siriwardene, 1970
Poultry	Sri Lanka		20	Rajaguru, 1973
	Calves & cows	India	20	Ann. Rpt. I.C.A.R. 1975-76
	Calves	India	30	Ann. Rpt. I.C.A.R. 1983
	Cows	India	25	Ann. Rpt. I.C.A.R. 1983
9. Sal				
- Sal seed meal (untreated)	Poultry	India	5	Verma, 1970
- Sal seed meal (treated)	Poultry	India	20	Sharma et al. 1977
	Cows	India	30	Sonwane & Mudgal, 1974
	Bulls	India	40	Shukla & Talapada, 1973
	Pigs	India	40	Pathak & Ranjhan, 1973
10. Spent tea leaf	Calves	Sri Lanka	17	Jayasuriya et al. 1978
	Calves	India	20	Ann. Rpt. I.C.A.R. 1983
11. Sugar cane				
- Bagasse (untreated)	Bullocks	Pakistan	10	Khan et al. 1962
- Bagasse (treated)	Sheep	Malaysia	20-30	Devendra, 1979b
12. Sunflower head meal	Sheep	India	48	Reddy et al. 1986
13. Sun hemp				
- Sun hemp leaves	Poultry	India	8	Reddy et al. 1970
14. Tamarind				
- Tamarind seed hulls	Calves	India	10-15	Reddy et al. 1979
	Calves	India	25	Ann. Rpt. I.C.A.R. 1983
15. Water hyacinth				
- Water hyacinth meal	Calves	India	10-20	Reddy & Reddy, 1979
16. Water melon				
- Water melon cake	Calves	India	20	Sastry et al. 1973

TABLE 7

THE REPLACEMENT OF SOYABEAN MEAL BY RUBBER SEED MEAL IN POULTRY
(Yeong, 1981)

	(i) Broiler production (5th-10th weeks age)		(ii) Egg production (mean of 50 weeks, 28th-77th weeks age)	
Diets (% composition)	Control	Rubber seed meal	Control	Rubber seed meal
Maize	66	53	62	45
Soyabean meal	19	7	22	8
Rubber seed meal	-	25	-	30
Fish meal	8	8	4	4
Leaf meal	2	2	2	2
Palm oil	3	3	-	1
$Ca_2(PO_4)_3$	1	1	1.6	1.5
Vitamin-Minerals	0.75	0.75	1	1
Salt	0.25	0.25	0.4	0.4
Limestone powder	-	-	7	7
DL-methionine	-	-	-	0.1
Cost/100 kg (M$)*	51.32	47.2	44.6	40.1
Average daily gain (g)	32.2	31.9	-	-
Feed efficiency	3.15	3.21	-	-
% Egg production	-	-	65.8	65.0
Average egg (kg)	-	-	12.6	12.3
Feed/gain in egg mass	-	-	2.7	3.0

* 1 US = $2.20 Malaysian

TABLE 8

LIFETIME PERFORMANCE OF DAIRY CATTLE FED LEUCAENA LEAF MEAL AND DRIED POULTRY LITTER IN RICE STRAW-BASED DIETS IN THE PHILIPPINES

(Adapted from Trung et al. 1987)

Parameters	Treatments 1	2	3	4
Initial live weight (kg)	198.1	165.5	168.1	184.3
Wt before calving (kg)	415.6	391.0	407.8	390.1
Average daily gain (kg)				
- Yearling to breeding	0.61	0.64	0.51	0.52
- Breeding to calving	0.40	0.46	0.41	0.42
Lactation length (days)	270.3	206.5	273.0	208.3
Total FCM yield (kg)	2093.5	1410.5	2140.9	1712.2
Persistency (%)	84.9	89.29	92.9	88.0
Butterfat (%)	4.01	3.87	3.26	3.72
Protein (%)	2.75	2.76	2.81	2.77
Total solids (%)	11.70ab*	11.28ab	11.99a	10.77b
Cost/kg gain (Pesos)+	33.1	23.5	22.1	27.9
Income from milk production (Pesos)+	4668.6	2960.6	6217.8	5300.3

Treatments 1 - 35% RS + 45% L and 20% concentrates
2 - 35% RS + 30% L + 15% DPL and 20% concentrates
3 - 35% RS + 22.5% L + 22.5% DPL and 20% concentrates
4 - 35% RS + 65% concentrates

* Row means without a common superscript are statistically signifant (P < 0.05)

+ Based on a commercial sacle (1 peso = US $0.05)

TABLE 9

EXAMPLES OF TOXIC PRINCIPLES IN SOME COMMON NON-CONVENTIONAL FEEDS

Type of feed	Toxic Principles
Banana waste, stems and leaves	Tannins
Cassava leaves, peeling and pomace	NCN (17.5 mg/100g in leaves)
Castor seed meal	Ricinoleic acid
Cocoa seed husks	Theobromine (Trace)
Coffee seed hulls, pulp	Caffeine and Tannins (2.8% DM)
Cottonseed cake	Gossypol (0.05-0.20%)
Cowpea seed meal	Trypsin inhibitor
Guar meal	Trypsin inhibitor and gum
Kapok	Cycloponopenoid acid
Mango seed kernel	Tannins (5-10%)
Neem seed cake	Tannins
Palm oil mill effluent	High ash (12-16% DM)
Rubber seed meal	HCN (9 mg/100g)
Sal seed meal	Tannins (6.2-13.7%)
Spent tea leaf	Tannins (12% DM)

TABLE 10

SOME EXAMPLES OF PRIMARY FEEDS FOR INTENSIVE UTILISATION BY LOCATION

Type of primary feed	Location	Species
Bananas	Philippines	Beef cattle, ducks
Cassava		
- Leaves	Thailand, Indonesia Philippines	Beef cattle, goats, and swamp buffaloes
- Pomace	Thailand, Indonesia Philippines	Pigs, ducks, lactating cattle and goats
Maize stover	Philippines, Indonesia	Beef cattle, swamp buffaloes, goats and sheep
Oil palm		
- POME, palm press fibre, palm kernel cake	Malaysia	Beef cattle, swamp buffaloes
Rice		
- Bran	Thailand, Indonesia, Philippines	Pigs, poultry and lactating ruminants
- Straw	Thailand, Sri Lanka, Philippines, Thailand	Beef cattle and swamp buffaloes
Sugar cane		
- Tops, bagasse	India, Pakistan, Thailand	Beef cattle and swamp buffaloes
Wheat		
- Bran	India, Pakistan	Pigs, poultry, lactating ruminants
- Straw	India, Pakistan	Beef cattle and swamp buffaloes

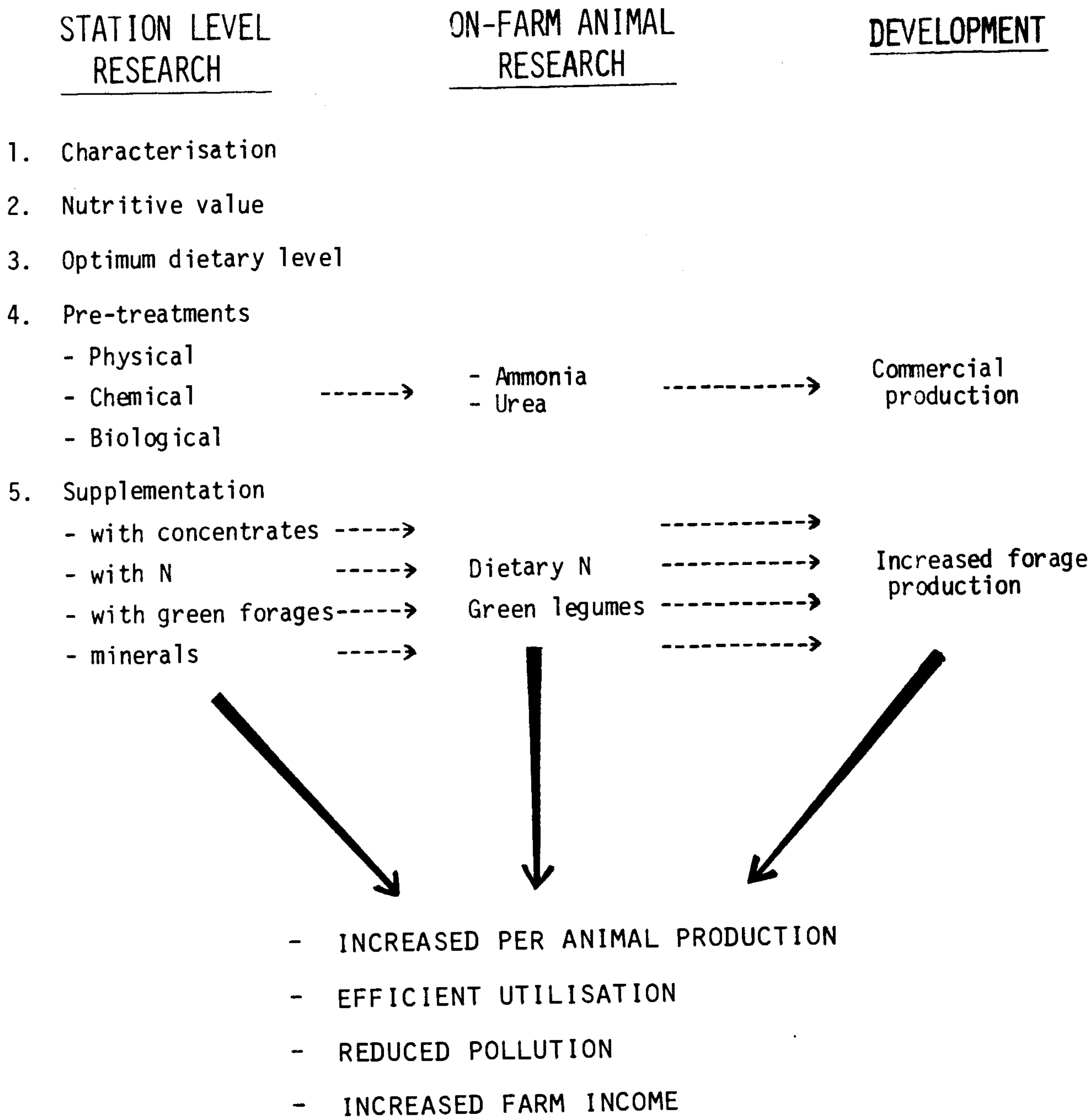

FIGURE 1. A STRATEGY FOR STATION LEVEL RESEARCH, ON-FARM ANIMAL RESEARCH AND DEVELOPMENT EXEMPLIFIED BY THE UTILISATION OF RICE STRAW IN ASIA.