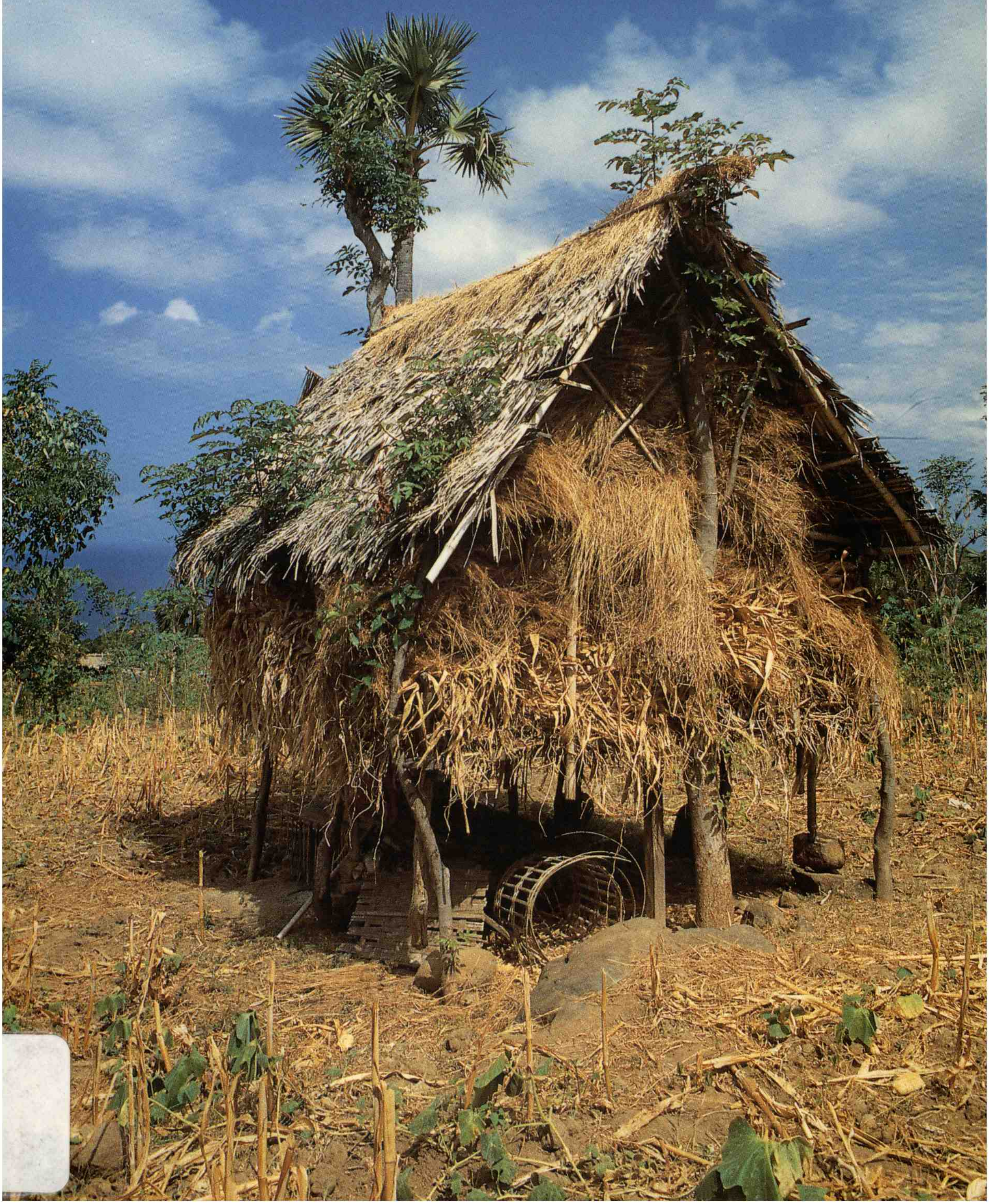
# NON-CONVENTIONAL FEED RESOURCES AND FIBROUS AGRICULTURAL RESIDUES

## Strategies for Expanded Utilization

Edited by C Devendra



# Non-conventional Feed Resources and Fibrous Agricultural Residues

## Strategies for Expanded Utilization

*Proceedings of a Consultation*
*held in Hisar, India,*
*21-29 March 1988.*

**Edited by**
**C DEVENDRA**





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**Abstract**

This publication presents the results of a consultation held in Hisar, India, between 21 – 25 March 1988. It focused specifically on expanding the utilization of non-conventional feeds and fibrous agricultural residues in South Asia (Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka). It noted the continuing problems related to chronic feed deficits throughout this region, and the inadequate efforts to reduce their magnitude. The current availability of the total feed resources and present patterns of utilization by ruminants (buffaloes, cattle, goats and sheep) and non-ruminants (pigs, poultry and ducks) were discussed in the context of the opportunities for expanding development efforts, especially at the farm level in the future. The assessment of current status and need for extending the available information led to the formulation of development strategies to enhance large-scale on-farm utilization of the available feeds with the participation of farmers, consistent with maximizing productivity (meat, milk, eggs, fibre and skins) from the animal genetic resources.

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# Strategies for the Intensive Utilization of the Feed Resources in the Asian Region

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**Abstract**

*Strategies for the intensive utilization of the feed resources in the Asian region are discussed in the context of continuing inefficiencies, inadequate application of available knowledge, and potential possibilities of improving per animal performance. Effective utilization of the crop residues, agro-industrial by-products, and non-conventional feed resources (NCFR) are reviewed in terms of priorities for use by animals. Improved efficiencies are justified by chronic feed deficit situations and need for economic animal production in South Asia. Attention is drawn to the annual availability of approximately 238 million tonnes of NCFR or 46 per cent out of an estimated production of 513 million tonnes of feeds from field, plantation and tree crops in Asia; 80-93 per cent of these feeds are suitable for ruminants. Optimum levels for the use of 16 NCFR as a guide to diet formulation are identified. Innovative feeding systems are needed that can demonstrate more economic animal performance, examples of which concern the use of various proteinaceous forages and urea-molasses block licks. Coupled with these, development strategies are urgently required that can stimulate large-scale on-farm testing of primary feedstuffs, backed by strong institutional support and wider resource use. The importance of large-scale on-farm feed utilization merits the highest priority, and far outweighs the need for further documentation on pre-treatments of dry roughages and the beneficial effects of supplementation. These initiatives can significantly influence higher levels of productivity from animals, and also alleviate the search for efficiency in the intensive utilization of the total feed resources in Asia.*

## I. Introduction

The subject of feed resources and their utilization represents possibly the most compelling task facing planners and animal scientists in all countries in the Asian region. The situation is particularly acute in South Asia where chronic annual feed deficits and increasing growths of the animal populations are common, thus making the problem a continuing saga.

Efficient utilization of the available feed resources is an extremely compelling task and the search for urgent solutions is justified by two interrelated reasons: 1) the concept of self-reliance which strives to achieve targets of food production based on the use of indigenous resources; and 2) the fact that feeding and nutrition are possibly the most important factors influencing production.

Additionally, and even more pertinent, the dissemination and application of development-oriented research is weak, relative to the vast reservoir of information that is available in experiment stations and universities. The situation is such that the output of research results in these situations is far greater than the rate of application of the results. Indeed, in many instances, the importance of application of the knowledge already available far outweighs the need for further documentation. A good example concerns the utilization of cereal straw which has attracted the attention of most animal nutritionists and institutions, with very few exceptions. Equally unfortunate is the fact that a good deal of research undertaken was broadly similar, uncoordinated and often inadequately understood by weak delivery systems.

It is appropriate therefore to enquire into the lethargy concerning application of research results that can stimulate more intensive use of the feed resources. This is especially justified in view of continuing low per animal performance within species, without exception, in which the production of animal products (meat, milk, eggs, skins and fibre) is unable to meet national targets. This has in turn raised doubts about the efficiency of existing animal production systems and the utilization of feed resources (Devendra, 1983).

This paper focuses on the available feed materials and examines strategies that can accelerate the more efficient utilization of these in the context of the major limitations related to large-scale and more intensive utilization of feed resources in Asia. These aspects have recently been reviewed (Devendra, 1987a), but are reiterated with specific reference to countries in South Asia, where the problems are particularly acute and the need for efficiency in the use of the available is greatest.

## II. The Animal Resources

Table 1 summarizes the types and magnitude of the animal resources in South Asia and the annual growth rate specific to each species. Among herbivores, the size of the domestic ruminant population is considerable, especially that of buffaloes, cattle and goats. Camels, donkeys and sheep are also prominent.

It is pertinent to point out that the data may not be altogether accurate, especially with reference to asses, camels, horses and mules. The available data for many of these species are estimates and for some like donkeys, yaks and chauri, no precise figures are available. Thus in terms of total animal resources, the magnitude is likely to be very much higher than these figures suggest and emphasize the brevity of problems related to balance feed availability and requirements.

**Table 1**

Animal Resources in South Asia (FAO, 1985)

| *Species* | *Population ($10^6$)* | *As % of total world population (%)* | *Annual rate of growth (1975-1985, %)* |
|---|---|---|---|
| *I. Herbivores* | | | |
| Buffaloes | 84.8 | 65.6 | 1.7 |
| Cattle | 244.6 | 19.3 | 0.9 |
| Goats | 125.4 | 27.3 | 2.1 |
| Sheep | 70.0 | 6.2 | 1.0 |
| Asses | 3.8 | 9.4 | 0.3 |
| Camels | 2.0 | 11.5 | 0.1 |
| Horses | 1.4 | 2.2 | 0.0 |
| Mules | 0.2 | 1.3 | 0.0 |
| *II. Non-Ruminants* | | | |
| Chicken$^+$ | 358.0 | 4.3 | 5.0 |
| Ducks$^+$ | 22.0 | 13.0 | 21.4 |
| Pigs | 8.9 | 1.1 | -ve |

$^+$ Million heads

Among non-ruminants, the duck population was significant in Asia. However, it is likely that since these are mainly reared in extensive and semi-extensive systems, they do not compete for the same feeds that are utilized by poultry and pigs. Concerning growth rates of individual populations, the highest increases were noted for goats and buffaloes among domestic ruminants. The growth rate of the asses, camels, horses and mule populations were generally static. Among non-ruminants, the duck population grew at a very rapid rate, followed by chickens.

## III. The Feed Resources

Three main categories of feeds are identifiable: crop residues, agro-industrial by-products (AIBP) and non-conventional feed resources (NCFR). It is appropriate to briefly discuss each of these categories.

### *1) Crop residues*

Crop residues are mainly fibrous materials that are by-products of crop cultivation. Due to the intensity of and emphasis on crop production in Asia, these form a high percentage of the total volume of the feeds produced annually.

Crop residues have a generally low crude protein content, in the range 3.3-13.3 per cent on a dry matter basis. This suggests a basic limitation in the value of some of the residues (e.g. bagasse and rice straw) around the border line of the 6-7 per cent dietary crude protein level required for promoting voluntary matter intake (VFI). Most of the residues are deficient in fermentable energy, reflected by the relatively low organic matter digestibility, and also the availability of minerals.

### 2) *Agro-industrial by-products*

Agro-industrial by-products refer to the by-products derived in the industry due to processing of the main products. They are, in comparison to crop residues, less fibrous and more concentrated, and have a higher nutrient content. Good examples of AIBP are molasses, rice bran, pineapple waste, palm oil mill effluent (POME) produced from refining the palm oil and coconut cake. In this paper, and for reasons of brevity, AIBP is used in general to include crop residues.

### 3) *Non-conventional feed resources*

Non-conventional feed resources (NCFR) are identified separately although they can be components of both crop residues and AIBP. The main reason for this is to focus on their under utilization especially in the context of their vast potential in Asia.

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 livestock. 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.

Examples of these new feed sources are oil palm by-products, single-cell proteins, feed materials of plant and animal origin (e.g. poultry excreta), and 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 (e.g. feather meal) and those from the processing of sugar, cereal grains, citrus fruits and vegetables for human consumption.

The distinction between traditional 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 summarizes the availability of NCFR in Asia and the Pacific. From field, plantation and tree crops alone, the total availability is approximately 513 million tonnes. Of this, about 238 $\times$ $10^6$ tonnes or 46 per cent are considered to be NCFR. It is stressed that this total availability is thus higher than the figure suggests, as it has not been possible to include calculations of feeds derived especially from animal slaughter and the food processing industries.

**Table 2**

The Availability of Non-Conventional Feed Resources in Asia and the Pacific (Devendra, 1988)

| *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

Many of the NCFR are currently designated as wastes, which is an inaccurate description. They are wastes to the extent that they have not been shown to have an economic value through utilization and conversion by animals into valuable products for human benefit. Recycling, reprocessing and utilization of all or a portion of the wastes offer the possibility of alleviating the existing limited feed resources. The AIBP and NCFR are of three categories:

(i) Energy-rich feeds from bananas, citrus fruits, pineapples, sugar cane and root crops (e.g. banana waste and molasses).
(ii) Protein supplements such as oilseed cakes and meals, animal by-products, by-products from the food industries and fish meals (e.g. coconut cake and feather meal).
(iii) By-products from cereal milling and palm oil refining (e.g. rice bran and POME).

## IV. Priorities for Use

Table 3 summarizes the priorities for using AIBP and NCFR in Asia according to their potential value and importance especially to individual species of animals. It categorizes the broad types of feeds, their essential characteristics and the main species which currently utilize them. In general, energy and protein concentrates are used mainly by non-ruminants and lactating ruminants. Crop residues are of three categories, the lowest quality of which are converted into useful animal products (meat, draught, skins and fibre) by the ruminants.

**Table 3**

Priorities for the Utilization by Animals of Agro-Industrial By-Products (AIBP) and Non-Conventional Feed Resources (NCFR) in Asia (Devendra, 1987a)

| | *Feed source* | *Characteristics* | *Species* |
|---|---|---|---|
| 1. | Energy and protein concentrates (e.g. rice bran, coconut cake, soyabean meal, and poultry litter) | High energy<br>High protein | Pigs, poultry, ducks, lactating ruminants |
| 2. | Good-quality crop residues (e.g. cassava leaves) | High protein<br>High energy | Pigs, ducks, lactating ruminants and used as supplements by 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 (e.g. cereal straws and bagasse) | Low protein<br>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.

## V. Feed Balance Sheets

Feed balance sheets provide an important means to assess adequacy or the extent of inadequacy concerning the nutrition of the animal resources. Associated with this assessment, they enable the development of two alternative strategies. One concerns measures to increase feed production, and more intensive and efficient use of the available feed resources. The alternative strategy is to expand animal production commensurate with excess, under-utilized feeds, and issues of conservation and feed security.

These contrasting situations are exemplified by India and Pakistan in the first category, and Sri Lanka in the alternative situation. It is therefore appropriate to briefly discuss these country comparisons.

Table 4 summarizes the situation in India in 1984. The feed deficits in terms of metabolisable energy (ME) and digestible crude protein (DCP) for the animal resources were about 32 per cent and 54 per cent respectively.

Table 5 provides a trend in the feed balance situation in India, between 1970 and 1984. Two major conclusions are apparent. Firstly, feed deficits and the malady of under-nutrition was a continuing problem. Secondly, there has been a trend towards a reduced feed deficit despite increased animal population over the 14 years.

The trend towards reduced deficits 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. Raj Reddy (1987) 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 6 illustrates a parallel situation in Pakistan also for the year 1984. The deficits in terms of total digestible nutrients (TDN) and DCP are about 25 per cent and 41 per cent respectively.

**Table 4**

Feed Availability and Requirements in India in 1984
(Adapted from Reddy, 1987)

| *Principal feed source* | *Availability+* | | *Total requirements++* | |
|---|---|---|---|---|
| | *Energy ($10^7$ Mcal ME)* | *DCP (t)* | *Energy ($10^7$ Mcal ME)* | *DCP (t)* |
| Crop residues and agro-industrial by-products | 5022.3 | 7437 | — | — |
| Fodder crops | 1228.0 | 3411 | — | — |
| Grasses+++ | 1149.0 | 2660 | — | — |
| TOTAL | 7399.3 | 13508 | 10933.5 | 33396 |
| % Deficit | — | — | 32.3 | 54.0 |

\+ ME — metabolisable energy; DCP — digestible crude protein

\++ Of herbivores (buffaloes, cattle, goats, sheep, asses, mules, yaks, and chauri) and non-ruminants (poultry and pigs)

\+++ From wayside grazing, orchards and rangelands

**Table 5**

Trends in Feed Balances in India
(adapted from Reddy, 1978)

| *Nutrient* | *1970* | | | *1984* | | |
|---|---|---|---|---|---|---|
| | *Availability*+ | *Requirement*++ | *% Deficit* | *Availability* | *Requirement* | *% Deficit* |
| Energy ($10^7$ Mcal ME)* | 6162.8 | 9877.9 | 37.6 | 7399.4 | 10933.5 | 32.3 |
| DCP ($10^4$ t)* | 113.2 | 297.8 | 1.9 | 135.1 | 344.0 | 54.0 |

+ From the same sources as in Table 4
++ Of herbivores (buffaloes, cattle, goats, sheep, asses, yaks, and chauri) and non-ruminants (poultry and pigs)
* ME — Metabolisable energy; DCP — Digestible crude protein

By comparison, Table 7 presents an alternative situation in Sri Lanka where there also exists a deficiency of 26 per cent TDN and 43 per cent DCP. However, the feed balance sheet did not take into consideration the total availability of feeds from other sources such as fodders, wayside grazing and many NCFR. It has been acknowledged that if full use can be made of these and the total feed resources available in the country, the availability of nutrients would be adequate to support the envisaged development of increased animal production (Ranjhan and Chadhokar, 1984).

**Table 6**

Feed Availability and Requirements in Pakistan in 1984
(Ministry of Food and Agriculture, 1985; Akram, 1987)

| *Principle feed source* | *Availability ($10^3$ t)*[+] | | *Total Requirements*[++] *($10^3$ t)* | |
|---|---|---|---|---|
| | *TDN* | *DCP* | *TDN* | *DCP* |
| Crop residues and agro-industrial by-products | 8359.9 | 947.5 | — | — |
| Fodder crops | 18059.5 | 692.8 | — | — |
| Grasses[+++] | 11200.0 | 700.0 | — | — |
| TOTAL | 37619.4 | 2340.3 | 50096 | 3951 |
| % Deficit | — | — | 24.9 | 40.7 |

[+] TDN — Total digestible nutrients; DCP — Digestible crude protein
[++] Of ruminants — buffaloes, cattle, goats and sheep
[+++] From canals, banks, roadsides, orchards, flood plains and rangelands

**Table 7**

Feed Availability and Total Feed Requirements
of Animals in Sri Lanka ($10^3$ mt)
(adapted from Ranjhan and Chadhokar, 1984)

| *Feed Availability* | *Total dry matter* | *Total digestible nutrients* | *Digestible protein* |
|---|---|---|---|
| Grasses[+] | 700 | 385 | 52.5 |
| Crop residues | 1877 | 835 | 37.5 |
| Concentrates[++] | 141 | 96 | 21 |
| Total | 2718 | 1316 | 111 |
| Requirements | 3708 | 1898 | 195 |
| % Deficit | 26 | 30 | 43 |

[+] 0.7 million ha producing on average 1 mt of DM per year
[++] Conventional sources

## VI. Inclusion in Feed Formulations

An important approach to wider and more intensive use of AIBP and NCFR in South Asian countries concerns the application of knowledge already available. This is especially the case in feed deficit situations such as in Pakistan, India and Bangladesh where maximizing animal performance necessitates that all available feeds are used completely and as efficiently as feasible. The attendant benefits are increased availability of animal products and also farm income.

In this context, optimum levels of utilization of individual feeds provide an important guide to their inclusion in practical diets for individual farm animals. These levels are the technically optimum levels of individual feeds which can be used to advantage, based on several studies on the nutritive value and practical feeding trials.

Table 8 brings together information on optimum levels based on a review of practical feeding trials where graded levels of 16 non-conventional feedstuffs were used. The table suggests for example, that a 30 per cent level of poultry excreta would appear to be optimal for ruminants and 5-10 per cent for poultry. With oil palm by-products, the optimum level of inclusion in ruminant diets is 30-40 per cent. With rubber seed meal, the corresponding level for all species of livestock in India, Malaysia and Sri Lanka appears to be 20 per cent. In India, cows and bulls appear to tolerate an optimum level of 40 per cent 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 obviously be influenced by other ingredients in the diet, the ability of individual species to utilize these materials and also the presence of toxic or deleterious components in the feeds.

## VII. Demonstration of Economic Benefits

The final value of including indigenous AIBP and NCFR in feed formulation is demonstration that high performance is compatible with economic advantage. The total cost of the inputs, including that of any pre-treatments needs to be weighed against the monetary value of the response. Beneficial results will have the effect of stimulating and expanding the potential value of the feeds used.

An example of this demonstration concerns the utilization 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 summarized in Table 9 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 9). It has been suggested that the combined inclusion of 23 per cent of LLM and 23 per cent of DPL was

## Table 8

Optimum Level of Utilization of some Important By-products 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 and Devendra (1977) |
| 2. Poultry excreta | Poultry | Malaysia | 5-10 | Ng and Hutagalung (1974) |
| | Poultry | India | 15 | Ann. Rpt. I.C.A.R. (1983) |
| | Sheep | Malaysia | 20-30 | Devendra (1976) |
| | Cows | Thailand | 30 | Tinnimit (1978) |
| | Cattle, Sheep | Pakistan | 30 | Iqbal Shah and Muller (1983) |
| *II. Plants* | | | | |
| 3. Castor | Buffaloes | India | 30 | Reddy, Reddy and Reddy (1986) |
| — Castor bean meal | Sheep | India | 10 | Sugunakar Rao *et al.* (1986) |
| 4. Cocoa | | | | |
| — Cocoa pods husk | Sheep | Malaysia | 30 | Devendra (1977b) |
| | Buffaloes, Cattle | Malaysia | 35 | Bacon and Anselmi (1986) |
| 5. Mango | | | | |
| — Mango seed kernel | Calves | India | 20 | Patel and Patel (1971) |
| | Bullocks | India | 40 | Patel, Patel and Talapada (1972) |
| | Cows | India | 10 | Ann. Rpt. I.C.A.R. (1983) |
| 6. Oil palm | | | | |
| — Palm oil mill effluent | Sheep | Malaysia | 40 | Devendra and Muthurajah (1976) |
| — Palm press fibre | Sheep | Malaysia | 30 | Devendra and Muthurajah (1976) |
| — Palm oil solids | Poultry and pigs | Malaysia | 10-15 | Devendra, Yeong and Ong (1982) |

| | | | | |
|---|---|---|---|---|
| 7. Pineapple | | | | |
| — Pineapple bran | Poultry | Malaysia | 15 | Ng and Hutagalung (1974) |
| 8. Rice | | | | |
| — Rice husk | Sheep | Malaysia | 5 | Devendra (1977a) |
| 9. Rubber | | | | |
| — Rubber seed meal | Pigs | Malaysia | 20 | Ong and Yeong (1977) |
| | Poultry | Sri Lanka | 20 | Buvanendran and Siriwardene (1970) |
| | Poultry | Sri Lanka | 20 | Rajaguru (1973) |
| | Calves and cow | India | 20 | Ann. Rpt. (1975-76) |
| | Calves | India | 30 | Ann. Rpt. I.C.A.R. (1983) |
| | Cows | India | 25 | Ann. Rpt. I.C.A.R. (1983) |
| | Pigs | India | 40 | Pathak and Ranjhan (1973) |
| 10. Sal | | | | |
| — Sal seed meal (untreated) | Poultry | India | 5 | Verma (1970) |
| — Sal seed meal (treated) | Poultry | India | 20 | Sharma, Wah and Jackson (1977) |
| | Cows | India | 30 | Sonwane and Mudgal (1974) |
| | Bulls | India | 40 | Shukala and Talapada (1973) |
| 11. Spent tea leaf | Calves | Sri Lanka | 17 | Jayasuriya, Panditharetne and Roberts (1978) |
| | Calves | India | 20 | Ann. Rpt. I.C.A.R. (1983) |
| 12. Sugar cane | | | | |
| — Bagasse (untreated) | Bullocks | Pakistan | 10 | Khan, Qazi and Schnedier (1962) |
| — Bagasse (treated) | Sheep | Malaysia | 20-30 | Devendra (1979) |
| 13. Sunflower head meal | Sheep | India | 48 | Reddy, Reddy and Reddy (1986) |
| 14. Sun hemp | | | | |
| — Sun hemp leaves | Poultry | India | 8 | Reddy, Rao and Subhan (1970) |
| 15. Tamarind | | | | |
| — Tamarind seed hulls | Calves | India | 10-15 | Reddy, Reddy and Reddy (1979a) |
| | Calves | India | 25 | Ann. Rpt. I.C.A.R. (1983) |
| 16. Water hyacinth | | | | |
| — Water hyacinth meal | Calves | India | 10-20 | Reddy, Reddy and Reddy (1979) |
| 17. Water melon | | | | |
| — Water melon cake | Calves | India | 20 | Sastry, Singh and Dutt (1973) |

**Table 9**
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)

| Parameter | 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% I + 22.5% DPL and 20% concentrates
4 — 35% RS + 65% concentrates

* Row means without a common superscript are statistically significant ($P < 0.05$)
+Based on a commercial scale (1 peso = US $0.05)

beneficial. Likewise in Pakistan, Hasnain (1983) has shown how the inclusion of poultry litter decreased feed costs in lactating animals.

## VIII. Deleterious Principals in Feedstuffs

Little is known about the deleterious effects, in animals, of feeding many AIBP and NCFR in the short and long term. Hydrocyanic acid (HCN) or prussic acid for example, is present 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. Tannins can inhibit the activity of micro-organisms in the rumen and depress the digestion of protein and fibre (McLeod, 1974). On the other hand, tannins have been used to protect proteins from breakdown in the rumen (Driedger and Hartfield, 1977). Methods of detannification have recently been reviewed (Gupta, 1986; Anjaneya Prasad, 1986). 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 10 provides a summary of various types of toxic principals found in the main AIBP and NCFR. This list is not exhaustive but provides limited information on the approximate contents of the toxic principals. More information is required on the type and extent of these toxic principals and especially their effects on animals.

**Table 10**

Examples of Toxic Principals in the More Common Agro-Industrial By-Products and Non-Conventional Feed Resources

| *Type of feed* | *Toxic principal* |
|---|---|
| Banana waste, stems and leaves | Tannins |
| Cassava leaves, peeling and pomace | HCN (17.5 mg/100g in leaves) |
| Castor seed meal | Ricinoleic acid (0.2%) |
| 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 (12-26% DM) |
| Rubber seed meal | HCN (9 mg/100g) |
| Sal seed meal | Tannins (6.2-13.7%) |
| Spent tea leaves | Tannins (12% DM) |
| Water hyacinth | Oxalic acid (2.4% DM) |

## IX. Strategy for Action

Cognisant of the prevailing situation and with the primary objective of expanding more intensive use of AIBP and NCFR, realistic development strategies are urgently required that can identify application of the available information to increase productivity from animals. A three-pronged strategy is suggested as follows:

### *1) Priorities in feed resource utilization*

One important prerequisite concerns priorities in feed resource utilization. Feed resource inventories need to be completed if this has not been done. Arising from this, feeds (especially AIBP and NCFR) need to be identified in terms of primary and secondary importance. These are defined as follows:

Primary feedstuffs : ingredients that form the main base in a feeding system. These constitute about 70-80 per cent in the diet.

Secondary feedstuffs : minor ingredients that form supplements in the diet. These constitute up to 20-30 per cent in the diet.

In this context, 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 11 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.

Potential nutritional strategies have been discussed previously (Devendra, 1986) and are reiterated below:

(i) More intensive use of AIBP and NCFR especially in stall-feeding systems.
(ii) Increased use of proteinaceous forages (e.g. cassava leaves, leucaena forage).
(iii) Increased use of dietary nitrogen sources.
(iv) Strategic use of supplementary protein sources.
(v) Use of urea-molasses block licks.

Of these strategies, the use of appropriate combinations of AIBP and NCFR for individual species and for a specific function will need attention to nutrient balance and palatability. Processing is only important if this is deemed essential and can be demonstrated to be cost effective. Extensive examples of processing of crop residues for formulating complete feeds have recently being reported (Reddy, 1986). Particular attention is drawn to the enormous potential, including economic benefits, concerning the use of various proteinaceous forages. The value of these forages in the diet has been demonstrated in several studies and, with reference to buffaloes, the beneficial effects have recently been reviewed (Devendra, 1987c).

### 2) *Large-scale on-farm testing*

Beyond the demonstration that feeds have economic benefits at the station level, the next step is to implement large-scale application of the results on-farm. Such trials have been far too few in the past and wider use of the available feeds in the future will be significantly affected by such on-farm work.

There is therefore a great need for widespread evaluation of new technologies through on-farm testing and demonstrations. On-farm animal research (OFAR) is 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 merits the highest priority in comparison to documentation of the effects of supplementation or pretreatments. This situation is exemplified with reference to the recent review on rice straw as a feed for ruminants (Doyle, Devendra and Pearce, 1986)

Concerning the utilization of feed resources, the most urgent development need is for more concerted efforts to apply available knowledge to large-scale on-farm testing. Presently, there is an imbalance in the proportion of research programmes in the station relative to on-farm participatory research with farmers. Major shifts in approaches are necessary from the more fundamentally-oriented research at the station or university farm level, to real farm situations. These efforts will require initiative, more innovating efforts, more commitment and a will to work with farmers. In view of logistical difficulties, increased resource use and costs are likely to be involved, but these can be justified on grounds of the value of transfer of technology and the potential impact it will have in the long-term on increasing productivity from farm animals. Presently, research programmes in most countries have tended to ignore this aspect, partly because of convenience, and partly because of the inability to consider the long-term relevance of research results in the wider context of ensuring utilization at farm level for which they were intended. With particular reference to feed resources, development and utilization merit special consideration, and it is suggested that more efforts are necessary in the future to shift the emphasis of the work to on-farm testing. The need for such efforts is illustrated in Figure 1 again with reference to the utilization of rice straw.

**Table 11**

Some Examples of Primary Feeds for Intensive Utilization by Location (Devendra, 1987a)

| *Type of primary feed* | *Location* | *Species* |
|---|---|---|
| Bananas | Philippines | Beef cattle, ducks |
| Cassava | | |
| — Leaves | Thailand, Indonesia, Philippines | Beef cattle, goats, 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 and buffaloes |
| Rice | | |
| — Bran | Thailand, Indonesia Philippines | Pigs, poultry, and lactating ruminants |
| — Straw | Thailand, Sri Lanka, Philippines, Indonesia | 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 |

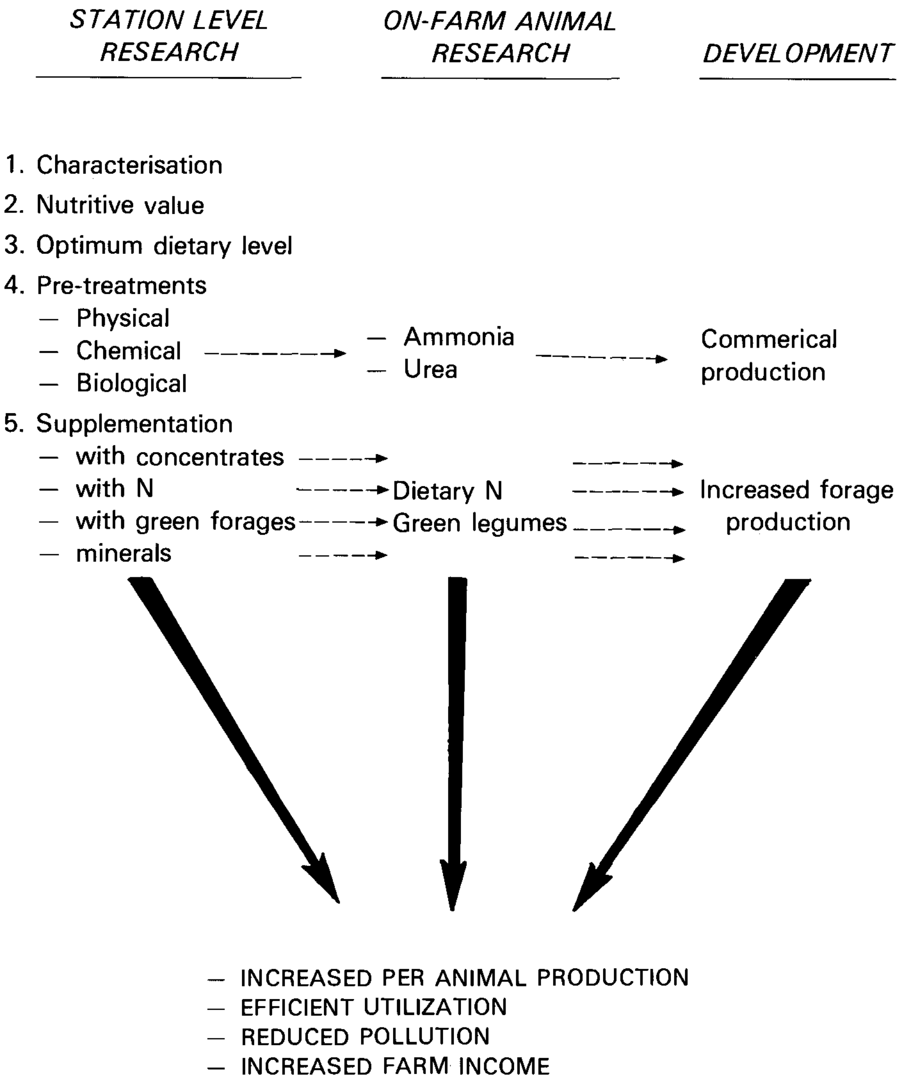


**Figure 1. A strategy for station level research, on-farm animal research and development exemplified by the utilization of rice straw in Asia (Devendra 1987b).**

Irrespective of the choice of feed(s) and location for successful application, acceptable feeding systems are those that are simple, practical, within the limits of the farmer's capacity and resource availability, convincing and consistently reproduceable. Moderate to low levels of animal 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 both success and the impact of new technology, on-farm work with the participation of farmers should be undertaken in the context of farming systems research.

*3) Institutional requirements*

Institutional support is essential for expanded and more intensive utilization of AIBP and NCFR in small farm systems. There are two aspects to this. One concerns the priority for this work seen in the context of abundant quantity produced, under-utilization, reduced cost of production, reduced dependence on imports and therefore greater foreign exchange savings, reduced pollution problems and further expansion in components of the animal industries. Unless high priority is given to this effort, the real benefits of this to the industries are unlikely to be realized.

Once the priority has been established, the next most pressing institutional task is commitment to the programme and the mode of its execution. This calls for the allocation of adequate resources (funds and manpower) and, even more importantly, the strategy that can place much more emphasis on on-farm research and development (Devendra, 1987b). With respect to AIBP and NCFR, inadequate OFAR represents an additional constraint to current under-utilization and needs to be corrected in future efforts. Associated with large-scale on-farm testing is the need for strong and efficient systems that can extend the benefits of the results in rural areas.

These strategies together call for a fresh impetus to more intensive utilization of the available feed resources, compatible with improved animal performance and increased benefits to the farming families. In particular, priorities for feed resource use, strong institutional support and wider application can make a significant impact on efficiency in the use of both the animal and feed resources in Asia.

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