FEED RESOURCE DEVELOPMENT FROM AGRO-INDUSTRIAL BY-PRODUCTS AND THEIR EFFICIENT UTILISATION IN SOUTH EAST ASIA AND THE PACIFIC

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ABSTRACT Agro-industrial by-products (AIBP) of potential value as animal feeds in South East Asia and the Pacific are characterised by abundant supplies, extremely variable quality and underutilisation. It is estimated that from field, plantation and tree crops alone, the total annual availability of AIBP in the Asia and Pacific region is approximately 513 million tonnes of which, 238 million tonnes or 46% is NCFR. Within the latter, 102.1 million tonnes are produced annually in South East Asia and the Pacific and the volume of production is estimated to increase about 3% annually. The AIBP include crop residues (CR) and non-conventional feed resources (NCFR), and in a number of countries, represent a surplus situation in which inadequate utilisation is consistent with a low level of productivity from animals. Consequently, several of the potentially valuable AIBP and especially NCFR have been designated as "wastes". This is unfortunate as it reflects a state of underutilisation and lack of more innovative use as animal feeds. "Wastes" are identified more closely with NCFR, and considerable opportunities exist for promoting and expanding their utilisation especially in large scale feeding systems for both ruminants and non-ruminants. In order to demonstrate use of these feeds in economic feeding systems, it is essential that their development is consistent with the choice of appropriate animal species and clear production objectives which are oriented towards a market demand for the animal products. Additional considerations that are relevant to the demonstration and development of economic feeding systems include inter alia detailed characterisation of the feeds, processing if appropriate, innovative feeding systems, in situ utilisation, and potential for wider application of the results. Case studies are mentioned with reference to the utilisation from oil palm by-products, rice straw and poultry litter. Strategies for promoting intensive utilisation of the potentially more important AIBP in individual countries are discussed in the context of more efficient utilisation of the available feed resources in South East Asia and the Pacific.

INTRODUCTION

A focus on the development of feed resources, consistent with strategies to expand and intensify their utilisation in the Asian region is justified by several factors. Foremost of these is continuing low productivity and overall total output from the animal genetic resources, notably the ruminants (buffaloes, cattle, goats and sheep). Secondly, there is also inefficient and inadequate utilisation of the available feeds in the face of serious feed deficits, rising prices of especially imported feed ingredients, and the demand for animal products to meet human requirements.

The situation is especially critical in Asia with its large reservoir of valuable and diverse animal genetic resources, extremes of climate from the temperate high altitude areas of the Himalayan region to the wet tropics in countries of South East Asia where high temperature, humidity and rainfall are more common. The available animals are associated with mainly small farms (1) in a variety of production systems with variable levels of intensification in all countries in the region. A feature in all these systems is the inadequate manner in which feeds have been underutilised by animals, and which is reflected in their low productivity. This emphasises the considerable opportunities that exist for taking much more advantage of the available feeds (2, 3).

It has already been pointed out (4) that developing countries cannot afford to waste crop residues. Currently, they cannot be ploughed into the land because of inadequate draught animal power (DAP), short duration between cropping seasons and the cost of chopping the cereal straws before usage in a methane digestor; for all these reasons, cereal straws and stovers are usually burnt or left to decompose, often causing a pollution problem. It has been suggested that an alternative system to utilise the crop residues efficiently is to feed them to ruminants and then recycle the excreta through a methane digestor (5).

There have been several national and regional meetings in South East Asia on the subject of available feeds and their utilisation, for example, in Malaysia (6, 7, 8), Indonesia (9, 10), Philippines (11), Japan (12, 13, 14) and Thailand (15). 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 {16}). One glaring conclusion from these meetings is that while notable advances have been made to focus on some feeds and their utilisation, as well as attendant techniques, the utilisation of research results and the extension of the potentially more important technologies to real farm situations is inadequate. Associated with this, there is also the point that increased productivity from the animal resources has not changed significantly in the context of more intensive, and expanded utilisation of the available feeds. This is especially the case with 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 availability of advanced temperate technology.

It is appropriate therefore to review current knowledge on AIBP and NCFR, their development and strategies for promoting more intensive and expanded utilisation of these feed materials.

ANIMAL RESOURCES

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

There exist large ruminant and non-ruminant animal resources. Among ruminants, about 97% of the buffaloes and 57% of the goats are found in Asia in terms of the total world populations of these species, followed by cattle and sheep of 30% and 28% respectively. There also exist sizeable populations of asses, camels, mules and horses, which as percentage of the total world population were 51%, 24% 26% and 38% respectively.

Among non-ruminants, ducks accounted for as much as 87% of the total world population, followed by 49% pigs and 39% chickens. The goat and buffalo populations were growing at the fastest rate, followed by cattle and sheep. Among non-ruminants, the chicken population is growing the fastest.

Ruminants are generally owned mostly by small farmers, peasants and landless labourers. In contrast, 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 pig 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.

Associated with the data on animal resources is their distribution and access to permanent pastures, forests and woodland. Table 2 sets out the extent of permanent pastures available and also land under forests and woodlands. Also given in the table is the corresponding magnitude of the ruminant livestock units available, based on calculations from FAO data. Of particular significance is the very high concentration of animals in Asia, and the marked imbalance between the total ruminant livestock units and available permanent pastures here compared to the other regions. This situation and the growing animal populations further emphasise the need to ensure that all available feeds are put to maximum efficient use.

Included in the table is a reference to forests and woodlands to reflect the potential importance of the herbage available under these perennial tree crops, including also the use of some of the more important leaves. These feed resources have not been adequately utilised in the past for want of adequate methodology to facilitate the process of integration, involving appropriate choice of species, objectives of production and integration that can ensure high productivity from the land due to the combined thrust of both animal and crop association. In South, South East Asia and the Pacific Islands for example, there exists about 20 X 10^6 ha under tree crops, and even if only half of this crop area is utilised by animals, the number of animal equivalents that can be carried, and productivity from them, assumes considerable magnitude (19).

FEED RESOURCES

Categories

For purposes of this paper, agro-industrial by-products (AIBP) include crop residues, by-products produced from the food processing and also non-conventional feed resources (NCFR).

Crop Residues

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

Crop residues have in general, a low crude protein content, in the range 3.3-13.3% on dry matter basis. This suggests a basic limitation in some of the residues (eg. bagasse and rice straw) around the borderline of the 6-7% dietary crude protein level required for promoting dry matter intake (DMI). There is also the point that most of the residues are deficient in fermentable energy, reflected by the relatively low organic matter digestibility, and also mineral nutrients.

By-products from Food Processing

Several agro-industrial by-products are derived in the industry due to processing of the main products during food production. They are in comparison to crop residues, less fibrous, 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. Table 3 illustrates examples of AIBP to include crop residues and NCFR commonly found in the Asian region.

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 (19).

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.

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 materials 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 as NCFR may in fact be traditional to the extent that it may have been fed for a long time, compared to situations elsewhere, such as in South East Asia, where because of greater availability of feeds, more NCFR exist.

Characteristics of NCFR

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

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

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

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

(4) 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.

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

(6) 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.

(7) 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.

(8) 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.

(9) 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, which is an inaccurate description and from the stand point of animal feeding, very unfortunate. They are wastes to the extent that their utilisation have not been demonstrated in terms of efficient utilisation and conversion by animals into valuable products to meet human needs. Demonstration of this benefit creates new feed materials of economic value and importance to animals. 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}).

QUANTITIES OF NON-CONVENTIONAL FEEDS PRODUCED

In the quest to maximise the availability of "wastes", 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 specific 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.

Tables 4 and 5 summarise the availability of NCFR in South East Asia and the Pacific from field, plantation and tree crops. The total availability of feeds from these sources to include 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. Within the latter, 102.1 million tonnes are produced annually in South East Asia and the

Pacific. It is stressed that the 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 or meat and bone meal) and those from the processing of sugar, cereal grains, citrus fruits and vegetables for human consumption.

Another example of a by-product from animals which is potentially important as a feed is poultry excreta. Poultry excreta or litter, consists of the dry excreta, and the feathers and broken eggs that drop beneath the poultry cages. It is available in large quantities in several countries, especially in those where poultry production assumes large commercial operations. It is a useful fertiliser for crop cultivation. It can also be used as a valuable feedstuff and considerable potential exists to incorporate it in the diet of farm livestock. Poultry excreta is of two main types : that obtained from caged layers and from deep litter. The former is more uniform and suited to non-ruminants. The latter is contaminated with other materials such as wood shavings which makes it more suited to ruminants. The litter from caged layers has approximately 30% true protein and the remainder is uric acid. It is relevant to discuss the utilisation in both non-ruminants and ruminants.

The total volume of poultry excreta produced in South East Asia and the Pacific is quite considerable. Table 6 shows that the approximate amounts produced in individual countries. The equivalent total amounts of crude protein (N x 6.25) and total digestible nutrients (TDN) produced were 4,384 and 12,569 thousand tonnes respectively, which are potentially very valuable for feeding animals.

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.

PRIORITIES FOR USE

Table 7 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.

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 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 *in situ*.

(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 largescale use of NCFR remains to be demonstrated.

DEMONSTRATION OF LARGE SCALE ON-FARM UTILISATION

Consistent with the observations that AIBP and especially NCFR are constrained by inefficient and inadequate utilisation, is the need for detailed formulation of the steps that are used to demonstrate utilisation. There are several important elements in this task which *inter alia* include :

(1) Choice of feeds.

(2) Extent of availability.

(3) Potential nutritive value.

(4) Methodology : balance between fundamental and applied aspects.

(5) Linkages across disciplines and institutions.

(6) Demonstration of economic benefit.

(7) Large scale on-farm testing.

(8) *In situ* utilisation.

(9) Farmer participation, and

(10) Definition of a model for feed resource development.

The above elements are by no means exhaustive, but it is essential that these need to be considered together in objectively planning towards demonstration of effective utilisation. Frequently, this is not done and many of the research projects on feed utilisation stand to be criticised because several of the elements listed are missing. Consequently, much of the work undertaken is only perceived to have application without proof of demonstration that it can be done and has relevance to the improvement of productivity of animals at the farm level.

It is essential that all these elements are considered and discussed at the initiation of the project involving the project leader, scientists from various disciplines, institutions, including extension personnel. A decision to start such a project is based on preliminary results of potential value and success, and concurrent discussion that enables a logical follow through of this potential in a concerted manner in which large scale utilisation can be demonstrated in terms of economic benefits. Such planning demands much more effort and organisation, definition of clear responsibilities at all levels of implementation, and collective participation and commitment of the various people in the project.

An example of how this is approached and in particular the steps that can be followed, is reflected in the situation concerning rice straw (2). The steps initially involve a consideration of choice of treatments, procedures, research at the station-level involving the characterisation, assessment of nutritive value and utilisation, pretreatments (physical, chemical and 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. It is equally essential to involve very early in the planning process, and throughout the duration of the on-farm work, extension personnel who can contribute to the stability of the activities.

CRITERIA FOR ON-FARM ACTIVITIES

Several aspects of the work to be extended to on-farm situations need to be considered and include *inter alia* 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, type and value of the inputs used and the outputs derived from the experiment, extent of farmer participation and other issues related to the economic analysis of the final results. Issues of marketing are also relevant. 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, degrees 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-farm 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 (19).

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.

It is essential that the work in toto be considered in two phases. Phase one includes all aspects of the fundamental work up to testing of the feed to determine its value and economic benefit. This phase can include an intermediate phase of large scale trials prior to the extension and use of the results to real on-farm situations. This intermediate phase has much merit, as not only does it ensures the degree of success that can be expected, but also determine how in anticipation, the results of the work can be made more convincing to participating farmers. Phase two of the work involves large-scale on-farm testing of the results from Phase one in real farm situations, involving participating farmers.

A final component of phase two includes the measurement of possible impact. In other words, the research and development programme can address the beneficial value of the derived technology in terms of impact with reference to such criteria as value added, real benefits to small farmers, peasants and landless labourers, income generation, pollution control and possible expansion in animal production activities.

An example of a well organised evaluation that has been undertaken at the station level, convincing of how an inadequately used feed can be put to efficient and economic use, concerns poultry litter in the Philippines.
The life-time performance of 20 crossbred diary cattle was studied over a four-year period involving dried poultry litter (DPL) and rice straw-based diets. The results of this study are summarised in Table 8 adapted from (20).

The results indicated that although there were no treatment effects, except for total solids content, inclusion of leucaena leaf meal (LLM) and DPL gave satisfactory growth rates (0.40 to 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, it has shown how the inclusion of poultry litter decreased feed costs in lactating animals (21).

There exist several good examples of studies that have been undertaken on-farm that demonstrate efficient and economic utilisation. Two such studies are cited both from Malaysia, which reflect this fact.

One study concerns utilisation by buffaloes and cattle in an oil palm estate to seek effective utilisation as well as control pollution. The animals were grazed as well as stall-fed for three years. Table 9 summarises the results. More recently, palm kernel cake, another important by-product has been used 100% in feedlot for beef cattle and average daily gains of 0.74 to 0.76 kg and a dressing percentage of 49.5% have been recorded in Sahiwal x Friesian cattle (23).

The second study is concerned with the utilisation of coffee and oil palm by-products. Table 10 demonstrates that these by-products can be put to effective and economic use by animals. Additionally, the study also showed that between the three systems of feeding compared, the feedlot method gave the best margin of profits.

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 (27, 28). The high costs of the pretreatments need to be weighed against the beneficial effects, including the extent of the animal response.

Table 11 presents a list of examples of potentially valuable AIBP and NCFR. These are primary feeds appropriate to individual species and location whose expanded utilisation can make a significant contribution to improved performance and productivity from the animal resources. 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 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 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.

DEVELOPMENT STRATEGIES

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, and

(4) Strategic supplementation.

(5) Wider use of leguminous forages

(6) Urea-molasses block licks.

Expanding the utilisation of AIBP including NCFR is also justified by the need for more intensification in the future. A shift from the traditional to more intensive systems of production is likely to result from other factors and include a scarcity of grazing land, need for more control over animals, and higher returns from stall-feeding system. The efficient utilisation of AIBP and NCFR remains central to this change.

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TABLE 1

ANIMAL RESOURCES IN ASIA (17)

Species	Population (10^6)	As % of total world population (%)	Annual rate of growth (1975-1985, %)
I. <u>Ruminants</u>			
Buffaloes	132.5	98.0	1.6
Cattle	384.0	30.4	0.8
Goats	295.8	56.8	1.6
Sheep	331.6	28.3	0.7
Asses	20.9	50.5	2.1
Camels	4.5	23.9	0.7
Horses	17.1	26.2	-ve
Mules	5.9	38.2	2.8
II. <u>Non-Ruminants</u>			
Chickens+	4019.0	39.3	9.5
Ducks+	453.0	87.3	2.7
Pigs	405.0	49.2	1.2

\+ Million heads

TABLE 2

EXTENT AND DISTRIBUTION OF PERMANENT PASTURES, FORESTS, WOODLANDS AND RUMINANT LIVESTOCK (18)

Region	Permanent pastures (10^6 ha)+	Forest and woodland (10^3 ha)+	Ruminant livestock units (10^6)++
Developing market economies			
Africa	631.2	645.7	138.4
Asia and the Far East	109.8	220.5	356.3
Latin America	512.7	928.8	253.2
Near East	267.6	95.2	67.0
Total	1521.3		814.9
Asian centrally planned economies	409.8	188.6	100.5
Total developing countries	1931.1	2078.8	915.4
World total	3170.8	4086.6	1319.6
As % of world total:	60.9	50.9	69.4

\+ Refer to 1985 data

++ Conversion factors: Buffalo 1.0, Cattle 0.8, Goats and Sheep 0.1

TABLE 3

NUTRITIONAL CHARACTERISTICS OF SOME EXAMPLES OF CROP RESIDUES AND AGRO-INDUSTRIAL BY-PRODUCTS IN ASIA

Feed source	Moisture (%)	Crude Protein+ (%)	Crude fibre (%)	Organic matter digestibility (%)
Crop residues[1]				
Cassava leaves	73.6-78.8	21.7-26.6	8.1-23.2	55.1-61.0
Groundnut vines	71.3	9.2	24.1	60.0-68.0
Maize stover	12.8-16.3	5.0	28.3	61.0
Pigeon pea forage	71.1-74.8	20.0-25.6	17.6-22.6	47.2-55.4
Rice straw	9.0-9.2	3.3-4.5	28.8-33.6	48.1-56.4
Sugarcane tops	72.0	3.8	38.0	43.0
Sweet potato vines	86.8	13.3	17.2	60.2
Wheat straw	9.0-10.0	3.2-3.6	37.1-41.9	44.6-54.2
By-products[1]				
Bagasse	3.9-4.7	2.9-6.9	10.3-39.3	49.0
Brewers grains	9.8-10.8	24.0-27.4	15.9-17.1	60.0
Cocoa pod husks	89.6	6.0	31.5	45.0
Coconut cake[2]	10.0	18.0	12.0	78.0
Molasses	24.5	1.6	-	90.0
Palm kernel cake[3]	5.7	14.2	20.2	66.8
Palm oil mill effluent	78.0-89.0	9.6	11.5	58.1-64.2
Pineapple waste	6.8	4.9	20.8	76.0
Poultry litter	6.4	40.4-45.7	18.0-21.2	54.2
Rice bran	9.3-11.4	11.4-17.4	10.4-20.0	62.0
Wheat middlings	12.7	20.5	9.0	69.0-71.4

[1] These include non-conventional feeds
[2] Expeller pressed
[3] Solvent extracted
+ On dry matter basis

TABLE 4

AVAILABILITY OF BY-PRODUCTS FROM FIELD CROPS IN ASIA AND THE PACIFIC (18)
(10^3m tons)+

Country / Field Crop By-product	Castor*	Cassava*		Cotton*	Maize*		Rapeseed*		Rice*		Sugarcane*		Total	As % of total
	bean meal	leaves	waste	seed meal	germ meal	stover	bran	meal	broken	husk	bagasse	greentops	availability	production
Burma	-	10.4	84.9	34.0	59.5	253.8	-	-	675.0	2400.0	1022.2	662.6	5202.4	2.3
D. Kampuchea	0.5	7.0	57.0	-	15.6	66.7	-	-	90.0	320.0	52.1	33.8	642.7	0.3
Indonesia	-	933.0	7597.5	13.6	980.4	4181.1	-	-	1767.4	6284.0	6885.0	4462.5	33104.5	34.9
R. Korea	-	-	-	0.4	19.2	81.9	2.1	4.2	350.6	1246.4	-	-	1704.8	1.8
Laos	-	5.9	47.9	5.1	6.3	26.8	-	-	67.1	238.4	27.5	17.9	442.9	0.5
Malaysia	-	27.0	219.5	-	4.3	18.1	-	-	83.7	297.6	305.6	198.1	1153.9	1.3
Philippines	9.5	120.9	984.4	3.8	706.4	3012.4	-	-	420.8	1496.0	3942.0	2555.0	13251.2	14.0
Thailand	17.1	1067.9	8695.4	26.8	713.5	3042.8	-	-	859.5	3056.0	6505.1	4216.3	28200.4	29.7
Vietnam	1.4	210.0	1710.0	2.6	102.0	435.0	-	-	728.9	2591.5	1782.0	1155.0	8718.4	9.3
Fiji Island	-	2.8	22.8	-	0.3	1.5	-	-	1.3	4.5	1161.0	752.5	1946.7	2.0
Papua New Guinea	-	7.4	59.9	-	0.2	0.7	-	-	-	-	59.9	38.9	167.0	0.3
Total	19.0	2662.3	19479.3	86.3	2607.2	11118.6	2.1	4.2	5044.3	17934.4	21742.7	14092.6	94793.0	100.0

+Calculated from F.A.O. Production Yearbook (1986).

TABLE 5

AVAILABILITY OF BY-PRODUCTS FROM TREE CROPS IN ASIA AND THE PACIFIC (18)
(10^3 mt)+

Country	Tree Crop	Cocoa		Oil Palm			Rubber++	Total	As % of total production
	By-product	Bean waste	Pods husks	Palm press fibre	Kernel meal	Mill effluent (dry)	Seed meal		
Indonesia		2.4	22.4	778.9	26.0	26.0	1035.0	1890.7	26.0
Malaysia		9.8	91.0	2725.3	90.8	90.8	1115.5	4123.2	56.6
Philippines		0.5	4.2	13.2	0.4	0.4	42.0	60.7	0.8
Thailand		-	-	72.0	2.4	2.4	816.5	893.3	12.3
Papua New Guinea		2.3	21.0	75.0	2.5	2.5	6.3	109.1	1.5
Vietnam		-	-	-	-	-	204.7	204.7	2.8
Total		15.0	138.6	3664.4	122.1	122.1	3219.5	7281.7	100.0

+ Calculated from FAO Production Yearbook (1986)

++ Calculated from the land area under mature rubber in 1987 and the assumption that average seed production from mature rubber trees was 1000 kg/ha/yr.

TABLE 6

ESTIMATED ANNUAL PRODUCTION OF NUTRIENTS IN POULTRY EXCRETA IN SOUTH EAST ASIA AND THE PACIFIC (20) (on DM basis)*

Country**	Thousand tons per year			
	Poultry excreta production	Organic matter	Crude protein (N x 6.25)	TDN
Burma	217.8	158.4	52.8	161.7
China	11853.6	8620.8	2873.6	8800.4
Indonesia	2640.0	1920.0	640.0	1960.0
Kampuchea	39.6	28.8	9.6	29.4
R. Korea	369.6	268.8	89.6	274.4
Laos	52.8	38.4	12.8	39.2
Malaysia	376.2	273.6	91.2	279.3
Philippines	330.0	240.0	80.0	245.0
Thailand	528.0	384.0	128.0	392.0
Vietnam	462.0	336.0	112.0	343.0
Fiji	39.6	28.8	9.6	29.4
Papua New Guinea	19.8	14.4	4.8	14.7
Total	18084.0	12312.0	4384.0	12568.5

* Based on an annual production of 90g of faeces/bird/day equivalent to 6.6kg dry matter/bird/yr, 4.8kg organic matter/bird/yr, 1.6kg crude protein (N x 6.25) bird/yr and 4.9kg TDN/bird/yr.

** Calculations were based on the population of chickens according to (20).

TABLE 7

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

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

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

TABLE 8

LIFETIME PERFORMANCE OF DAIRY CATTLE FED LEUCAENA LEAF MEAL AND DRIED POULTRY LITTER IN RICE STRAW-BASED DIETS IN THE PHILIPPINES (22)

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% 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 scale (1 Peso = US$0.05)

TABLE 9

ECONOMICS OF UTILISING OIL PALM BY-PRODUCTS BY BUFFALOES AND CATTLE IN MALAYSIA (24)

Capital Items	$ Malaysia*
Building-Feeding mixing storage office	30,000
Housing	54,000
Feed mixing equipment	55,000
Feedlot construction	67,800
Vehicles and equipment	132,700
Total capital items	$340,000
Operating Costs	
Cattle purchases - 2,260 @ $238.50	539,000
Administration, salaries, wages	152,000
Feeding material purchases	5,700
Transport operating costs	12,000
Veterinary costs	13,000
Depreciation on capital items	25,000
	$746,700
Income	
Cattle sales	
2,260 less deaths @ 3% = 2,192 @ $505.00	$1,106,960
Income in excess of costs	$ 360,260

* 1 US $ = $2.20 Malaysian

Assumptions :

1. The feedlot is on an oil palm estate adjacent to the palm oil mill. Supplies of oil palm by-products are at no cost.

2. The palm oil mill has a capacity of 30 tonnes/hour.

3. The feedlot cattle numbers are sufficient for consumption of POME produced in the lowest production months, eg. 2,000 tonnes of POME containing 90% moisture.

4. The POME could be processed to reduce the moisture content from 90 to 75% or lower.

5. The 2,260 cattle consume 11.8 kg of POME with 75% moisture (2.9 kg dry matter/head/day).

6. The cattle were purchased at 90 kg live weight and fed for 1 year giving a daily gain of 453 g.

TABLE 10

ECONOMIC UTILISATION OF COFFEE AND OIL PALM BY-PRODUCTS AT THE FARM LEVEL IN MALAYSIA (26)

Parameter	Group[1]		Grazing (control)
	Feedlot	Semi-feedlot	
Expenditure			
Avg feed intake (kg/day)	4.5	2.7	-
Cost of ration/kg (¢)[2]	22.1	22.1	-
Cost of ration/day ($)	1.0	0.6	-
Revenue			
Avg daily gain (kg/day)	0.5	0.4	0.2
Revenue from gain ($/day)[3]	1.7	1.3	0.5
Gross profit			
Gross profit ($/day)	0.7	0.7	0.5
Margin over control (%)	30.2	32.1	-

[1] Average per animal.

[2] Based on cost of feed ingredients (30% coffee by-product, 37 palm kernel cake, 30% copra cake, urea 2% and mineral mixture 1%).

[3] Based on cost of cattle at $3.50/kg live weight.

TABLE 11

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