Research on Nutrition and Feed Resources to Enhance Livestock Production in Malaysia

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Abstract

Between 1988 and 1989 there has been a positive growth of 3.58, 1.92 and 22.17% for cattle, goats and sheep, respectively whilst a negative growth of 3.16% was recorded in buffalo. Malaysia imports to the tune of $M 631,316,500 ringgit livestock feeds for which about 95% is for non-ruminants whilst the remainder is for ruminants. As such, livestock in Malaysia are still largely dependent on pasture and fodder and to a certain extent on agro-industrial by-products. Except for palm kernel cake (PKC) and a few other ingredients which have been incorporated into poultry rations, the other fibrous by-products are basically used *in situ*, in limited amount.

A sizeable population of sheep and cattle is being introduced into the plantations in order to utilize the natural feed resources underneath. The carrying capacity is judiciously monitored since the forage availability is highly dependent on the availability of forage under the canopy. Flushing with concentrates is performed especially in the pre- and post-natal stages. If the stocking rates are judiciously controlled, the amount of palatable forage available will be sufficient to cover growth and pregnancy stages of the livestock.

Cases of toxicity (mineral and anti-nutritional factors) and deficiencies have been reported in animals consuming native and some of the improved forages. Similarly, some of the agro-industrial by-products of the oil-extracted meals such as palm kernel cake (PKC) and palm oil mill effluent (POME), caused vitamin deficiency and/or mineral imbalances when fed singly to the livestock.

Preliminary trials in terms of processing some of the more fibrous by-products such as cocoa pods, oil palm trunk and oil palm fronds have been performed. Nevertheless, the technology has not attained the stage where these by-products could be commercialized.

Current research on nutrition and feed resources includes :

1) Characterization and updating of the various parameters for the non-conventional as well as conventional ingredients, respectively.
2) Evaluation of the nutrient requirements for the different species and physiological stages of livestock.
3) Screening and evaluation of new forage and fodder species for range conditions and those suitable under shade environment in the plantation.

Most of these studies will be continued in the future, including studies on spectro-computing for feed characterization and quality control, plus formation of a decision support system for feed ingredients, nutrient requirements and for feed formulation, based on the INFIC format.

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Introduction

Despite the small base population, the ruminant sub-sector has generally experienced a positive growth. Between 1988 and 1989, there has been a positive growth of 3.58, 1.92 and 22.17%, respectively for cattle, goats and sheep. However a negative growth of 3.16% was recorded in buffalo (Table 1).

Table 1 Livestock population in Peninsular Malaysia (1988 and 1989)

Year	Buffaloes	Cattle	Goats	Sheep
1988	139,674	586.408	277,900	148,159
1989	135,260	607,414	283,240	181,002
%increase/decrease	−3.16	3.58	1.92	22.17

Since the implementation of the double cropping system for rice in the major granary areas and due to the better understanding of the management technologies for integration of ruminants under plantations, the majority of the ruminant populations have been introduced into plantations. It is apparent that because of the high cost of development of land for pastoral use, the integration of ruminants under the tree crops would be the logical option for ruminant production. This system is supplemented by intensive feedlotting as well as grazing on improved pastures. In all cases, commercial orientation is emphasized. Such commercial orientation is also emphasized for the smallholders who tend to mix the different types of production systems where possible, despite the limitation of the land area.

The integration of livestock under plantation crops offers the greatest potential since there are more than 3 million hectares of land under the major commodity crops (rubber-1,938,000 ha, oil palm-1,686,000 ha, coconut-300,000 ha and the expanding fruit orchards-185,000 ha). Of these, rubber and oil palm offer the best option whilst coconut is more commonly intercropped with cocoa and only where it is cultivated as a monocrop, is extensive rearing of livestock practiced. The integration of livestock, especially sheep, under fruit orchards is in the experimental stage.

Intensive feedlotting is currently being adopted by the larger commercial firms/entrepreneurs and it is capital-intensive since the feeder cattle are imported. The volume of production determines the profitability of the enterprise. On the other hand, improved pastures are normally found in governmental and institutional breeding farms and in the two existing commercial farms. A few more farms based on improved pastures are being contemplated.

Natural forages

The availability of natural forage resources in oil palm and rubber plantations at different ages of the trees is shown in Fig. 1. As indicated, the amount of herbage declined from about 2.8–4.8 ton/ha dry matter (DM) at the immature stages (2–5 years old trees) to about 0.1–1.0 ton/ha DM at the mature stages (6–22 years old trees) and to about 2.0 ton/ha DM in older trees (Chen *et al*., 1991). The amount of herbage is highly correlated with the light penetration which in turn is highly dependent on the canopy of the tree crops. The critical sub-systems for the integration of livestock under the tree crops have been modelled by Dahlan (1989) with the conceptual model being depicted in Fig. 2. Through the mathematical model, Dahlan computed that with the present oil palm hectarage alone, an estimated 18.89 $\times 10^3$ GJ of ME equivalent of forage was available at any particular time under the oil palms. Earlier, Lane (1984) estimated the total DM available under the tree crops, roadside verges, paddy fields and grazing reserves at 4,780.5 × 10^3 tons/year with a percentage contribution of 42.1%, 5.4%, 22.1%, 0.9%, 1.4%, 27.6%, and 0.5%, respectively under rubber, coconut, oil palm, roadside verges, paddy fields bunds, fallow paddy fields and grazing reserves. Tunku Mahmud *et al.* (1988) estimated that 5,020,190 metric tons DM of forages are available per year of which 85% are under plantations (public and private sectors), 1.99% consist of improved pastures and 12.3% are in single cropping and fallow paddy areas. Despite the discrepancies in the estimation of the dry matter availability, it is evident that the integration of livestock under the tree crops is the most suitable strategy for livestock production.

Under the tree crops, the sun-tolerant herbage species dominate the field in the early stages of the tree crop development and they are gradually replaced by the shade-tolerant species when the canopies close. The shade-tolerant species persist for almost two-thirds of the economic life-span of the tree crops. There are 60–70 plant species available under the young tree canopy and the species diversity declines to 20–30 species under the older canopy. Great variations in terms of species also exist between the different agro-climatic environments. The ferns are generally found under the mature canopies whilst species such as *Asystasia intrusa* are found in the humid zones of the southern part and not in the northern part of Peninsular Malaysia and strangely not in Sarawak.

The nutritive value of the herbage consumed by cattle and sheep is comparatively high. The crude protein (CP) of grasses on offer ranges between 6.7–11.4% (Lane, 1984 ; Chen *et al.*, 1991). It is not uncommon that through selective grazing, the animals may consume forage

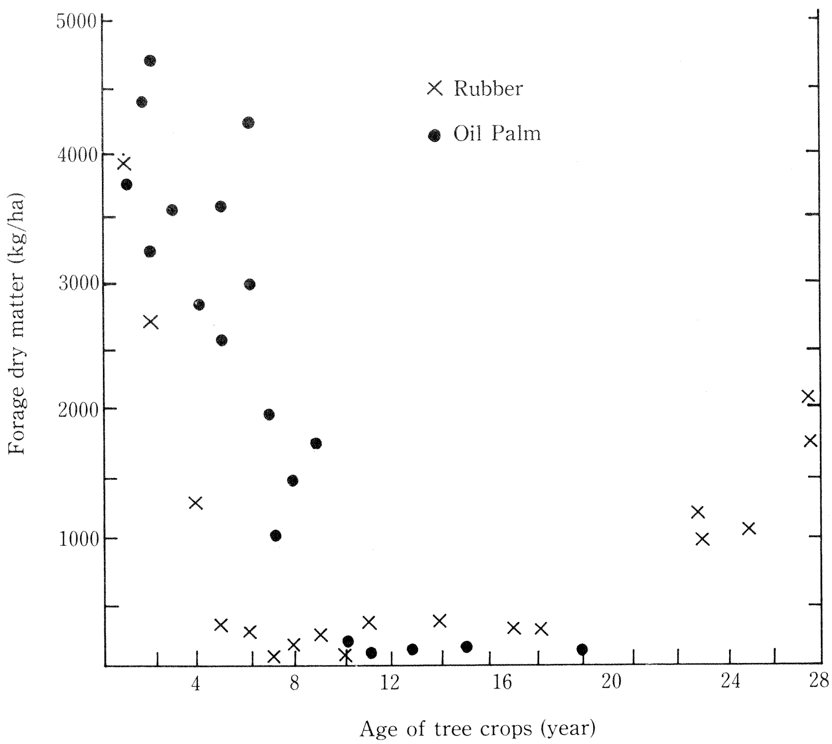

Fig. 1 Availability of forage dry matter at different ages of rubber and oil palm trees.

with 16% CP or even higher in cases of broad-leaved species and ferns. The estimated concentrations of metabolizable energy (ME) are 7.1–8.9 MJ/kg DM for grasses on offer and up to 10.1 MJ/kg DM for forage consumed whilst Chen *et al*., (1991) give an estimated ME of 7.13, 1.17, 5.34 and 8.34 MJ/kg DM for grasses, legumes, ferns and edible dicots, respectively. The composition of the more common native forages found in Malaysia is indicated in Table 2.

Based on the model developed by Dahlan (1989) and the stocking rate studies carried out by Chen *et al*. (1988), the utilizable areas under tree crops for integration will be able to sustain the current total population of livestock and the presumptive increase in the foreseeable future (Fig. 2). In fact, based on the ME computed by Dahlan (1989), the oil palm plantations alone can carry about 513,141 animal unit equivalent of cattle. Despite the potential, integration of livestock under tree crops has not been fully accepted by the

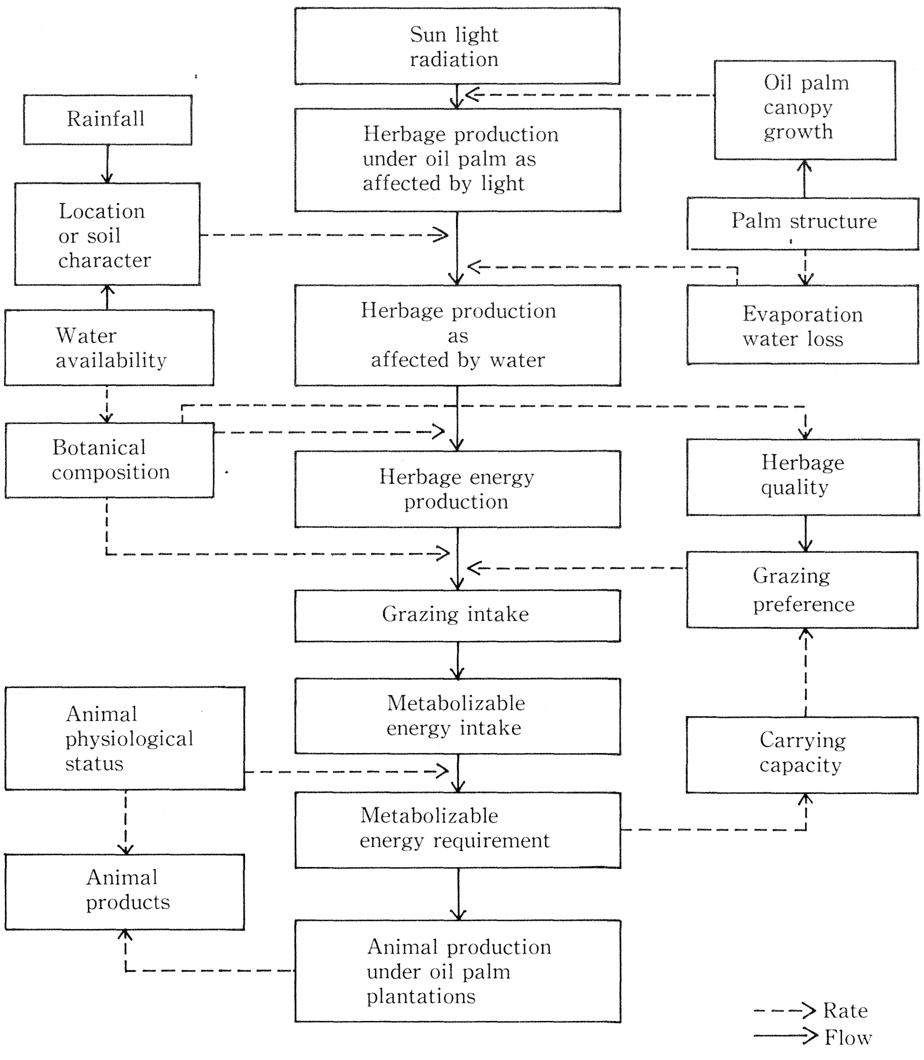

Fig. 2 Conceptual model of cattle production in oil palm plantation.

Table 2 Proximate analysis of some of the more palatable native forages in Malaysia

Species	Dry matter	As % dry matter			ME[z] (MJ/kg DM)
		Crude protein	Crude fiber	Ether extract	
Axonopus compressus	29.6	7.5	30.8	1.4	8.7
Brachiaria mutica	27.5	6.3	32.4	1.8	8.2
Imperata cylindrica	36.5	11.7	32.0	1.9	9.2
Ischaemum muticum	35.0	14.9	27.7	1.6	10.6
Paspalum conjugatum	21.7	11.0	28.6	1.6	9.2
Aystasia coromandeliana	12.1	19.0	25.6	3.3	11.7
Mikania cordata	9.6	17.6	22.9	2.4	11.3

[z] Metabolizable energy (MJ/kg DM) = 13.3 + 0.17 (CP) −0.19 (CF)
CF = crude fiber content

plantation management, lest those under the Ministry of Land and Regional Development and some plantations in the private sector. The superimposition of rearing of livestock under the plantations, increases the complexity of the management and that together with the presumptive side-effects of damage by livestock to the tree crops and the possible negative effect of soil compaction, prevents the adoption of the technology.

Grazing of livestock on native forages is not without its problems. Sheep grazing *Mikania cordata* (75% by species composition) and with Cu contents ranging between 23.6 and 27.3 ppm demonstrate hemoglobinuria, jaundice and diarrhea due to Cu toxicity. *Asystasia intrusa*, a herbacious dicot plant commonly found under plantation crops, could also cause Cu toxicity in grazing sheep due to the high Cu content (about 12 ppm). Excessive accumulation of Cu in the liver of sheep (1,015 ppm) grazing *Asystasia* species has been reported (Wong *et al*., 1988). The associated Cu toxicity can be attributed to the high Cu intake and the concomitant low intake of Mo and S. Sheep grazing on an *Asystasia* diet also experienced negative balances for Fe (-48.6%) and Zn (-21.6%).

Cases of Na, P, Co and Zn deficiencies have also been reported by Wan Zahari and Devendra (1985) for specific locations in Malaysia.

Improved pastures

As for the improved pastures, as of the end of 1988, out of the 18,137 ha of grazing reserves suitable for development, only 6,699 ha had been planted with pasture crops. The more common improved grasses and legumes which have been planted include guinea, setaria, napier, *Digitaria* and *Brachiaria*. Despite the problems of *Heteropsylla cubana*, which besets the planting of *Leucaena*, it is still the best legume to supplement the inadequate amount of protein offered by forages.

As in the natural pastures, the agro-climatic environment affects the productivity of the improved pastures, as shown in Table 3 which lists the mean dry matter yield of the different types of forages on three different soil types (Wong, 1980).

The amount of CP for the improved grasses ranged from 10 to 16% depending on the species, age at cutting and the system of production, whether N-fertilized or legume-grass mixed sward. The ME also ranged from 7.80 to 8.78 MJ/kg DM. The details of the proximate analyses of some of the more important improved pastures are indicated in Table 4. It is evident that the quality of the improved pastures deteriorates very quickly within 6 weeks.

Of the improved legumes, the utilization of *Leucaena* predominates. At 12-week cutting, the values for CP, EE, ash, CF, ADF and NDF for *Leucaena* were 26.50%, 4.25%, 5.9%, 15.5%, 44.1%, and 64.2%, The corresponding values for *Centrosema pubescens* were 22.2%, 2.72%, 8.75%, 30.9%, 38.7% and 67.8%. The IVDMD for *Leucaena* was 48.8%.

Animals grazing on some species of improved forages also experienced various problems. For example, sheep grazing on pure swards of *Brachiaria decumbens* experienced photosensitization and hepato-toxicity. The symptoms included edema of the ears, submandible and eyelids. There was also a severe photosensitization of the unpigmented areas.

Table 3 Mean annual dry matter yields (ton/ha) of some promising grasses defoliated at 6 weekly intervals in three regional stations

Grasses	Serdang[z] (Orthoxic Tropudult)	Jalan Kebun (Oligotrophic Peat)	Sg. Baging[Y] (Marine Sand/Bris)
Brachiaria decumbens	19.4	24.5	11.8
Brachiaria dictyoneura	14.8	—	4.6
Brachiaria humidicola	18.9	—	—
Brachiaria mutica	24.7	26.3	16.5
Panicum maximum cv. Tanganyika	27.7	30.3	—
Panicum maximum cv. Typica	26.1	—	—
Panicum maximum cv. Hamil	15.5	19.6	2.8
Digitaria setivalva (Mardi digit)	20.5	25.4	3.8
Digitaria sp. Slenderstem	18.2	23.1	11.8
Pennisetum purpureum (Local)	30.0	16.3	3.4
Setaria sphacelata var. Splendida	18.6	16.6	0.5
Setaria sphacelata cv. Kazungula	20.6	15.8	6.7
Tripsacum laxum	23.0	21.0	2.0
Average yield	21.4	21.9	6.4

[z] Adapted from Wong, C. C. (1980).
[Y] Estimated yields.

Table 4 Proximate analyses of some of the more important improved grasses

Grass/cutting interval (week)	*In vitro* DMD %	CP	CF	Ash	Estimated ME (MJ/kg DM)[z]
			g/kg DM		
Setaria					
2	66.00	189.86	256.69	99.61	9.18
4	60.29	143.17	286.17	98.58	8.42
6	56.09	121.95	314.42	86.38	7.96
8	53.09	104.71	329.27	77.67	7.62
Digitaria					
2	64.24	158.37	273.97	95.77	8.98
4	59.04	139.64	301.79	81.83	8.41
6	55.32	100.89	319.74	79.29	7.92
8	51.90	88.14	343.47	67.80	7.36
Napier					
2	65.60	178.08	256.54	115.55	8.97
4	59.35	124.31	301.65	95.55	8.32
6	54.60	100.89	330.58	91.00	7.71
8	50.92	70.15	343.20	73.33	7.76
Guinea					
2	64.04	172.87	279.34	111.23	8.80
4	57.69	127.27	324.10	88.17	8.16
6	53.88	91.05	350.90	80.63	7.71
8	49.89	62.57	343.20	69.83	7.24
Signal					
2	63.52	154.92	269.66	97.76	8.96
4	57.66	119.29	300.10	81.00	8.22
6	55.03	92.58	325.61	77.86	7.89
8	53.56	76.00	345.73	68.73	7.66

[z] ME (MJ/kg DM) = 0.15 (DMD% + 2% units) $\left(\frac{100 - \text{Ash}\%}{100}\right)$

Source : Wan Hassan, 1987.

Physiologically, the toxic substance also affects the reticulo-rumen motility and microbial activity in the rumen. Ruminal stasis occurs after 3 weeks of grazing. There is also a corresponding decrease in the volatile fatty acid profile in the rumen whereby the intoxicated sheep experience a 3-fold, 2 ½-fold and 1-fold decrease in acetic, propionic and butyric acid profiles, respectively as compared to the control. The levels of serum glutamate oxaloacetate transaminase (SGOT) and gamma glutamyl transferase (GGT) in the blood increased, which is indicative of liver malfunction. Post-mortem examination also showed that the liver was enlarged and the gall-bladder distended. Salam and Rajion (1990) assumed that the toxicity could be attributed to the alkaloids sarsasapogenin and tigogenin, whilst Abas Mazni and Sharif (1986) did not attribute it to any specific alkaloids and indicated the possibility of toxicity caused by the derived metabolites. About 50% of sheep and 4% of cattle grazing on pure swards of *Brachiaria decumbens* have been reported to die due to the toxicity problem.

The effects of mimosine toxicity from *Leucaena leucocephala* have also been studied. Goats fed more than 50% *L. leucocephala* in diets experienced toxicity, with a DHP (3-hydroxy-4 (1H) -pyridone) concentration of about 0.1% in the urine. The goats were not able to degrade DHP due to the absence of DHP-degrading bacteria in the rumen.

As for the natural grasses, mineral deficiency symptoms for Na, P and Co have also been observed and required the supplementation of sodium chloride, tonofosfan and Co/Vitamin B_{12}.

Agro-industrial by-products

Besides the native and improved forages and agro-industrial by-products which have been used in conventional feed formulations, the other agro-industrial by-products are also being utilized to a limited extent *in situ*. The amount of agro-industrial by-products which have been traded commercially and the estimated availability of the other non-conventional agro-industrial by-products are indicated in Table 5.

It is apparent from the proximate composition indicated in Table 6, that these agro-industrial by-products cannot be fed singly to the livestock and will have to be formulated into balanced rations. In addition to the low overall nutritive value, the quality is variable and the supply is also inconsistent in most cases. Also, due to the bulkiness, collection, storage and processing become difficult. These factors add up to the reasons why most of the agro-industrial by-products are not commercialized. However, the technical feasibility of utilizing most of these agro-industrial by-products as animal feed has been proven beyond doubt.

The livestock response using the various formulations will be presented in the paper entitled "Status of the utilization and animal performance of selected fibrous crop residues with emphasis on processing of oil palm frond (OPF) for ruminant feed in Malaysia".

It is pertinent also to indicate that the excess/deficiency of certain minerals and vitamins in some of these by-products requires judicious formulations. This is exemplified by PKC in which the fat soluble vitamins (especially vitamin A) are lacking. Solvent-extracted PKC contains 0.09-0.23 μg Vit A (retinol)/g feed, whilst the expeller-pressed PKC contains a larger amount of Vit A (0.19-0.45 μg/g feed). These values can not fulfill the daily requirement of growing cattle or sheep with the estimated requirements of 20 and 10 μg/kg LW respectively. POME on the other hand contains 3.7 μg Vit A/g feed.

The Ca : P ratio in PKC is unbalanced (0.34 : 1) and therefore Ca supplementation is required. Cu concentration in PKC is high and due to these characteristics this by-product is not suitable for certain species or physiological stages. When animals are fed solely with PKC there is a negative balance of -21.5% for Mn, -20% for Fe and -52.9% for Zn.

It has also been observed that the growth of bulls consuming 100% POME was significantly retarded due to the poor skeletal growth and poor mineralization attributed to the lower digestibility of Ca and Mg in POME-fed animals. It is possible that the higher fat content in POME (7.84%) reduces the Ca absorption.

Cocoa pod husks and cocoa shell meal contain the alkaloid theobromine (3,7-dimethyl-xanthine) at levels ranging between 0.17 and 0.20% and 1.8 and 2.1%, respectively. Generally the fresh cocoa pods show higher nutritive values as compared to the dried cocoa husks. Cocoa pod husks have been successfully utilized in feedlot ration.

Owing to the inconsistency in the supply and variability in quality, the utilization of agro-industrial by-products requires further formulations and processing due to the fact that 80% of the agricultural by-products are characterized by a high fiber content (>25%), low nitrogen (<6%) and low dry matter digestibility (45%).

Table 5 Estimated availability of conventional and non-conventional agro-industrial by-products

Type	Availability (tons)	Source
Rice		
Broken rice	5% of rice production	
Rice bran and polished	56,253 (1984)	DVS, 1987
Rice straw	1,500,000 (est.)	
Oil palm		
Palm kernel cake (PKC)	726,000 (1987)	MARDI/TARC report, 1990
Palm oil mill effluent (POME)	590,000 (1987)	MARDI/TARC report, 1990
Palm press fibre (PPF)	2,200,000 (1987)	MARDI/TARC report, 1990
Oil palm trunk (OPT)	490,000 (est. 1987)	M. Hussin *et al.*, 1986
Oil palm fronds (pruned)	14,970,000 (est. 1987)	M. Hussin *et al.*, 1986
Tapioca		
Tapioca chips		
Tapioca refuse	53,504 (1984)	DVS, 1987
Coconut		
Copra cake	27,701	DVS, 1987
Cocoa		
Cocoa pods	201,000	Wong and Abu Hassan, 1988
Cocoa shell (CSM)	8,800	Wong and Abu Hassan, 1988
Coffee		
Coffee pulp	20,000	Mohd. Sukri, 1984
Sago		
Sago refuse		
Pineapple		
Pineapple waste Solids	24,507	Devendra, 1981
Sugar cane		
Bagasse	300,000	Devendra, 1980c
Leaves, tops	200,000	Devendra, 1980c
Molasses	52,136	
Fish		
Fish meal	21,867	DVS,1987

Table 6 Proximate analysis of some of the Malaysian agro-industrial by-products

Type	Composition								
	DM	CP	CF	ADF	NDF	EE	Ash	NFE	GE Cal/g
Rice									
Broken rice	93.75	6.85	3.74	2.26	—	0.57	4.29	79.40	4,039
Rice bran	89.12	13.33	10.27	14.74	—	10.99	8.12	55.30	3,403
Rice husk	90.54	3.74	34.07	—	—	1.80	17.97	34.80	3,776
Rice straw	91.00	6.80	29.75	69.00	54.80	0.65	20.30	45.80	4,512
Oil palm									
Palm kernel cake (PKC)	91.94	16.28	18.16	45.34	84.67	3.42	4.42	60.05	4,329
Palm oil mill effluent (POME)	91.53	13.62	23.62	40.37	42.92	11.13	17.12	34.00	4,225
Palm press fiber (PPF)	92.59	5.55	35.18	55.00	76.11	8.66	7.03	29.60	4,064
Oil palm trunk (OPT)	92.60	2.40	39.40	52.20	74.40	0.60	3.40	54.20	4,375
Oil palm fronds (OPF)	91.57	6.47	36.73	48.76	69.18	1.77	4.50	42.00	4,389
Tapioca									
Tapioca chips	91.55	3.00	25.20	5.17	—	25.20	6.13	—	3,767
Coconut									
Copra cake	91.15	20.45	31.47	—	—	8.95	5.78	—	4,596
Cocoa									
Cocoa pods	88.29	6.61	30.37	—	60.87	0.67	8.55	42.00	4,147
Cocoa shell meal (CSM)	92.95	21.28	12.80	30.39	—	5.96	6.80	55.00	4,358
Coffee									
Coffee hull	91.40	11.20	25.12	—	59.76	1.38	5.41	48.30	4,420
Fish									
Fish meal	87.16	46.68	—	8.32	4.24	28.18	—	—	4,134
Sago									
Sago refuse	81.58	1.90	12.70	3.12	—	0.30	10.32	74.90	—
Pineapple									
Pineapple waste solids	88.61	5.87	19.20	—	66.17	1.32	4.55	58.67	4,583
Sugar cane									
Bagasse	91.17	2.13	4.80	55.95	—	0.91	3.98	36.20	—

Note : CE=gross energy, DM=dry matter, CP=crude protein, CF=crude fiber, ADF=acid detergent fiber, NFD=neutral detergent fiber, EE=ether extract, NFE=nitrogen-free extract

Evaluation of the nutrient requirements

Evaluation of the nutrient requirements is being conducted using balance trials and regression analyses. Results of the daily energy and protein requirements for the different species and at different physiological stages are listed in Tables 7 and 8. Research has also been initiated in the field of mineral nutrition, in relation to the mineral requirements and supplementation.

Spectro-computing

Owing to the possible enactment of the feed act, it is imperative that feed analyses be

Table 7 Daily energy requirement by species at different physiological stages

Species	Physiological stages	Requirement		Reference
Swamp buffaloes				
Adult bulls	maintenance[Z]	611	KJ $ME/kg^{0.75}$	Devendra and Wan Zahari, 1981
		422	KJ $ME/kg^{0.75}$	
	growth[X]	0.349	KJ $ME/kg^{0.75}$	Liang and Samiyah, 1989
Murrah buffaloes				
	maintenance	443	KJ $ME/kg^{0.75}$	Liang and Samiyah, 1989
		422	KJ $ME/kg^{0.75}$	
	growth[X]	0.462	KJ $ME/kg^{0.75}$	Liang and Samiyah, 1989
Kedah-Kelantan cattle				
	maintenance[Y]	615.9	KJ $ME/kg^{0.75}$	Devendra, 1980a
Sahiwal-Friesian cattle				
	maintenance	433	KJ $ME/kg^{0.75}$	Liang, Azizan, Samiyah and Dollah, 1990
		334	KJ $ME/kg^{0.75}$	
	growth[X]	0.535	KJ $ME/kg^{0.75}$	Liang, Azizan, Samiyah and Dollah, 1990
Sheep				
	maintenance	471.8	KJ $ME/kg^{0.75}$	Devendra, 1981
Goat (Kambing Katjang)				
	maintenance	378.1	KJ $ME/kg^{0.75}$	Devendra, 1967a
		602.5	KJ $ME/kg^{0.75}$	Devendra, 1983
	growth[X]	42.6	KJ ME/kg gain	Devendra, 1967a,
	lactation	4.84	KJ ME/kg 4% fat corrected milk	Devendra and Burns, 1970

[Z] For heifers : 584 KJ $ME/kg^{0.75}$ (Liang, 1987)
[Y] For heifers : 662 KJ $ME/kg^{0.75}$ (Liang, Samiyah and Hirooka, 1988)
[X] For each g of liveweight gain

Table 8 Daily protein requirement by species at different physiological stages

Species	Physiological stages	Requirement	Reference
Swamp buffaloes			
	maintenance	1.50 g DCP/$kg^{0.75}$	Devendra, 1985
		4.2 g CP/$kg^{0.75}$	Yusof, 1989 (unpublished)
	growth[W]	11.7 g CP/$kg^{0.75}$	Yusof, 1989 (unpublished)
Kedah-Kelantan cattle			
	maintenance	1.37 g DCP/$kg^{0.75}$	Devendra, 1985
		5.93 g CP/$kg^{0.75}$	Yusof, 1989 (unpublished)
	growth[W]	6.93 g CP/$kg^{0.75}$	Yusof, 1990 (unpublished)
Sheep			
	maintenance	8.45 g CP/22.5$kg^{0.75}$	Devendra, 1976
Goat (Kambing Katjang)			
	maintenance	1.47 g DCP/$kg^{0.75}$	Devendra, 1980b
		3.60 g CP/$kg^{0.75}$	Devendra, 1983
	growth[W]	0.274g DCP/kg gain	Devendra, 1967b
	lacation	67.8 g DCP/kg milk (4.5% BFC)	Devendra and Birns, 1970
Sahiwal-Friesian cattle			
	maintenance[Z]	2.1 g DCP/$kg^{0.75}$	Yusof, 1989 (unpublished)
		5.65 g CP/$kg^{0.75Y}$	Yusof, 1989 (unpublished)
	growth[W]	12.1 g CP/$kg^{0.75Y}$	Yusof, 1991 (unpublished)
	pregnancy[X] 7th month	6.23 g CP/$kg^{0.75}$	Yusof, 1991 (unpublished)

[Z] For cows
[Y] For heifers
[X] First pregnancy
[W] For 0.5 average daily gain (kg)
Note : CP=crude protein, DCP=digestible crude protein

performed rapidly. For most of the conventional materials, spectro-computing pre-calibrations are already available. Nevertheless, because of the proposed incorporation of the non-conventional agro-industrial by-products in future feed formulations, calibrations for individual ingredients and possibly of the rations need to be developed. Some examples where spectro-computing using Near Infrared Spectroscopy (NIRS) can be useful in enhancing quality control for ingredients are depicted in Fig. 3 (a) and (b), respectively, for palm kernel meal (PKM) and rice bran (Abu Bakar *et al*., 1990 ; Faizan *et al*., 1991).

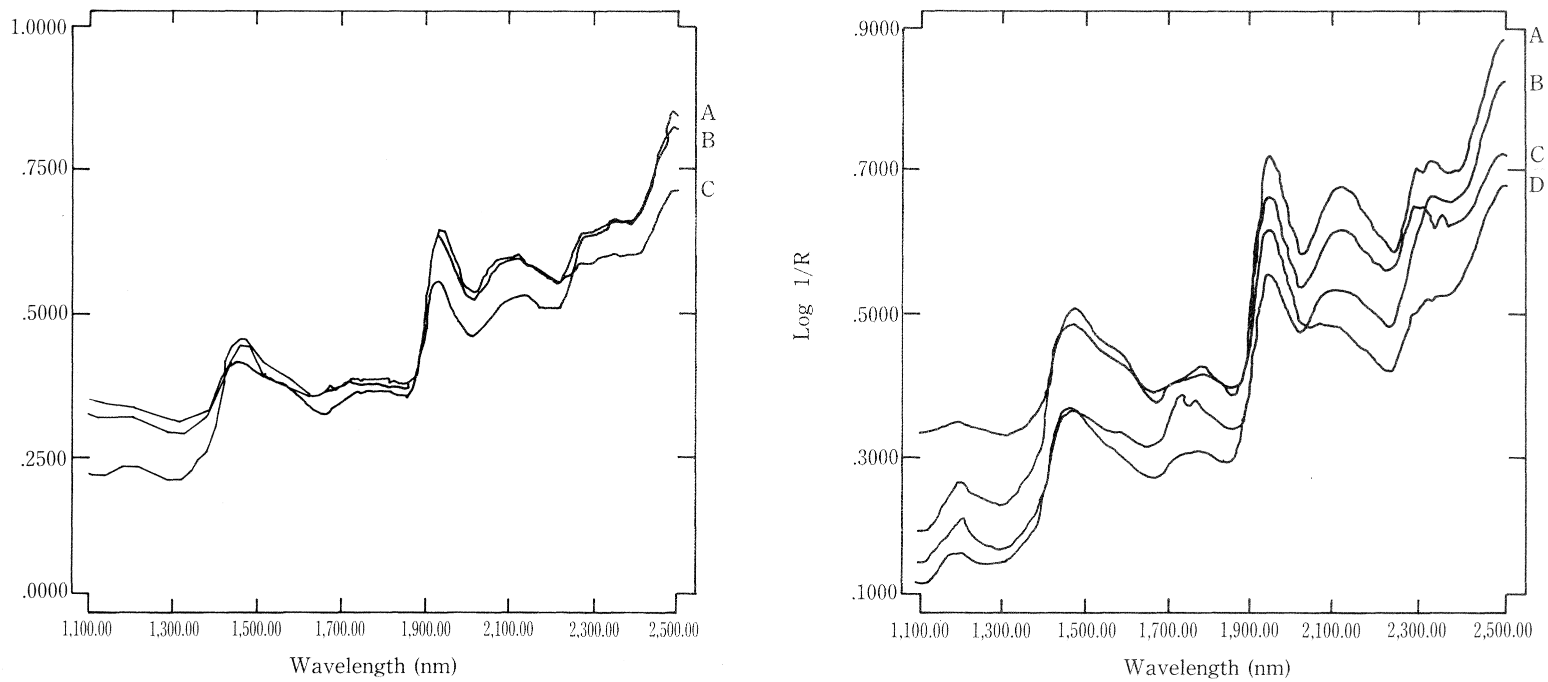

Fig. 3 NIR spectra of (a) oil palm and (b) rice by-products.

(a)

	Predicted composition (%) CP	ADF	Fat
A : 50% palm kernel meal+ 50% palm kernel shell	03.21	40.68	—
B : 100% palm kernel meal	15.99	37.27	—
C : 100% palm kernel shell	00.00	45.05	—

(b)

	Predicted composition (%) CP	ADF	Fat
A : 100% rice husk	04.00	44.54	01.78
B : 50% rice husk+ 50% rice bran	09.25	—	05.62
C : 100% rice bran	16.52	01.92	18.05
D : 100% rice bran (1 year old)	08.97	—	05.48

Feed processing

Several small machines have been designed to facilitate the processing of some of the more fibrous materials. The copra cake crusher has successfully been modified to crush cocoa pods. Nevertheless, mechanization especially for the collection and storage of feeds seems to be one of the weakest links in the attempts to commercialize the utilization of fodder and agro-industrial by-products. Other processing technologies such as steaming, wafering and others have also been successfully tested on a number of by-products (Oshio *et al.*, 1990).

Strategies for research on livestock nutrition and feed resources

Owing to the commercial orientation that is being contemplated in livestock production, it is imperative that research on nutrition, utilization and processing of feed resources be orientated to meet these objectives.

The above objectives entail the implementation of the following strategies (Fig. 4).

a) Characterization and updating of the various parameters (composition and digestive

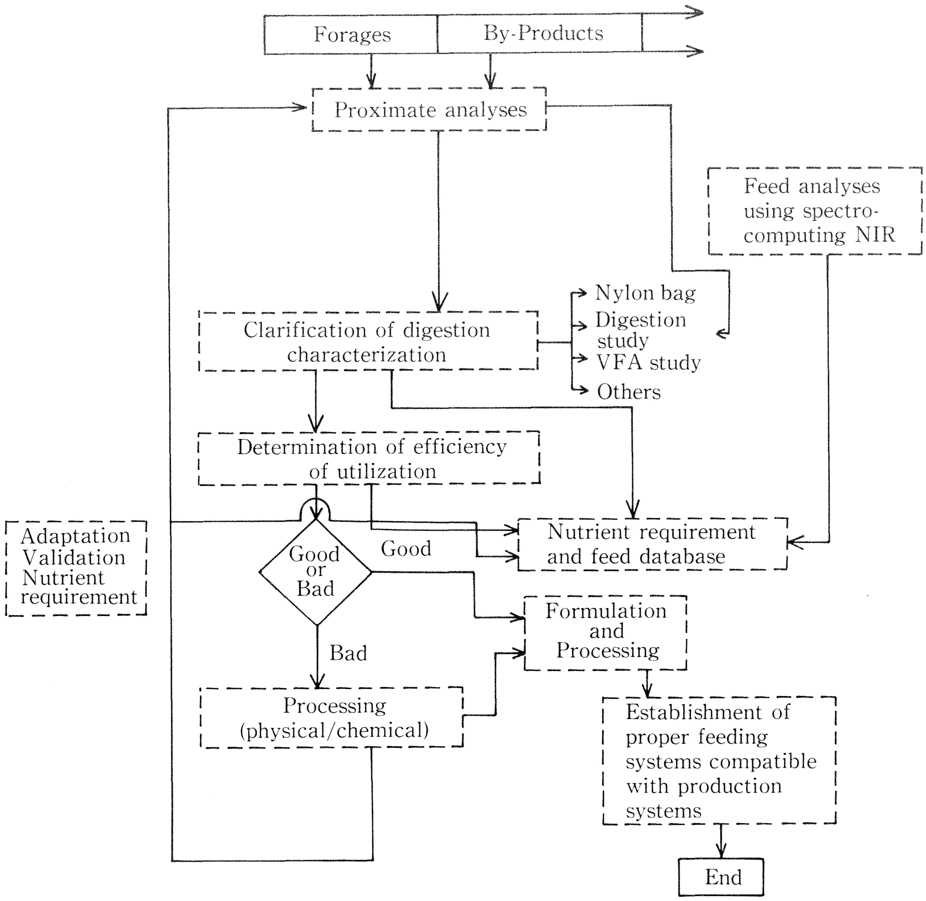

Fig. 4 Strategy for nutrition and feed resources research.

characteristics) for the non-conventional as well as conventional ingredients, respectively.

b) Validation of the nutrient requirements for the different species and physiological stages of livestock.
c) Screening and evaluation of new forage and fodder species for the open range and those which are shade-tolerant for the plantations.
d) Development of suitable machinery and technology for feed production, collection, storage and processing.
e) Development of feed and nutrient requirement databases based on the International Feed Information Centre (INFIC) format.
f) Development of suitable feeding technology for specific production systems.

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Discussion

Ku Vera, J. C. (Mexico) : We do not observe toxicity of *Leucaena leucocephala* in cattle and goats in Mexico, presumably due to the low mimosine content or the ability of the rumen population to degrade mimosine to non-toxic components.

Answer : Goats fed more than 50% *L. leucocephala* experience toxicity with 3-hydroxy-4 (IH) pyridone (DHP) about 0.1% in the urine. Goats lack DHP-degrading bacteria and the effect is being monitored in cattle.

Haryanto, B. (Indonesia) : Since *Asystasia intrusa* contains high nitrogen levels and uses a large amount of nitrogen, I wonder whether it is a useful plant in rubber and oil palm plantations.

Answer : In the plantations of rubber and oil palm, weeding is practiced at the base of the trees and *Asystasia* is allowed to grow in the inter-row space where the animals are grazing. Spot fertilization is implemented at the base of the trees to prevent the depletion of nitrogen associated with the uptake by *Asystasia*.

Argañosa, A. S. (Philippines) : Livestock-tree integration seems to be a thrust in Malaysia although open spaces under oil palm and rubber trees in plantations can be used in a limited period of time (12 years). Considering the importance of rubber and oil palm in the Malaysian economy, what is the future of the livestock production in Malaysia?

Answer : Looking at the present scenarios for the economy, the integration of livestock offers the best option for animal production. Feedlotting is practiced on a limited scale but is economically sensitive. Opening up of new land for pastoral use is expensive. These factors convinced us that the integration of livestock in plantations is the most suitable strategy.

Tsuda, T. (Japan) : When animals are being grazed under orchard or rubber trees, aren't the trees experiencing a direct damage?

Answer : The animals are introduced when the trees are tall enough so that the growing shoots will not sustain any damage. For example the animals are introduced into rubber and oil palm plantations which are about three years old. Since compaction occurs only at the base of the trees where the animals are not grazing, compaction due to the trampling effect associated with the introduction of the animals into the plantations can be prevented.

Kume, S. (Japan) : What is the mechanism of copper toxicity in sheep in Malaysia? I noticed that the copper content of the grass given to the animals was only 12ppm which is not very high?

Answer : The mechanism has not been elucidated. We have monitored the levels of serum glutamate oxaloacetate (SGOT) and gamma glutamyl transferase (GGT) in sheep grazing *Brachiaria decumbens*. The increase in the levels of these two enzymes along with post-mortem lesions suggests the presence of liver malfunction associated with the high levels of copper. It is also well known that sheep are very sensitive to high levels of copper.

Haryanto, B. (Indonesia) : Could you comment on the nutrient requirements for animal in the tropics? Standard nutrient requirements have already been fixed (NRC, ARC). Are you satisfied with these requirements for the Malaysian cattle?

Answer : We are attempting to validate the nutrient requirements for our own populations of cattle using local feed resources to determine whether adjustments in the protein, energy or mineral contents should be made. We have noticed some variations between what is proposed by NRC and ARC and the data obtained through our own studies.