Nutritive Values of Major Feed Ingredient in Tropics* - Review -

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ABSTRACT : Majority of livestocks are kept in the tropics. Demand for animal products (meat and milk) is continuously increasing and is related to human population growth. Consequently, potential feeds should be continuously identified particularly on their nutritive values. Crop residues and agricultural by-products are the main feed sources for feeding livestock in the tropics. Their nutritive values ranging from low to medium quality level although Some agricultural by-products such as cotton seed meal and coconut meal are rich in nitrogaen contents. From literatures, nutritive values in these ingredients are mainly based on their chemical composition and to some extent based on limited number of *in vivo* studies. However, optimum of inclusion in the diet is suggested. Development of tree legumes should be thoroughly considered since they grow well in most tropical regions. In order to improve nutritive value of tropical feeds, biological treatments should be considered. Effect of secondary compounds decreasing efficiency of nutrient utilization in the rumen, to some extent could be reduced by introducing probiotics. (*Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 3 : 493-502*)

Key Words : Tropical Feeds, Nutritive Values, Ruminants

INTRODUCTION

Interaction between decreasing arable land, high density of animal populations and traditional ruminant production systems may be responsible for reduction in animal production. Feed shortage during dry season or high cost of concentrate feeds are common. It has been estimated that by year 2020, world population will be about 8 billions and most of the population growth will occur in developing countries which are mainly in the tropics. In animal industry, utilization of local feedstuffs vary. Approximately, 80 to 95% utilization of feedstuffs of local origin in manufacture for animals in India, Pakistan, Thailand, Sri Lanka, Bangladesh, Nepal, and the Philippines but those are about 40 to 50% in Malaysia and 70 to 75% in Indonesia, respectively (Devendra, 1992).

This paper compiles information on nutritive values of feed ingredient in the tropics. It covers quantity, quality, and usages in livestock.

Table 1. Availability of by-products from Filed Crops in Asia and the Pacific (10^3 MT)

Field crop / Country / By-product	Castor	Cassava		Cotton	Maize	Rapeseed		Rice		Sugarcane		Total availability	As % of total production
	bean meal	leave	waste	seed meal	germ meal	bran	meal	broken	husk	bagasse	greentops		
Bangladesh	-	-	-	4.7	0.5	39.6	79.2	1,197.0	4,256.0	9045.4	1,173.8	7,656.2	3.1
Bhutan	-	-	-	-	13.8	-	-	3.7	14.1	1.6	2.1	35.3	
Canbodia	0.5	16.7	23.2	0.4	19.6	-	-	94.5	357.0	29.7	38.5	580.1	0.2
China	129.8	223.1	3,331.1	-	1,289.3	979.2	1,958.4	8,073.1	30,498.5	7,470.5	9,684.0	66,637.0	26.1
India	281.1	367.2	1,106.7	1,126.7	1,326.0	794.0	1,588.3	1,960.5	18,275.0	26,730.0	34,650.0	88,205.2	35.6
Indonesia	-	1,160.0	3,495.2	2.6	1,075.1	-	-	54.0	7,406.0	3,296.2	4,272.8	20,761.9	
R. Korea	-	-	-	7.2	510.0	1.6	0.7	369.0	1,088.0	-	-	11,976.5	0.8
Laos	-	7.1	19.8	4.3	0.3	-	-	54.9	207.4	15.5	20.1	329.4	0.1
Malaysia	-	28.0	84.3	-	5.8	-	-	76.4	288.5	189.0	245.0	917.0	0.4
Myanmar	-	4.0	12.6	23.4	45.9	-	-	611.1	2,308.8	121.9	542.5	3,670.2	1.5
Nepal	-	-	-	-	190.4	-	-	129.1	487.9	121.9	158.0	1,087.3	0.4
Pakistan	0.5	-	-	1,232.5	190.4	44.8	89.6	215.8	815.3	4,988.3	6,466.3	14,043.5	
Philippines	0.9	129.2	396.7	3.0	768.7	-	-	425.7	1,608.0	2,374.8	3,078.4	8,785.4	5.6
Sri Lanka	-	342.3	103.3	-	19.4	-	-	87.7	331.3	97.2	126.0	1,106.2	0.5
Thailand	23.9	1,643.2	4,935.4	28.9	757.5	-	-	958.5	3,621.0	4,950.2	6,416.9	23,344.5	9.4
Vietnam	2.3	203.0	611.3	2.6	155.0	-	-	814.5	3,621.0	789.8	1,023.8	7,221.3	2.9
Fiji Is.	-	2.2	5.5	-	0.1	-	-	1.7	3,077.0	432.0	560.0	4,078.5	1.5
Papua New Guinea	-	8.1	23.3	-	0.1	-	-	-	-	43.2	56.0	130.7	0.1
Total	439.1	4,133.1	14,158.4	2,435.9	6,364.9	1,859.2	37,162.2	15,127.2	278,260.8	52,557.2	68,514.2	247,666.2	100.0

Source: FAO Production Year Book (1989) cited by Devendra (1992).

FEED QUANTITY

Feed quantity refers to amount of crop residues and agricultural by-products available in any region or country (see table 1-7). China and India are the countries producing the highest agricultural by-product.

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* This paper has been presented at Pre-Conference Symposium II entitled "Management of Feed Resources and Animal Waste for Sustainable Animal Production in Asia-Pacific Region Beyond 2,000" of the 8th World Conference on Animal Production on June 28, 1998 at Seoul National University, Seoul, Korea. The paper has been reviewed and edited by Prof. I. M. Nitis (Indonesia) and Prof. H. T. Shin (Korea).

Table 2. Major by-product feeds from tree and field crops, with approximate extraction rates in Asia and the Pacific

Crop	By-product feed	Approximate extraction rate (%)
Tree Crops		
Cocoa (Theobroma cocoa)	Cocoa bean waste	5-10
	Cocoa pod husks	70
Coconuts (Cocos nucifera L.)	Coconut meal	35-40
Oil palm (Elaeis guineensis)	Oil palm sludge (dry)+	2
	Palm press fibre	12
	Palm kernel cake	2
Rubber (Hevea brasiliensis)	Rubber seed meal	55-60
Sago (Metroxylon sago)	Sago refuse	55
Field Crops		
Castor (Ricinus communis L.)	Castor meal	45-50
Coffee (Coffea arabica)	Coffee hulls and coffee pulp	70
Cotton (Gossypium spp.)	Cotton seed meal	40-45
Maize (Zea mays)	Maize germ meal	8-10
	Maize strover	16-18
Rice (Oryza sativa)	Broken rice	10
	Rice bran	4-5
	Ricehusk	10
	Ricestraw	15-17
Sugar cane (Saccharum officinarum)	Bagasse	100*
	Green tops	12-15
	Molasses	15-20
Cassava (Manihot esculenta Crantz)	Tapioka waste	3-4
		55-59
Wheat (Triticum aertivum L.)	Wheat bran	
	Wheat straw	100*

+ Now reffered to as palm oil mill effluent (DOME).
* Imples equivalent weight to the yield of grains.
Source: Devendra (1976).

Table 3. Availability of some crop residues in South East Asia (000t)

Feed component	Indonesia	Malaysia	Philippines	Thailand
Rice hulls[1]	5,145	300	1,225	2,780
Rice straw[2]	38,306	2,009	11,535	22,841
Maize stover[3]	12,000	27	10,155	10,656
Sorghum stover[4]	9	-	-	981
Cassava leaves[5]	286	22	138	1,020
Sugarcane bagasse[6]	2,944	120	2,576	1,020
Sugarcane tops[7]	1,962	80	1,717	1,952

(Adopted from Ranjhan, 1986; cited by Roxas et al., 1997)
[1] At 90% DM level; [2] Extractin rate=15% (85% regarded as unpalatable or very poor); [3] Ratio of grain to straw=1:1; [4] Ratio of grain to straw=1:3; [5] Estimated at 6% of cassava production; [6] Estimated at 12% of cane production; [7] Estimated as 20% of cant production or 8% of dry yield.

Table 4. Estimated areas of rice harvested and straw production

Country	Rice Harvested	Straw Production
Bangladesh	10,100	21,700
Burma	4,800	14,500
China	35,300	172,184
India	39,500	90,000
Indonesia	9,000	34,300
Japan	2,273	12,958
Kampuchea DM	600	1,700
Korea REP*	1,200	7,608
Laos	700	1,002
Malaysia	700	2,000
Nepal	1,300	2,744
Pakistan	2,000	5,210
Philippines	3,400	8,150
Sri Lanka	700	2,200
Thailand	9,300	18,535
Vietnam	5,200	14,500

(IRRI, 1982 and FAO, 1983; cited by P. T. Doyle, C. Devendra and G. R. Pearce, 1986).
* 15% for feed, 46% for fertilizer, 20% for fuel, 12% for roofing, 7% for others (reported by Im and Park, 1983 cited by Doyle et al., 1986).

Table 5. Utilization of rice straw in Asia

Country/Region	Purpose	% of total availability
Bangladesh	Feed	74.4
Korea	Feed	15.0
	Fertilizer	46.0
	Fuel	20.0
Thailand	Feed	75-82
China	Feed	25.0
Southeast Asia[1]	Feed	30.4

[1] The countries involved are Cambodia, Indonesia, Laos, Malaysia, Mongolia, Myanmar, The Philippines, Thailand and Vietnam. Compiled by Devendra (1997).

Table 6. Total by-products (000 tonnes) of sugarcane based industry in Indonesia

By-products	1987	1990
Millable cane stalk*	25,779	28,074
Cane leaves*	8,010	8,758
Cane tops*	3,609	3,930
Bagasse	8,350	9,152
Filter cake	1,031	1,137
Molasses	1,031	1,106

* Fresh weight. (Soepardi, G. and S. Tedjowahjono, 1991)

Table 7. Crop production and cropland per TLU for tropical African countries

Country	Crop Production (t/TLU/Year)					
	Sorghum /Millet	Maize	Total Cereals	Grain	Roots and tubers	TL U/Ha of cropland
Senegal	0.69	0.08	0.84	0.57	0.12	2.97
Benin	0.14	0.34	0.50	0.12	1.39	0.43
Malawi	0.20	1.60	1.84	0.33	0.30	0.33
Rwanda	0.32	0.20	0.54	0.34	1.29	0.53

(World bank, 1989; cited by de Leeuw, 1997)

Table 8. The chemical composition of non-conventional feedstuffs in Asia and the Pacific (% DM Basis)

Feedstuff	Chemical composition								
	DM	CP	CF	EE	Ash	NFE	Ca	P	GE (MJ/kg)
1.									
Palm kernel cake	90.6	19.0	16.0	2.0	4.2	58.8	0.23	0.31	18.07
Palm press fibre	86.2	4.0	36.4	21.0	9.0	23.6	0.30	0.13	17.61
Palm oil mill effluent	900	10.6	18.3	17.0	12.1	42.0	0.75	0.50	17.66
Pineapple bran	87.4	4.8	25.5	1.9	4.5	63.3	0.29	0.24	13.43
Raji straw	-	3.6	38.9	1.5	9.6	45.4	-	-	-
Rain tree pods	-	15.9	11.8	1.5	3.8	67.0	-	-	-
Rice broken	98.6	7.5	7.0	1.1	5.0	79.4	0.32	0.34	-
Sago refusee	26.0	1.9	6.0	0.4	3.0	88.8	0.05	0.04	13.06
Sal seed meal	-	9.2	2.4	1.0	3.6	83.8	0.12	0.19	-
Sugar cane bagasse	95.3	2.7	37.4	0.3	5.7	53.9	0.11	0.31	13.31
Sugar cane tops	-	3.8	50.8	1.8	4.9	51.5	0.18	0.02	20.15
Sunflower heads	-	7.2	16.6	2.9	10.6	62.6	1.40	0.12	-
Sunflower straw	94.2	2.6	30.1	0.9	15.0	514.5	0.39	0.09	-
Sun hemp hay	-	22.3	26.3	10.2	6.5	34.7	-	-	-
2. Leaves									
Bambo (hay)	87.7	12.0	27.0	0.8	18.0	42.2	0.19	0.13	-
Banana	27.1	16.1	23.7	8.4	9.4	42.2	-	-	-
Canna	11.5	11.4	25.6	3.2	10.1	39.7	-	-	15.19
Cassave	21.7	22.6	8.1	2.9	6.0	60.4	0.98	0.20	8.45
Eucalyptus	50.3	3.4	30.0	2.9	16.1	47.6	-	-	-
Gliricidia	25.0	14.7	19.9	5.4	4.7	55.3	0.46	0.14	23.08
Jakfruit	36.6	14.0	22.1	3.8	11.5	48.5	-	-	6.53
Leucaena (Philippines)	52.6	12.6	5.4	1.6	2.2	78.2	0.37	0.07	-
Leucaena Leaves (Malaysia)	30.0	22.0	19.6	6.9	4.4	47.2	0.55	0.13	22.18
Leucaena leaves stems+pods(Malaysia)	30.1	17.4	30.5	3.8	4.6	43.6	0.30	0.14	32.59
Lathana	13.3	27.8	10.9	2.0	5.5	53.8	0.80	0.15	14.10
Mulberry	-	15.0	15.3	7.4	14.3	48.0	2.42	0.42	-
Mulberry	-	15.0	15.3	7.4	14.3	48.0	2.42	0.42	-
Oil Palm leaves and petioles	91.4	4.9	27.2	2.2	5.8	51.3	-	-	-
Sesbania	85.6	22.6	18.4	2.1	9.3	47.6	1.10	0.32	-
Singapore Rhododendron	35.5	10.8	24.7	2.8	7.8	53.9	1.44	0.19	10.54
Sorghum straw	-	3.5	39.7	1.7	9.7	45.4	-	-	17.36
Sugar cane green tops	26.0	6.4	33.9	1.7	7.6	50.4	-	-	17.36
Teak leaves	-	4.9	20.3	3.1	20.1	51.5	2.38	0.08	-
Tea waste	-	28.0	18.0	3.0	6.0	45.0	-	-	-
Water hyacinth	14.7	12.1	22.5	1.7	13.3	50.4	1.62	0.50	10.38
3. Legumes									
Centrosema Pubescens	24.3	22.2	30.9	2.5	9.5	34.9	0.78	0.45	15.15
Sesame meal	91.9	38.5	7.8	14.7	12.5	26.8	2.44	1.29	17.66
4. Miscellaneous									
Bambo seeds	9.3	10.0	11.0	-	3.6	75.0	-	-	-
Banana whole plant	18.5	3.7	28.0	3.6	17.8	46.9	0.22	0.12	-
Feather meal	91.9	88.5	1.6	2.3	5.6	2.0	0.26	0.20	-
Groundnut leaves and stems	17.6	19.9	34.5	4.8	9.9	30.9	-	-	14.22
Poultry litter	36.0	24.2	25.4	2.1	18.1	30.2	-	-	15.88
Rubber seed meal	89.0	33.6	3.5	11.2	4.7	47.0	0.13	0.50	14.69
saw dust	-	2.9	60.1	3.0	5.4	61.1	0.21	0.01	-
Tamarind seed huls	-	9.1	11.3	0.6	3.5	75.5	0.26	0.76	-
Tobacco seed / cake	-	29.9	22.3	10.3	12.7	25.7	-	-	-
Wood pulp	94.9	1.1	44.0	0.5	18.1	36.4	30.4	0.09	-

Source: Devendra (1992)

Sugarcane top and bagasse are predominant. Cassave leaves are plenty in both Insonesia and Thailand. The extraction rate is a useful indicated since it estimates the amount of potential feeds derive from crops. Multiflier used to convert cereal grain yields to fibrous by-product quantities in Asia is estimated by Kossila (1988).

Furthermore, some potential crop residues produced in Southeast Asia are presented in table 3. Indonesia produces rice straw, maize stover, sugarcane bagasse and sugarcane top higher than those from the other countries. Estimation of rice straw produced in Asia is presented in table 4 and 5. Rice straw produced is often scattered and this condition may be responsible for lowering utilization of the straw as feed particularly in Indonesia. Furthermore, rice areas are usually not as livestock area so that transportation could be a limiting factor.

Sugarcane by-products are presented in table 6. Estimated availability of dry fodder/straw from grain and groundnut crops in India in the year 1983-84 are reported by Singh and Rangnekar (1986), crop residues (Singh et al., 1997). While quantity of raw material produced in Sri Lanka is reported by Rajaguru (1986). Thailand's major crop and by-product yields in crop year are presented by Khajarern and Khajarern (1985). Major agricultural systems in small and medium-sized farms located in different agroecological zones of tropical America is reported by Quiroz et al., 1997. Types and availability of fibrous residues and byproducts in Sri Lanka are reported by Rajaguru (1984). While availability of by-products in Indonesia is reported by FAO (1987) and Rahardjo (1981) cited by B. Tangenjaya (1994). Furthermore, raw materials for animal feed production in Indonesia are presented by BPEN (1991) cited by B. Tangenjaya (1994).

FEED QUALITY

Chemical composition of non-conventional feedstuffs in Asia and the Pacific are presented in table 8.

Cell wall composition of fibrous residues is presented in table 9 while chemical composition and mineral content of them are presented in table 10, 11, 12, 13, and 14.

Table 9. Cell characteristics of some fibrous residues (as % of dry matter)

Fibrous	Cell content	Cell wall	Cellulose	Hemi-cellulose	Lignin	Silica
Rice straw	21	79	33	26	7	13
Barley straw	19	81	44	27	7	3
Wheat straw	20	80	39	36	10	6
Oat straw	27	73	41	16	11	3
Sorghum stover	26	74	31	30	11	3
Sugarcane bagasse	18	82	40	29	13	2

(Jackson, M. G., 1977)

Cotton seed contains 31.7% CP, 30.4% Crude Fat, 10.2% NDF, 7.8 ash, 0.4% Ca, 1.0% P and 5866 kcal/kg (Dwi Yulistiani, M. Rangkuti, A. Wilson, dan Muryanto, 1989).

Kapok seed meal contains 84.7% DM, 32.4% CP, 62.1% NDF and 4125 cal/kg (Martawidjaja, M., and M. Rangkuti, 1989). Tapioca waste (onggok) contains 88.7% DM, 1.2 CP, 39.2% NDF, 11.6% ADF, 1.6% lignin, 3959 cal/kg DM (Rangkuti, M., and M. Martawidjaya, 1989). Thahar and Mahyudin (1993) summarized ground fodder, shrub or tree fodder, and crop residues available in Indonesia.

Table 10. Average chemical composition and mineral content of fibrous feedstuffs (DM basis)

Composition	Rice straw	PPF * Hay	Peanut Waste	Baby Corn Waste	Cane Top	Bagasse
Dry Matter	90-93	91	89	-	24.8	92.7
Organic Matter	-	-	91	93	89.9	-
Crude protein	3.3-4.5	9.3	9.3	11.3	5.5	2.7
Crude fibre	26-34		39.9	18.8	37.9	43.1
EE	1.2-1.7	14.7	2.0	2.8		4.5
Ash	11-19	6.4	9.4	6.5		
NFE	35-55		39.4	61		45.0
NDF	-	75.4			78.6	
ADF	-	52.8			74.2	
GE (MJ/kg)	14-16	19.2	17.6	16.9		
Ca (%)	0.1-0.6					
P (%)	0.1-0.4					
Mg (%)	0.2-0.5					
K (%)	0.6-2.4					
Cu (ppm)	1-2					
Zn (ppm)	68-81					
IVDMD (%)					34	
IVOMD (%)					34	
Source:	(1)	(2)	(3)	(3)	(4)	(5)

(1) Devendra, C. 1979; (2) Aznam, Z. 1982; (3) Boolom Cheva-isarakul. 1982; (4) A. Musofie. 1987; (5). Gerpacio and Castillo (1979) cited by DB. Roxas. 1984.

* Palm Press Fibre. Malaysia (1987) produced 2.220 million tonnes of PPF vs only 1.210 million tonne PPF in 1980, and oil palm trunk 1.32 million tonnes in 1990 (Anonymous, 1990). Processing and utilization of oil palm by-products for ruminants. Collaboration between TARC, Japan and MARDI, Malaysia.

Table 11. Proximate composition of the most prevalent fibrous by-products (% DM basis)

Byproduct	Crude Protein	EE	Crude Ash	Crude Fibre	NFE
Rice straw	4.2	0.9	27.5	15.2	47.3
Rice hull	2.5	0.9	36.2	16.0	44.4
Maize stover	6.1	1.6	36.8	8.5	6.9
Maize cob	3.0	0.6	34.6	2.4	59.4
Sorghum stover	3.5	1.6	35.0	3.9	56.0
Cassava leaf	22.6	2.9	8.1	6.0	60.4
Sweet potato vines	20.0	3.1	15.3	17.4	44.2
Banana leaf & Stem	4.9	4.1	27.6	17.8	46.4
Pineapple waste	4.8	1.9	25.5	4.5	63.3
Sugarcane leaf & top	6.4	1.7	33.9	7.6	50.4
Sugarcane bagasse	2.7	0.3	37.4	5.7	53.9
Soybean stover & pod	4.2	0.9	38.5	6.1	50.2
Mungbean stover & pod	9.2	1.5	38.1	11.3	39.9
Kenaf leaf top	25.9	4.0	11.2	10.0	48.9

(Khajarern, S and I. Khajarern, 1985)

Table 12. Mean concentration of macro (g/kg DM) minerals in various fibrous materials used a ruminant feeds in South East Asia

Material	Ca	P	Na	Mg
RICE STRAW				
Indonesia	0.4-5.5	0.2-2.7	<0.01-2.5	1.0-3.3
Malaysia	1.1-5.8	0.5-4.1	0.6-0.9	1.2-13.6
India	2.5-6.7	0.2-5.4	1.4-3.0	-
Thailand	3.6-4.1	0.7-2.5	0.6-0.9	1.7-2.9
BAMBOO LEAVES				
Indonesia	2.2-10.6	0.9-1.5	0.7-1.8	0.7-2.1
Malaysia	1.6-14.3	1.0-2.3	0.3	1.1-7.9
MAIZE STOVER				
Indonesia	1.4-3.6	1.6-4.2	0.5-0.9	1.2-2.6
BANANA LEAVES				
Indonesia	1.7-10.3	1.7-3.8	0.01-2.4	2.6-3.7
Malaysia	0.6-11.4	0.9-2.5	0.4-0.7	1.0-7.4
SUGARCANE TOPS				
Indonesia	2.5-7.2	1.6-2.3	0.8	1.7-2.6

Source: Little (1985)

Table 13. Mean concentration of trace (mg/kg DM) minerals in fibrous materials used as ruminant feeds in South East Asia

Material	Zn	Cu	Mn	Fe
RICE STRAW				
Indonesia	2-59	1.5-4.2	53-720	18-690
Malaysia	15-81	1-5	279-672	47-195
BAMBOO LEAVES				
Indonesia	9-43	3.2-4.8	66-180	75-130
Malaysia	0-16	0-5	5-90	4-89
MAIZE STOVER				
Indonesia	11-41	1.8-17	24-150	66-280
BANANA LEAVES				
Indonesia	7-10	4.3-8.0	170-500	88-230
Malaysia	13-94	4-10	191-330	4-91
SUGARCANE TOPS				
Indonesia	22	3.2	180	85

Source: Little (1985)

Table 14. Chemical composition of whole sugar cane and cane tops (% DM basis)

Constituents	Whole cane	Cane tops	Bagasse
Nitrogen	0.4	0.9	0.4
Total sugar	48.0	25.0	3.0
Crude fibre	28.0	35.0	48.0
Cell wall	79.0	65.0	82.0
Ash	6.0	8.0	3.2
Hemicellulose	26.0	20.0	30.0
Cellulose	36.0	38.0	40.0
Lignin	10.0	7.0	12.0
Silica	3.0	1.8	2.0
Calcium	0.3	0.1	-
Phosphorus	0.3	0.4	-
Sodium	-	-	-
Potassium	2.8	2.3	-

Source: Rangnekar (1991)

Digestibility values of crop residues and agricultural by-products are presented in tables 15, 16 and 17. Crude protein content of tree foliages and their digestibility values are presented in table 18.

Table 15. Dry matter digestibility and nitrogen contents in a range of crop residues (%)

Crop residues	Digestibility	Nitrogen
Sugaracane bagasse	40	0.5
Sugarcane tops	56	1.0
Rice straw	43	0.8
Sorghum stover	51	1.0
Maize stover	50	0.8
Sweet maize stover	59	0.8
Banana leaves	64	2.8
Banana stems	62	0.5
Cassava leaves	56	4.0
Peanut vines	64	2.4
Sweet potato vines	66	2.5
Pigeonpea forage	70	2.3

(Dixon and Egan, 1987)

Table 16. Variation in *in vitro* digestibility and nitrogen content of a number of crop residues (%)

Crop residues	n	Digestibility		N content	
		Mean	Range	Mean	Range
Ricestraw	63	42	30-55	0.85	0.54-1.38
Soybean stover	3	28	15-38	0.47	0.43-0.52
Cowpea residue	8	52	48-54	1.82	1.62-1.97

Source: Dixon and Egan (1987)

Table 17. Nutritive values (%) of the residues and by-products of cropscommonly cultivated in Central America[1]

Crop residues or by-products	DM	N	CWC	IVDMD	Ca	P
Maize stalk	83.2	0.67	76.4	40.4	0.23	0.19
Sorgum straw	82.6	0.83	6	54.0	0.40	0.14
Rice straw	89.0	0.69	78.2	42.3	0.21	0.31
Rice polishings	89.3	3.66	6.4	87.6	0.23	0.72
Cassava folliage	26.1	3.36	34.5	52.9	0.62	0.42
Cassava tubers	32.0	0.58	5.3	79.0	0.09	0.12
Sweet potato folliage	14.6	2.32	29.5	74.6	0.86	0.40
Bean haulm	92.0	0.61	26.7	45.6	-	-
Cotton seed (whole)	91.6	3.66	20.5	76.6	0.15	0.73
Sugarcane tops	24.0	0.86	68.3	69.3	0.31	0.28
Sugarcane bagasse	48.4	0.39	90.8	30.3	-	-
Sugarcane molasses	75.0	0.65	-	>95.0	0.73	0.11
Banana fruits	21.2	0.72	2.7	96.0	0.23	0.09
Banana psudo-stems	6.8	0.38	38.7	77.4	0.18	0.14
Banana leaves	21.8	1.95	53.2	45.9	0.51	0.19
Coffee pulp	20.0	2.13	21.0	61.2	0.55	0.11
Coffee hulls	89.6	0.48	45.7	48.0	0.15	0.02

(Quiroz et al., 1997)

[1] DM=Dry Matter; N=Nitrogen; CWC=Cell wall constituents; IVDMD=in vitro dry matter digestibility; Ca=Calcium; P= Phosphorus.

Table 18. Crude Protein (CP) content and in vitro dry matter digestibility (IVDMD) of some tree foliages used for animal feeding in the Latin American humid lowland tropics (%)

Latin name	CP	IVDMD
Erythrina poeppigiana	24.2	51.4
Gliricidia sepium	24.8	62.2
Leucaena leucocephala	22.0	52.7
Pithecellobium dulce	24.1	59.6
Enterolobium cyclocarpum	21.7	68.8
Morus spp	24.2	79.3
Cindoscolus acutinifolium	41.7	84.4
Sambucus mexicana	24.3	75.8
Hibiscus rosa-sinensis	19.9	71.2
Verbesina myriocephala	20.3	69.8
Verbesina turacensis	20.2	68.4
Diphysa robinoides	26.9	69.8
Malvaviscus arboreus	21.0	68.3
Cestrum baenitzii	37.1	65.8
Spondias purpurea	16.5	56.6
Guazuma ulmifolia	15.6	54.1
Cecropia peltata	19.8	51.7
Brosimum alicastrum	16.1	59.0
Cassia siamea	13.9	60.6
Acacia angustissima	19.9	23.2
Albizia falcataria	20.3	42.2
Calliandra calothyrsus	20.2	21.0
Inga spp.	21.8	23.2

(Adopted from Valerio, 1990; Benavides et al., 1992; Araya et al., 1994; cited by Quiroz et al., 1997)

Higher crude protein contents are not necessary higher in digestibility values. For example, *Inga spp.* has 21.8 % CP but it has only 23.2% IVDMD vs 68.8% IVDMD % for *V. myriocephala* which has 20.3 % CP. Potential anti-quality factors in crop residues and agricultural by-products are presented in table 19.

Table 19. Example of toxic principals in the more common agroindustrial by-products and non-conventional feed resources

Feed	Toxic principal
Banana waste, stems and leaves	Tannins
Cassava leaes, peeling and pomace	HCN (17.5 mg/100 g in leaves)
Castor seed meal	Ricinoleic acid (0.2%)
Cocoa seed husks	Theobromine (Trace)
Coffee seed hulls, pulp	Caffeine and tannins (2.8% DM)
Cotton seed cake	Gossypol (0.05 - 0.20%)
Cowpea seed meal	Trypsin inhibitor
Guar meal	Trypsin inhibitor and gum
Kapok	Cycloponopenoid acid
Mango seed kernel	ash (12-26% DM)
Rubber seed meal	HCN (9 mg/100 g)
Sal seed meal	Tannins (6.2-13.7%)
Spent tea leaves	Tannins (12%)
Water hyacinth	Oxalic acid (2.4% DM)
Sugarcane bagasse*	Lignin 8-10%
Sunflower straw*	Tannins 1.5%
Tea waste*	Tannins 1.9%

(Reviewed by Devendra, 1988)

USAGES

Strategic feeding using mixed tree legumes shortened calving interval from 15 months down to 13 months (Winugroho et al., 1995). Utilization of tree legumes and probiotic Bioplus are nationally recommended in Indonesia (Anonymous, 1997). Tree legumes which are high in nitrogen content usually contain anti-quality factors. Tannin-protein linkages in Calliandra are common and are believed to be responsible for lowering nutrient utilization of it when dried. Introducing probiotic

Table 20. Some example of primary feeds for intensive utilization by location

Type of primary feed	Location	Species
Banana	Philippines	Beef cattle, ducks
Cassava:		
-Leaves	Thailand, Indonesia, Philippines	Beef cattle, goats, swamp, buffaloes
-Pomace	Thailand, Indonesia, Philippines	Pigs, ducks, lactating, cattle, 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
Sugarcane:		
-Tops, bagasse	India, Pakistan, Thailand	Beef cattle and swamp buffaloes
Wheat:		
- Bran	India, Pakistan	Pig, poultry, lactating ruminants
- Straw	India, Pakistan	Beef cattle and swamp buffaloes

(Devendra, C., 1988)

Table 21. Priorities for crop residues use by animals in Asia

Type of residue	Nutrient potential	Species (product/service)[1]
Good-quality (e.g. oilseed cakes and meals, cassava leaves)	High-protein High-energy supplement, minerals	Pigs, chickens, ducks, ruminants (milk, meat)
Medium-quality (e.g. coconut cake, palm, kernel cake, sweet patato, vines)	Medium-protein	Pigs, chickens, ruminants, (meat, milk)
Low-quality (e.g. cereal straws, palm press fibre, stovers)	Low-protein ver fibrous	Ruminants (meat, draught), camels, donkeys, horses (draught)

[1] Ruminants refers to buffaloes, cattle, goats and sheep. (Devendra, 1997)

Tabel 22. Optimum level of utilization of some important by-products diets for farm animals in Asia

Non-conventional Feedstuffs	Species	Location	Optimum level of inclusion in the diet (%)
I. Animal			
1. Blood meal	Pigs	Malaysia	3
2. Poultry excreta	Poultry	Malaysia	5-10
	Poultry	India	15
	Sheep	Malaysia	20-30
	Cows	Thailand	30
	Cattle	Pakistan	30
	Sheep		
II. Plants			
3. Castor (Castor bean meal)	Buffaloes	India	30
	Sheep	India	10
4. Cocoa (Cocoa pods husk)	Sheep	Malaysia	30
	Buffaloes	Malaysia	35
	Cattle		
5. Mango (Mango seed kernel)	Calves	India	20
	Bullocks	India	40
	Cows	India	10
6. Oil palm			
- Palm oil mill effluent	Sheep	Malaysia	40
- Palm press fibre	Sheep	Malaysia	30
- Palm oil solids	Poultry and pigs	Malaysia	10-15
7. Pineapple (Pineapple bran)	Poultry	Malaysia	15
8. Rice (Rice husk)	Sheep	Malaysia	5
9. Rubber (Rubber seed meal)	Pigs	Malaysia	20
	Poultry	Sri Lanka	20
	Poultry	Sri Lanka	20
	Calves and Cow	India	20
	Calves	India	30
	Cows	India	25
	Pigs	India	40
10. Sal			
- Sall seed meal (untreated)	Poultry	Inida	5
- Sal seed meal (treated)	Poultry	India	20
	Cows	India	30
	Bulls	India	40
11. Spent tea leaf	Calves	Sri Lanka	17
	Calves	India	20
12. Sugar cane			
- Banasse (untreated)	Bullocks	Pakistan	10
- Banasse (treaed)	Sheep	Malaysia	20-30
13. Sunflower head meal	Sheep	India	48
14. Sun hemp (Sun hemp leaves)	Poultry	India	8
15. Tamarind (Tamarind seed hulls)	Calves	India	10-15
	Calves	India	25
16. water hyacinth (Water hyacinth meal)	Calves	India	10-20
17. Water melon (Water melon cake)	Calves	India	20

(Devendra, C., 1988)

Table 23. The effect of feeding rice straw on ruminant production

Animal	Treatment	Supplement	ADG (g/day)
Beef cattle	5% Urea	2 kg concentrate	493
	0	2 kg concentrate	296
	0	1.1 kg cassava leaf+0.6 kg tapioca waste	214
	0	24% gliricidia+grass+coconut meal+mineral	330
	0	5% molasses+ 11% soyabean waste	280
	0	5% molasses+20% cassava leaf	280
Draft cattle	0	50% grass + 0.8 kg tapioca waste + 0.5 kg kapok seed meal	391
Buffalo	3% urea	1 kg soyabean waste	303
	0	1% concentrate (LW)	478
Goats	10% urea	0	27
	10% urea	25% cassava leaf	84
	10% urea	25% cassava leaf	101

(Winugroho, 1991)

Table 24. Approximate feed value and level of ration ingredients used for lotfeeding in SE Asia (dry feed basis) (Ffoulkes, 1997)

Feedstuff	DM (%)	CP (%)	RDP (%)	CF (%)	ME (MJ/kg)	Ca (%)	P (%)	Max (%)
ROUGHAGE								
Forage Maize (75 days)	25	8.00	53	30	9.9	0.34	0.23	25%
Forage Maize (Stover)	25	5.50	65	30	8.9	0.60	0.10	10-20%
Sugarcane Tops	28	6.00	65	35	7.7	0.50	0.20	25%
Napier Grass(75 days)	21	8.50	65	34	7.5	0.50	0.30	25%
Rice Straw	92	3.90	75	39	5.5	0.50	0.20	10%
Pineapple Pulp	12	3.30	75	26	10.1	0.40	0.10	20%
CONCENTRATE								
Palm Kernel Cake	89	19.00	74	13	12.2	0.30	0.70	<50%
Copra Meal	90	20.00	35	7	12.5	0.20	0.70	25%
Corn (Cracked/Ground)	91	10.00	75	3	12.5	0.03	0.30	85%
Corn Bran	90	9.60	60	13	12.5	0.06	0.73	15-25%
Wheat Pollard	88	17.60	79	8	11.0	0.20	1.00	45%
Rice Bran	91	14.00	66	13	11.8	0.07	1.60	15-25%
Tapioca Waste	90	2.00	90	3	12.0	0.60	0.20	<50%
Sago Rasps.	89	0.50	75(?)	5	10.0	0.64	0.02	30%
Soyabean Meal	89	47.20	65	8	13.7	0.27	0.70	5-10%
Groundnut Meal	86	34.00	80	27	11.7	0.20	0.60	25%
Meat/Bone Meal	90	50.00	51	0	10.5	9.00	4.70	10%
Spent Grains	22	24.00	73	15	10.0	0.33	0.13	15%
Cotton Seed (Whole)	93	21.10	65	22	14.0	0.16	0.76	10-15%
Kapok Seed Meal	90	31.00	45	30	8.7	0.50	1.30	10%
Cocoa Bean Shell	91	22.60	45	14	12.6	0.15	0.27	10%
Leucaena Leaf Meal*	92	26.70	45	21	10.9	2.20	0.30	10%
Green Bananas	22	5.75	80(?)	4	13.0	0.06	0.20	<60%
Molasses	75	5.00	100	0	12.5	0.60	0.10	15,90%
Urea	100	(287)	100	0	0	0	0	<2%
MINERALS								
Limestone	100	0	0	0	0	34.00	0	
Dicalphos	100	0	0	0	0	22.00	19.30	

Notes: DM, Dry Matter; CP, Crude Protein; RDP, Rumen Degradable Protein; CF, Crude Fibre; ME, Metabolisable Energy; MJ, Megajoules; Ca, Calcium; P, Phosphorus.

* up to 40% utilization in the sheep ration (Balogun and Otchere, 1995).

Bioplus increased dry matter digestibility of dried Calliandra when fed to sheep (Yeni Widiawati and Winugroho, 1996). Previously, Winugroho et al (1993) demonstrated that probiotic Bioplus increased dry matter digestibility of materials containing anti-quality factors such as theobromine in cocoa by-product. Bioplus was made by selecting mix culture microbes from rumen content which is conditioned to specific target (Winugroho et al, 1993; 1996).

Utilization of crop residues and agricultural by-products as feed is presented in table 20 and 21.

Optimum levels of procedures and agricultural by-products as feeds are presented in table 22, 23 and 24.

Upper part of rice straw was reported better than the lower part (Winugroho et al, 1983). This might be due to higher protein content and the upper part was easy to chew.

Feeding Australian Commercial Cattle in South East Asia, Ffoulkes (1997) presented approximate feed value an level of ration ingredients used for lotfeeding (table 24).

Ishida and Abu-Hasan (1997) reported that oil palm frond (OFF) could constitute 30 to 40% of cattle ration in Malaysia. OFF contains 70% fibre and 22% soluble carbohydrates on a dry matter basis.

FEED INFORMATION CENTER

Network between private sectors working in animal industry are the most beneficiary market for a centre informing new potential feed resources. Together with local government, information on what, how much, when, where and price would be a good source for the related users.

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