ALTERNATIVE RAW MATERIALS FOR ANIMAL FEED

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ABSTRACT

The increase in world fuel prices in the last few years has charged the global animal feedstuffs. In Malaysia, the feed industry is dependent on the importation of corn and soybean meal as the poultry and swine industries are almost totally based on corn soya bean meal diets. However, there are many byproducts and coproducts available in Malaysia as alternatives to corn or soy bean. Since Malaysia has more than 4 million hectares of oil palm plantation and after processing for the oil, large quantities of several byproducts are produced. This paper describes several available byproducts and co products in Malaysia, their nutritive value and their problems.

Key words: Byproducts, non conventional feed, Malaysia

ABSTRAK

BAHAN PAKAN ALTERNATIF UNTUK PAKAN TERNAK

Peningkatan harga minyak dunia dalam beberapa tahun ini telah membebani bahan pakan dunia. Di Malaysia, industri pakan tergantung pada importasi jagung dan bungkil kedelai karena industri unggas dan babi hampir secara total bergantung pada jagung dan bungkil kedelai. Namun demikian, terdapat banyak produk samping dan produk ikutan tersedia di Malaysia sebagai alternatif pengganti jagung dan kedelai. Hal ini dikarenakan Malaysia memiliki perkebunan sawit lebih dari 4 juta hektar dan diproduksi produk samping dalam jumlah besar. Makalah ini menguraikan beberapa produk samping dan produk ikutan yang tersedia di Malaysia, dari segi nilai nutrisi dan permasalahannya.

Kata kunci: Produk samping, pakan non konvensional, Malaysia

INTRODUCTION

The increase in world fuel prices in the last few years have changed the global animal feedstuffs supply and subsequently, prices. Corn is not only used for human and animal consumption but also competes in the world market for the production of ethanol, the future biofuel. Currently, US are producing about 40% of the world ethanol production of about 80,000 million liters (MARKET RESEARCH ANALYST, 2009). In the US, it takes about 1 acre of corn produced (3 MT) to produce 700 liters of ethanol. China, Cuba, Brazil, and India are also embarking on the production of biofuel in anticipation with future shortage of fossil fuel. As a result, the byproducts from the ethanol production, especially dried distillers grain (DDG) and DDG with solubles (DDGS) will dominate the market and will no doubt be important coproducts for animal feed. Similar to brewers grain which is the co product of the brewing industry, DDG and DDGS will be valued coproducts available in many parts of the world. There are many other byproducts and coproducts used in animal feed in Europe and US, including milling byproducts, poultry litter, straws and stovers, citrus pulp and beet pulp, corn gluten feed and others (see Table 1). In Malaysia, starch crops, for example cassava, sweet potato and sago can be alternatives to corn in poultry diets. Nutritionally, these crops can provide the energy for livestock but research on large scale production and processing is still lacking. Tropical legumes such as peas, grams and beans can be good sources of protein for livestock.

The feed industry in Malaysia

The feed industry in Malaysia is dependent on the importation of corn and soyabean meal as the poultry and swine industry are almost totally based on corn-soya bean meal diets. The poultry and swine industry are both well established and have traditionally been dependent on corn-soyabean based diets, with very little non-conventional feed ingredients. As such, the price of farm products depends on the world market prices of corn and soya bean meal. The ruminant industry on the other hand, is not too dependent on imported feeds as same of the local byproducts are

Table 1. Typical composition of feeds for catlle and sheep (All values except dry matter are shown on a dry matter basis)

Feedstuffs	DM %	CP %	Bypass protein %	EE %	CF %	ADF %	NDF %	Ash %	Ca %	P %	K %	S %	Zn ppm	TDN %	DE Mcal/lb.	NEm Mcal/lb.	NEg Mcal/lb.
Alfalfa dehydrated 17%	92	19	60	3.0	26	35	45	11	1.4	0.25	2.7	0.24	19	61	1.22	0.61	0.31
Barley straw	88	4	--	1.9	42	57	82	7	0.3	0.05	2.0	0.15	7	49	0.98	0.48	0.11
Blood meal	92	80	80	1.3	1	--	--	5	0.3	0.26	0.1	0.43	5	61	1.22	0.61	0.13
Brewers grains wet	24	26	60	6.5	15	22	42	5	0.3	0.60	0.1	0.32	50	81	1.62	0.87	0.58
Brewers dried grain	92	28	60	7.5	15	22	42	4	0.3	0.60	0.1	0.32	50	81	1.62	0.87	0.58
Cattle manure dried	92	17	--	2.6	34	37	55	14	1.2	1.00	0.5	1.78	240	38	0.76	0.39	0.00
Corn stover mature	80	6	--	1.3	35	40	70	7	0.5	0.09	1.6	0.17	--	59	1.18	0.58	0.28
Corn cobs	90	3	50	0.5	36	39	88	2	0.1	0.04	0.8	0.35	5	48	0.26	0.47	0.09
Corn gluten feed	90	26	--	2.9	9	--	41	7	0.4	0.75	0.6	0.20	100	82	1.64	0.88	0.59
Corn gluten meal	91	45	65	2.5	5	9	37	4	0.2	0.50	0.2	0.60	45	84	1.68	0.91	0.61
Distillers grain corn	91	30	65	8.2	14	16	41	2	0.1	0.45	0.2	0.46	35	84	1.68	0.91	0.61
Distillers grain corn With solubles	92	29	50	10.0	10	18	44	5	0.3	0.85	0.7	0.32	90	88	1.76	0.97	0.65
Distillers dried solubles	93	30	--	9.5	4	7	23	8	0.4	1.40	1.8	0.40	91	88	1.76	0.97	0.65
Poultry fat	99	0	--	99.0	0	0	0	0	0.0	0.00	0.0	--	--	195	3.90	2.38	1.82
Feathermeal hydrolyzed	94	91	50	3.3	2	20	20	4	0.2	0.78	0.3	1.80	53	68	1.36	0.69	0.41
Garbage municipal cooked	23	16	--	23.3	8	50	59	11	1.6	0.45	--	--	--	75	1.50	0.78	0.50
Linseed meal (solvent extracted)	91	39	40	1.9	10	18	25	6	0.4	1.00	1.4	0.47	60	76	1.52	0.80	0.52
Molasses cane	76	5	0	0.0	0	0	0	10	1.1	0.08	3.6	0.46	30	75	1.50	0.78	0.50
Molasses cane dried	94	10	0	0.6	3	0	0	14	1.2	0.15	4.0	0.46	30	74	1.48	0.77	0.49
Peanut meal (solvent extracted)	91	52	30	1.3	11	--	14	5	0.2	0.65	1.2	0.30	22	77	1.54	0.81	0.53
Poultry litter dried	87	26	0	3.0	18	--	--	19	2.7	1.80	1.7	1.26	340	64	1.28	0.64	0.36
Soybean flake (hull)	91	12	10	2.8	39	47	65	4	0.6	0.17	1.0	0.09	24	71	1.42	0.73	0.46
Sunflower meal (solvent extracted)	93	50	--	3.1	12	--	40	8	0.5	0.80	1.1	0.33	21	65	1.30	0.65	0.37

Table 2. Nutrient content of some non-conventional feed resources in Malaysia**

Feedstuffs	Dry matter (%)	Crude protein (%)	ME poultry (MJ/kg)	ME ruminants (MJ/kg)	Crude fibre (%)	Crude fat (%)	Ca (%)	P (%)
Root crops: Cassava meal, sweet potato	20 – 27	3 – 4	10.5	11.00	4 – 6	2 – 4	0.6 – 1.2	0.4 – 1.0
Pineapple skins	20	8	6	10.5	20	5	.3	.2
Oilseed meal: linseed, cottonseed meal, sunflower seed,	88 – 91	35 – 40	10.5	10.0	12.0	1.7	0.17	1.0
Palm kernel cake,	90	16	8.0	10.50	18	4	0.27	0.48
Palm oil mill decanter cake	25	15	8	10	18	15	1	0.3
Palm oil mill effluent (POME)	25 – 30	9	6	8	15	13	0.76	1.27
Copra meal	91	20	-	8.0	26	4	0.03	0.26
Sago pith meal	90	5	12.0	12.0	10	2	0.14	0.04
Sago waste	25	4	10.5	10.5	35	1	0.12	0.02
Restaurant waste, bakery waste	20 – 25	20-25	11.50	12.0	10 – 15	20 – 30	0.63	0.34
Rice bran	90	15	10.5	11.0	13	15	0.1	1.7
Rice husks	91	5	4	6	45	1	0.25	0.07
Legume leaves, peas, winged bean, grams	20 – 25	15 – 25	10.5	11.0	15 – 25	5 – 12	0.2	0.3
Poultry byproduct	94	60	10.5	10.5	2.1	17.1	3.75	1.8
Feather meal	94	85-90	6.5	6.5	2	5.0	1.19	0.6

**Adapted from various sources

largely incorporated in their diets. For example, palm kernel cake which is available in large quantities has been used in ruminant diets for many years. Rice bran is also an important feed ingredient in the ASEAN region.

Byproducts and residues of industrial crops

Malaysia has more than 4 million hectares of oil palm plantation and after the fruits are processed for their oil, large quantities of byproducts which include materials that can be used as feed for livestock are produced. These byproducts include palm kernel cake (PKC), decanter cake, palm oil mill effluent (POME), empty fruit bunch (EFB) and palm press fibre (PPF). These byproducts amount to million of tonnes annually, and in the past, they were disposed off. Nowadays, PPF and EPF are shredded and used in the horticultural industry as mulches and potting material. They are also burnt at the mill to provide energy for drying, etc. The POME is obtained after the waste ponds are cleaned up and the solids removed. With the increasing costs of feed, more and more of these byproducts are used as feed ingredients for livestock. PKC is the main coproduct obtained after the extraction of oil from palm kernels. This product is well-used in the ruminant industry as a feed ingredient for beef and dairy cattle. Malaysia exports more than 1.5 million MT of PKC annually to Europe, New Zealand, Japan, Korea and other countries. Decanter cake is also a byproduct of the oil palm milling industry and is also used as animal feed. From the rice industry byproducts such as rice bran, rice polishing and rice hulls are used in animal feed. Rice bran is a coproduct and a valued feed ingredient in ASEAN region. Although rice hulls have very little calorific value, it has been included in cattle diets to form the bulk of the feed. Some studies have been conducted to look at the nutritive value of rice hulls.

PALM KERNEL CAKE (PKC)

Malaysia produces more than 2.5 million MT of PKC annually. PKC also known as palm kernel meal, is obtained after the extraction of palm kernel oil usually through the screw press or expeller method. Quite often PKC is also called palm kernel expeller. The crude protein of PKC ranges from 12 – 18% and the ME for poultry is rather low (circa 8 MJ/kg) while for ruminants the ME ranges from, 10.5 – 11.0 MJ/kg. This is because of the high crude fibre content which comprised of mainly beta-mannans and other non-starch polysaccharides. Subsequently, it is used mainly in ruminant feed. In the last 10 years or so, much effort have been directed towards using PKC as feed for poultry. Its high crude fibre content limits its use in poultry ration to about 15%. Adding cellulase, mannanase and other cocktails of enzymes mixtures have apparently improved the digestibility. Solid state fermentation (SSF) has been carried out using various types of bacteria and fungi, including *Aspergillus niger*, *Aspergillus oryzae*. *Rhizopus* spp. and *Trichoderma harzianum.* The results are variable and no conclusive evidence to support the feasibility of using SSF in treating PKC for poultry. Nevertheless, SSF still remains an option as a method of improving nutritive value of PKC. While its use in poultry ratio is limited, studies have shown that ducks can tolerate higher levels (up to 40%) of PKC. Studies are still on-going on the fermentation of PKC using different microorganisms.

DRIED DISTILLERS GRAIN (DDG) AND DDG WITH SOLUBLES (DDGS)

One of most abundant byproducts of fermentation of grain is the distillers' grains. This coproduct is classified into distillers' dry grains (DDG), the dried residue of distillers' grains, and distillers' dry grain with solubles (DDGS), the DDG with syrup added. DDG accounts for approximately 30% of dry grains for ethanol production, and it contains 25 – 28% protein, 8 – 9% fat, 5% ash and the remainder is nonstarch polysaccharides (NSP). It is estimated that the world production of DDG is about 60 million tonnes each year. The nature of the NSP is composed mainly of cellulose and arabinoxylans. Currently, DDG is used predominantly in cattle feed although in some countries it is also used in swine and poultry rations (PARSONS *et al.*, 2006). One issue that is associated with DDG is that there is great variability in the sulfur content in U.S. DDGS. This results from ethanol plant operators using sulfuric acid to clean their equipment. The sulphur content in the DOGS ranges between 0.4 percent to 1.3 percent; a value higher than 0.4% may have some diet consequences. Another issue is the variable nutrient content and availability. The biggest issue here is available lysine, which can be a limiting factor especially for pigs or poultry. Another issue is the presence of mycotoxins which is more related to the regions where the corn comes from. In regions with high condensation, the chances of fungi growth in corn is high, hence the risks of mycotoxins contaminations.

COPRA MEAL

Copra meal is the cake obtained after coconut oil is extracted using expeller method from the coconut flesh. More than 53 million tonnes of coconut are produced in the world and this yielded about 1.8

million tonnes of copra meal. Countries like Indonesia, Phillipines and Solomon Island produce most of the world copra. In terms of nutrient content, it has about 20% crude protein, but its use in monogastric diets and fish diets (THORNE *et al*., 1990; OLUDE *et al*., 2008), is limited due to a very high level of NSP. The NSP make up 45 to 60% of the dry matter and consist predominantly of mannans (galactomannans and mannans), just over 10% cellulose but low in lignin (TEVES *et al*., 1989). It has been reported that approximately 30% of the copra NSP is soluble in hot water, but their nutritional properties are yet to be defined. The glucomannans are comprised of β (1,4)-linked glucose and mannose units, whilst the galactomannans consist of β (1,4)-mannan backbone substituted with single units of α (1,6)-galactose. In Malaysia, copra meal is no longer produced as there is no processing plant for coconut oil extraction.

OTHER NON CONVENTIONAL FEEDS

Sago waste and sago pith meal

Sago (*Metroxylon sagu*, Rott.) is a type of palm that grows on peat soils and in wetlands. It is one of the few starch bearing palm species found in the tropics. High concentration of starch deposit occurs in the trunk of the palm and this palm has been harvested for the production of starch for human consumption and also for industrial purposes. The use of sago as animal feed has been practiced for many years. Farmers cut the sago trunk to expose the starch and poultry and pigs are allowed to feed on the starch. The pith can also be harvested, dried and milled to produce sago pith meal which is a high energy feed that can be used to replace corn in poultry diets. In the starch extracting the sago pith is ground in the wet form and starch granules decanted and collected. In doing so large quantities of sago waste, which still contain more than 20% starch is produced. This sago waste is commonly used as feed for ruminants but need to be fed in the wet form. Drying the sago wastes can be costly and storage in the wet form is not possible.

Sugar cane

The use of byproducts derived from sugarcane industry, especially molasses, has been practiced for many years, although mainly for ruminant feeding (SANCHEZ and PRESTON, 1980). Molasses is a good source of energy and is used in compounded feed formulations as a binder for pelleting and also to avoid dustiness. Much work have been done on the feeding of cane molasses together with cane biomass (sugar cane tops) for beef cattle. There has also been work done on the feeding of molasses and cane juice to pigs (PRESTON *et al.*, 1968). Use of the cane juice as a substitute for grain in poultry diets has not been successful due mainly to the physical difficulties experienced by chickens in consuming a low-density liquid diet.

Noncereal feed resources

Reject cassava roots, sweet potato tubers, banana and plantain fruits, have long been fed to poultry in villages and in small holder farms. There appears to be no reported research on the use of these feed resources in intensive on-farm feeding systems. This is because waste or reject cassava or bananas are not available in large quantities and their availability tend to be sporadic and not consistent. Large scale production of cassava chips has been practiced in ASEAN countries, mainly Thailand, and is exported to Europe.

Restaurant wastes

The feeding of food waste or garbage to pigs and other livestock is common practice throughout the world. Kitchen waste or waste from restaurants may be fed to poultry but most commonly to swine. The high disposal costs encourage the use of these waste in animal feed. Restaurant waste in general tends to contain more than 20% crude protein and hence a good source of protein for animals. The fat content is also high, about 20 – 25%, which is obvious as we use a lot of oil in preparing our food. Crude fiber levels are low and most minerals are generally low to adequate, for pigs and poultry (KWAK and KANG, 2006; WESTENDOF and MYER, 2008). However, the low DM (average 27%) and the high variability of nutrients are major limitations. Food waste to be fed to animals must be heat treated to reduce the risk of foreign animal diseases and to eliminate other harmful pathogens.

Animal waste

Animal waste, which include rumen gut content and poultry litter can also be sources of energy and protein. There are as yet no data on the total amounts of animal waste included in animal feeds, although it is known that some farmers practice adding some dried poultry litter in beef cattle rations. Recycling animal waste into animal feed has been practiced for many years to reduce feed costs. In the U.S., Food and Drug Administration (FDA) does not officially endorse the use of animal waste in feed and is very concerned about the presence of pathogens and drug residues in animal waste, particularly poultry litter. Guidelines have been drawn on the safe use of processed animal waste in that it should not contain pathogenic microorganisms, pesticide residues, or drug residues that could harm animals or human.

Problems associated with non-conventional feeds (NCF)

The term non-conventional feeds implicate that these feedstuffs or feed ingredients are not usually used in standard or generally commercial compounded feeds. They are used under the following circumstances, such as when conventional are expensive and non conventional feed are relatively cheaper, when conventional feeds are in short, supply, or when there is oversupply of non-conventional feeds. In practice, NCF are not available on national or world wide basis but tend to be more localized. Much of these feeds tend be less researched and are little characterized and analyzed in detail for their nutritive value. These include processed feed ingredients that are byproducts from other industries such as DDGS, high protein distillers dried grains, corn gluten meal, corn germ, wheat middlings, soybean hulls, alfalfa meal, de-hulled sunflower meal, cotton seed meal, glycerol, and bakery waste. Quite anti nutritional compounds are present in these ingredients such as gossypol in cottonseed, glycosinolates in canola products, tannins in peas and legumes, alkaloids in lupins, phytates and mycotoxins in cereal grains and byproducts of grains. However, these anti-nutritional compounds can usually be managed (Table 3). In many cases, they do not represent major limitations to the use of alternative feed ingredients. Many alternative feed ingredients, especially byproducts of agro-industries, for example palm kernel cake, sago waste, rice bran, rice husks, soyabean hulls, and DOGS contain relatively high concentrations of crude fiber, which can limit the inclusion rate of these ingredients in diets fed to poultry or swine. Other problems associated with conventional feed include presence of toxins and contaminants, poor digestibility and ease of handling.

Processing of NCF

NCF are not normally used directly. They need to be processed before they can be included in compounded feeds. The reasons for processing of NCF are to reduce moisture, reduce bulkiness, i.e. increase density, ease of transportation and delivery, to destroy toxins and pathogenic bacteria. Studies on processing of cereal straws have extensively been reviewed by several workers (SUNDSTOL and OWEN, 1984). In the tropics, studies by Jayasuria have discussed the limitations of using NCF.

Costs of producing NCF

One of the many constraints of using NCF and agricultural byproducts is the costs of processing and transportation. Rice straw, for example, has very little monetry value but may be costly due to the costs of transportation. It is advisable that the use of straw *in situ* will reduce costs of transportation, hence, lower the overhead costs. Similarly, the use of pineapple skins, corn stovers, and sago wastes.

Table 3. Examples of some of the anti-nutritive factors in NCF

Raw materials	Problems	Remediation
Leucaena seeds	Anti-trypsin factor	Heat processing, cooking
Cocoa pod	Theobromine	Sundrying, heat processing
Rice bran	Phytate, phytic acid	Add enzyme phytase
Soya hulls	Phytate	Add enzyme phytase
Peanut meal	Anti-trypsin factor, mycotoxins	Heating, add zeolite
Poultry byproducts	Poor amino acid balance, bacterial contamination	Supplementation with lysine, methionine, heat treatment
Jatropha seeds	Toxins, phorbols, anti-trypsin	Alkali treatment and autoclaving, methanol reatment
Pineapple skins	Bulky, very high moisture	Press and oven-dry or sun-dry
Cassava	Hydrogen cyanide	Heat treatment, sun –drying, cooking
Restaurant wastes	Pathogenic bacteria, disease, contaminants, high oil, high moisture	Heat treatment, cooking
Animal wastes, poultry litter	Pathogenic bacteria, disease, pesticide residues	Heat treatment, cooking, autoclaving

Storage and preservation

Not much work has been done to establish storage procedures. For example: decanter cake (from oil palm kernel crushers) is a palatable feed but its moisture content is around 40% and needs to be used immediately. Its oil content ranges from 5 – 10% and can easily be spoilt (rancid) with in a few days of storage. Decanter cake would be a good source of energy for ruminants provided that it can be stored for longer period. Similarly, sweet corn stovers are good fibre source for ruminants but tend to lose it nutritive value if not dried immediately upon harvesting. Suitable processing and storage conditions need to establish suitable and optimum processing procedures.

Future work with NCF

Before we can use NCF, a thorough examination on the nutritive value in terms of their metabolisable energy, nutrient content and palatability needs to be examined. Variability in nutrient content needs to be established such that if we know a certain feed comes from a certain area then we can expect the nutritive value to be as such. The amino acid content is also important if the NCF is meant for monogastrics, nevertheless for ruminant, the rumen degradable and undegradable protein content need to be established. Fatty acids composition can also be useful in that the NCF may be useful in producing niche products with different fatty acids. Nutrient digestibility and availability need to be defined before proper ration formulations can be conducted.

Other low cost treatments to increase digestibility need to be established so that farmers can apply. For example treating straw and other fibrous byproducts using sodium hydroxides and acids may not be feasible now as in recent years the costs of these chemicals are prohibitive for small scale treatment at smallholder farm basis. The use of urea treatment may still be feasible although in some countries the price has also rocketed. Another problem that may contribute to the poor utilization of agriculture and small home food industries are logistics. Because these products are available in small quantities, there need to be a concerted effort in terms of collection, storage and distribution of these byproducts so that they can reach the farmers on time and in the required quantities.

CONCLUSION

With the fluctuating prices of feed ingredients, alternative feed ingredients are of increasing interest as substitutes for more traditional ingredients used in animal diets. Many of these alternative feeds have differing nutrient content compared to the traditional ingredients. Popular alternative ingredients include corn coproducts (e.g., distillers dried grains, distillers dried grains with solubles, corn gluten feed, corn gluten meal, rice bran, palm kernel cake, legumes (e.g., peas, soybean hulls), wheat milling byproducts, sunflower meal, and even grains other than corn (e.g., barley, oats, rice, sorghum, wheat) and coproducts from the restaurant industry and bakery industry. To utilize these feeds efficiently, we must know their nutritive value and chemical composition so that they can be used in existing ration formulations. The measurement of all categories of carbohydrates and their characterization will ensure that their use can be effective to meet the necessary nutritional and physiological requirements of animals. Starch, hydrolyzable carbohydrates, rapidly and slowly fermentable carbohydrates, non-starch polysaccharides, total dietary fiber, and detergent fibers are carbohydrate fractions that can affect certain aspects of animal metabolism such as nutrient intake and digestion, glycaemic response, immune response, and rumen ecology. Similarly, the amino acid content, fatty acids contents are also important so that some of these alternative feeds may be of certain functions and can create new niches in the animal products preferred by certain consumers.

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