

## Non-Conventional Concentrates in Temperate Asian-Australasian Countries\* - Review -

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**ABSTRACT :** The huge amount of demand for feedgrains from this region could not possibly be met by producing countries from the other regions. In order to fulfill this increasing demand for conventional raw materials, an alternative for the conventional raw materials produced in the Asia and Pacific region is becoming increasingly more important. A potential alternative is concentrates or non-conventional concentrates produced locally in relative abundance in this region. These feedstuffs include feed grains, by-products from the milling, sugar industries, brewing and distilling industries. Vegetable, citrus, and animal by-products from abattoir, feather meal and blood meal are also possibilities. In addition to more widespread use of unconventional feed sources, the following approach is recommended to improve utilization and performance. These include establishing the nutritive value of non-conventional feeds, quality control to minimize variability, proper storage and processing to assure the nutritive value and prevent mycotoxin contamination, properly balance amino acids with protein sources, supplementation with synthetic amino acids and the use of enzymes to increase digestibility. Currently, practical applications for these resources in feed formulation are negligible despite the potential. The socio-economic aspects will dominate the use of these non-conventional concentrates. In the future, the feed industry will resolve the problems in using locally available raw feed materials. (*Asian-Aus. J. Anim. Sci.* 1999. Vol. 12, No. 3 : 460-466)

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### INTRODUCTION

The populations of the Asia Pacific region (3.39 billion) represent 59% of the total world population of 5.72 billion and will remain at this level in the future. This means that the Asia Pacific region will comprise 4.17 billion people in 2010 while the world population will reach 7.03 billion (Bourne, 1997). Due to the rapid growth in the world's economies, demand for animal products will increase. For instance, India predicts to increase egg consumption by 50% and poultry meat consumption by 100% over the period 1993 to 2000 (Tandon, 1995). Increasing population and per capital consumption in this region increases the demand for animal products. Hence a tremendous amount of demand for raw materials. Presently, demand for corn and soybeans for livestock production in some countries, i.e., Japan, Korea, India and Taiwan are beyond their own production capacity which requires dependence upon imports from other regions of the world. China, for example, was the world's second largest exporter of grain in 1992 but will become the world's fourth largest importer by 2004. China changed from a net grain exporter of 8 million tons in 1993/94 to a projected net grain importer of 14 to 15 million tons in 1995/96 according to recent estimates (Brown, 1995). This net shift of 23 million tons almost equals the annual amount of Canadian grain exports. Other countries in Asia

which will also expect to become grain importers by 2004 are Indonesia, Thailand and Vietnam (Bourne, 1997). The huge amount of demand for feedgrains from this region could not possibly be met by producing countries from the other regions. In order to fulfill this increasing demand for conventional raw materials, an alternative for the conventional raw materials produced in the Asia and Pacific region is becoming increasingly more important. A potential alternative is concentrates or non-conventional concentrates produced locally in relative abundance in this region. These feedstuffs include feed grains, by-products from the milling, sugar industries, brewing and distilling industries. Vegetable, citrus, and animal by-products from abattoir, feather meal and blood meal are also possibilities.

### FEED GRAINS

#### Rice

It is the principle food crop in this region which produces 91% of the world's rice production (483 million tons) according to FAO (1988). Rough rice or paddy rice grain with hull, relatively low in protein and requires grinding before use for swine and poultry due to its' very hard and abrasive grain. Cost and trypsin-inhibitors in the outer seed coat usually dictate the upper limits for use. Up to 30% of rough rice can be used in both poultry and swine diets without negative effects on growth and feed efficiency. However, with inclusion of more than 30% rice in the diet, the performance of the animal displays negative growth and development.

#### Barley

It is produced in Korea, China, India, Iran and Japan, but only important as a feed grain in Japan and Korea. Barley content has a similar level of protein and

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a better profile of amino acids than corn (Maner, 1985). The problems with  $\beta$ -Glucans and the low energy content of the grain limits its use in high-energy broiler diets. Growing and finishing swine perform satisfactorily with barley as the major grain, but the feeding value is inferior to corn based diets. Proper processing through grinding, pelleting, flaking, or the inclusion of enzymes improve its feeding value (Yu et al., 1998).

### Sorghum

Is a popular crop in the drier areas of this region and is the third most widely grown cereal in Asia after rice and corn. The energy value is equal to or slightly lower than corn and is almost compatible to corn in feeding value. It may completely replace corn in both poultry and swine diets. Normal sorghum has an extremely hard peripheral endosperm which is resistant to water penetration and digestion. It requires more intense processing to achieve optimal digestibility. Tannin above a certain level can inhibit ration utilization particular in energy utilization. In general, the tannin level ranges from 0.18% in commercial sorghum to 1.47% in bird-resistant varieties. The low tannin variety can replace corn in both poultry and swine diets, while high tannin grains can substitute for only 50% of the corn diet unless properly processed to eliminate tannin content.

### Millets

Asia accounts for 45% of the world millet production. China is one of the major producing countries. It contains more protein than corn, especially pearl millet. The feeding value of pearl millet is similar or superior to that of sorghum, wheat and barley, but inferior to corn (Mohamedain et al., 1986; Shrivastav et al., 1990). It contains greater fat than oats which is rich in polyunsaturated fatty acids. It contains energy equal to corn and can replace corn in up to 40% of the diet (Ayyaluswami and Jaganathan, 1967), but it may produce an oily body carcass.

## FOOD INDUSTRIES BY-PRODUCTS

### Rice milling by-products

Milling of rough rice produces 50-60% polished rice, 1-17% broken rice, 2-3% polishing, 6-8% bran, and 20% hull. Broken rice has a nutritive value compatible to corn and can substitute for corn in poultry and swine diets (Sinha et al., 1980; Maner et al., 1971). Rice bran is the major rice milling by-product and has several notable features. It contains high oil (13%) with an energy value similar to the grain itself. However, it also contains rancidity factors that favor auto-oxidation in warm, humid climates. These include lipoxidases that promote the oxidation of unsaturated fatty acids when the bran is separated from the rice. Autoclavings can inactivate the lipase, improve performance and overcome the rancidity problem (Kratzer et al., 1974; Chiou and Hsu, 1982). Rice bran also has several heat labile

anti-nutritional substances, trypsin inhibitor and an anti thiamin factor that can be destroyed by moist heat (Deolankar and Singh, 1979). Swine may develop zinc deficiency signs when fed a diet containing rice bran. This may be attributed to the high phytate in the rice bran that interferes with the bioavailability of divalent cations such as Ca, Mg, Zn and Fe (Reddy et al., 1982).

## ROOTS AND TUBERS

### Cassava root meal

Cassava is the highest energy yield crop per acreage of land under tropical conditions (Coursey and Haynes, 1970). Although it is produced under tropical conditions, China is also one of the major producers. Cassava root meal is low in fiber and protein, but high in starch, with a 95 to 106% ME value relative to that of corn. It contains cyanogenic glucosides that liberate hydrocyanic acid. Removing the peel is the simplest way to eliminate the hydrocyanic acid, since the cyanide concentration is ten times higher in the peel than in the flesh of the root (Ravindran et al., 1983). Cassava root meal, properly processed and supplemented, can totally replace corn in the animal diet. It therefore is the greatest potential non-conventional raw material that can replace corn. The optimum inclusion levels for cassava meal in poultry are as follows: for mash diets, broiler starter/chick starter 20%, broiler finisher/ chick grower 30%, layer 40%. In pelleted diets: Broiler starter/ chick starter 50%, Broiler finisher/grower/layer 60%.

### Sweet potato tuber meal

Asia produces 90% of the world production of sweet potato tuber. China, Japan and Korea are among the leading producers. Sweet potato tuber meal contains low protein but high energy value. Sweet potato chips have about 79% of the ME content of corn for swine (Wu, 1980) and can replace corn in swine finisher diets (Tor-Agbidye et al., 1990). The feeding value of fresh sweet potato is only 25 to 33% in a swine diet due to the high moisture content, while dry sweet potato has 87 to 100% the feeding value of corn. Sweet potato, although it contains a trypsin inhibitor in raw, fresh tubers, it is devoid of trypsin inhibitor in the dehydrated meal (Lin and Chen, 1980). It can replace up to 50% of the corn when properly pelleted and protein supplemented. The tubers can also be ensilaged and replace 30% of corn in diets for growing swine.

### Oil seed meal

Oilseed meals are by-products of vegetable oil production. Oil seed crops are grown primarily for their oil, but the protein rich by-product meals left after oil extraction are also valuable protein sources for animal feeds. The oil extraction is carried out either by mechanical processing or solvent extraction. The solvent method is more efficient in removing the oil with less than 2% left in the residual meal. The mechanical

pressing is more common in Asia. It contains more residual oil (5 to 10%) in the meal, inferior quality protein and less digestible amino acids. This may be attributed to heat damage during processing. Major oil seeds that are produced in temperate Asia are soybean, cottonseed, peanut, rapeseed, sunflower seed, sesame and linseed. The locally produced soybean meal available for animal feed in Asia is low (APO, 1990) due to human consumption, low yielding cultivars and sub-standard agronomic practices. Cattle and pig production in Asia has traditionally used a variety of locally available oil seed meals, but in poultry production such feed diversity is less accepted.

#### **Cottonseed meal**

Cottonseed meal ranks third among world oilseed production. China is one of the major cottonseed producing countries. In the commercial extraction of cottonseed oil, cottonseed is processed so as to leave the gossypol in the cottonseed meal. The cottonseed is subjected to heat treatment before extraction. In the presence of heat, gossypol reacts with protein to produce "bound gossypol." This reaction, resulting in a lowered lysine availability, occurs primarily with the amino acid lysine. The toxicity of cottonseed meal is associated with non bound or "free gossypol." For ruminants, the level of free gossypol in the diet should not exceed 0.01%, or approximately 9% of dietary cottonseed meal. Cottonseed meal has a lower protein content and a higher fiber content with a lower ME value than soybean meal. Many essential amino acids, particularly lysine, are lower than soybean meal. Their availability to poultry is also lower (Nwokolo et al., 1976). For the above mentioned reasons, together with the presence of the gossypol, limits the use of cottonseed meal in poultry and swine diets. The toxic effects of gossypol can be reduced by the addition of iron salts to the diet. Free gossypol reacts with iron and thus becomes "bound" or physiologically inactive. When diets are formulated to compensate for the limitations of cottonseed, low gossypol meals can be fed to growing poultry with good results. When used in combination with lysine-rich supplements, they may replace up to 40% of the protein from soybean meal in broiler diets and cause no adverse effects. Cottonseed meal can be used only to a limited extent in layer diets due to egg yolk discoloration and mottling. Traditionally cottonseed meal is limited to 2% in poultry feed, 6% in swine feed and should be avoided in duck formulations if aflatoxin is a concern.

#### **Peanut meal**

China is one of the major producing country. Peanut production in India and China account for over 60% of the world production (FAO, 1988). It is also called groundnut in some countries. Peanut meal contains 45 to 50% crude protein and is quite deficient in lysine. Tannin is present in peanut skin. The protein digestibility tends to be low and the amino acid

availability may also be low. The feeding value of peanut meal is markedly inferior to soybean meal as a protein source for swine, even with lysine supplementation (Orok et al., 1975). Replacing more than 50% of the protein from soybean with peanut meal decreases performance in broilers and layers. A combination of peanut meal with protein sources rich in lysine and methionine improves its nutritional value (Singh et al., 1981; Singh and Prasad, 1979). Peanut meals are frequently contaminated with aflatoxins, hence it is not recommended for young poultry diets. Another problem with peanut meal is that it produces soft pork. To avoid this condition, swine should not be fed full-fat peanuts for several weeks before slaughter (West and Myer, 1987). Generally, high quality peanut meal can be used for chickens; up to 6% in broilers and 9% in layers. As a safety precaution, an upper limit of 4% is recommended for poultry.

#### **Rapeseed meal / canola seed meal**

World rapeseed production of 23 million tons is currently the third most important oil seed (FAO, 1988). China is one of the major producers. It is produced from the two different oilseed varieties, *B. napus* and *B. campestris*. They exhibit differences in nutritional characteristics (Ward et al., 1985). The latter variety was evolved in Asia.

Rapeseed contains glucosinolates, a toxic compound that inhibits the metabolism of the thyroid gland and may induce goiter. This undesirable toxic compound also reduces palatability, therefore it should be limited in poultry and swine diets. Canadian plant breeders have been very successful in modifying rapeseed to give it desirable agronomic and nutritional properties keeping it low in erucic acid and glucosinolates. These "double zero" varieties have been renamed and called canola to distinguish them from toxic rapeseed. Unfortunately, in Asian countries, which produce more than half of the world's rapeseed crop, there has been less progress in the development of low-glucosinolate varieties that are adapted to local conditions. Thus varieties high in glucosinolate (up to 5.0%) continue to dominate in this region. Rapeseed meal contains 36-38% protein with balanced essential amino acid profiles. The sulfur-containing amino acid is higher and lysine content is lower while the amino acid availabilities are lower than soybean meal (Nwokolo et al., 1976). Canola meal should not be fed to layers of the Rhode Island Red breed to avoid producing fishy odor eggs. This breed of layer lacks the enzyme to convert the sinapine metabolites, trimethylamine, into oxides. Canola can be included in up to 20 to 30% in poultry diets without adverse effects (Leeson et al., 1987). The raw canola seed can be fed to swine, up to 15%, with no ill-effects (Shaw et al., 1990). The Canola Council of Canada recommends the maximum inclusion rate as follows: poultry starter/grower 20%, layer/breeder 10%. Swine starter 8%, grower/breeder 12% and finisher 18%.

### Sunflower meal

Sunflowers are grown mainly in northerly climates. China is also one of the major producers. Sunflower meal contains high fiber (11 to 13% crude fiber) and very low lysine content, limits its use for poultry and swine. The combination of high protein (40 to 45%) and high fiber makes it quite suitable for ruminants, particularly for dairy cattle and goats, which require a high protein diet. Sunflower meal contains phenolic compounds, chlorogenic acid, which have adverse effects on palatability and may reduce protein digestibility. Decorticated sunflower meal is hull removed meal and contains higher protein (45 to 47%) and lower fiber (10 to 12%) than regular sunflower meal. With lysine supplementation, the decorticated sunflower meal can replace up to 50% of the soybean meal in broiler and layer diets (Singh et al., 1981). Sunflower meal is not recommended for use in swine creep/starter diets. Up to 2/3 of soybean meal may be substituted with good quality sunflower meal with supplemented lysine in grower and finisher feed. However, feed efficiency will be reduced significantly by using partially dehulled sunflower meals due to the high fiber and lower energy content.

### Sesame meal

Sesame has been cultivated in Asia for thousands years. The nutrient value of sesame depends upon the method of processing. It contains high protein (40%) high ash and the nutritional value is compatible to soybean meal. It is an excellent source of methionine, cystine and tryptophan, but is deficient in lysine. Good quality meal can be included in up to 15% of a poultry diet. For maximum growth and efficiency, it should be supplemented with lysine or blended with high lysine ingredients such as soybean meal or fish meal (Daghir et al., 1967). With proper supplementation, it can replace 100% of the soybean meal in cereal-based diets.

### Linseed meal / flaxseed meal:

Since it contains low protein (35%), and is severely deficient in lysine, it is more suitable for ruminant and horses than for swine and poultry. Linseed meal contains two types of toxic factors. One is a depeptide called linatine, composed of glutamic acid and 1-D-amino-proline. The latter amino acid is an antagonist of pyridoxine. Thus it may induce pyridoxine deficiency in swine and poultry. The performance of swine and poultry fed a linseed meal diet can be improved with supplementary pyridoxine (Bishara and Walker, 1977). The other type of toxin that occurs in linseed meal is cyanogenic glycosides that are similar to those found in cassava. The cyanogenic glycosides in linseed meal have protective effects against selenium toxicity (Jensen and Change, 1976). It also contains a mucilage coating that is unique to linseed meal and limits its nutritive value. The mucilage contains a water-dispersible carbohydrate that is almost completely indigestible. This makes the meal a laxative and causes problems with beak necrosis

in poultry.

## SUGAR INDUSTRY BY-PRODUCT

### Cane molasses

It is a major by-product of the sugar cane industry and is a valuable cereal replacer. It is high in carbohydrates and contains 70% of the ME in corn. High levels of final molasses inclusion in the diet causes a wet excreta and watery feces problem due to its' high potassium and ash content. Inclusion of high-test molasses can be used up to 30% or more without adverse effects (Lopez et al., 1976). Molasses is generally used to improve energy content and to increase the voluntary intake of the diet because of its high palatability. The optimum level of inclusion in the wet feeding system is often dependent upon the stickiness of the material. Inclusion of up to 15% molasses in the diet can be accepted in pelleted feed (Blackburn, 1984). Energy in molasses is most efficiently utilized by cattle when it comprises 20% of the total dietary energy (Baker and Lonsdale, 1980).

### Brewing and distilling by-products

Brewers' grains are the by-products from brewer industry. It is an extracted residue of barley malt, alone or in mixture with other cereal grains or grain products resulting from production of wort or beer. These products are rich in crude protein, crude fiber, ether extract, vitamins and minerals. The nutrient contents of these products except for starch are proportionally richer than most of the barley. It contains high protein and crude fiber. Therefore, it is mostly used as a protein supplement for cattle. Relatively high quantities (35 to 40 kg per day) can be given to lactating cows without adverse effects on health and milking performance, provided the cattle are introduced to the feed gradually and the grains are free of mold. Because the grains are heated during malting and mashing, it provides an undegradable protein source to the ruminant (Chen et al., 1998a; Chiou et al., 1995). The equivalent by-product to brewers' grains is from corn, sorghum or rice distilleries. It has a similar feed value to brewers' grains, but often the spent liquor from the distillation process is mixed with the draff and dried to produce sorghum or rice distiller dark grains. Both the liquids and solids are useful sources of protein and energy for ruminants (Chiou et al., 1998a). Inclusion of dried rice distillers' grain up to 10% (dry basis), wet sorghum distillers grains up to 30% did not affected milk yield of the lactating cows (Huang et al., 1998; Chiou et al., 1998b). The liquids may be condensed into syrups to avoid the high cost of complete drying. It can also be ensiled for grass silage with good results (Chen et al., 1998b).

## STRATEGIES TO IMPROVE UTILIZATION OF FEED RESOURCES

In addition to more widespread use of unconventional

feed sources, the following approach is recommended to improve utilization and performance. These include establishing the nutritive value of non-conventional feeds, quality control to minimize variability, proper storage and processing to assure the nutritive value and prevent mycotoxin contamination, properly balance amino acids with protein sources, supplementation with synthetic amino acids and the use of enzymes to increase digestibility.

#### **Establish nutritive value**

Research and development efforts are required to establish a feed library for nutritive values in addition to the proximate analysis of the non-conventional feedstuffs. These compilations provide only approximate nutritional value information. The feed nutritionist should recognize the existing wide variability in the composition of the same feedstuff available in different countries and even in different locations within a country because of the differences in soil, climatic, agronomic and processing conditions. Nutritionists have to consider this variation in specific recommendations. The amino acid profiles that are determined from chemical analysis do not fully reflect the protein quality and adequacy for production purposes, since digestibility and availability of the different amino acids in a protein are different. The digestibility of amino acids in non-conventional feedstuffs is in general lower than conventional feed due to inferior processing, storage and quality control. This shows that feed formulates based on the digestible rather than total amino acid concentrations in feedstuffs obtain better performance in animals (Johnson, 1992). Data on the digestibility and availability of amino acids are the best measure for the feedstuffs of a temperate region in Western countries. In the application of this data to the Asia and Pacific region especially in tropical situations, one must take precautions to make the proper adjustments, giving necessary consideration to the differences in the origin and processing conditions of the ingredients.

#### **Quality control to minimal variability**

It is no longer sufficient to value the raw material with just a wet chemical assay. Physical or microscopic measurements such as texture and screen analysis, bulk density, odor and color are also important to prevent adulteration. The uniformity and particle size of the various ingredients are important for proper mixability. Bulk density is most the inexpensive procedure to examine the adulteration of sand or filler such as in feather meal, soyhull, pollard etc. The color and uniformity of particles indicate the freshness of the raw materials, degree of processing or potential blending of over-heated and under-heated meals together. Meals should not have a burned, musty or ammonia smell that would indicate overcooking, spoilage or possible adulteration. Urease test and chick assay for biogenic amines in fish meal and meat meals for overheating or spoilage of the material. Protein solubility in 0.2% KOH

is useful to determine the degree of overheating in soybean and sunflower meals (Zhang and Parsons, 1994) and in 0.5% for canola and rapeseed meal (Anderson-Hafermann et al., 1993).

#### **Proper storage and processing**

Seasonable and unreliable supply in local produced non-conventional feedstuffs require proper storage to meet the constant demand of the raw materials. In general, more than a 20% loss of feedgrains in storage is not uncommon in this region. Losses are caused by insects, mites, storage fungi and rodents. Fungus is responsible for causing mycotoxins that can be lethal or seriously reduce animal performance and may result in unacceptable residues in the animal products (Mortensen et al., 1983). The simplest way to store grain is in the dried form (approximately 5 to 15% moisture) in containers that provide protection from moisture, insects and mites.

Feedgrains are processed to aid digestion, to destroy weed seeds, to detoxify the anti-nutritional factors and to facilitate the mixing of ingredients in the manufacture of compound feeds. Pelleting reduces the bulkiness and dustiness and the separation of components. Protein concentrates are produced both as by-products and as primary products. Ideally, the processes involved in the preparation of a protein concentrate should create or maintain a satisfactory palatability and texture, maximize availability of amino acids, inactivate pathogens and anti-nutritional factors and produce a product that will not degrade during storage.

#### **Balancing amino acids**

Most cereals and cereal replacers are deficient in lysine, tryptophan and sulfur amino acids, while most of the non-conventional protein supplements are deficient in one or another amino acid. Proper supplementation of the deficient amino acid by blending the deficient with the abundant protein in the diet or incorporating synthetic amino acids will also benefit the animals performance. The concept of ideal protein in both swine and poultry diets should be applied in practical feed formulation.

#### **Use of enzymes to increase digestibility**

Most of the non-conventional raw materials and by-products are inferior in quality to conventional feed material and hence are used less efficiently by the animals. Hence there is vast potential in the Asia Pacific region for incorporating enzymes in non-conventional raw materials and by-products to increase the nutritive value. For example, enzyme inclusion may reduce the adverse effects of soluble non-starch polysaccharides (NSP) on nutrient digestibility in poultry and swine. Supplements of exogenous lipase to diets containing 20 or 40% Australian full fat rice bran improves growth rate and feed conversion in chicks. The increased bioavailability of energy in rice bran by the use of an exogenous lipase has been demonstrated (Pluske et al.,

1997). The inclusion of 30% cassava root meal in the diet depressed growth and feed conversion, while adding amylase markedly increased the live-weight and voluntary intake in broilers (Samarasinghe and Wenk, 1993). Supplementation of  $\beta$ -glucanase improved the performance of animals fed on a barley diet (Yu et al., 1998). Phytase supplementations in the diet also improved weight gain and feed conversion due to the elimination of the interference of nutrient absorption caused by phytates (Reddy et al., 1982). In general, non-conventional raw materials are often less uniform in nutritive value and should be tested prior to inclusion in diets to ascertain the precise enzyme required to target the substrate. Therefore, it is necessary to better understand the variability associated with these materials so that enzyme application can be targeted efficiently for maximum benefit.

It is likely that greater emphasis will be placed on overall economic efficiency than on maximum utilization of feed resources. Currently, practical applications for these resources in feed formulation are negligible despite the potential. The socio-economic aspects will dominate the use of these non-conventional concentrates. In the future, the feed industry will resolve the problems in using locally available raw feed materials.

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