We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

15

The Alternatives to Soybeans for Animal Feed in the Tropics

Archimède H[1], Régnier C[1], Marie-Magdeleine Chevry C[1],
Gourdine JL[1], Rodriguez L[2] and Gonzalez E[3]
[1]INRA-UE143, Prise d'Eau, 97170 Petit-Bourg,
[2]Finca Ecológica TOSOLY, AA#48 Socorro, Santander Sur,
[3]UMR-INRA CIRAD SELMET, 2 place Viala, 34060 Montpellier cedex 1,
[1]Guadeloupe French West Indies
[2]Colombia
[3]France

1. Introduction

There are many alternatives to soya for animal feed in the tropics (e.g. meals coming from local protein-rich resources such as beans, peas, aquatic plants or leguminous foliage). The study and evaluation of such alternatives must be based on their amino acid availability and profile, using the approach of investigating non-ruminant species. For this criterion, there is often a gap between the amino acid profiles of plant resources and the profile of amino acids truly available for the animal. In the short and medium term, new studies have to be performed to take into account the large diversity of rich protein resources in the tropics. Overall, the alternatives are broader for herbivores than for other animal species, since the concentration of fibre and secondary compounds is a limiting factor that will discriminate their proposal of use among domestic animal species. Such evaluations must also take into account the farming system functions and productive purposes. The paradigm is changing and, compared to years ago, maximising animal performance is not the priority goal of the systemic approach. Currently, multiple animal responses to alternative diets should be taken into account for their optimisation. A criterion such as environmental impact is often decisive in the combination of global and local approaches.

2. The alternatives to soybeans for animal feeding and farming systems development in the tropics

Traditionally, the two main protein sources for livestock feed are protein crops (e.g. legumes) and animal by-products. Large amounts of animal by-products come from industry (mainly meat and fish meal). The technologies for manufacturing these products are strict in order to avoid health crises (e.g. BSE). Even if their use is limited to certain animal species, in some regions (like the European Union) their use is currently legally forbidden. The safety assessment of animal protein for animal feed can also be performed directly at the farm level. As in some Asian experiences (e.g. integrated farming systems in

Vietnam), some fish species are included into the cycle with a multi-species breeding approach. Other experiences include, for example, small-scale worm production for poultry nutrition. Until now, this kind of technology has mainly been associated with small farms.

Some foliage, seeds and fruits from protein-rich plants are excellent sources of protein. The high efficiency of photosynthesis in the tropics is an asset. In addition, there is a great diversity of such plants rich in proteins which are potentially utilisable by animals. This biodiversity is in contradiction with the low number of resources actually used.

There is also a great potential to produce high yields of protein on farms with the inclusion of tropical species of forage trees and shrubs and aquatic plants in farming scenarios. The protein yields of such crops are sometimes higher than that of soya, as illustrated by Figure 1. However when one takes into account the digestibility of the biomass produced, soybeans retains high productivity.

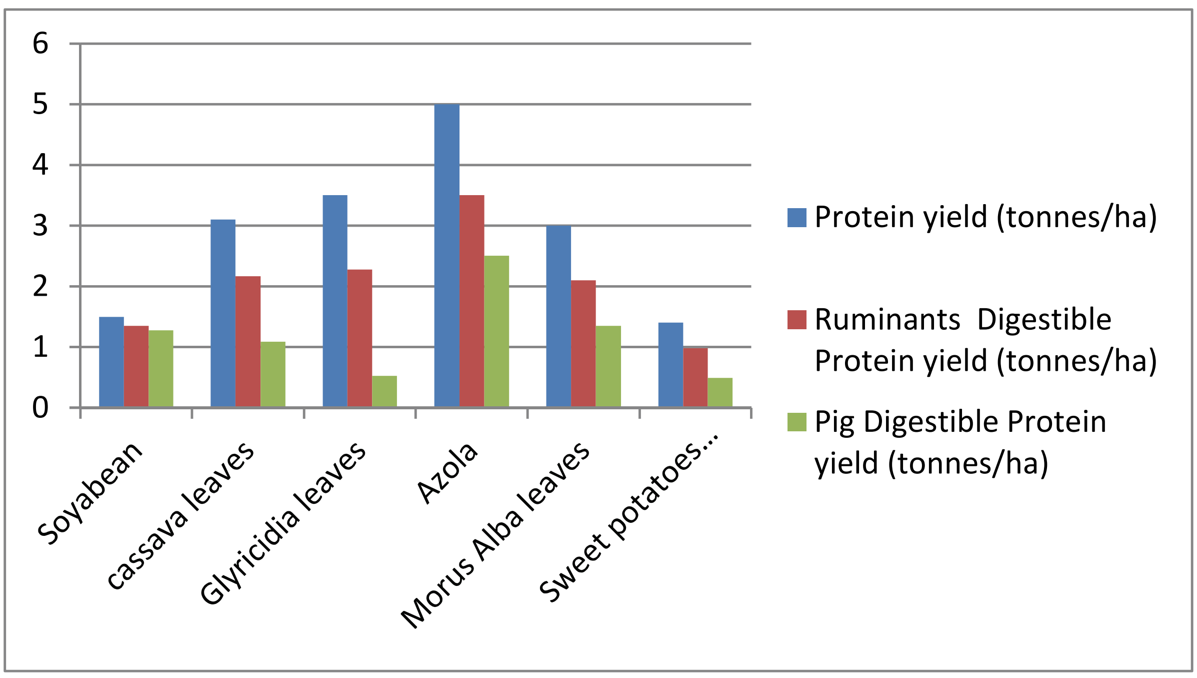


Fig. 1. Comparative protein yields in some typical crops from grown tropical latitudes.

The interest of plants as soybean alternative resources are very variable in the function of the target animal species considered because of the features of their digestive physiologies. The ability of certain animal species (i.e. ruminants) to digest fibre and synthesise some essential amino acids because of the presence of a large microbial population in the digestive tract gives them a clear advantage. Consequently, differences have to be made between herbivores (ruminants, horses, rabbits) and other animal species (i.e. non-ruminants or monogastrics like pigs or poultry). Globally, herbivores are able to valorise all plant fractions (foliage, seeds and fruits). Non-herbivores will be able to valorise mainly seeds, fruits and low fibre content foliage. Moreover, with the non-herbivores, the valorisation of foliage is better with low total fibre diets like molasses, sugar cane juice…

Soybean is widely used in conventional intensive animal feeding systems because of its known high protein content (38-42%) and good amino acid balance and digestibility (Baker, and Stein, 2009; Cervantes-Pahm *et al*., 2008; Hartwig, *et al*., 1997; Johnson, 2008; Opapeju *et al*., 2006). Actually, there is a consensus on the criterion that the amino acid content, balance and ileal digestibility of the abovementioned plant resources are the major criteria at the time of selecting the best alternatives. Unfortunately, these indications remain scarce for many alternatives to soya. Conventional concentrates based on cereals and soybean meals are generally imbalanced, in particular with regard to methionine, cysteine and threonine (Ogle, 2006). Most green forages are reasonably high in protein and contain concentrations of the essential amino acids that are close to matching the pig's requirements (Ogle, 2006). This means that if they are combined with an energy source that is extremely low in protein and fibre, such as sugarcane juice, molasses, sugar palm juice or cassava root meal, then the essential amino acid content of the overall diet will still be balanced and the protein content can be reduced by up to 30-35 % (Ogle, 2006).

Anti-nutritional factors could penalise choosing some foliage species. Many of the green forages in the tropics that are potentially valuable sources of protein contain anti-nutritional factors that can depress animal performance, such as cyanogenic glycosides, trypsin inhibitors, mimosine, goitrogens, oxalic acid, tannins and saponins. However, many of these can be inactivated to a greater or lesser extent by various processing methods, such as heat treatment, sun-drying or ensiling (Ogle, 2006).

3. Industrial oil seed by-product resources

Feed cakes, as by-products of the oil industry, comes from various seeds rich in oil and are widely used as animal feed (Table 1). Feed cakes are thus mainly used as a source of protein. The protein content and their amino acid profiles vary with the botanical origin of the seeds. They may also contain varying amounts of oil depending on the technology employed to perform oil extraction. They are also more or less rich in fibre in accordance, once more, with the botanical origin of the seed, or whether the seed has been peeled or not. Some seeds, depending on the variety, can contain large quantities of more anti-nutritional substances that can be eliminated by technological treatments. The amount of fibre and its digestibility affect the energy value of meals. Cakes richer in fibre are normally given to ruminants while the less fibre-rich by-products can be used by all animal species. Improper storage of the meal may cause the development of some toxic fungi (e.g., aflatoxin) that could put livestock health at risk.

4. Seed resources

Several reports concerning the interest in seeds as feed have been made: Bhat and Karim 2009; Mekbungwan, 2007 and Ekanayake et al. 2000. In temperate and tropical areas, the search for alternative protein sources has led to an increasing interest in the use of grain legumes. These legumes supply protein and are nitrogen-fixation crops in rotation or mixed crops within farms. One limit of grain legume use of in animal nutrition is the high concentration of secondary plant metabolites (protease inhibitors, alkaloids, lectins, pyrimidine, glycosides, saponins) found in some species. These metabolites, in some concentrations, can induce feed refusals (tannins, alkaloids), reduced nutrient digestibility (tannins, protease inhibitors, lectins) or even toxic effects (alkaloids) (Jezierny, 2010). Generally, secondary metabolites are more abundant in wild species compared with cultivated species.

In the tropics, some legumes seeds are food and feed and consequently competition potentially exists between humans and animals. Table 2 lists some tropical grain legumes.

	Soybeans cake	Palm cake expeler	Cotton Cake	Cophra expeler	Cacao	Peanut Cake
Component (g/ 100 g DM)						
NDF	12.2	65.8	31.8	49.7	37.6	20.1
ADF	7.3	40.4	22.2	26.1	28	14
ADL	0.7	12.1	6.8	6.1	14.5	4.6
MAT	45.3	14.8	36.3	20.5	25.2	49.2
Lysine	6.1	2.7	4	2.6	4.3	3.3
Threonine	3.9	3	3.2	3	3.3	2.7
Methionine	1.4	1.8	1.5	1.4	0.9	1
Cysteine	1.5	1.1	1.7	1.3	1.1	0.9
Methionine + Cysteine	2.9	2.9	3.1	2.7	2	1.9
Tryptophan	1.4	0.7	1.3	1.3	1.1	1.2
Isoleucine	4.6	3.5	3.1	3	3.5	3.3
Valine	4.8	5	4.4	4.7	3.8	3.9
Leucine	7.4	6	5.6	5.8	6.2	6.2
Phenylalanine	5	3.9	5.1	4.1	4.2	4.7
Tyrosine	3.3	2.1	2.7	2	2.7	3.7
Phenylalanine + Tyrosine	8.4	5.9	7.8	6.1	6.9	8.4
Histidine	2.7	1.8	2.9	1.9	1.6	2.3
Arginine	7.4	11.2	10.6	10.6	5	11.5
Alanine	4.4	3.9	4.2	3.9	4	4
Aspartic acid	11.3	7.8	9.1	7.5	8.6	11.3
Glutamic Acid	17.8	18.1	18.6	17	15	18.8
Glycine	4.2	4.3	4	4.1	3.2	5.6
Serine	5	4.2	4.3	4.3	4	4.7
Proline	5.9	2.9	3.4	3.4	3.2	3.8

Table 1. Chemical composition of some cakes used in livestock diets (INRA 2004)

	Vigna Unguiculata (1)	*Canavalia Ensiformis (2)*	*Sesbania Spp (3)*	*Cajanus Cajan (4)*
Component (g/ 100 g DM)				
NDF	5.1-5.8	7.8.-10.4	10.9-15.8	6
MAT	21.5-26.4	24.9-35	33.1-32.3	25
Lysine	7.1-16.7	4.63-5.6	3.86-4.55	7.2
Threonine	3.7-8.6	3.26-4.24	2.08-2.45	3.2
Methionine	1.5-3.2	1.05-3.8	0.96-1.03	1
Cysteine		0.59-1.13	0.66-0.75	
Tryptophan		0.84-1.28	1.28-1.63	0.8
Isoleucine	4.9-11.2	3.4-7.4	2.39-3.06	3.8
Valine	5.7-12.7	3.09	2.52-3.00	4.3
Leucine	8.3-19.0	5.85-7.64	4.32-5.36	7
Phenylalanine	5.8-14.1	3.4-5.01	2.80-3.55	4.4
Tyrosine	5.4-5.9	2.58-3.54	2.14-2.75	
Histidine	3.4-7.9	2.80-4.23	7.41-12.53	3.9
Arginine	15.2-17.7	3.6-5.56	5.87-8.58	
Alanine		3.38-3.98	2.58-3.00	5.9
Aspartic acid		8.98-10.78	5.96-7.27	
Glutamic acid		9.33-10.90	10.45-13.64	
Glycine		3.99-4.56	3.63-4.76	
Serine		3.61-5.37	3.14-3.94	
Proline		3.06-4.97	2.61-3.39	

1)Tshovhote et al, 2003; Adbooye et al, 2007. 2) Siddhuraju and Becker, 2007; Ekanayake et al, 2000; Sridhar and Seena, 2006; Ekanayake et al, 1999.
3) Hossain and Becker, 2001.4) Mekbungwan, 2007

Table 2. Nutrients and amino acid composition of some legume seeds

5. Foliage resources

Several reviews have been made concerning the interest of foliage as feed: Wanapat, 2009; Preston, 2006 and Leng, 1997. A large diversity of foliage can be used as protein resources. As indicated for cakes, their chemical compositions vary with the botanical origin, level of protein, fibre and secondary compounds as well as the technologies used to discriminate the foliage. The first reported works concerning high protein foliage concerned ruminants. Leng (1997) indicated that the role of fodder trees in ruminant diets can be seen as threefold:

- "as a N and mineral supplement to enhance fermentative digestion and microbial growth efficiency in the rumen of cattle on poor quality forage
- As a source of post-ruminal protein for digestion. In this role, the influence of secondary plant compounds in binding protein and making it insoluble is of particular importance
- As a total feed, supplying almost all the biomass and other nutrients needed to support high levels of animal production".

A low level of tannin (less than 5% dry matter) can have a positive impact by protecting the protein against ruminal degradation and contributing to enhanced intestinal amino acid flow useful for the animal. Dried foliage improves ruminant growth compared with fresh material. This response might be related to a change in the decrease of protein solubility in the rumen and increasing the bypass protein content of dry leaves. Drying also reduces the tannin content of the leaves.

Patra et al (2008, 2009) conducted a meta-analysis on the effect of supplementation of forages with foliages for ruminant diets. The main conclusions are: 1) organic matter digestibility of rations increases, following a linear law. The laws of response to crude protein content of the forage and the total diet are quadratic with an optimum reached with 14-15% of foliage in the total diet, 2) The CP digestibility of the diet is affected by the percentage of foliage in the diet, the CP content and the amount of crude protein supplied by the foliage, the NDF content of foliages, 3) The maximum intake of organic matter and digestible protein are reached with respectively 37 and 42% of foliage in the diet. The optimum catalytic properties (rumen microbial digestion) is achieved with 16% of foliage in the diet, although due to the response on intake, 42% of foliage in the diet are needed to achieve optimum animal performance.

Preston (2006) did a review on the interest of foliage as pig feed. A large diversity of resources can be used. Foliage with a low level of fibre is the best feed and needs to be associated with low fibrous diets.

Recently, Regnier (2011) studying the intake and digestion of several foliages concluded that, due to their high fill unit and low digestibility, their contribution should not exceed 25% of the total dry matter intake in growing pigs to avoid penalising their growth. The non-protein nitrogen, and therefore not usable by pigs, contributes 25-30% of the total nitrogen content in the foliages. The digestibility of amino acids was varied from 15 to 45%. Leterme (2009, 2010) had similar conclusions but indicated that sows digested better these resources compared to growing pigs.

5.1 General considerations

Table 3 reports the chemical composition of several foliages. There is variation with contradictory values being reported by different authors.

Foliage has a relatively low level of crude fibre and a ratio of sulphur amino acids relative to lysine close to that in the "ideal protein" (Preston 2006). The wide differences found in many reports for amino acid levels in cassava and sweet potato leaves, for example, emphasises the need for a coordinated research effort in which common samples of the most useful protein-rich leaves are distributed for analysis to several laboratories where the necessary equipment and expertise are available (Preston 2006).

	Ideal protein (1)	Soybean meal (2)	Water spinach (3)	Cassava leaves (4)	Sweet potato leaves (5)	Duckweed (7)	New cocoyam (6)	Mulberry (3)
g AA/kg N*6.25								
Lysine		63.2	42.7	56-65	39	43	46	50.6
Methionine			13.5	18-21	16.3	27.9	14.3	16.5
Cysteine			10.3	15-16	5.27	7.38	12.6	12.0
Met+Cys		28.3	23.8	33-37	39	35.3	26.9	28.6
Threonine		38.9	39.5	47	51	42	39.5	45.1
As proportion of lysine = 100								
Lysine	100	100	100	100	100	100	100	100
Met+Cys	59	44.8	56	53-57	55	82	58.5	56.4
Threonine	75	61.6	92	76	114	98	85.6	89.1
Composition of fresh leaves, g/kg fresh matter								
DM			83	320	161	62	180	261
Composition, g/kg DM								
Crude protein		51.8	267	245	282	370	248	222
Crude fibre		31	155	156	128	77	142	172
Ash		62	142	84	109	16	133	126

(1)Wang and Fuller 1989; (2) Martin 1990 ; (3) Phiny et al 2003; Phiny 2006, personal communication; (4) Eggum 1970; (5) Woolfe 1992; (6)Rodríguez et al 2006; (7) Le Thi Men 2006

Table 3. Major essential AA in the "ideal protein", soybean meal and leaves of selected protein-rich leaves (Preston 2006)

In the following, we concentrate the discussion on some potential tropical resources, which should be taken into account as alternatives to the use of soybean meal in animal nutrition.

5.2 Giant Taro (Alocasia macrorrhiza) and New cocoyam (Xanthosoma sagittifolium) leaves

Giant Taro is widely distributed in tropical latitudes. It has high protein (24% in DM) and low crude fibre (15% in DM) contents (Gohl, 1973). Nevertheless, many varieties have a pungent taste caused by oxalate crystals which also cause the mouth to itch (Gohl, 1973). In Cambodia, for example, farmers traditionally boil the leaves before feeding them to pigs as in the fresh state the leaves are not readily consumed (Preston 2006).

"New Cocoyam" is thought be native to South and Central America. It is highly palatable to pigs (Rodríguez *et al*. 2009). With growing pigs fed a low fibrous diet like sugarcane juice, a level of 50% of substitution of soybean meal protein with New cocoyam leaves did not affect growth as illustrated in Figure 2.

5.3 Sweet potato (*Ipomoea batatas*) foliage

The crude protein and crude fibre content of the foliage of sweet potato vary largely with the variety and the plant fraction (leaves or stem). Crude protein contents range from 26.5 to 32.5% and 10.4 to 14.1% in leaves and stems, respectively (Preston, 2006). Mean values of

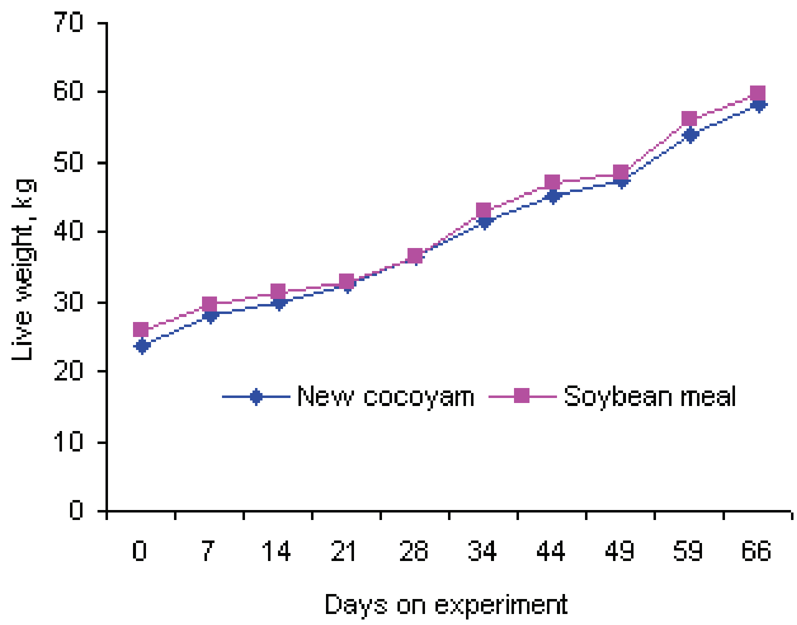


Fig. 2. Growth curves of pigs fed a basal diet of sugarcane juice supplemented with soybean meal or a 50:50 mixture (equal protein basis) of the leaves of "New Cocoyam" and soybean meal (Preston, 2006).

crude fibre are 11.1 and 20.7% for leaves and stems, respectively (Preston, 2006). The total essential amino acid content in the protein is higher than in soybean protein (Phuc et al, 2000 2001; Montagnac et al., 2009).

Van Ann et al. (2005) have compared in Vietnam four crossbred *(Large White* x *Mon Caï*) diets formulated with protein from fish meal, groundnut cake, ensiled sweet potato leaves and ensiled sweet potato leaves with lysine. They concluded that sweet potato leaves can replace fish meal and groundnut cake in traditional Vietnamese diets for growing pigs. Nguyen et al (2010) indicated that sweet potato vines replacing 70% of the CP from fish meal in diets and providing 35% of the total CP had no effect on the performance and carcass traits of *Large White* × *Mong*.

5.4 Mulberry (*Morus alba*) forage

An overview of the interest of mulberry as feed is available from Sánchez (2000, 2002). Mulberry agronomic productivity, palatability and nutritive value make it an important resource for improving and intensifying a large variety of livestock production practices. Mulberry foliage is used for ruminants and monogastric animals. The protein content is high (15 to 28% depending on the variety) in the leaves and young stems, with a good essential amino acid profile (Sánchez 2002). No anti-nutritional factors or toxic compounds have been reported. Mineral content is high. The leaves are used as supplements replacing concentrates for dairy cattle, as a main feed for goats, sheep and rabbits and as an ingredient in monogastric diets (Leterne, 2009).

5.5 Cassava (*Manihot esculenta*) leaves

Cassava leaves are rich in protein and the total essential amino acid content in the protein has been reported to be higher than in soybean protein (Phuc, 2000; Montagnac et al., 2009). However, the high HCN content of fresh cassava leaves limits its use. Processing this forage with technologies like drying or ensiling can markedly reduce the HCN content (Borin et al., 2005). Nguyen et al. (2010) evaluated the effects of replacing 70% of the protein from fish meal by protein from ensiled or dry cassava leaves on the performance and carcass characters of growing F1 (*Large White* × *Mong Cai*) pigs in Central Vietnam. The results showed that final body weight, daily average weight gain (450 g/day) and the dry matter intake and feed conversion ratio (FCR) among experimental treatments were not significantly different. It was concluded that using ensiled or dry cassava leaves replacing 70% of the CP from fish meal in diets and providing 35% of the total CP had no effect on the performance and carcass traits of the *Large White* × *Mong Cai* pigs.

5.6 Duckweed (*Lemna spp.*)

Duckweed (*Lemna spp*.) are small floating aquatic plants found worldwide. They are monocotyledons of the botanical family *Lemnaceae* and form dense mats over large areas of the water surface. Duckweeds are free-floating and do not have stems or typical leaves.

Leng et al (1995) reported that, in sewage water in Australia, the protein content of duckweed increased from 20-25 to 35-40% in dry matter when N in the water increased from <5 to 15 mg/litre). In this same trial, the yields of duckweed dry matter were in the range of 10 to 30 tonnes/ha/year, equivalent to protein yields of duckweed of as high as 10 tonnes/ha/yr.

Anh and Preston 1997 compared the growth of ducks fed with cassava meal and sugar. The protein sources were soya meal or duckweed. It was reported that duckweed can be used as a non-conventional protein source to completely replace soya bean meal and could be the sole source of protein in diets for ducks. Nevertheless, the availability of protein in duckweed should be lower than that of soya bean. This result has been explained by the fibre contents of the products. There was more fibre in duckweed (10% dry matter) than in soya bean meal (about 5% fibre), so it is likely that the digestibility of the protein in duckweed is the factor limiting its utilisation.

Preston (2000) reported mean growth of 500 g/day against 400 g/day for pigs fed with fresh duckweed protein source versus rice by-products on farms in Central Vietnam.

6. Conclusions

In conclusion, within the vast tropical biodiversity, there are many plant resources to replace partially or completely soybeans in livestock diets. The possibilities of substitution of soybean by other resources are more important for herbivores in relation to non-herbivores. Resources alternative to soybean are used mainly on smallholder mixed farming involving livestock and crops. In the modern farming systems, livestock receive diets based on cereal and soybean as the main sources of energy and protein respectively. Further research needs to be performed to study the alternatives to soya.

7. References

Baker, K. M., Stein H. H. 2009. Amino acid digestibility and concentration of digestible and metabolizable energy in soybean meal produced from conventional, high-protein, or low-oligosaccharide varieties of soybeans and fed to growing pigs. Journal of Animal Science 87, 2282–2290.

Bhat, R., Karim, A.A., 2009. Exploring the nutritional potential of wild and underutilized legumes. Comprehensive reviews in food Science and food safety 8, 305-33.

Borin, K., Lindberg , J. E., Ogle, R. B. 2005. Effect of variety and preservation method of cassava leaves on diet digestibilityby indigenous and improved pigs Journal of Animal Science80, 319-324.

Cervantes-Pahm, S. K., Stein, H. H. 2008. Effect of dietary soybean oil and soybean protein concentration on the concentration of digestible amino acids in soybean products fed to growing pigs. Journal of Animal Science 86:1841–1849.

Ekanayake, S., Jansz E.R., Nair, B. 2000.Literature review of an underutilized legume:*Canavalia gladiata* L. Plant Foods for Human Nutrition 55, 305–321.

Eknayakea, S., Jansz, ER., Nair, B.1999. Proximate composition, mineral and amino acid content of mature Canavalia gladiata seeds. Food Chemistry 66, 115-119.

Hartwig, E. E., Kuo T. M., Kenty M. M.1997. Seed protein and its relationship to soluble sugars in soybean. Crop Science 37, 770–778.

Hossain, MA., Becker, K. 2001. Nutritive value and antinutritional factors in different varieties of *Sesbania* seeds and their morphological fractions. Food Chemistry 73 421-431.

INRA, 2004. Tables de composition et de valeur nutritive des matières premières destinées aux animaux d'élevage Porcs, volailles, bovins, ovins, caprins, lapins, chevaux, poissons - Sauvant D., Perez J.-M., Tran G. coord., 2e édition revue et corrigée, ISBN 2-7380-1158-6 2004, 304 p. INRA Editions Versailles.

Jezierny, D., Mosenthin, R., Bauer E. 2010.The use of grain legumes as a protein source in pig nutrition: A review. Animal Feed Science and Technology 157, 111–128.

Johnson, L. A. 2008. Oil recovery from soybeans. Pages 331–375 in Soybeans, Chemistry, Production, Processing, and Utilization. L. A. Johnson, P. J. White, and R. Galloway, ed. AOCS Press, Urbana, IL.

Leng, R A., Stambolie, J H., Bell, R. 1995 Duckweed-Potential high protein feed resource for domestic animal and fish. Livestock Research for Rural Development. Volume 7, Number 1.

Leng, R A., 1997. Tree foliage in ruminant nutrition. FAO Animal Production and Heath Paper 139.

Mekbungwan, A. 2007. Application of tropical legumes for pig feed. Animal Science Journal 78, 342-350.

Leterme, P., Botero, M., London, A. M., Bindelle, J., Buldgen A, 2009. Nutritive value of tropical tree leaf meals in adult sows. Animal Science 82, 175–182.

Leterme, P., Londono, AM., Ordonez, D C., Rosales, A., Estrada, F., Bindelle, J., Buldgen A. 2010. Nutritional value and intake of aquatic ferns (Azolla filiculoides Lam. and Salvinia molesta Mitchell.) in sows. Animal Feed Science and Technology 155, 55–64.

Montagnac, A. J., Christopher, R. D., Tanumihardjo S. A..2009. Nutritional value of cassava for use as a staple food and recent advances for improvement. Compr Rev. Food Sci. Food Saf.8:186-194.

Nguyen Duc Anh ., Preston T R. 1997. Evaluation of protein quality in duckweed *(Lemna spp.)* using a duckling growth assay. Livestock Research for Rural Development. Volume 7, Number 1.

Opapeju, F. O., Golian, A., Nyachoti, C. M., Campbell , L. D.. 2006. Amino acid digestibility in dry extruded-expelled soybean meal fed to pigs and poultry. Journal of Animal Science 84,1130–1137.

Ogle R B 2006. Forages for pigs: nutritional, physiological and practical implications Workshop-seminar "Forages for Pigs and Rabbits" MEKARN-CelAgrid, Phnom Penh, Cambodia, 22-24 August, 2006. Retrieved December 19, 110, from http://www.mekarn.org/proprf/ogle.htm

Patra, AK. 2008. A meta-analysis on effects of supplementing low-quality roughages with foliages from browses and tree fodders on intake and growth in sheep. Livestock Science.121, 239–249.

Patra, AK. 2009. Effects of supplementing low-quality roughages with tree foliages on digestibility, nitrogen utilization and rumen characteristics in sheep: a meta-analysis. Journal of Animal Physiology and Animal Nutrition 94, 338-353.

Phuc, B. H. N., Lindberg J. E. 2001. Ileal digestibility of mino acids in growing pigs given cassava root meal diets with inclusion of cassava leaves, leucaena leaves and groundnut foliage. Animal Science 72, 511-517.

Phuc, B. H. N., Ogle, B., Lindberg, J. E.. 2000. Effect of replacing soybean protein with cassava leaf protein in cassava root meal based diets for growing pigs on digestibility and N retention. Animal Feed Science and Technology 83:223-235.

Preston T R 2006. Forages as protein sources for pigs in the tropics. Workshop-seminar "Forages for Pigs and Rabbits" MEKARN-CelAgrid, Phnom Penh, Cambodia, 22-24 August, 2006. Retrieved December 19, 110, from http://www.mekarn.org/proprf/preston.htm.

Ravindran, V., 1993. Cassava leaves as animal feed: Potential and limitations. J. Sci. Food Agric. 41:45-53.

Régnier, C. 2011. Valorisation des ressources alimentaires tropicales (feuillages et tubercules) chez le porc. Thèse de doctorat, Université des Antilles et de la Guyane, 203 p.

Rodríguez, L., Peniche, I., Preston T R., Peters, K. 2009: Nutritive value for pigs of New Cocoyam (*Xanthosoma sagittifolium*); digestibility and nitrogen balance with different proportions of fresh leaves and soybean meal in a basal diet of sugar cane juice. Livestock Research for Rural Development. Volume 21, Article #16. Retrieved December 20, 2010, from http://www.lrrd.org/lrrd21/1/rodr21016.htm

Sanchez, MD., 2002. Mulberry for animal production. FAO Animal Production and Heath Paper 147.

Sánchez MD., 2000. Mulberry: an exceptional forage available almost worldwide!.World Animal Review. 93(1), FAO, Rome.

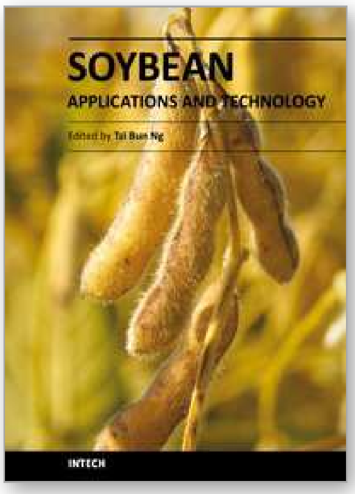
Sridhar K.R., Seena S. 2006. Nutritional and antinutritional significance of four unconventional legumes of the genus Canavalia – A comparative study. Food Chemistry 99, 267–288.

Siddhuraju, P., Becker, K. 2005. Nutritional and antinutritional composition, in vitro amino acid availability, starch digestibility and predicted glycemic index of differentially processed mucuna beans (Mucuna pruriens var. utilis): an under-utilised legume. Food Chemistry 91, 275–286.

Tshovhote, N.J., Nesamvuni, A.E., Raphulu, T., Gous, R.M. 2003.The chemical composition, energy and amino acid digestibility of cowpeas used in poultry nutrition. South African Journal of Animal Science 33, 65-69.

Van An, L., Hong, T. T. T., Ogle, B., Lindberg, J. E. 2005. Utilization of ensiled sweet potato (*Ipomoea batatas* (L.) Lam) leaves as a protein supplement in diets for growing pigs. Tropical Animal Health Production 37, 77-88.

Wanapat, M. 2009. Potential uses of local feed resources for ruminants. Tropical Animal Health Production 41, 1035–1049.



Soybean - Applications and Technology
Edited by Prof. Tzi-Bun Ng

ISBN 978-953-307-207-4
Hard cover, 402 pages
Publisher InTech
Published online 03, February, 2011
Published in print edition February, 2011