Peanut meal

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Common names

Peanut, groundnut, goober, earthnut, Chinese nut [English], arachide, cacahuète, cacahouète, pistache de terre, pois de terre [French], pinotte [French/Canada], Erdnuß [German], arachide [Italian], amendoim, alcagoita, caranga, mandobi [Portuguese], avellana americana, cacahuete, cocos, maní [Spanish], karanga, mjugu nyasa, mnjugu nyasa [Swahili], grondboontjie [Afrikaans], podzemnice olejná [Czech], jordnød [Dansk], kacang tanah [Indonesian, Malay], kacang brol [Javanese], földimogyoró [Hungarian], pinda, aardnoot, grondnoot, olienoot of apennoot [Dutch], Orzacha podziemna, orzech ziemny, orzech arachidowy, fistaszki [Polish], mani [Tagalog], yer fıstığı [Turk], lạc, đậu phộng, đậu phụng [Vietnamese], [Amharic], فول سوداني [Arabic], [Bengali], بادام‌زمینی , پسته‌شامی [Persian], [Khmer], 땅콩 [Korean], [Hindi], אגוז אדמה [Hebrew], [kannada], [Malayalam], [Nepali], ラッカセイ [Japanese], [Punjabi], Ара́хис культу́рный, арахис подзе́мный, земляно́й оре́х [Russian], [Tamil], [Telugu], ถั่วลิสง [Thai], مونگ پهلی [Urdu], 花生 [Chinese]

Products:

- Peanut meal, peanut cake, peanut oil meal, peanut oil cake, groundnut meal, groundnut cake, groundnut oil meal, groundnut oil cake
- Solvent-extracted peanut meal, deoiled peanut meal, Solvent-extracted peanut meal, deoiled groundnut meal
- Expeller peanut meal, expeller groundnut meal

Note: the names *peanut* and *groundnut* are interchangeable. The former is more used in American English while the latter is more used in international literature.

Species

Arachis hypogaea L. [Fabaceae]

Feed categories

- Legume seeds and by-products
- Oil plants and by-products
- Plant products and by-products

Related feed(s)

- Peanut skins
- Peanut hulls
- Peanut forage
- Peanut seeds

Description

Peanut meal is the by-product of the extraction of oil from peanut seeds (also called peanuts) (*Arachis hypogaea* L.). It is a protein-rich ingredient that is widely used to feed all classes of livestock. Peanut meal is the 6th oil meal ingredient produced in the world after soybean meal, rapeseed meal, sunflower meal, cottonseed meal and palm kernel meal (USDA, 2016). Peanut meal is generally considered as an excellent feed ingredient due to its high protein content, low fibre, high oil (for expeller meal) and relative absence of antinutritional factors. It is often the default high protein source in regions where soybean meal is too expensive or not available. However, aflatoxin contamination remains a serious issue, particularly for peanut meal produced from seeds grown in smallholder systems (See **Potential constraints**). After the aflatoxin crises of the 1960-1970s, importations towards developed countries nearly stopped and the product is now mostly used in countries of production (FAO, 1979).

Peanut meal is produced by mechanical extraction only (expeller) or by mechanical extraction followed by solvent extraction. It is also sold in pellet form. Expeller meal consists of light gray to brownish pieces (flakes) of variable size with a smooth, somewhat curved surface. Solvent-extracted meal consists of light gray to brownish flakes of varying sizes. Peanut meal pellets vary between 1.5 and 40 mm in diameter and are light to dark gray in colour (TIS, 2016).

Distribution

Peanut is native to South America. It was cultivated in Peru at least as early as 1500 BCE and probably earlier. The Incas already used it for its seeds, that were eaten toasted, and its oil. After the arrival of Europeans in America, peanut was spread worldwide. An oil mill was established in Spain in 1800 and West Africa became the primary source of peanut exportation in the 19th century (Pattee, 2005). Peanut is a now a major crop widely distributed throughout tropical, subtropical, and warm temperate areas in Asia, Africa, Oceania, North and South America, and Europe (Freeman et al., 1999). In 2014, peanut cultivation covered 25.7 million ha worldwide, including 13.1 million ha in Africa (51%), 11.2 million ha in Asia (44%) and 1.3 million ha in the Americas (5%) (FAO, 2016).

- Peanut is cultivated throughout Africa. Sudan, Nigeria, and Senegal are the main producers. In Western and Central Africa, peanut is cultivated in semi-arid areas: growing season 75-150 days, annual rainfall 300-1200 mm. In Southern and Eastern

Africa, peanut is also grown above 1500 m with rainfall 300-1000 mm.

- In Asia, most of the production occurs in India and China though peanut is also grown in Indonesia, Myanmar, Bangladesh, and Vietnam. In India, about 80% of the peanut area is rainfed, grown in southern, western, and parts of central India during the southwest monsoon. The remaining 20% is irrigated, grown in the post-rainy season and in summer in southern, eastern and central India. In China, peanut is grown in rotation with wheat and maize. 25% of the production comes from the Shandong province in northern China. Growing condition are diverse: rainfall ranging from 400 to 2000 mm, 150 to 300 frost-free days per year.
- Argentina and Brazil together account for 66% of the peanut produced in Latin America and the Caribbean. The crop is grown mainly in semi-arid regions.
- In the USA, production is concentrated in the southeast, in the Virginia-Carolina area, and the southwest.
- In Europe, peanut is grown only in Bulgaria and small parts of Greece, Spain, and Yugoslavia (Freeman et al., 1999).

Crushing peanuts for oil and meal remains a major use for peanut production, even though direct utilisation for food has been steadily increasing since the 1970s. About 41% of the world peanut production was crushed in 2010-2013, but variations between regions are large: only 11% of the production is crushed in North America *vs* 50% in Eastern Asia and 64% in Southwestern Asia (Fletcher et al., 2016). The worldwide production of peanut meal was 6.6 million t in 2015/2016 and gained only 1 million t since 1995, as the proportion of peanut oil and meal relative to other oil crops actually declined (USDA, 2016). Developing countries contribute about 94% of the world peanut production, grown mostly under rainfed conditions, predominantly in Asia and Africa (Dwivedi et al., 2006). In 2015, 70% of the production came from China (3.5 million tons) and India (1.1 million t) and 19% came from Africa (particularly Nigeria, Sudan and Tanzania) (USDA, 2016). More than 90% of peanut meal is consumed locally and its trade is rather limited. In 2015, about 100,000 t were exported, 70% by Argentina, Senegal, Nicaragua and Sudan (Oil World, 2015).

Processes

Oil extraction

The peanut fruit is made of an external shell (21–29%) and the nut (79–71%), consisting of a thin hull ("skin") (2-3%), the nut itself (69-73%) and the germ (2.0-3.5%) (van Doosselaere, 2013). In the industrial extraction process, the seeds are first cleaned and 90-95% of the shells removed by corrugated rolls, by pounding or by centrifugation (5-10% shells are necessary for proper extraction). Kernels are broken up using a hammer mill or bar cracking machine and then subjected to a cooking process. A moisture content of 3-4% moisture at 95-105 °C is typical for straight expeller processing resulting in a cake containing 17-18% residual oil. Full pressing requires a cooking moisture content of 10–12% with the addition of live steam followed by drying at 100–115 °C, resulting in 8-10% residual oil. The expeller cake is conditioned to 10% moisture, flaked, and extracted with hexane in either percolation- or immersion-type extractors (List, 2016). There are many variants of this process. Sometimes the shells are not removed, and some processes remove the skins, resulting in a "white cake" (van Doosselaere, 2013). In Senegal, 100 kg of peanut fruits are first dehulled (yielding 25-35 kg of shells). The skins are removed and the kernels are ground into a paste which is cooked and then pressed, yielding 25-40 kg of oil cake (Lambaré, 2015).

Solvent extraction is less common than for other major oil meals. In the USA, as of 2014, only one processing plant (out of 4) was using solvent extraction (List, 2016). Solvent-extracted peanut meals have typically less than 1% residual oil while non solvent-extracted meals (cakes) contain about 5-20% oil.

Aflatoxin detoxification

Various processes have been proposed to remove aflatoxins from peanut meal (Piva et al., 1995). A process based on the application of aqueous ammonia was developed in France in the 1980s and found to be very effective (Viroben et al., 1983). This process was used in France until 2005 and is still used in Senegal as of 2016 (Tran, personal communication). In 1992, the explosion of an ammonia tank and the subsequent toxic cloud caused the deaths of more than 100 people in Dakar. After this accident, the safety of the detoxification plant was reinforced (ARIA, 2006). Other detoxification processes have been developed, using hydrogen peroxide (India, Sreedhara et al., 1981) or formaldehyde and calcium hydroxide (USA, Codifer et al., 1976; Italy, Piva et al., 1985), but it is not known if they were implemented industrially. Both the French and the Indian processes decreased protein solubility, but this effect, while detrimental for monogastrics, could be beneficial for ruminants by increasing the proportion of rumen-undegradable protein. Indeed, formaldehyde treatment has been used to decrease the protein degradability of peanut meal in ruminants (Gupta et al., 1984; Gupta et al., 1985).

Forage management

Peanut cultivation falls under two broad categories (Freeman et al., 1999).

- **Low-input systems**. In most countries in Africa and Asia, peanut is grown primarily for food by smallholder farmers as a semi-subsistence crop. The crop is cultivated under rainfed conditions, with no inputs other than land and labor. It is subjected to drought stress and to high levels of pest and disease infestation. Average yields are about 700 kg/ha and can vary substantially from year to year.
- **High-input systems**. In the USA, Australia, Argentina, Brazil, China, and South Africa peanut is grown for food and oil on a commercial scale using improved varieties, modern crop management practices, irrigation, and high levels of inputs such as fertilizer, herbicides, and pesticides. Farm operations are generally mechanized. Yields in these systems are considerably higher (2-4 t/ha) and more stable than in low-input systems.

Environmental impact

Like other legume crops, peanut cultivation helps improve soil fertility through biological nitrogen fixation, and can thus contribute to significant improvements in the sustainability of cropping systems (Freeman et al., 1999).

Datasheet citation

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- Gilles Tran, AFZ
- Denis Bastianelli, CIRAD
- Denis Bastianelli, CIRAD

Peanut meal

Nutritional attributes

Peanut meal is a high-protein feed. Its protein content is usually about 50-55% DM and ranges from 42% to more than 60% DM, depending on the amount of oil, skins and hulls. Peanut cake processed at the farm and that includes shells and much residual oil can have a protein content < 40% DM. Peanut meal is deficient in lysine and low in methionine and tryptophan. Mechanically extracted meals may contain more than 5 to 7% fat, and thus tend to become rancid if stored more than 5 to 6 weeks during summer and 8 to 12 weeks during winter (Cunha, 1977; Seerley, 1991). Peanut meal is generally more fibrous than soybean meal, with a crude fibre often 10% DM for meal containing a fair amount of skins and shells fragments. Due to the wide range of extraction processes, the residual oil content is highly variable, from less than 3% for solvent-extracted meals to 10% or more for mechanically-extracted cakes. Oleic acid (C18:1); linoleic acid (C18:2) and palmitic acid (C16:0) account for more than 90% of the fatty acids of peanut oil (Davis et al., 2016). Peanut oil contains about 50% oleic acid and 30% linoleic acid but there are large variations in their respective proportions: reported values for oleic acid range from 35 to 82% and values for linoleic acid range from 3 to 43%, due to natural variations and also to the existence of oleic-rich (and linoleic-poor) varieties (Davis et al., 2016; Pattee, 2005).

Potential constraints

Aflatoxins

Peanuts are particularly vulnerable to contamination by fungi *Aspergillus flavus* and *Aspergillus parasiticus.* These fungi produce aflatoxins, that are known to cause cancers in humans. increase incidents of hepatitis viruses B and C, lower the immune response, impair growth in children and cause childhood cirrhosis. In poultry and livestock, aflatoxin can cause feed refusal, loss of weight, reduced egg production, and contamination of milk (ICRISAT, 2016). Aflatoxin contamination may occur in the field, after peanuts are dug but before harvest, during transport, and during storage. Either elevated temperatures or drought stress alone increased aflatoxin production, but high temperatures appeared to have a greater impact. Key requirements of postharvest management of aflatoxin are control of seed moisture and insects. Both *A. flavus* and *A. parasiticus* are xerophiles and can grow and produce aflatoxin at relative moisture around 85%. Storage below this moisture or at 10°C will prevent aflatoxin production in storage (Payne, 2016).

In 1960, aflatoxin-contaminated peanut meal from Brazil fed to poultry killed thousands of turkey poults in the United Kingdom, drawing attention to these contaminants (FAO, 1979). New regulatory measures in importer countries such as European Union member states led to a significant restriction of the trade of peanut and peanut products, and particularly of those produced in sub-Saharan Africa (Waliyar et al., 2007; ICRISAT, 2016). The demand for peanut meal in industrialised countries evaporated in the 1970-1980s. France, which imported 400,000 t of peanut meal in 1973 (FAO, 1979), only imported 4000 t in 2014 (Oil World, 2015). Former UN Secretary-General Kofi Annan once claimed that "EU regulation on aflatoxins costs Africa $670 million each year in export" (Wu et al., 2012). As of 2016, the maximum authorised content in the EU for aflatoxin B1 in feed materials is 0.02 mg/kg (20 ppb or µg/kg) (Commission Directive 2003/100/EC).

Since the 1980s, the reduction of aflatoxins in peanut products have been the subject of considerable research focused on the following areas:

- Increase awareness of local populations about aflatoxin issues
- Implementation of pre-harvest, post-harvest and storage practices and technologies for mitigating contamination
- Identification/development and use of resistant peanut cultivars
- Biological control agents
- Methods for detoxifying peanut products

The objective of aflatoxin management in producing countries is both to decrease aflatoxin exposure in their populations and to increase the export of peanut products that are negatively impacted by aflatoxin regulations (Waliyar et al., 2007; ICRISAT, 2016). As of 2016, aflatoxin contamination in peanut production in tropical countries and particularly in low-input systems, still remains a major problem, as shown by many surveys conducted in China (Wu et al., 2016), Zambia (Bumbangi et al., 2016), Ethiopia (Chala et al., 2016), Nigeria (Ezekiel et al., 2013), Cameroon (Kana et al., 2013), India (Kolhe, 2016a) and Brazil (Oliveira et al., 2009). Aflatoxin contamination of peanut meal in these surveys sometimes reaches 100% with values well beyond international standards.

Progress in aflatoxin resistance breeding has been limited (Holbrook et al., 2016). Biological control using nonaflatoxigenic strains of *Aspergillus* has been shown to be effective in Argentina, Australia, the Philippines, and the US with reductions ranging from 85% to 98% (Payne, 2016). In Mali, a combined approach using resistant/tolerant cultivars, the application of lime and manure and better harvesting and drying techniques helped to reduce aflatoxin by 80-94% (ICRISAT, 2016).

Antinutritional factors

Like other legume seeds, peanuts contain substances with potential antinutritional effects, such as tannins, which are present in the seed coats (Sanders, 1979), lectins and trypsin inhibitors (Ahmed, 1986; Ahmed et al., 1988a; Ahmed et al., 1988a). These substances have received little attention, perhaps because the antinutritional factors in peanut seem less deleterious than those of other legumes. For instance, a comparison of soybean and peanut flour in rats showed that the raw peanut flour was much better tolerated than raw soybean flour even though lectin concentration and antitrypsic activity were similar in both seeds (Sitren et al., 1985). Peanut lectins can be fully inactivated by heat (moist heat being more effective than dry heat) (Ahmed, 1986) so it is possible that regular conditions involved in peanut seeds and meal processing are enough to make peanut products safe for animal feeding. Still, tannins may be a contributing factor for low protein digestibility of peanut meals (Chiba, 2001).

Ruminants

Peanut meal is a good source of protein for ruminants and there are no restrictions on the use of peanut cake, provided that it is not contaminated by aflatoxin. It is a potential alternative to soybean meal or cottonseed meal. Non-dehulled peanut cake has a high fibre content that makes it a useful corrective for cattle feeding on grass that is low in fibre (Göhl, 1982). It has been observed, however, that it was preferable to mix peanut meal with other protein sources for better meat and dairy performance (Martin, 1991; Sheely et al., 1942). It is possible that the sometimes contradictory results obtained with peanut meal are caused by unexamined aflatoxin contaminations.

Peanut meal is little exported and not longer much used for ruminants in developed countries, but is widely used as a protein source in tropical countries where it is an indigenous crop (Blair, 2011). In India, for instance, peanut meal is fed to cattle, buffalo, sheep and goats (NDDB, 2012). In studies conducted in these countries, peanut meal is sometimes the protein source used in the control diet. Literature about the use of peanut meal for ruminants has become rather scarce since developed countries stopped using it, but Brazilian researchers have been investigating this product again since the 2010s.

Aflatoxin toxicity

Aflatoxin contamination has been shown to be lethal or at least very detrimental to cattle, particularly to young ones. Administration of 1 mg/kg of aflatoxin B1 in the diet of 6-month old steers during 133 days resulted in animal death or in reduced live weight gains. Administration of 0.2 mg/kg aflatoxin B1 in the diets of calves also reduced live weight gains. Dairy cows fed diets containing 13-20% aflatoxin-contaminated peanut meal showed significant reductions in milk yield (McDonald et al., 2002).

Digestibility and degradability

Peanut meal is highly digestible in ruminants, with OM digestibility values above 80% (Sauvant et al., 2004). Its energy value is about 89-92% that of soybean meal (Sauvant et al., ,2004; NRC, 2001). Peanut meal protein is very degradable (N effective degradability comprised between 72 and 90%).

Dairy cows

Peanut meal was recommended in the USA in the 1940s for its palatability and nutritive value, which was described as comparable to that of other oil meals with a similar protein content (Sheely et al., 1942). A more recent trial found that a diet containing 21% peanut meal fed to dairy cows during periods of heat stress resulted in better milk yield and DM intake than that obtained with a diet containing 16% peanut meal or a soybean meal-based control diet (Hamid et al., 1989). In the UK, several trials in the 1970s concluded to the suitability of peanut meal as a protein supplement for dairy cows fed grass silage. Dairy cows fed high digestibility perennial ray-grass silage supplemented with barley or peanut cake (1 kg supplement per 10 kg milk) had the best milk yield and DM intake of silage with peanut cake supplementation (Castle et al., 1976).

In Brazil, crossbred dairy cows managed on Guinea grass and supplemented with peanut cake (from biodiesel production) in full substitution of soybean meal showed similar intake, digestion, blood parameters and ingestive behaviour to those of cows fed the soybean meal diet (Neto et al., 2015). Peanut cake could replace up to 100% soybean meal in the supplement of grazing lactating crossbred cows without altering the feeding behavior or physiological parameters of the animals (Costa et al., 2015). In The Gambia, lactating cows grazing local pasture supplemented with peanut cake at 425 or 850 g/day for the last 3 or 5 months of the dry season showed increases in milk yield, in growth rate of the sucking calves, and decreases in losses of cow live weight (Little et al., 1991).

Pre-ruminant calves

In India, pre-ruminant calves could be reared successfully on a calf starter where peanut meal replaced fish meal, with only a slight decrease in average daily gain and feed efficiency (Sahoo et al., 1998).

Growing cattle

Early experiments in the USA demonstrated that peanut meal was an excellent protein supplement of high palatability and valuable for growing animals, fattening steers and breeding animals (Sheely et al., 1942). In Brazil, a more recent trial showed that the replacement of soybean meal with peanut cake from biodiesel production at levels up to 100% in the diet of feedlot-finished young bulls does not promote significant changes in carcass traits or beef quality, although it modifies the fatty acid profile of the longissimus thoracis, with a beneficial increase in the levels of polyunsaturated fatty acids (Correia et al., 2016). In Chile, finishing beef heifers fed a diet containing 21% peanut cake had daily live weight gain and carcass results similar to those obtained with a diet containing 17% soybean meal (Rojas et al., 2011). In Mauritius, crossbred bulls fed urea-molasses and either leucaena or peanut cake (2% live weight or *ad libitum*) did not consume the groundnut cake well and performance with leucaena was better than with groundnut cake (Hulman et al., 1978). In Australia, however, the supplementation of weaned steers grazing native pastures with leucaena, peanut meal (680 g/d) or a combination of both improved the body weight performance of the steers over the post-weaning winter and the following autumn, the best performance being obtained with the leucaena/groundnut combination (Addison et al., 1984).

There have been early attempts in India at treating peanut meal with formaldehyde to protect its protein in the rumen. In calves fed a diet containing 48.5% peanut meal, replacing half of untreated peanut meal with formaldehyde-treated peanut meal (1.5 g/100 g protein) resulted in better N retention (Gupta et al., 1984).

Sheep

In India, sheep fed a basal diet of wheat straw supplemented with either sunflower cake or peanut cake (at maintenance requirement for protein) had similar nutrient intake (Dutta et al., 2002). In Brazil, peanut cake added to the diet of lambs in partial or total substitution of soybean meal did not affect the physical-chemical characteristics of the meat. However, the total replacement of the soybean meal altered the proximate composition and fatty acid profile of the meat (Bezerra et al., 2016), in ways similar to the ones observed in beef cattle by Correia et al., 2016. Another Brazilian trial concluded that peanut meal could fully replace soybean meal in the diets of crossbred lambs with no effect on intake and health parameters (Duarte et al., 2015). In Nigeria, a comparison of peanut cake and palm kernel cake fed *ad libitum* as supplement to West African Dwarf sheep was defavourable to peanut cake, as it resulted in a much lower daily gain and feed efficiency than palm kernel meal (Martin, 1991).

Goats

In India, goats fed a basal diet of wheat straw supplemented with either sunflower cake or peanut cake (at maintenance requirement for protein) had similar nutrient intake (Dutta et al., 2002). In Cameroon, West African Dwarf goats fed fresh Guatemala grass and various combinations of cassava flour and peanut cake had maximum liveweight gain with either 200 g/d cassava + 100 g/d peanut cake or 200 g/d cassava + 150 g/d peanut cake (Njwe et al., 1989). In Ethiopia, Somali goats fed *Hyparrhenia rufa* hay, supplementation with a mixture of peanut meal and wheat bran promoted feed intake, DM and protein digestibility, and N retention (Betsha et al., 2009). Two trials in Brazil led to mixed conclusions: partial substitution of soybean meal by peanut meal in the diets of crossbred goat kids affected negatively intake and daily gain (Silva et al., 2015) but it had no effect on carcass characteristics and quality, and on the fatty acid profile of meat (Silva et al., 2016).

Pigs

Peanut meal is a source of protein and energy in pigs. However, due to its low lysine content, it cannot be used alone as protein supplement for weanling or grower-finisher pig diets, and it is required to use it in combination with ingredients high in lysine or with lysine supplementation, though performance still tend to be lower than with soybean meal, even with supplementation (Chiba, 2001). The residual oil in expeller peanut meal may cause soft fat in bacon pigs and therefore, the solvent-extracted meal may be preferable (Göhl, 1982). Its energy value in pigs is roughly similar to that of soybean meal, at least for well-dehulled peanut meal (Sauvant et al., 2001).

Many early studies found that peanut meal fed alone resulted in lower performance. Replacing soybean meal completely with peanut meal resulted in lower feed intake, slower growth rate, and lower feed efficiency in pigs weaned at 15 days of age, and reduced digestion coefficients at 7 to 8 weeks of age (Combs et al., 1963). Replacing 50 or 100% of soybean meal with peanut meal in diets for 5-weeks-old starter pigs resulted in reduced growth performance. Lysine supplementation of the peanut meal diet did not alleviate the growth depression of young pigs (Orok et al., 1975). Grower-finisher pigs fed peanut meal diets without amino acid supplementation grew slower than those fed soybean meal diets. Supplementation with only lysine was partially effective, but supplementation with lysine and methionine alleviated the decrease in growth (Brooks et al., 1959). Weight gain and feed efficiency decreased linearly as substitution of soybean meal with peanut meal increased from 0 to 15%. Performance was increased with lysine and methionine supplementation, but it was considerably lower than in pigs fed the soybean meal diet (Aherne et al., 1985). When diets for growing pigs were formulated to contain about 16% protein using high lysine maize and peanut meal, the lysine content of high lysine maize, although higher than that of normal maize, was not adequate to overcome the lysine deficiency (Thomas et al., 1972). Pigs fed a sorghum-peanut meal starter diet had the best gains and feed efficiency when the diet was formulated to include 8% fish meal. However, performance was still lower than with a maize-soybean meal starter ration (Ranjhan et al., 1964). There was no difference in performance of pigs fed diets containing 15 to 20% peanut meal plus 3 to 4% blood meal compared with pigs fed the soybean meal diet (Ilori et al., 1984) .

Poultry

Peanut meal is a valuable feed resource for poultry, and it is used very widely. Its nutritional value can vary according to crude fibre and fat content (Batal et al., 2005). The main limitations for its use are:

- The amino acid profile is deficient in lysine, threonine and methionine. This can be taken into account in feed formulation, but most publications show that a part of the sub-optimal results obtained with peanut meal are due to unbalanced diets.
- The risk related to aflatoxins contamination, especially in regions where peanut mycotoxin contamination is frequent (Kana et al., 2013). Aflatoxins are a major concern in poultry, and peanut meal should be rejected if there is a suspicion of contamination (mould, bad storage etc.). Peanut meal can be detoxified, but this process reduces both amino acid content (especially lysine) and digestibility (Piva et al., 1995; Zhang et al., 1996).

Phytase addition seems to enhance the nutritive value of peanut meal, not only through mineral availability but also by an increase in metabolizable energy (Driver et al., 2006).

Broilers

Most studies show that peanut meal can be used efficiently at levels of 5-15% in diets (El-Boushy et al., 1989). However, some experiments suggested that performance of diets formulated with peanut meal as the main protein source often lead to lower growth performance than diets with soybean meal (Costa et al., 2001; Ghadge et al., 2009; Khalil et al., 1997). The results are better when peanut meal is used in mixture with other protein sources. Peanut meal also gives lower performance than other protein sources such as cottonseed meal or sunflower meal (Diaw et al., 2010; Singh et al., 1979). Low protein diets should be avoided with peanut meal (Olomu et al., 1980). The problem is linked to amino acid content, but can remain even with amino acid (threonine) supplementation (Costa et al., 2001).

The recommendation is to use peanut meal in combination with other protein sources in broiler diets, and to take a great care of amino acid balance in formulation, taking digestibility into account especially in processed / detoxified peanut meal.

Layers

Peanut meal can be used in layers with little effect on laying rate, egg weight and body weight (Lu et al., 2013; Pesti et al., 2003). However, when compared to other protein sources like soybean meal or sunflower meal, peanut meal can result in significantly lower performance (Naulia et al., 2002b; Singh et al., 1981). This negative effect of peanut meal is observed when it is used as the main protein source, but not in mixture with soybean or sunflower (Naulia et al., 2002a; Sayda et al., 2011). In diet formulated with low crude protein content, peanut meal tends to induce lower performance (Naulia et al., 2002b; Pesti et al., 2003). No negative effect on fertility or hatchability was observed (Singh et al., 1981).

The recommendation is to be careful to amino acid balance in formulation with peanut meal in diets for layers, and to associate different protein sources in formula in order to avoid risks of lowered performance.

Quails

In laying quails, the use of 10% peanut meal had no effect on performance, while higher incorporation levels lowered laying rate. Fertility and hatchability were affected by peanut meal (Bayram et al., 2001).

Rabbits

Peanut meal is used for rabbit feeding in many peanut-producing countries. However, due to the risk of aflatoxin contamination and the high sensitivity of rabbits to aflatoxins, the use of peanut meal may not be presently recommended for feeding rabbits.

Aflatoxin toxicity in rabbits

Rabbits are very sensitive to aflatoxins, 10 to 100 times more than most of the other farm animals (Lebas et al., 1998). Performance impairment could be observed in the rabbit with as little as 15 µg/kg of aflatoxin B1 in complete diet, barely below the EU regulation of 20 µg/kg (Lebas et al., 1998; Mézes, 2008). High levels of contamination such as 500 µg/kg feed or more result in noticeable clinical problems in rabbits within few weeks (Lakkawar et al., 2004). In some cases, 100-150 µg/kg of aflatoxin B1+G1 was enough to result in acute intoxication (Nowar et al., 1994). Lower contaminations such as 15 to 100 µg/kg feed may result in chronic aflatoxicosis. There are no apparent external symptoms or health problems during the period of distribution of the contaminated diet, but feed and water consumption are rapidly reduced more or less in relation with the dietary aflatoxin level. This decrease is followed few weeks later by the alteration of metabolism of liver, kidneys, heart, testis or of skeletal muscles (Kolhe, 2016b). In addition, both cell-mediated immunity and humoral immunity of rabbits are impaired (Sahoo et al., 1996), inducing a higher susceptibility to pathogens such as *Bordetella bronchiseptica* or *Pasteurella multocida* (Venturini et al., 1990; Ghoneimy et al., 2000). Teratogenic effects of aflatoxins were also described in the rabbit (Wangikar et al., 2005).

Using peanut meal in rabbit feeding

In countries where other oil meals are available, such as Europe, peanut meal has been completely eliminated from the manufacture of rabbit feeds in order to avoid any risk associated with aflatoxin contamination, even at low levels (Lebas et al., 1998; Lebas et al., 2013). In peanut-producing countries, where peanut meal is an easily available protein-rich feed ingredient, it is frequently used for rabbit feeding at levels varying from 15% up to 45-50%, with no determination of aflatoxin contamination. In those countries, peanut meal is often considered as a conventional source of protein and as such used in control diets in feeding trials (Omole, 1982; Godwa et al., 1998; Ajayi et al., 2007; Oluokun, 2005). There is indeed a risk of uncontrolled chronic aflatoxicosis in feeding trials aiming to assess local feeds for replacing peanut meal. As there is no determination of aflatoxin contamination in the peanut meal used in control diets, positive results for substitution may be misinterpreted because they result from a decrease or a suppression of aflatoxin in the best experimental diets rather from the actual nutritive value of the tested feed ingredient.

Peanut meal protein is largely deficient in lysine, sulphur amino acids and threonine (Lebas, 2013) and natural or artificial sources of amino acids are necessary to obtain a balanced diet. The calcium content is very low (about 0.2% DM, *i.e.* 15% of requirements), but this deficiency could be easily corrected with concentrated sources of calcium such as oyster shells, bone meal or calcium carbonate.

Fish

Peanut meal has been evaluated in carps, tilapias and catfish. Studies tend to indicate that peanut meal is acceptable in fish diets but only in limited amounts, usually less than 15% dietary level in herbivorous and ominvorous fish, and less than 10% for carnivorous fish. Amino acid supplementation (lysine, threonine and methonine) may be necessary. It is also important to make sure that peanut meal is free of aflatoxins (Hertrampf et al., 2000).

Carp

Peanut meal was reported as being used in Thailand in carp diets at the level of 25% (Hertrampf et al., 2000). In India, carp fingerlings fed a mixture of peanut cake and rice bran had better growth than fish fed a cattle feed, but the latter was more economical (Sathyanarayanappa et al., 2000). Young carps fed a diet based on pelleted peanut cake had better growth than those fed natural fish food organisms and conventional fish feed. Water quality and proximate composition of fish flesh were similar (Nagaraj et al., 1990). A more recent trial in China was less positive: inclusion of peanut meal at 25 or 50% (as fed basis) in the diets of juvenile crucian carp (*Carassius auratus gibelio* x *Cyprinus carpio*) had deleterious effect on growth rate and feed conversion ratio and also produced health risks (Cai ChunFang et al., 2013).

Tilapia

An early study in Taiwan reported that the specific growth rate of blue tilapia (*Oreochromis aureus*) fed on an all peanut protein diet was only 58% that of fish fed a fish meal-based control (Wu JenLei et al., 1977). A later study in the UK with Mozambique tilapia (*Orechromis mossambicus*) fry found that peanut meal was an acceptable protein source but only at a low inclusion level (25% of diet protein, 17% dietary level) as growth decreased rapidly with increasing levels of peanut meal. Since the peanut meal sample was almost free of aflatoxins, the poor performance was possibly explained by its low methionine level (Jackson et al., 1982). In Turkey, more recent studies, also conducted with Mozambique tilapia fry, have confirmed that peanut meal is acceptable only at low rates of fish meal substitution (10 or 20% replacement, 6 or 13% dietary level) as higher rates depress growth and feed efficiency (Yildirim et al., 2014; Yildirim et al., 2016).

Catfish

Peanut meal was reported as being used in Thailand in catfish diets at the level of 25% (Hertrampf et al., 2000). In Nigeria, various combinations of cottonseed meal and peanut meal (for a total inclusion rate of 29%) were tested on *Clarias gariepinus* fingerlings. The best growth was obtained with 50:50 cottonseed:peanut (about 15% inclusion rate each), which is explained by the authors by the complementary amino acid profiles of both oil meals (Tiamiyu et al., 2013)

Crustaceans

White shrimp (*Litopenaeus vannamei*)

Several studies have assessed the value of peanut meal in white shrimp diets and concluded that only part of fish meal can be replaced by it. An experiment with juvenile white shrimp concluded that about 12% peanut meal could be used to substitute 20% of the animal protein mix in the diet. If the palatability of the diet can be improved, up to 35% peanut meal could be used to replace 60% of the animal protein mix (Lim, 1997). In white shrimp fed a basal diet containing 30% fish meal, replacing more than 10% of the fish meal with peanut meal (3.8% dietary level) depressed weight gain rate, special growth rate and protein efficiency ratio (Yang QiHui et al., 2011). Better results were obtained with a mixture of soybean meal and peanut meal partially replacing fish meal: it was possible to use 20% fish meal instead of 30% by including 14% soybean meal and 16.5% peanut meal. Higher substitution rates were detrimental to performance (Yue YiRong et al., 2012). Another study recommended a maximum inclusion rate of 14% peanut meal (Liu XiangHe et al., 2012)

Red swamp crayfish (*Procambarus clarkii*)

In juvenile red swamp crawfish, the inclusion of 25% peanut meal (30% of diet protein, partial substitution of soybean meal) was detrimental to growth. The substitution of 30% fish meal by peanut meal depressed intake and diet digestibility (Hertrampf et al., 2000).

Other species

African giant land snail (*Archachatina marginata*)

A mixture of cassava flour and groundnut cake was used successfully to feed African giant land snails (Amubode et al., 1995).

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Peanut meal

Description | Nutritional aspects | Nutritional tables | References

Tables of chemical composition and nutritional value

- Peanut meal, oil < 5%, low fibre
- Peanut meal, oil < 5%, high fibre
- Peanut meal, oil > 5%

Avg: average or predicted value; SD: standard deviation; Min: minimum value; Max: maximum value; Nb: number of values (samples) used

Peanut meal, oil < 5%, low fibre

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	90.4	1.5	86.5	93.4	210
Crude protein	% DM	53.3	5.0	42.5	63.8	221
Crude fibre	% DM	7.1	1.3	4.5	9.9	220
NDF	% DM	16.7	7.2	9.8	37.5	19 *
ADF	% DM	10.0	1.7	5.9	12.2	18 *
Lignin	% DM	2.8	1.1	0.5	4.5	25 *
Ether extract	% DM	2.1	1.2	0.3	4.9	146
Ether extract, HCl hydrolysis	% DM	2.4	0.8	1.0	4.6	14
Ash	% DM	6.9	1.3	4.6	9.6	144
Total sugars	% DM	12.4	2.3	8.1	14.4	8
Gross energy	MJ/kg DM	20.0	0.5	19.2	20.3	6 *

Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	1.8	0.9	0.1	3.9	69
Phosphorus	g/kg DM	6.9	0.6	5.7	8.1	70
Potassium	g/kg DM	13.9	1.6	12.0	17.6	18
Sodium	g/kg DM	0.1				1
Magnesium	g/kg DM	3.9	0.3	3.3	4.3	15
Manganese	mg/kg DM	48	23	29	103	9
Zinc	mg/kg DM	62	5	54	69	8
Copper	mg/kg DM	18	2	14	21	9

Amino acids	Unit	Avg	SD	Min	Max	Nb
Arginine	% protein	11.2				1
Histidine	% protein	2.4				1
Isoleucine	% protein	3.2				1
Leucine	% protein	5.9				1
Lysine	% protein	3.5		3.5	3.5	2
Methionine	% protein	1.0				1
Phenylalanine	% protein	4.8				1
Threonine	% protein	2.5				1
Tryptophan	% protein	0.7				1
Valine	% protein	3.8				1

Ruminant nutritive values	Unit	Avg	SD	Min	Max	Nb
OM digestibility, ruminants	%	83.7				*
Energy digestibility, ruminants	%	84.3				*
DE ruminants	MJ/kg DM	16.9				*
ME ruminants	MJ/kg DM	12.6				*
Nitrogen degradability (effective, k=6%)	%	75				1

Pig nutritive values	Unit	Avg	SD	Min	Max	Nb
Energy digestibility, growing pig	%	79.0				*
DE growing pig	MJ/kg DM	15.8				*
MEn growing pig	MJ/kg DM	14.5				*

NE growing pig	MJ/kg DM	9.0				*
Nitrogen digestibility, growing pig	%	81.0				1

The asterisk * indicates that the average value was obtained by an equation.

References

AFZ, 2011; CIRAD, 1991; CIRAD, 1994; CIRAD, 2008; De Boever et al., 1988; De Boever et al., 1994; Knabe et al., 1989; Krishna, 1985; Masoero et al., 1994; Nehring et al., 1963; Neumark, 1970; Perez et al., 1984; Vérité et al., 1990; Vermorel, 1973

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Peanut meal, oil < 5%, high fibre

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	89.4	1.6	85.2	93.8	1261
Crude protein	% DM	54.5	3.5	45.0	63.0	1297
Crude fibre	% DM	13.5	1.7	8.9	18.2	1174
NDF	% DM	26.6	5.6	12.5	38.1	122 *
ADF	% DM	16.6	1.9	10.5	20.4	125 *
Lignin	% DM	5.9	1.2	2.8	8.6	157 *
Ether extract	% DM	0.9	0.5	0.1	2.9	917
Ash	% DM	6.4	0.6	4.8	8.1	789
Total sugars	% DM	9.0	1.1	7.1	11.0	42
Gross energy	MJ/kg DM	20.2	0.7	18.4	21.1	30 *

Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	1.6	0.6	0.4	3.3	438
Phosphorus	g/kg DM	6.1	0.4	5.0	7.3	440
Potassium	g/kg DM	15.3	0.9	13.1	17.2	103
Sodium	g/kg DM	0.0	0.1	0.0	0.4	58
Magnesium	g/kg DM	3.4	0.2	3.0	3.9	109
Manganese	mg/kg DM	41	6	31	54	53
Zinc	mg/kg DM	60	4	53	71	52
Copper	mg/kg DM	15	2	12	19	53
Iron	mg/kg DM	579	168	305	724	7

Amino acids	Unit	Avg	SD	Min	Max	Nb
Alanine	% protein	4.4	0.8	3.5	5.5	6
Arginine	% protein	12.6	2.8	10.4	17.5	5
Aspartic acid	% protein	11.9	2.2	10.2	15.5	6
Cystine	% protein	1.3	0.2	1.1	1.7	5
Glutamic acid	% protein	19.6	4.2	16.1	26.5	6
Glycine	% protein	5.9	1.0	5.1	7.5	6
Histidine	% protein	2.3	0.4	2.1	2.9	4
Isoleucine	% protein	3.7	0.7	3.3	4.9	5
Leucine	% protein	6.6	1.0	5.9	8.5	6
Lysine	% protein	3.5	0.4	3.1	4.1	7
Methionine	% protein	1.1	0.1	0.9	1.2	6
Phenylalanine	% protein	5.0	0.9	4.5	6.8	6
Proline	% protein	5.2	2.7	3.5	8.3	3
Serine	% protein	5.0	1.0	4.1	7.0	6
Threonine	% protein	2.8	0.5	2.5	3.6	6
Tryptophan	% protein	0.8	0.3	0.4	1.0	3
Tyrosine	% protein	3.5	0.9	2.9	5.1	5
Valine	% protein	4.1	0.8	3.1	5.6	6

Ruminant nutritive values	Unit	Avg	SD	Min	Max	Nb
OM digestibility, ruminants	%	81.6				*
Energy digestibility, ruminants	%	82.5				*
DE ruminants	MJ/kg DM	16.7				*
ME ruminants	MJ/kg DM	12.3				*
Nitrogen digestibility, ruminants	%	79.4				*
a (N)	%	27.0				1
b (N)	%	70.4				1
c (N)	h-1	0.107				1

Nitrogen degradability (effective, k=4%)	%	78				*
Nitrogen degradability (effective, k=6%)	%	72	6	72	90	7 *

Pig nutritive values	Unit	Avg	SD	Min	Max	Nb
Energy digestibility, growing pig	%	76.1				*
DE growing pig	MJ/kg DM	15.4				*
Nitrogen digestibility, growing pig	%	85.4				1

Poultry nutritive values	Unit	Avg	SD	Min	Max	Nb
AMEn cockerel	MJ/kg DM	11.6	0.2	11.6	12.5	3 *
AMEn broiler	MJ/kg DM	11.6				*

The asterisk * indicates that the average value was obtained by an equation.

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Peanut meal, oil > 5%

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	92.3	2.1	87.3	96.5	218
Crude protein	% DM	49.1	4.8	38.5	59.9	236
Crude fibre	% DM	7.0	2.2	3.1	13.4	220
NDF	% DM	18.1	3.3	7.8	21.4	41 *
ADF	% DM	9.9	2.9	5.2	14.8	43 *
Lignin	% DM	2.7	1.3	0.5	4.9	38 *
Ether extract	% DM	9.8	3.4	5.3	19.6	212
Ash	% DM	5.8	0.9	3.6	8.1	215
Total sugars	% DM	10.2	1.7	8.7	12.7	7
Gross energy	MJ/kg DM	21.7	1.7	18.9	25.9	15 *

Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	1.2	0.4	0.1	2.8	134
Phosphorus	g/kg DM	6.3	0.8	4.6	8.0	133
Potassium	g/kg DM	13.5	1.2	10.6	16.3	86
Sodium	g/kg DM	0.2	0.1	0.0	0.3	10
Magnesium	g/kg DM	3.4	0.3	2.8	4.0	84
Manganese	mg/kg DM	47	16	23	76	14
Zinc	mg/kg DM	59	10	35	72	15
Copper	mg/kg DM	16	4	12	23	13
Iron	mg/kg DM	612		216	1009	2

Amino acids	Unit	Avg	SD	Min	Max	Nb
Alanine	% protein	4.2	0.8	3.5	5.8	7
Arginine	% protein	12.0	0.7	11.0	13.4	9
Aspartic acid	% protein	12.6	2.0	10.2	16.2	6
Cystine	% protein	1.0		0.9	1.2	2
Glutamic acid	% protein	20.5	3.8	16.7	27.9	7
Glycine	% protein	6.0	0.8	5.2	7.6	7
Histidine	% protein	2.5	0.3	2.1	3.0	9
Isoleucine	% protein	3.4	0.2	2.9	3.8	9
Leucine	% protein	6.5	0.9	5.6	8.6	10
Lysine	% protein	3.5	0.4	2.7	4.2	10
Methionine	% protein	1.0	0.1	0.9	1.2	6
Phenylalanine	% protein	5.0	0.7	4.0	6.6	9
Proline	% protein	4.0	1.0	2.5	4.8	6
Serine	% protein	5.1	0.7	4.5	6.6	7
Threonine	% protein	2.9	0.4	2.6	3.7	10
Tryptophan	% protein	1.1	0.4	0.7	1.8	5
Tyrosine	% protein	3.8	0.8	2.9	5.1	6
Valine	% protein	4.1	0.5	3.4	5.3	10

Secondary metabolites	Unit	Avg	SD	Min	Max	Nb
Tannins (eq. tannic acid)	g/kg DM	1.3		0.5	2.1	2

Ruminant nutritive values	Unit	Avg	SD	Min	Max	Nb
OM digestibility, ruminants	%	83.7		82.6	83.7	2 *
Energy digestibility, ruminants	%	85.3		85.3	87.6	2 *
DE ruminants	MJ/kg DM	18.5				*
ME ruminants	MJ/kg DM	14.0		13.3	14.2	2 *
ME ruminants (gas production)	MJ/kg DM	12.1				1
Nitrogen digestibility, ruminants	%	94.0				1
a (N)	%	67.3				1
b (N)	%	32.7				1
c (N)	h-1	0.120				1
Nitrogen degradability (effective, k=4%)	%	92				*
Nitrogen degradability (effective, k=6%)	%	89				*

Pig nutritive values	Unit	Avg	SD	Min	Max	Nb
Energy digestibility, growing pig	%	79.2				*
DE growing pig	MJ/kg DM	17.2				*
MEn growing pig	MJ/kg DM	16.0		15.0	16.1	2 *
NE growing pig	MJ/kg DM	10.6				*
Nitrogen digestibility, growing pig	%	83.0		83.0	83.0	2

Poultry nutritive values	Unit	Avg	SD	Min	Max	Nb
AMEn broiler	MJ/kg DM	11.7		11.4	12.1	2

The asterisk * indicates that the average value was obtained by an equation.

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- Gilles Tran, AFZ
- Denis Bastianelli, CIRAD
- Denis Bastianelli, CIRAD

Peanut meal

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