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Cashew (Anacardium occidentale L.) nuts and byproducts

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Common names

Tree

Cashew tree, cashew nut tree, cashewnut tree, cashew [English]; Anacardier, cajou [French]; kasjoeboom, acajouboom, olifantsluisboom [Dutch]; anacardo, marañon, merey [Spanish]; cajueiro, acaju, acajaíba, acajuíba, caju-comum, cajueiro-comum, cajuil, caju-manso, cajuzeiro, ocaju [Portuguese]; kasjoeboom [Afrikaans]; มะม่วงหิมพานต์ [Thai]; đào lộn hột [Vietnamese]; [Bengali]; [Gujarati]; [Hindi]; [Maharati]

Fruit (nut) and byproducts

- Cashew nut, cashewnut, blister nut [English]; noix de cajou [French]; kasjoenoot [Dutch]; castaña de cajù, caujil, alcayoiba, merey a la nuez, nuez de la India, pajuil, jocote marañon, pepas [Spanish]; castanha de caju, farelo do castanha de caju [Portuguese]; kasjoenoeut [Afrikaans]
- Cashew nut meal, cashew nut reject meal [English]
- Cashew Nut Shell Liquid (CNSL) [English]; baume cajou [French]

Pseudofruit and its byproducts

- Cashew apple [English]; pomme cajou, pomme de cajou [French]; merey a la fruta, marañon [Spanish]; pedúnculo de caju [Portuguese]; kasjoeappel [Afrikaans]
- Cashew bagasse, cashew pomace, cashew apple pulp, cashew pulp, cashew apple waste [English]; pulpe de pomme cajou [French]; bagaço de caju [Portuguese]

Species

Anacardium occidentale L. [Anacardiaceae]

Synonyms

Acajuba occidentalis (L.) Gaertn., *Anacardium microcarpum* Ducke, *Cassuvium pomiferum* Lam.

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Description

The cashew tree (*Anacardium occidentale* L.). is a medium-sized tropical tree mainly cultivated for its fruit (cashew nut) and pseudofruit (cashew apple). It is also a multipurpose species that provides a broad range of services. About 30-40% cashew kernels are discarded during the process of roasting and are then fed to livestock (Göhl, 1982).

Morphological description

The cashew tree is a spreading, low-branched, evergreen, medium-sized tree. It can grow to a height of 6-12 m. It is many branched. The crown has a globose shape and is 6-15 m large in diameter, though a specimen in Brazil is famous for its circumference of 500 m. The cashew tree is deeply taprooted and develops many lateral roots that enable its survival during dry periods (Orwa et al., 2009). The leaves are alternate, leathery, borne in terminal clusters, oval-obovate-shaped, 10-20 cm long x 5-10 cm broad. Pale green or reddish when young, they become dark green when maturing (Orwa et al., 2009).The inflorescences are 15-25 cm long terminal panicles of male, female and bisexual flowers. Flowers are pentamerous, no more than 1 cm in diameter, yellowish-pink in colour, and very fragrant. They are attractive to bees and provide a good source of honey (Morton, 1987; FAO, 1982). The fruit is a kidney-shaped nut consisting in a double-walled shell with a hard epicarp, a poisonous mesocarpe and a thin endocarp, and an edible kernel surrounded by a thin testa. The fruit does not split open at maturity, but once its fruit is fully grown but not yet ripe, its receptacle swells and becomes a fleshy, juicy, pear-shaped or apple-shaped edible pseudofruit that is called the cashew apple (Orwa et al., 2009; Morton, 1987). This pseudofruit has a very

conspicuous yellow, red or red-and-yellow colour.

Uses

The cashew tree is a multipurpose species and cashew products have a wide range of utilizations. The kernel of the cashew nut, the pseudofruit (cashew apple) and the leaves are edible. Almost all parts of the cashew tree are reported to have ethnomedicinal properties (Morton, 1987).

- **Cashew nuts** (kernels) must be extracted from their poisonous shell with caution in order not to be contaminated by the toxic substances embedded in the mesocarp. Once extracted from the nut, the kernels are roasted to destroy the remaining toxins (Orwa et al., 2009; Morton, 1987). The kernels are a nutritious food as they contain good amounts of fats, protein, carbohydrates, vitamins and minerals.
- **Discarded cashew nuts** are nuts unfit for human consumption. They are often referred to as **cashew nut meal** or **cashew nut reject meal** in the literature. They are used to feed livestock.
- **Cashew apples** (the pseudofruit) are too fragile to be suitable for transport and relished only in production areas such as Brazil, Mozambique and Indonesia. They can be eaten fresh in salads, pressed to make juices, cooked in syrup or made into jams for preservation.
- **Cashew pulp** is the residue of the separation of the nut from the pseudofruit and **cashew bagasse** (**cashew pomace**, **cashew apple waste**) is the residue of the juice extraction from the pseudofruit. Both products are suitable for livestock feeding. It should be noted that the term "cashew pulp" is ambiguous and sometimes used for the bagasse (Geron et al., 2013).
- **Cashew nut oil meal** or **cashew nut oil cake** is the residue of the oil extraction from kernels. It is suitable for livestock feeding.
- **Cashew nut testa** are the red skins that are manually or mechanically removed in the final step of preparing cashew nuts for confectionery. These skins may contain pieces of broken kernels and can be used as feed (Donkoh et al., 2012).
- **Cashew tree leaves** can be cut and eaten fresh or cooked.
- **Cashew tree timber** provides good firewood and can make valuable charcoal. The nut shells can be burnt to produce heat in the plants processing Cashew Nut Shell Liquid.
- **Cashew Nut Shell Liquid** (CNSL), also known as **cashew shell oil**, is contained in the fruit mesocarp. CNSL is a mixture of 70% anacardic acid (a salicylic acid analog and a strong skin irritant), 18% cardol, and 5% cardanol. The two latter components are caustic phenolic substances that readily polymerize and are used for epoxy resins, varnishes, and many high-tech materials that can stand high temperatures, such as brake linings (Orwa et al., 2009; Duke, 1983). CNSL is also used as a pesticide against termite in timbers and the bark gum is repellent to insects (Duke, 1983).

Distribution

The cashew tree is native to tropical America, from Mexico and the West Indies to Brazil and Peru. It was brought to Mozambique by the Portuguese in the 16th century. It is now widely naturalized in the tropics, particularly in coastal areas (Orwa et al., 2009; Duke, 1983; FAO, 1982). The cashew tree grows wild in many places and is found from sea level up to an altitude of 1000 m (FAO, 1982). It can grow in places where annual rainfall ranges from 700 mm to 4200 mm (but does better between 700 and 2000 mm) and where annual temperature is between 21°C and 28°C (Orwa et al., 2009; Duke, 1983; FAO, 1982). The tree is very tolerant of drought and can survive a 2-5 months dry season (Duke, 1983). Cashew nut production and quality are better if the period during flowering and fruit maturation is dry (Orwa et al., 2009). The cashew tree can grow in a wide range of soils including sterile, very shallow savanna soils. In very dry areas, it needs well-drained, deep soils to survive (Orwa et al., 2009; Duke, 1983). The tree is not as salt tolerant as other coastal tree species and it cannot survive frost (Orwa et al., 2009; Duke, 1983).

In 2013, the world production of cashew nuts was 4.39 million t. The 5 most important producers were Vietnam (1.1 million t), Nigeria (0.97 million t), India (0.75 million t), Côte d'Ivoire (0.45 million t) and Benin (0.18 million t). The 5 most important producers of cashew apples were Brazil, Mali, Madagascar and Guyana (FAO, 2015).

Processes

Harvest and end-products

Cashew nuts are harvested when mature, and fruit and pseudofruit are separated. In Asia, the nut is the most valuable product and is separated from the apple which remains on the ground or goes to waste. The nut is then sun-dried before kernel extraction (Mohod et al., 2011). On the contrary, in South America and the West indies, the cashew apple is the most important product and is processed into juice, jams and beverages (ITDG, 2002; Morton, 1987).

Kernel extraction

The cashew shell, when broken to extract the kernel, releases a caustic liquid (CNSL) that is a strong skin irritant. Processing requires gloves, or the nuts must be tumbled in sawdust or ashes to absorb the liquid (ITDG, 2002). Manual kernel extraction as practiced in some countries can cause serious burns on the hands of the workers. Several processes have been developed to reduce this hazard, such as pan- or drum-roasting, steaming prior to shelling and soaking in hot oil. In the roasting process, the exudate catches fire and produces a thick black and irritating smoke that contaminates air (Sengupta, 2007). After roasting, the nuts are quenched with water to prevent further burning. The waste water has also some contaminant effect and must be treated (Mohod et al., 2011; Sengupta, 2007). The roasted shells become brittle and can be easily opened (Mohod et al., 2011). In the steaming process, the nuts are placed in a boiler and steam-cooked, which makes shelling easier and produces a higher percentage of whole kernels due to the increased elasticity of the nuts and kernels (Mohod et al., 2011). In the oil soaking process, the nuts are put in a bath of hot oil (around 190°C) for a couple of minutes. The heat eases the CNSL release and nut shelling. Once the kernels are extracted, the thin testa surrounding them is removed by drying (ITDG, 2002).

Forage management

The cashew tree is a long-lived perennial, easy to grow, that can survive 50 to 60 years (Azam-Ali et al., 2001). It can be propagated by seed or vegetative materials. The seeds should be sown at 5-8 cm depth and at 10 m x 10 m distance (Orwa et al., 2009). Vegetative propagation is made by layering, budding or grafting. Once established, the trees can be thinned to 20 m x 20 m distance and grown at no more than 250 trees/ha (Orwa et al., 2009; Duke, 1983). In the earlier stages of growth, the tree should be weeded to conserve soil moisture. The tree starts bearing fruits after 3 years and reaches full production between 10 and 30 years (Orwa et al., 2009). Fruiting mainly occurs in the dry season but is possible year-round (Duke, 1983). Fruit maturity is obtained in 3 months after flowering. Once mature, fruits are dropped off. Cashew nut production ranges from 10 to 48 kg/tree/year.

Environmental impact

Health and environmental issues

The shelling of cashew nuts has deleterious effects on worker health and environment as seen above in **Processes**. CNSL is harmful to the skin, the smokes contaminate air and the wastewater contaminates soil and water. In India, the installation of cashew nut extraction plants is regulated: it is forbidden to build a cashew factory in the vicinity of hospitals, schools, airports and public buildings, and extraction plants must be distant of at least 500 m from each other (Sengupta, 2007).

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Nutritional attributes

Cashew nuts

Discarded cashew nuts unfit for human consumption have a protein content in the range of 18-27% DM, and an oil content of 36-51% DM. Note that the scientific literature often use the term "cashew nut meal" for discarded cashew nuts. The fibre content is generally low (crude fibre < 8% DM) but can be much higher (up to 16%) when the product contains a large proportion of shells (Lebas et al., 2012). Cashew nut oil consists largely in unsaturated fatty acids (60% acid oleic, 22% acid linoleic) (Lima et al., 2004).

Cashew nut oil meal

Cashew nut oil meal contains about 32-42% DM of crude protein and highly variable amounts of oil, depending on the extraction process. The fibre content is extremely low (crude fibre < 2% DM).

Cashew pulp and cashew bagasse

Cashew pulp and cashew bagasse have a variable amount of protein (8-15% DM) and are very rich in fibre. Lignin content is high (10-18% DM).

Cashew leaves

Cashew contain 9-15% DM of protein, with a high lignin content (15% DM) and a high content in condensed tannins (16% DM) (Mecha et al., 1980; Keir et al., 1997; Reddy et al., 2008).

Potential constraints

Cashew Nut Shell Liquid

CNSL is a resinous phenolic substance that is highly corrosive and produce blisters, particularly on the fingers of workers who shell the nuts manually. Fresh cashew nuts should never be eaten raw, neither should they be broken before being processed (Small, 2011). It is necessary to wear gloves or use mechanical/chemical processes during kernel extraction (ITDG, 2002).

Cashew nuts

Ground cashew nuts have been reported to cause diarrhoea if fed in large amounts to calves and dairy cows (Göhl, 1982).

Cashew apple ethanol intoxication

Cattle consuming fallen cashew apples at the time of harvest were reported to have difficulties in rumination and dizziness, due to possible ethanol intoxication (Assis et al., 2009). Several cases of cattle poisoning due to cashew apples have been reported in Brazil (Ribeiro Filho et al., 2012). Most of the outbreaks occurred after animals were allowed to eat fresh cashew apples *ad libitum*. It was suggested that cashew apple poisoning could be due to ethanol production in the rumen by fermentation (Ribeiro Filho et al., 2012). However, the poisoning lasts only a few hours, is reversible without treatment and seems to be non-lethal (Ribeiro Filho et al., 2012).

Ruminants

Cashew nut meal (CNM)

Discarded cashew nuts, usually called cashew nut meal, is an energy and nutrient rich product that can be used at relatively high levels in ruminant diets, though one should pay attention to its high oil content. Most trials have taken place in Brazil.

Dairy cows

Up to 24% cashew nut meal (i.e. 7 kg/day) could be included in the concentrate to supplement sugarcane-based daily rations (Pimentel et al., 2007). CNM could be included at 50% dietary level in a total mixed ration based on maize silage (Pimentel et al., 2012a). In both experiments, CNM inclusion did not change milk yield in comparison to the control diet (Pimentel et al., 2012a; Pimentel et al., 2007). CNM inclusion (24%) in a sugarcane-based diet decreased milk fat content from 36.8 g/kg to 26.6 g/kg (Pimentel et al., 2012a). In maize silage diet, CNM had no effect on DM intake (21.3 kg/day) (Pimentel et al., 2012a). CNM inclusion at 24% of a sugarcane-based diet significantly reduced sugarcane DMI from 7.7 to 7.05 kg DM/day and overall diet DMI from 14 kg DM/day to 13.22 kg DM/day (Pimentel et al., 2007). The form in which cashew is offered (separately or mixed into the diet) may explain those contradictory results. The inclusion of cashew nuts in the ration did not affect rumen fermentation parameters (Pimentel et al., 2012b). CNM included at 20% in dairy cow diets in the north-eastern Brazilian semi-arid conditions decreased the interval between post-partum and first ovulation (Brasil, 2003).

Sheep

Cashew nut meal can be safely introduced into sheep diets provided that the dietary lipid content is kept below 6-7%, as higher values will decrease fibre digestibility, DM intake and forage digestibility (Silva et al., 2013). CNM could be included at 13-18% into a concentrate fed (1.2% BW) to supplement hay in reproductive rams. It had no negative effect on sperm quality (Medeiros, 2005; Oliveira et al., 2014). CNM included at 12 or 24% into a concentrate fed to adult ewes as a supplement to hay had variable effects depending on its inclusion rate. At the lower level, no deleterious effect was observed. At 24% inclusion, CNM increased the number of degenerated oocytes and lowered the proportion of viable oocytes. It was thus recommended to limit its inclusion in ewes (Fernandes et al., 2014).

Table 1. Ruminant trials with cashew nut meal (CNM)

Animal	Country	Breed	Experiment	Inclusionrate	Main results	Reference
Sheep	Brazil	Santa Ines males (50 kg)	CNM replacing soybean meal in a concentrate for reproductive males	13% in total diet	No effect on DMI or sperm quality	Medeiros, 2005
Sheep	Brazil	Santa Ines males (25 kg)	Increasing levels of CNM into TMR	0 to 11.5%	No effect on DMI or DMD, but the higher level tended to decrease DMI	Pimentel et al., 2011
Sheep	Brazil	Unknown breed, male and female (26 kg)	Increasing levels of CNM (in place of soybean meal and maize) into a concentrate fed at 30% plus 70% forage	0 to 36% into concentrate	No effect on DMI or DWG (74.4 /d) but the DWG tended to be lower with the highest CNM level (55.4 g/d)	Rodrigues et al., 2003
Sheep	Brazil	Various breed (23 kg)	Diet with 13% CNM compared to diet without CNM	13%	No effect on DMI (75-77g/kg $BW^{0.75}$) or DMD (71-73%) of the ration but it decreased NDF digestibility (50 *vs.* 54.7%)	Silva et al., 2013
Sheep	Brazil	Fattening young crossbred goats (5-6 months)	Effect of fattening concentrate with CNM (for its richness in oleic acid) or without on meat quality	13%	No positive effect of CNM on meat quality	Santos-Filho et al., 2005
Goats	Brazil	Castrated goats (17 kg)	Increasing levels of CNM with *Cynodon* hay	10 to 25%	No effect on DMI; DMD and OMD tended to increase with CNM levels	Moraes, 2007

Cashew bagasse

Most trials with cashew bagasse have taken place in Brazil, usually with sheep. It is sometimes unclear whether the product tested is the bagasse (by-product of the juice extraction) or only the non-extracted pulp.

Nutritive value

Cashew bagasse has a low *in vitro* DM digestibility (46%), probably due to its high fibre and lignin content (Pereira et al., 2008). Ensiling up to 36% cashew bagasse with elephant grass silage improved the nutritive value of the silage and provided better conservation of silage (Ferreira et al., 2004). Treating cashew bagasse with urea improved its nutritive value (Dantas Filho, 2010).

Sheep

Including 19% dried cashew bagasse in growing sheep diets containing elephant grass, sorghum and soybean meal resulted in the better fermentation parameters (Rogerio et al., 2009). A mixture of dried cashew pulp and leucaena leaf meal at 50:50 ratio was found to be suitable for growing sheep in Brazil (Leite et al., 2005). Fed alone, fresh or dried cashew bagasse as forage had no effect on animal performance or age of puberty (Rodrigues et al., 2010). Dried cashew bagasse ensiled with elephant grass improved silage DM intake and growth of young sheep (Ferreira et al., 2004). Dried cashew bagasse could replace 50% of tropical forage in the diet of gestating and lactating ewes or of young growing male lambs without negative effects on reproductive performance of ewes or age of puberty of lambs (Rodrigues et al., 2010; Rodrigues et al., 2011). Used as forage for fattening lambs, dried cashew bagasse improved feed conversion ratio and resulted in better carcass characteristics (Silva et al., 2011).

Cattle

In India, sun-dried cashew bagasse could partly replace (50%) groundnut meal in a concentrate offered to Gir dairy cows to supplement a forage-based diet without modifying milk yield (Sundaram, 1986).

Table 2. Ruminant trials with dehydrated cashew bagasse (DCB) or pulp (DCP)

Animal	Country	Breed	Experiment	Rate of use	Main results	Reference
Sheep	Brazil	Santa Ines males (25 kg)	Increasing levels of DCB in a TMR diet in place of soybean meal	0, 10, 20, 30 or 40%	No effect on the diet DMI (1.4-1.6 kg DM/d); decrease of DMD (from 72.3 to 56.4%) and DWG (from 295 to 187 g/d) with increasing DCP levels	Dantas Filho et al., 2007
Sheep	Brazil	Santa Ines males (55 kg)	DCB treated with 6% urea included in a TMR in place of soybean cake	0 to 33% into TMR	DMI increased with DCP level, but DMD or OMD tended to decrease. Less body weight loss after lambing, higher DMI, no adverse effect on reproduction	Dantas Filho, 2010
Sheep	Brazil	Santa Ines ewes (43 kg)	DCB replacing tropical forage in a complete diet offered 90 d before and after lambing	50% in the diet	Less body weight loss after lambing, higher DMI, no adverse effect on reproduction	Rodrigues et al., 2011
Sheep	Brazil	Santa Ines males (7-9 kg)	DCB replacing tropical forage in a complete diet offered after weaning until puberty	50% in the diet	No effect on DWG (105-112 g/d) or age at puberty	Rodrigues et al., 2010
Sheep	Brazil	Cross breed growing male (12 kg)	DCB replacing sorghum silage offered with concentrate	*ad libitum*	Same DWG (118-133 g/d) and lower DMI (0.97 *vs.* 1.47 kg DM) and better feed conversion and better carcass characteristics	Silva et al., 2011
Sheep	Brazil	Various breed (18-20 kg)	Increasing levels of DCP associated with leucaena meal at various levels	Ratio varying from 30/70 to 70/30%	The best daily weight gain (153 g/d) obtained with 50/50% ratio compared to others (112-139 g/d)	Leite et al., 2005
Goats	Brazil	unknown (18 kg)	Increasing levels of DCB associated with *Cynodon* sp. hay	Ratio varying from 18/82 to 72/28%	DMI or OMI increased with DCP levels; but DM or OM digestibility decreased beyond the 46% level	Moraes, 2007
Dairy cows	India	Gir cow early lactation	DCB partly replacing groundnut meal in a concentrate offered as supplement to straw and green grass	10% in concentrate	No difference on milk yield (5.2 kg/d) or forage DMI (6.2 kg/d)	Sundaram, 1986

Cashew nut shells

In Nigeria, cashew nut shells included at up to 20% in West African dwarf goats fed on elephant grass-based diet resulted in lower feed intake, lower nutrient digestibility coefficients, lower daily weight gain and degraded feed conversion ratio. However, they had no impact on blood parameters, even at 30% dietary level, and could reduce feed costs (Ocheja et al., 2014; Okolo et al., 2012).

Cashew Nut Shell Liquid (CNSL)

It has been suggested that CNSL may reduce methane emissions from ruminants (Kobayashi, 2012). *In vitro* experiment showed that CNSL could favorably alter rumen microbes and inhibit methane production. In dairy cows, CNSL increased the production of propionate both *in vitro* and *in vivo* at 4 g/100 kg BW but not at lower levels (Coutinho et al., 2014).

Cashew tree leaves

Cashew tree leaves are not a good supplement. They have a high concentration in tannins and lignin, which explains the low values observed for DM intake and DM digestibility in goats (Reddy et al., 2008). In India, cashew tree leaves offered as a supplement (300 g/d) to male goats fed *ad libitum* with elephant grass (*Pennisetum purpureum*), failed to improve diet DM digestibility (Reddy et al., 2009). In Nigeria, cashew leaves fed alone to lambs did not meet their nutritional requirements and caused nitrogen losses (Anugwa et al., 1987).

Pigs

Cashew nut meal (CNM)

In Côte d'Ivoire, cashew nut meal could be fed at up to 6% dietary level to post-weaning pigs (6 to 12 week-old) without deleterious effect on growth performance. In growing pigs (12 to 24 week-old), including more than 5% CNM in the diet resulted in lower feed intake, lower daily gain and lower final liveweight though it had no deleterious effect on health parameters. It was suggested that CNM could partly replace maize in the ration (Yao et al., 2013). An experiment in Nigeria concluded that CNM could be included in the diets of weaner pigs to replace soybean meal at up to 10% level with little or no deleterious effect on rate of gain (Fanimo et al., 2004). It was reported that a much higher inclusion rate of CNM (30%) had no deleterious effect on animal performance and reduced feed costs (Oddoye et al., 2011). In fattening pigs, diets containing CNM produced better results than groundnut meal diets (Fetuga et al., 1974).

Cashew nut oil meal

In Nigeria, growing pigs could be fed on cashew nut oil meal (expeller extracted) during 8 weeks at up to 28% dietary level. These pigs had better feed intake, better true digestibility of N and better N retention than those fed on groundnut meal (Fetuga et al., 1974).

Cashew apples and cashew bagasse

In the Philippines, fattening pigs could be fed on 20% fresh cashew apples or 20% sun-dried cashew apples used as a supplement to a mixed ration made of rice bran, maize meal and fish meal. Animal performance was not significantly different from those obtained with the control diet, and feed costs were significantly reduced (Acero et al., 2013). In Brazil, dried cashew bagasse could be fed to growing pigs at up to 20% dietary level. Compared to soybean meal or sorghum, dried cashew bagasse had low protein digestibility (12%) and low energy digestibility (23%) which resulted in low metabolizable energy (1051 kcal/kg) and reduced metabolizable energy of the diet (3225 kcal/kg *vs.* 4125 kcal/kg) (Farias et al., 2008).

Cashew nut testa

In rats used as a model for pig feeding, cashew nut testa could be fed at up to 15% dietary level. However, increasing cashew nut testa in the diet resulted in decreased feed intake, decreased water intake, lower liveweight gain and lower efficiency of feed utilisation, and it was suggested that optimal level would be 5% inclusion (Donkoh et al., 2012). In Nigeria, cashew nut testa (used as a protein source and substitute for groundnut meal) and dusa (a by-product of alcohol production from sorghum) included at 25% dietary level each in the diet of growing pigs (19 kg LW) were shown to have no deleterious effect on animal performance (Adesehinwa et al., 2004). In Brazil, however, the inclusion of cashew nut testa in finishing pig rations resulted in degraded feed conversion ratio, reduced carcass yield, bacon thickness and fat:meat ratio. It increased feed costs and was subsequently not recommended (Pinheiro et al., 2000).

Poultry

Cashew nut meal (CNM)

Broilers

Cashew nut meal can be included in broiler diets. Several experiments suggest that up to 20% CNM can be used without consequences on broiler performance (Oluwasola, 2006; Freitas et al., 2006; Sogunle et al., 2009). In some cases, growth performance and feed efficiency were improved by CNM, probably due to higher energy value than anticipated in feed formulation (Sogunle et al., 2009; Freitas et al., 2006). Feed intake was not negatively affected, and sometimes increased (Ojewola et al., 2004). Performance was slightly affected at the highest inclusion levels (30%) (Sogunle et al., 2009). Enzyme addition had no effect on CNM utilization (Fuentes et al., 2001). Internal fat deposition can be increased with high CNM diets, probably because of its high fat and energy content (Freitas et al., 2006; Oluwasola, 2006). There was no negative effect on meat quality, although meat from broilers fed CNM diets had a higher fat content (Adeyeye et al., 2007).

Turkeys

In turkey poults, CNM was tried with success at 8% inclusion in diets (Ogungbenro et al., 2013).

Layers

In layers, CNM tended to have a negative effect on egg production. Laying performance decreased and feed efficiency was lowered with increasing CNM levels. Laying rate was 3% lower when only 5% CNM was added in the diet, and 14% lower when 25% CNM was used. Feed intake was stable (Cruz et al., 2015) or slightly lowered (Odunsi, 2002).

Cashew nut oil meal

In layers, the use of defatted cashew nuts improved results compared to full-fat CNM (Akande et al., 2015).

Cashew apples

In Cambodia, dried and ground cashew apples could be included at up to 15% in the diet of growing ducks without adverse effect on weight gain (Meng Song et al., 2008).

Cashew bagasse

In broilers, the addition of 5% to 15% dehydrated cashew bagasse in the diets did not significantly affect growth performance,

but feed intake was increased and feed efficiency was degraded (Ramos et al., 2006).

Rabbits

Cashew nut meal (CNM)

In Nigeria, several studies have shown that cashew nut meal may replace 75% of full-fat soybeans in the diet of growing rabbits without alteration of growth rate or nutrients digestibility (Akindiji Akindele, 2002; Ademilua, 2003). At 100% replacement, the growth rate and feed efficiency were slightly altered, but this lower performance may be more the consequence of the low lysine content of cashew nut proteins (4% protein, below requirement) compared to that of soybeans (6%, above requirements) than the consequence of any type of noxious content in the cashew nuts. Growth performance in rabbits was identical or close to that of the control diet when up to 20% cashew nut meal was introduced in balanced diets, independently of the fibre content. Even at such inclusion rate there was no significant adverse effect on carcass characteristics and sensory attributes (Akinnusi et al., 2007).

Cashew pulp and cashew bagasse

In Nigeria, including sun-dried cashew pulp (Aribido et al., 2010) or cashew bagasse (Fanimo et al., 2003) in rabbit diets gave the best average daily gain, feed conversion ratio and protein efficiency ratio with diets containing the 30-35% cashew waste. However, a significant reduction in protein digestibility was observed (Fanimo et al., 2003). Dried cashew pulp and cashew bagasse may thus be considered as suitable sources of protein and energy for rabbit feeding.

Fish

No information was found about the use of cashew nut products in fish nutrition (2015). Cashew bark extracts have been used as piscicides in Nigeria and as a stupefiant in order to ease fish cropping (Ekpendu et al., 2014; Fafioye, 2005).

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Tables of chemical composition and nutritional value

- Cashew nut kernels
- Cashew oil meal
- Cashew bagasse, dried

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

Cashew nut kernels

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	93.6	3.8	83.1	96.7	15
Crude protein	% DM	22.6	2.3	17.6	26.3	17
Crude fibre	% DM	3.7	2.4	0.9	7.1	9
NDF	% DM	20.2	5.2	15.9	28.8	5
ADF	% DM	9.2	4.2	4.3	11.9	3
Lignin	% DM	2.9		2.2	3.6	2
Ether extract	% DM	44.0	4.3	35.8	50.9	16
Ash	% DM	3.4	1.6	1.3	7.1	17
Gross energy	MJ/kg DM	27.9		26.8	27.9	2 *

Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	1.1	0.7	0.2	2.2	7
Phosphorus	g/kg DM	4.8	2.4	1.5	8.4	8
Potassium	g/kg DM	3.5	3.9	1.1	8.0	3
Sodium	g/kg DM	1.3	0.7	0.6	2.0	3
Magnesium	g/kg DM	1.8	0.6	1.2	2.5	3
Manganese	mg/kg DM	14	8	8	23	3
Zinc	mg/kg DM	36	20	17	56	3
Copper	mg/kg DM	22				1
Iron	mg/kg DM	118	78	50	223	4

Amino acids	Unit	Avg	SD	Min	Max	Nb
Arginine	% protein	9.9				1
Cystine	% protein	1.1		0.6	1.7	2
Glycine	% protein	4.2				1
Histidine	% protein	2.0				1
Isoleucine	% protein	3.8				1
Leucine	% protein	6.8		6.6	7.1	2
Lysine	% protein	4.0		3.9	4.2	2
Methionine	% protein	1.4		1.4	1.4	2
Phenylalanine	% protein	3.7				1
Threonine	% protein	3.3		3.1	3.5	2
Tryptophan	% protein	1.5		1.3	1.6	2
Tyrosine	% protein	2.7				1
Valine	% protein	5.2				1

Fatty acids	Unit	Avg	SD	Min	Max	Nb
Palmitic acid C16:0	% fatty acids	8.8				1
Stearic acid C18:0	% fatty acids	7.9				1
Oleic acid C18:1	% fatty acids	60.3				1
Linoleic acid C18:2	% fatty acids	21.5				1
Linolenic acid C18:3	% fatty acids	0.5				1

Pig nutritive values	Unit	Avg	SD	Min	Max	Nb
Energy digestibility, growing pig	%	84.3				*

DE growing pig	MJ/kg DM	23.5				*
Nitrogen digestibility, growing pig	%	87.2				1

Poultry nutritive values	Unit	Avg	SD	Min	Max	Nb
AMEn cockerel	MJ/kg DM	21.2				1
AMEn broiler	MJ/kg DM	19.6				1

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

References

AFZ, 2011; Akande et al., 2015; Aletor et al., 2007; Fetuga et al., 1973; Fialho et al., 1995; Lima et al., 2004; Madaan et al., 1984; Oddoye et al., 2011; Odunsi, 2002; Pimentel et al., 2012; Piva et al., 1971; Regadas Filho et al., 2011; Rodrigues et al., 2003; Silva et al., 2008; Silva et al., 2013; Sogunle et al., 2009

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Cashew oil meal

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	93.7	2.5	91.4	96.9	4
Crude protein	% DM	36.6	3.4	32.3	41.7	5
Crude fibre	% DM	0.9		0.8	1.1	2
Ether extract	% DM	16.9	8.2	7.6	27.4	4
Ash	% DM	5.1	0.9	3.8	5.7	4
Gross energy	MJ/kg DM	22.4				*

Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	1.5		0.7	2.4	2
Phosphorus	g/kg DM	12.0		5.5	18.5	2
Potassium	g/kg DM	2.0		1.6	2.3	2
Sodium	g/kg DM	1.1		0.5	1.7	2
Magnesium	g/kg DM	3.2		2.0	4.5	2
Manganese	mg/kg DM	11				1
Zinc	mg/kg DM	25				1
Iron	mg/kg DM	139				1

Secondary metabolites	Unit	Avg	SD	Min	Max	Nb
Tannins (eq. tannic acid)	g/kg DM	14.3				1

Pig nutritive values	Unit	Avg	SD	Min	Max	Nb
Energy digestibility, growing pig	%	88.7				*
DE growing pig	MJ/kg DM	19.8				*

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

References

Akande et al., 2015; Aletor et al., 2007; Fetuga et al., 1974; Lima et al., 2004; Ojewola et al., 2004

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Cashew bagasse, dried

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	89.9	3.8	84.8	96.3	6
Crude protein	% DM	14.9	2.5	10.5	18.7	8
Crude fibre	% DM	11.7	2.5	8.4	14.3	4
NDF	% DM	70.4	8.1	64.4	81.8	4
ADF	% DM	40.0	5.4	33.1	44.7	4
Lignin	% DM	14.9	4.5	9.7	17.7	3
Ether extract	% DM	3.6	1.8	1.5	6.6	6
Ash	% DM	4.4	1.3	2.7	6.3	6
Gross energy	MJ/kg DM	20.6				*

Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	2.7		0.9	4.5	2

Phosphorus	g/kg DM	3.0				1

Amino acids	Unit	Avg	SD	Min	Max	Nb
Lysine	% protein	3.8				1
Methionine	% protein	1.3				1

Secondary metabolites	Unit	Avg	SD	Min	Max	Nb
Tannins (eq. tannic acid)	g/kg DM	18.0				1

Pig nutritive values	Unit	Avg	SD	Min	Max	Nb
Energy digestibility, growing pig	%	46.7				*
DE growing pig	MJ/kg DM	9.6				*
Nitrogen digestibility, growing pig	%	72.8				*

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

References

Dantas Filho, 2010; Fanimo et al., 2003; Farias et al., 2008; Moraes, 2007; Ramos et al., 2006; Regadas Filho et al., 2011; Rodrigues et al., 2010; Sundaram, 1986

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