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Pigeon pea (Cajanus cajan) seeds

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Common names

Pigeon pea, no-eye pea, no-eyed pea, tropical green pea, cajan pea [English]; pois d'Angole, pois cajan, pois-congo, ambrevade [French]; guandú, gandul, guandul, frijol de palo, quinchoncho [Spanish]; guandu, andu, anduzeiro, guandeiro, feijão boer [Portuguese]; Straucherbse [German]; pwa kongo [Haitian creole]; gude, kacang gude [Indonesian]; caiano [Italian]; umukunde [Kinyarwanda]; pī kula [Tongan]; Đậu triều [Vietnamese]; 木豆 [Chinese]; [Gujarati]; [Hindi]; キマメ [Japanese]; نخود کفتری [Persian]; Голубиный горох [Russian]; [Tamil]

Species

Cajanus cajan (L.) Huth [Fabaceae]

Synonyms

Cajanus bicolor DC., *Cajanus flavus* DC., *Cajanus indicus* Spreng., *Cytisus cajan* L.

Feed categories

- Legume seeds and by-products
- Plant products and by-products

Related feed(s)

- Pigeon pea (Cajanus cajan) forage

Description

Pigeon pea (*Cajanus cajan* (L.) Huth) is one of the most common tropical and subtropical legumes cultivated for its edible seeds. Pigeon pea is fast growing, hardy, widely adaptable, and drought resistant (Bekele-Tessema, 2007). Thanks to drought resistance it can be considered of utmost importance for food security in regions where rain failures are prone to occur (Crop Trust, 2014).

Morphology

The fruit of *Cajanus cajan* is a flat, straight, pubescent, 5-9 cm long x 12-13 mm wide pod. It contains 2-9 seeds that are are brown, red or black in colour, small and sometimes hardcoated (FAO, 2016a; Bekele-Tessema, 2007).

Uses

Dry pigeon peas (seeds) are common in Indonesian and Indian cuisines. In India, pigeon peas are soaked, dried, hulled and split to prepare dhal. In Indonesia, pigeon peas are fermented with *Rhizopus* mould then soaked, dehulled and cooked to produce tempeh. Fermentation with *Aspergillus oryza* yields a sauce similar to soy sauce (Orwa et al., 2009). Dry peas can be ground and mixed with wheat flour in order to increase the flour protein content. Immature pods may be cooked in curries and other relishes (Orwa et al., 2009).

Cajanus cajan has numerous uses in animal feeding. The leaves and pods are valuable and palatable protein-rich fodder. Leaves are sometimes used to replace alfalfa in ruminants diets where alfalfa cannot be grown. Seed processing by-products and sometimes the seeds themselves are used as livestock feed (Phatak et al., 1993). The seeds can be fed to poultry, and mixtures of pigeon pea with maize grain were successful in Hawaii (Orwa et al., 2009). Plant breeders have created varieties adapted to drier conditions, more resistant to diseases and suited to different production systems and cropping cycles (Valenzuela, 2011). Since the 1990s there has been a great scope for selecting cultivars with not only higher grain yields but also higher forage yields and crude protein (Phatak et al., 1993).

Distribution

The origin of *Cajanus cajan* is either Northeastern Africa or India (Ecocrop, 2016; van der Maesen, 1989). Its cultivation dates back to at least 3000 years (Mallikarjuna et al., 2011; van der Maesen, 1989). It is now a pantropical and subtropical species particularly suited for rainfed agriculture in semi-arid areas thanks to its deep taproot, heat tolerance and fast growing habit (Mallikarjuna et al., 2011). *Cajanus cajan* can be found in both hemispheres from 30°N to 30°S and from sea level to an altitude of 2000 m (3000 m in Venezuela) (Ecocrop, 2016). It is very heat-tolerant and grows better in places where temperatures range from 20° to 40°C and which are deprived of frost (FAO, 2016a). Though sensitive to frost, pigeon pea keeps growing at temperatures close to 0°C and tall plants can survive light frost. It does better where annual rainfall is above

625 mm but it is highly tolerant of dry periods and, where the soil is deep and well-structured, it still grows with as low as 250 to 375 mm rainfall. Pigeon pea can grow on a wide range of soils ranging from sands to heavy black clays, with variable pH. However, best pH range is within 5-7. It has low tolerance of soil salinity, but some cultivars were reported to tolerate high (6-12 dS/m) salinity (Duke, 1983). *Cajanus cajan* is sensitive to salt spray and waterlogging. Under shade, it shows reduced growth and bear thin, pale green foliage and few pods (FAO, 2016a).

World production of pigeon peas was 4.85 million t in 2014. The main producers were India (3.29 million t, 65% of world production), Myanmar (0.57 million t), Malawi (0.3 million t), Kenya (0.28 million t), Tanzania (0.25 million t). Most of the production occurred in Asia (79.1%), followed by Africa (17.6%) and the Americas (2.5%) (FAO, 2016b).

drilling management

Establishment

Pigeon pea can be grown for seed production, forage production or both. Some double purpose cultivars have been developed. Pigeon pea cultivated for food can be sown alone or intercropped with cereal crops like maize, millet, or with oilcrops like cotton, groundnut, sesame or with grain legumes such as cowpea (*Vigna unguiculata*) (Bekele-Tessema, 2007; Cook et al., 2005; Duke, 1983). Seeds should be sown (drilled, broadcasted or hand dibbled) in a weeded, deep and well prepared seedbed at 2.5 cm to 10 cm depth (Valenzuela, 2011; AFF, 2009; Duke, 1983). Sowing should be done on a 2 m grid as a sole crop (Cook et al., 2005). Pigeon pea does not establish easily. It may require irrigation during the first 2 months if rainfall is insufficient. It is important to make effective weed control (Valenzuela, 2011; AFF, 2009; Duke, 1983). In association with maize, it has been recommended that pigeon pea density remains about 2 plants/m² so that competition for water is not to high for maize (CIMMYT, 2011). Pigeon pea has a very variable growing pattern. Depending on the cultivar, the location and time of sowing, flowering can occur as early as 100 days to as late as 430 days . In the West Indies, the range was within 60-237 days between planting and podding, time for flowering being only 60 days. In India, pigeon pea could require 8 months before flowering (Duke, 1983).

Harvest

Pod harvest can be done by hand-picking over a long period in gardens and hedge crops. The harvest begin when about 75% of the pods have turned brown. In small farms, the plant is traditionally cut at the base with a sickle. It is possible to use a combine-harvester if the plants have matured uniformly and the pods are at a uniform level above the ground (CIMMYT, 2011; van der Maesen, 1989). The cut branches are dried on the field or tied in bundles which are stacked upright in order to dry, and then threshed with wooden flails, by cattle trampling or with a threshing machine (FAO, 2016a; Singh et al., 1992). Another harvesting methode consists in hand-picking pods once, then letting the plant regrow, and hand-picking a second time and sometimes a third time if the quantity of pods make the practice profitable (Singh et al., 1992). If hand-picking is not possible, it is advised to cut the upper parts of the stems bearing the mature pods and let enough foliage so that the plant can regrow (Singh et al., 1992). In Colombia, pigeon peas are cultivated for feed but once for beans and once for forage: during the first year, the peas are used for poultry rations, they are cut at 0.5 m high and, in the second year, they are cut at 1 m high and cattle are then allowed to browse the forage regrowth (FAO, 2016a).

Yield

Pigeon pea is a prolific seed producer: seed yield varies from 0.5 to 2 t/ha in the world (Ecocrop, 2016). In Kenya, it was reported to be about 1 t/ha (OAF, 2015). Under the harsh conditions of the South Sahel, only 650 kg of beans could be produced for human consumption (FAO, 2016a). Under optimal conditions, in sole cropping, seed yields were reported to be as high as 5 t/ha in India and about 3-4 t/ha in Indonesia (van der Maesen, 1989). In Asia, in marginal areas, yields were 700 kg/ha in sole cropping while intercropping systems with maize yielded only 175 kg/ha (van der Maesen, 1989). In Australia and India, short-duration varieties (less than 100 days) have yielded 5 t/ha (Phatak et al., 1993). The pods can withstand weather damage (Mullen et al., 2003). After the first year of growth, seed production declines in subsequent years (Duke, 1983).

Environmental impact

Cover crop, soil improver and green manure

Pigeon pea is used as a contour hedge in erosion control (Bekele-Tessema, 2007). An N-fixing legume, it does not need inoculation before sowing. It was reported to fix 40-97 kg N/ha/year in Africa and up to 235 kg N/ha/year in Florida, 88% being used for pods and seeds formation. Pigeon pea cultivation would be able to provide 40-60 kg N/ha to the following crop (Valenzuela, 2011). Pigeon pea had a large residual effect on maize, increasing grain yield by 57% and total plant dry matter by 32% (Kumar Rao et al., 1983). The extensive root system of *Cajanus cajan* improves soil structure by breaking plow pans, and enhances water holding capacity of the soil (Crop Trust, 2014; Mallikarjuna et al., 2011). Its deep taproot is able to extract nutrients (like P) from the soil low layers, and bring them to upper layers where they can benefit to other crops (Valenzuela, 2011). The leaves and immature stems can be cut and used as a green manure (OAF, 2015). Fallen leaves act as a mulch and are estimated to return about 40 kg N/ha. They return organic matter, preventing erosion due to heavy rains, and reduce soil temperatures (Ecocrop, 2016).

Windbreak and shade provider

Tall varieties of pigeon pea are reported to be good windbreaks. Pigeon pea is able to provide shade to young coffee or vanilla plants, and to forest seedlings in nurseries (Valenzuela, 2011).

datasheet citation

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Nutritional attributes

Pigeon pea seeds are a source of protein and energy as they are are rich in protein (18-28% DM) and carbohydrates (starch 37-45% DM), and relatively poor in fibre (crude fibre < 10% DM). The amino acid profile is close to that of soybean (Oshodi et al., 1993).

Potential constraints

Pigeon pea seeds contain various antinutritional factors that can have deleterious effects depending on the animal species: hemagglutinins, trypsin and chymotrypsin inhibitors, cyanoglucosides, alkaloids, oxalate, hydrogen cyanid, saponins, phytates, urease and tannins (Onwuka, 2006, Iorgyer et al., 2009; Nwoagu et al., 2010, Das et al., 2002). *Cajanus cajan* contains more trypsin and chymotrypsin inhibitors than soybean seeds, and about as much as chickpeas. The antinutritional factors of pigeon pea are responsible for the poor protein digestibility of pigeon pea in pigs, and are more detrimental to performance and feed conversion ratio than those of chickpeas, which suggests the presence of other factors than protease inhibitors (Batterham et al., 1990). Heat treatments such as cooking or extrusion reduce the amount of trypsin and chymotrypsin inhibitors and increase pigeon pea digestibility (Onwuka, 2006; Batterham et al., 1993; Batterham et al., 1990). Pigeon pea seeds contains no appreciable amounts of condensed tannins (Singh, 1988; Dzowela et al., 1995).

ruminants

Pigeon peas are of similar quality than other legumes seeds, and can be used as a protein supplement in ruminant diets even at high inclusion rates. Pigeon peas are highly digestible and supply high quality protein (Corriher et al., 2007). In a comparison of several legume seeds in the Southern Great Plains of the USA, the protein and *in vitro* digestible DM of cajan pea seeds indicated that they could be efficient replacements for maize or cottonseed meal in livestock diets, assuming that cajan pea could generate enough grain biomass to be cost-effective. Though not as effective as soybean, cajan pea was capable of accumulating useful levels of protein and digestible dry matter under the variable growing conditions of the study (Rao et al., 2009). The nutritive value of pigeon pea may also be limited by low sulfur concentration, below ruminant requirements (Whiteman et al., 1980).

Dairy cows

In the USA, pigeon pea seeds could be included at a rate of 20% (DM basis) in a maize silage based diet without any detrimental effect on DM intake (22.5 kg DM/d) and milk production (42 kg/d) on early lactation Holstein cows (Corriher et al., 2010).

Beef cattle

Pigeon peas may be a great creep feed for beef calves due to its high protein and low fat levels. In the USA, when calves were creep fed pigeon peas or oats on Bermuda grass pastures, calves fed pigeon peas had 14% greater average daily gains than those fed oats, and had 15% higher weaning weights and 49% greater average daily gains than those calves without creep feeding (Hill et al., 2006). In yearling beef heifers fed on a maize silage based diet (silage:concentrate ratio of 75:25 on a DM basis), pigeon pea seeds could fully replace whole cotton seeds, corn gluten feed or maize/soybean meal with no effect on the average daily gain (Corriher et al., 2007).

Sheep

On a rice straw based diet containing 50% of concentrate, total and iso-nitrogenous replacement of ingredients (maize, bran, oil meals) by ground pigeon pea seeds had no effect on DM intake, *in vivo* DM diet digestibility and average daily gain. Dry matter intake level ranges from 2.9 to 3.6% BW with an incorporation rate of pigeon pea seeds from 17 to 57% in a rice straw based diet (Cheva-Isarakul, 1992).

Pigs

Pigeon pea seeds can be a source of protein for pigs. However, the nutrient and energy digestibility of pigeon peas were found to be much lower than that of soybean meal, particularly for protein (50 *vs* 81%) (Mekbungwan et al., 2004). However, no detrimental effect of pigeon pea on intestinal vili of growing pigs could be found and it was concluded that pigeon pea seed meal could be used in pig diets (Mekbungwan et al., 2003).

The inclusion of 25 top 75% pigeon pea meal to the diet of growing pigs linearly depressed growth rate, feed intake and feed conversion ratio and performance was lower than that of pigs fed on soybean meal or chickpeas (Batterham et al., 1990). This results confirmed earlier results where 45% ground pigeon pea meal was included in growing pigs diet: pigs had lower daily gain and degraded FCR (Grimaud, 1988). Similar trends were reported in weaner pigs (6-7 kg) fed on 20% raw or cooked pigeon pea seed meal. Piglets fed on pigeon pea seed meal had lower weight gain and lower feed intake, and feed cost was higher with pigeon pea than with the control (Etuk et al., 2005). Only low levels of pigeon pea seed meal (12-14%) were reported to provide acceptable results in growing pigs (20-60 kg) (Fuji et al., 1999).

Poultry

The nutritional profile of pigeon pea is interesting for poultry, with values close to field pea. Antinutritional factors are present

but in a lesser quantity than for other legume seeds, leading to higher nutritive value (Nwokolo et al., 1985; Ologhobo, 1992). For example, the toxicity assessed by the effect of pigeon pea on organ weights or blood parameters is generally low (Ologhobo, 1992). However a high variability in nutritional value is reported in literature, with sometimes low digestibility values (Chrysostome et al., 1998; Nwokolo, 1987; Yamazaki et al., 1988). This can be due to:

- **Variation in composition and antinutritional factors**. For example, white-seeded varieties are sometimes claimed to have a higher nutritional value than dark ones (Odeny, 2007) even if experiments have sometimes failed to confirm this (Nwokolo et al., 1985).
- **Diet formulation**. In some cases the level of amino acids (particularly methionine) is deficient in experimental diets, which can lead to mis-interpretation of results (Babiker et al., 2006)
- **Technological treatments**. Thermal treatments seem to have a positive effect on protein digestibility and energy value (Chrysostome et al., 1998; Onu et al., 2006).

Broilers

Although the results are not always consistent between experiments, it is generally observed that pigeon pea lowers performance (Oso et al., 2012; Onu et al., 2006). High inclusion rates above 20% degrade performance (Amaefule et al., 2011; Ani et al., 2011; Etuk et al., 2003) but degradation also occurs at rates as low as 5 to 10% (Babiker et al., 2006; Saeed et al., 2007; Oso et al., 2012). The effect seems to be higher in starters than in finisher broilers (Igene et al., 2012; Ani et al., 2011). Feed intake is often unaffected or even increased, which suggests that pigeon pea does not induce palatability problems (Tangtaweewipat et al., 1989). However, in this case feed efficiency is degraded. In some cases, growth performance was maintained with 10 to 20% raw pigeon pea (Ologhobo, 1992; de Oliveira et al., 2000; Tangtaweewipat et al., 1989; Iorgyer et al., 2009).

Many trials tried to improve performance with technological treatments such as thermal treatments (roasting or cooking), soaking, fermentation or dehulling (Onu et al., 2006; Abdelati et al., 2009). In most cases the growth performance of broilers is improved, with no clear advantage to one particular processing except that fermented pigeon pea did not allow good animal performance (Oso et al., 2012). Optimization of thermal treatments showed that over-processing (e.g. autoclaving at 120°C for 30 mn) led to decreased performance (Pezzato et al., 1995). Toasted pigeon pea could support growth up to 27% in finishers while performance was degraded (although non significant) in younger birds (Ani et al., 2011). Amino acid balance is important: several authors improved performance with methionine (but no lysine) addition (Amaefule et al., 2011; Babiker et al., 2006). This could be linked to the deficiency of pigeon pea in sulfur-containing amino acids (methionine and cystine) and the low digestibility of protein in raw pigeon pea. Amino acid deficiency could also explain increased feed intake in some contexts.

In summary, the general recommendation in broilers would be to limit incorporation to 10% pigeon pea in young animals. With processed (*e.g.* toasted) pigeon pea and in older animals, higher incorporation rates as 20% could be used. In less intensive conditions, higher rates could be tested if pigeon pea is available at low cost. However, feed efficiency can be lowered. In any case, particular attention should be paid to amino acid supply, particularly methionine.

Layers

Using pigeon pea often leads to reduced performance in laying hens. Hen-day egg production tends to decrease with raw pigeon pea (Amaefule et al., 2007b; Agwunobi, 2000; Tangtaweewipat et al., 1989) although in some experiments production is maintained with 20% pigeon pea (Udedibie et al., 1989). Feed intake increases, which leads to a degradation of feed efficiency (Amaefule et al., 2006c; Amaefule et al., 2007a). Delayed start of lay has been recorded (Amaefule et al., 2006c; Amaefule et al., 2007a). Technological treatments such as toasting or boiling can improve performance (Amaefule et al., 2006c; Amaefule et al., 2007b). Pigeon pea can be used in pullets (Amaefule et al., 2004; Amaefule et al., 2006b). Technological treatments improve the efficiency of use of pigeon pea (Amaefule et al., 2006b). The recommendations are the same as in broiler finishers.

The overall recommendation in layers is to use pigeon pea with care to avoid a degradation of feed efficiency. It should be safe to use 10% pigeon pea in layer diets, with a special care on methionine content in the diet. Higher rates (20%) can be tested especially if a technological treatment can be applied to pigeon pea.

Quails

In quails, toasted pigeon pea allowed good growth performance even at 20-30% in the diet. However, increased feed consumption led to a degradation of feed efficiency (Yisa et al., 2013).

Rabbits

Pigeon pea is a potential source of protein for rabbits but information about the use of pigeon pea in rabbit is scarce and not very conclusive. It should be noted that while pigeon pea contains many antinutritional factors, some, such as phytates, are neutral for rabbits and others, like saponins or tannins, are considered of interest for rabbit nutrition, a minimum level of these molecules being considered as positive factor (Lebas, 1987; Dalle Zotte et al., 2012). Other substances may be more or less removed by different treatments, but moderate levels are well tolerated by rabbits, even the cynanogenic glycosides (Nwaogu et al., 2010).

The use of pigeon pea seeds in rabbits has been tested in Nigeria. In a comparison of raw and boiled seeds (20% dietary level), boiled seeds gave a higher growth (13.2 g/d *vs* 10.3 g/d) but this could be simply the result of the much higher protein level in boiled seeds, which is actually unusual since a slight decrease in protein content is reported in other studies expected (Iheukwumere et al., 2008; Iorgyer et al., 2009). Another comparison of raw and boiled pigeon pea seeds is unusuable due to erroneous data for body weight, feed conversion ratio and to a statistically inefficient sampling of animals (Iheukwumere et al., 2008). In favour of the possibility of safe inclusion of raw pigeon pea seeds, the absence of effect of raw seeds on liver or testis development should be underlined (Iheukwumere et al., 2008). In any case, boiled pigeon pea seeds (30 to 60 minutes and then dried) could be used safely for growing rabbits up to 30% of the diet, but higher levels were not tested (Amaefule et al., 2005; Ani, 2008). With soaked pigeon pea seeds (12 h in cold water + 2-3 days sun-drying) the inclusion rate could be safely increased up to 40% and the average daily gain increased with the incorporation level (Duwa et al., 2011). This latter result suggests that raw pigeon pea could most probably also be used in rabbit feeding since this type of soaking reduced only part of the antinutritional factors such as cyanogenic compounds (Onwuka, 2006). Nevertheless, a comprehensive study on the use of raw pigeon pea seeds rabbit feeding remains necessary before it is possible to provide recommendations on their use in rabbit nutrition.

Fish

Pigeon pea is a potential source of protein with a well-balanced amino acid profile that could replace fish meal in fish diets, but the presence of antinutritional factors may limit their use (Ndau et al., 2015).

Nile tilapia (*Oreochromis niloticus*)

Pigeon pea seeds, raw or soaked, have been included to replace 15, 30 or 45% fish meal in isonitrogenous juvenile diets. Inclusion of pigeon pea, either raw or soaked decreased animal growth rate compared to the control diet. However, growth performance of fish fed on soaked pigeon pea diets were closer to that of fish fed on control diet, and it was concluded that soaked pigeon pea could replace fishmeal in fish diets in order to reduce feed costs (Ndau et al., 2015). When pigeon pea meal (pressure-cooked and sun-dried) was used to replace soybean meal, it was reported that 60% replacement resulted in better nutrient utilization and better growth in fish (Obasa et al., 2003).

Channel catfish (*Clarias gariepinus*)

In Nigeria, channel catfish juveniles could be fed on diets containing 40% protein and where pigeon pea meal replaced up to 100% soybean meal (Hammed et al., 2013). In a comparison of raw and heat-processed seeds showed that raw pigeon peas had deleterious effects on growth and on health parameters (hemoglobin, hematocrit, red blood cells and white blood cells were all reduced). Fried pigeon pea and boiled pigeon pea did not yield satisfactory weight gains but had no significant effect on health parameters. Only 16h-soaked pigeon peas resulted in higher weight gains and had no effect on blood parameters. It was concluded that soaked pigeon peas could be included in channel catfish larvae at up to 65% dietary level (Ogunji et al., 2005).

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Tables of chemical composition and nutritional value

- Pigeon pea (Cajanus cajan), seeds

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

Pigeon pea (Cajanus cajan), seeds

Main analysis	Unit	Avg	SD	me	Max	Nb
Dry matter	% as fed	89.2	2.0	86.2	92.8	13
Crude protein	% DM	22.4	2.5	18.4	27.8	15
Crude fibre	% DM	8.5	2.1	5.8	11.2	14
NDF	% DM	18.8		15.5	22.1	2
ADF	% DM	13.2		10.5	15.8	2
Ether extract	% DM	2.2	1.8	0.9	7.7	14
Ash	% DM	4.6	0.9	3.6	7.1	17
Starch (polarimetry)	% DM	45.8				1
Total sugars	% DM	2.2				1
Gross energy	MJ/kg DM	18.7	0.6	18.1	19.7	6 *

Minerals	Unit	Avg	SD	me	Max	Nb
Calcium	g/kg DM	3.6	3.7	1.2	9.6	8
Phosphorus	g/kg DM	3.3	1.5	1.0	6.0	9
Potassium	g/kg DM	10.1	5.3	3.8	14.8	5
Magnesium	g/kg DM	1.4	0.2	1.2	1.7	5
Manganese	mg/kg DM	17				1
Zinc	mg/kg DM	69				1
Copper	mg/kg DM	22				1

Amino acids	Unit	Avg	SD	me	Max	Nb
Alanine	% protein	5.2	1.4	3.6	6.3	3
Arginine	% protein	5.7	1.5	3.2	6.8	5
Aspartic acid	% protein	9.7	1.8	7.6	11.0	3
Cystine	% protein	1.5	0.4	1.1	2.2	6
Glutamic acid	% protein	19.1	4.8	15.9	24.7	3
wistaria	% protein	3.9	0.2	3.6	4.0	3
Histidine	% protein	3.2	0.5	2.2	3.8	7
Isoleucine	% protein	3.7	0.4	3.1	4.1	7
Leucine	% protein	7.2	1.1	5.5	8.6	7
Lysine	% protein	6.5	0.8	5.6	7.8	7
Methionine	% protein	1.0	0.4	0.3	1.5	7
Phenylalanine	% protein	8.9	0.9	7.7	10.4	7
Proline	% protein	4.4		3.5	5.4	2
Serine	% protein	4.5	0.3	4.2	4.8	3
Threonine	% protein	3.4	0.6	2.6	3.9	7
Tryptophan	% protein	0.6	0.2	0.3	0.9	5
Tyrosine	% protein	2.4	1.0	0.4	3.8	7
Valine	% protein	4.5	1.0	2.9	5.7	7

Secondary metabolites	Unit	Avg	SD	me	Max	Nb
Tannins (eq. tannic acid)	g/kg DM	3.9		3.0	4.9	2

Tannins, condensed (eq. catechin)	g/kg DM	11.1				1

Ruminant nutritive values	Unit	Avg	SD	me	Max	Nb
OM digestibility, ruminants	%	91.3				*
Energy digestibility, ruminants	%	89.3				*
OF ruminants	MJ/kg DM	16.7				*
ME ruminants	MJ/kg DM	13.5				*

Pig nutritive values	Unit	Avg	SD	me	Max	Nb
Energy digestibility, growing pig	%	76.7				*
DE growing pig	MJ/kg DM	14.3	2.4	12.3	17.1	3 *
MEn growing pig	MJ/kg DM	13.6				*
DO growing pig	MJ/kg DM	9.9				*
Nitrogen digestibility, growing pig	%	88.4		84.8	92.0	2

Poultry nutritive values	Unit	Avg	SD	me	Max	Nb
AMEn broiler	MJ/kg DM	14.1	0.5	13.7	14.7	4

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

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Pigeon pea (Cajanus cajan) seeds

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