# Karanja (Millettia pinnata)

Description | Nutritional aspects | Nutritional tables | References

*Click on the "Nutritional aspects" tab for recommendations for ruminants, pigs, poultry, rabbits, horses, fish and crustaceans*



## Common names

Karanja, Karanj, pongam, Indian beech, Pongamia tree, Indian pongamia; Pongamia [Inglés] arbre de pongolote [French]; Igiti cy'Ubuhinde [Kinyarwanda]; pongami, honge [Swahili]; [Mayalayam]; malapari, mempari [Indonesian]; bangkong [Javanese], ki Pahang laut [Sundanese], kranji [Madurese]; Pokok mempari, mempari, kacang kayu laut, biansu [Malaysian]; bani [Philippines]; [Bengali]; 水黄皮[Chinese]; [Hindi; Marathi]; [Tamil]; [Telugu]; หยี น้ำ[Thai]; Đậu dầu, cây SOI Ấn Độ, cây Pongam, cây Honge [Vienamese]

**Products**: karanja oil cake, karanja oil meal, karanja press cake, karanja oilcake, karanja oilmeal, karanja presscake, karanj oil cake, karanj oil meal, karanj press cake, karanj oilcake, karanj oilmeal, karanj presscake, pongam oil cake, pongam oil meal, pongam press cake, pongam oilcake, pongam oilmeal, pongam presscake

## Species

*Millettia pinnata* (L.) Panigrahi [Fabaceae]

## Synonyms

*Cytisus pinnatus* L.; *Derris indica* (Lam.) Bennet; *Galedupa indica* Lam. *Galedupa pinnata* (L.) Taub.; *Pongamia glabra* Vent.; *Pongamia mitis* Kurz; *Pongamia pinnata* (L.) Pierre; *Millettia novo-guineensis Kanehira* & Hatusima

Though the taxon *Millettia pinnata* was suggested as early as 1988, karanja is still often referred to as *Derris indica* or *Pongamia glabra* in the literature (Orwa et al., 2009; Daniel, 1997).

## Feed categories

- Oil plants and by-products
- drilling plants

## Related feed(s)

## Description

Karanja (*Millettia pinnata* (L.) Panigrahi) is a fast-growing, multipurpose tree of the humid tropic. It is one of the few N-fixing trees that produce oilseeds (Sangwan et al., 2010; Orwa et al., 2009). With the increasing production of oil for biofuel, large amounts of oil cake are available for livestock feeding. Karanja is the popular name of *Millettia pinnata* in Hindi while it is called pongam in tamil (Punitha et al., 2006).

### Morphology

Karanja is a medium-sized evergreen or briefly deciduous tree, usually about 8 m tall but able to reach 15-25 m (Sangwan et al., 2010; Orwa et al., 2009). The trunk is straight or crooked, 50 cm in diameter, covered with grey to greyish brown bark, smooth or vertically fissured (Daniel, 1997). Karanja has a deep and thick taproot with several secondary lateral roots (Daniel, 1997). The branches are spreading or dropping and form a broad hemispherical crown of dark green leaves. Branchlets are hairless with pale stipule scars. Leaves are alternate, pinnately compound, pinkish-red when young becoming glossy dark green at maturity (Orwa et al., 2009). The leaves consist of 5 to 7 glabrous leaflets borne in pairs (2 or 3) and a single terminal one on slender stalks. The leaflets are ovate-elliptical, about 5-10 cm long and 4-6 cm wide, pointed at the tip. The inflorescence is a 6-27 cm long raceme of typically papillonaceous, very fragrant flowers. The flowers are lavender, pink white in colour, finely pubescent, and 15-18 mm long. Fruits are numerous, elliptical, 3-6 cm long x 2-3 cm broad, hard, woody, and indehiscent pods. Pods contain 1-2 seeds (Orwa et al., 2009; Daniel, 1997). Seeds are bean-like, 1.5-2.5 cm long x 1.2-2.0 cm wide, dark brown in colour, oily. They contain 30-40% oil (Daniel, 1997). The tree sheds its pods which produce a long lasting litter on the soil. The seeds germinate only when the pod husks decay, several months after dropping (Morton, 1990).

### Uses

Karanja is increasingly used for oil production due to its use in biodiesel. Oil was formerly used as illuminant, raw material for soaps, varnishes and paints or as an insect repellent in storage installments and as mosquito repellent (George et al., 2005; Wood et al., 2001). Karanja wood can be used as fuelwood, and wood ashes as a dyeing agent. Roots yield pinnatin, a dyeing pigment. The bark is fibrous and can be turned into rope. The leaves are potential sources of fodder. The fragrant flowers are a source of pollen and nectar from which bees produce dark honey. The karanja tree hosts lac insects and is valued as an ornamental. Many parts of the tree are used in ethnomedicine (Orwa et al., 2009; Daniel, 1997). Karanja tree is an important species for afforestation. Leaf shedding produces large amounts of organic litter (Morton, 1990).

Oil extraction yields a presscake that can be used as a fertilizer or as animal feed for ruminants and poultry (Sreedevi et al., 2009; Scott et al., 2008). However, its feeding value is disputed because of bitterness and antinutritional factors (see **Potential constraints** on the "Nutritional aspects" tab) (Scott et al., 2008). Three main types of karanja oil cakes are available, namely rotary pressed, expeller pressed and solvent-extracted, the composition of which depends on the degree of decortication and method of oil extraction (Dutta et al., 2012).

## Distribution

Karanja is indigenous to the Indian subcontinent and Southeast Asia. It was reported to have originated from India, Myanmar, Malaysia and Indonesia. It was successfully introduced into humid tropical regions of the world as well as parts of Australia, New Zealand, China and the USA (Scott et al., 2008). In many countries, the cultivation of karanja has increased considerably due to its high oil potential (2-8 t/ha/yr in Australia) (Murphy et al., 2012).

Karanja is a fast growing species occuring in humid tropics from sea level up to 1200 m (not above 600 m in the Himalayan foothills), where annual rainfall ranges from 500 to 2500 mm with a 2-6 months dry period, and where temperatures are between 1°C and 38°C. Karanja is highly tolerant of salinity and alkalinity and can grow on seashores. However, growth on saline soils is suspected to reduce tree nodulation and growth performance (Murphy et al., 2012). Karanja does well on most soils (sandy, stony to clayey) at a pH ranging from 6 to 9. The karanja tree prefers well-drained soils with assured moisture for optimal growth, particularly at the early stages of growth (Murphy et al., 2012; Sangwan et al., 2010; Orwa et al., 2009).

## drilling management

Karanja can be sown or propagated by branch cuttings or root suckers (Daniel, 1997). Its growth is fairly slow in its early stages of development, and annual weed control is necessary during the first 3 years after planting (Orwa et al., 2009). It should be planted in blocks at 2 x 2 m or 5 x 5 m intervals. It produces profuse root suckers and is not suitable as an agroforestry species (Orwa et al., 2009). The karanja tree starts fruiting 4 to 7 years after planting and full production is achieved within 10 years (Murphy et al., 2012). It can produce 0-30 kg seeds per year. A field planted at approximately 5 x 5 m intervals can host 350 trees. At 20 kg/tree average yield, an annual production of 7 t of seeds can be expected (Murphy et al., 2012).

## Environmental impact

### Afforestation and soil reclamation

Karanja is promoted as being able to produce oil on low productive, degraded or salt-affected soils (Murphy et al., 2012). Karanja trees have been used for coalmine soil reclamation and revegetation in India (Maiti, 2012).

### Soil binder and improver

In India, karanja has been traditionally used by villagers on slopy uplands to bind the soil (Kumar, 2004).

## datasheet citation

Heuzé V., Tran G., Delagarde R., Hassoun P., Bastianelli D., Lebas F., 2016. *Karanja (Millettia pinnata)*. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/636 *Last updated on September 15, 2016, 0:49*

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- Legume seeds and by-products
- Oil plants and by-products
- Fruits and by-products
- Roots, tubers and by-products
- Sugar processing by-products
- Plant oils and fats
- Other plant by-products
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- Animal by-products
- Dairy products/by-products
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- Insects
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- Minerals
- Other products

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- Literature databases
- Feeds and plants databases
- Organisations & networks
- Books
- Journals

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Description | Nutritional aspects | Nutritional tables | References

## Nutritional attributes

The protein content of expeller cake ranges from 24 to 30% DM and 27-333% for solvent-extracted karanja oil meal. Karanja cake has a low fibre content: the crude fibre level varies from 4 to 7% DM. Cakes obtained by rotary and expeller extraction have a higher content of residual oil (6-15%), while solvent-extracted karanja meal contain little oil (< 2%).

## Potential constraints

### Karanjin and pongamol

Karanja oil cake, and particularly the lipid fraction, contains two furanoflavones karanjin and pongamol, that are toxic and make the cake unpalatable. The oil contains also polyphenolic compounds. Many treatments have been tested since the 1970s to remove these undesirable substances, including physical treatments (autoclaving, pressure cooking, water soaking, water washing, solvent extraction and partial deoiling), chemical treatments (sodium hydroxide, lime, addition of binder) and microbiological treatments (*S. cerevisiae* and *Aspergillus oryzae*) treatments (Scott et al., 2008; Nagalakshmi et al., 2011; Dutta et al., 2012). However, while some treatments such as deoiling or pressure cooking are more effective than others to reduce karanjin, none of them appeared to make the processed cake completely suitable, feasible and wholesome for animal feeding. Also, the cost of detoxification discourages the use of karanja oil cake (Nagalakshmi et al., 2011; Dutta et al., 2012).

### Protease inhibitors

Karanja oil cake contains protease inhibitors. Different methods have been assessed to reduce their activity, as summarized in the following table.

**Effects of treatments on trypsin and chymotrypsin inhibitors of karanja (Rattansi et al., 1997):**

| Technological treatment | Trypsin inhibitor reduction | Chymotrypsin inhibitor reduction |
|---|---|---|
| Solvent-extraction | 34% | 15% |
| Autoclaving | 83% | 15% |
| Fermentation | 33% | 15% |
| Gamma radiation (1, 5, 10 and 50 kGy) | 4-83% | 3.7-78% |
| 2.4% HCl | 100% | 100% |

A more recent method consists in autoclaving the cake with lime, then refluxing with 2% HCl and finally neutralizing with NaOH. This treatment improves the protein digestibility of the cake (Scott et al., 2008).

## ruminants

### Karanja oil cake

Most studies on the use of karanja for ruminants deal with oil cakes obtained after various oil extraction processes aiming at reducing or eliminating antinutritional factors. Based on results obtained on cattle, sheep and goats, it is recommended to limit karanja cake at 15-20% (DM basis as sole protein source, or partly replacing another oil meal). Beyond this level, karanja cake tends to decrease growth and milk production. The variability of some results could be due to the oil extraction process undergone by the seed.

#### Cattle

Crossbred dairy cows could be fed on solvent-extracted karanja meal used to partially (50%) replace groundnut meal. Karanja inclusion had no effect on DM intake, daily weight gain, milk production and milk composition. Higher inclusion rates decreased voluntary feed intake (Konwar et al., 1987b). Similar results were observed in bulls when solvent-extracted karanja karanja oil meal replaced more than 50% groundnut meal in their straw-based diet (Konwar et al., 1987d). In bull calves, expeller karanja oilcake included at 4% in a concentrate diet has been depressed feed intake, caused histopathological changes in vital organs and produced toxicity symptoms (Gupta et al., 1981, cited by Dutta et al., 2012).

#### Sheep

*In vivo* DM and OM digestibilities of karanja cake were reported to be high (85 and 80% respectively) in adult ewes fed on *Brachiaria* hay (Chandrasekaran et al., 1989).

All experiments on the effect of karanja oil cake on sheep performance have been conducted in India on male lambs at different ages and over long periods. Raw, expeller, solvent-extracted or detoxified karanja oil cake have been tested in lamb diets at dietary levels ranging from 5 to 16%. The main objective was the total or partial replacement of commercial oil meals (soybean, sunflower, groundnut or mustard). The main results are presented and summarized below in the table below.

| Breed | Experiment | Substitution rate | Dietary level | Main results | Reference |
|---|---|---|---|---|---|
| Native male lambs | Detoxified karanja cake replacing soybean meal (SBM) in a concentrate fed with finger millet straw at 3% BW | 0, 50 or 75% of SBM | 9-15% | After 140 days, lambs fed with the 75% level had lower weight compared to control (18 *vs.* 24 kg). DMI of diet or | Dineshkumar et al., 2013 |

| | | | | | |
|---|---|---|---|---|---|
| (13 kg, 6 m) | | | | each component (concentrate and straw) were not different. | |
| Male lambs (13.7 kg, 6.5 m) | Detoxified karanja cake replacing SBM in a concentrate fed with finger millet straw at 3% BW (concentrate:straw ratio 50:50) | 0, 25, 50 or 75% of SBM | 5-15% | Over 140 days, total DMI decreased (from 685 to 511 g/d) with increasing karanja cake levels. OMD was lower with the 2 higher levels of karanja cake. Rumen parameters were not modified. Final BW was lower with the highest karanja cake level compared to 0 and 25% (17.8 *vs.* 24.4 kg). | Rao et al., 2015 |
| Native male lambs (10 kg, 6-7 m) | Expeller karanja cake (24%) or solvent extracted karanja cake (20%) replacing 50% groundnut cake (GNC) into a concentrate fed (~230 g/d) with oat hay | 0 or 50% of GNC | 9-10% | Over 98 days, DMI of concentrate or hay was not different. DMD (53.5 *vs.* 59 %) and DWG were lower (49 *vs.* 60 g/d) with expeller treatment than with control or solvent treatment. | Ravi et al., 2000 |
| Native male lambs (10,5 kg, 6-7 m) | Expeller karanja cake (24%) or solvent extracted karanja cake (20%) replacing GNC into a concentrate (~275 g/d) fed with straw | 0 or 50% of GNC | 14-16% | Over 255 days, DMI of concentrate or straw was not different. No effect on DMD but CP digestibility was lower with expeller karanja cake. Up to 5 week experiment had no effect on DWG then it is null in both expeller and solvent karanja cake. | Singh et al., 2006 |
| Native male lambs (13 kg, 3.5 m) | Solvent extracted karanja cake treated with toxin binder (B-karanja cake), lime (L-karanja cake) or washed (W-karanja cake) replacing SBM in a concentrate fed with oat straw | 0 or 50% of SBM | 11-14% | After 90 days feeding, BW was lower with B-karanja cake and L-karanja cake (17.3 *vs.* 23 kg). Concentrate DMI was also lower (184 *vs.* 278 g/d). Straw DMI was lower with the 3 solvent extracted karanja cakes than with the control (155 *vs.* 240 g/d). Digestibility was not modified. | Soren et al., 2009a,Soren et al., 2009b |
| Nellore male lambs (28 kg, 9-10 m) | Karanja cake compared to sunflower and groundnut cake into a total mixed ration based on sorghum forage (40%) and concentrate (60%) | 100% | 12% | Over 155 days, DMI (77 *vs.* 101 g/d) and DWG (28.3 *vs.* 79 g/d) were lower with karanja cake than with sunflower and groundnut cake (75.3-82.7 g/d). OM digestibility was higher (70.4 *vs.* 60,5%) but CP digestibility was lower (53 *vs.* 59%). | Nagalakshmi et al., 2011 |

*DMI: dry matter intake; DWG: daily weight gain*

Karanja oil cake has generally no effect on diet intake except in one study (Nagalakshmi et al., 2011). The DM or OM digestibility of the diet was either unchanged (Singh et al., 2006) or decreased with higher levels of karanja cake (Ravi et al., 2000; Rao et al., 2015). In comparison with other oil meals, diet digestibility was found higher with karanja cake (Nagalakshmi et al., 2011). Protein digestibility decreased with expeller karanja cake and was not modified with solvent-extracted karanja meal (Ravi et al., 2000; Singh et al., 2006; Nagalakshmi et al., 2011).

The lower DM intake and daily weight gain observed with karanja oil cake could be due to either tannin and/or trypsin inhibitors that reduced nitrogen utilization but had no effects on rumen parameters. Daily weight gain was almost always lower with the highest levels of karanja cake whatever the treatment, except in some cases when the cake was solvent-extracted or washed (Ravi et al., 2000; Singh et al., 2006). Expeller or solvent-extracted karanja cake had a negative effect on carcass characteristics with heavier liver and kidneys, and lighter testis (Singh et al., 2006). Detoxified karanja cake had no effect on carcass characteristics or organ weight (Nagalakshmi et al., 2011; Rao et al., 2015) except liver that was lighter (271 *vs.* 325-371 g) at 15% karanja cake level (Rao et al., 2015). Blood parameters are not modified, except urea which is higher with expeller karanja cake (Ravi et al., 2001). Karanja cake depresses immunocompetence and has deleterious effects on testicular function or ram lambs, probably due to the presence of the toxic compound karanjin (Dineshkumar et al., 2013; Nagalakshmi et al., 2011).

Expeller karanja cake (Ravi et al., 2000; Singh et al., 2006) and to some extent solvent-extracted karanja cake (Singh et al., 2006) are not recommended for young animals for a long term feeding because they are more sensitive to the toxic compounds in karanja cake (Ravi et al., 2000). Washing solvent-extracted karanja cake seems to be an efficient way to remove residual karanjin. It is recommended to limit the amount of detoxified karanja cake into a concentrate at less than 18% (about 10% in the total diet) when fed to young male lambs in order to avoid reproduction and health problems (see **Potential constraints** above).

#### Goats

In growing kids (about 6 kg and 5-6 months), solvent-extracted karanja meal could be used for a long growing period (266 days) at up to 30% (replacing 45% of soybean cake) into a concentrate fed at 200 g/d plus maize forage, without marked effect on DM intake, DM digestibility and daily weight gain. At 40% dietary level, daily weight gain was lower (22 *vs* 33-38 g/d) and DM and protein digestibilities tended to be lower (Srivastava et al., 1990).

### Karanja leaves

Karanja leaves are not much appreciated by livestock. In Nigeria, karanja leaves were reported to be unpalatable (Wood et al., 2001). In steers, the DM digestibility of green fresh leaves or of litter leaves of karanja were 37% and 34% respectively, and were the lowest among 27 other tropical forage tree species (Lowry, 1995).

## Poultry

### Broilers

Karanja is toxic to broilers. Karanja seeds included at 5% in broiler diets led to halved growth performance (Natanam et al., 1989c). This mainly comes from the lipid fraction since 1% or 2% oil degraded performance as much as 10% to 20% expeller cake (Natanam et al., 1989b). Toxicity resulted in increased liver and pancreas weights (Natanam et al., 1989b). Raw expeller karanja cake degraded results with a very strong degradation of growth performance in broilers when fed at 10 or 20% of the diet (Natanam et al., 1989b). 40% karanja cake led to 100% mortality. Solvent extracted karanja cake also lowered growth performance and feed efficiency (Panda et al., 2008a; Panda et al., 2008b). The effect was observed with an inclusion level of 6%, and increased at higher levels of inclusion.

Technological treatments have been tested for karanja detoxification. Simple treatments such as autoclaving or water soaking were inefficient (Natanam et al., 1989b; Natanam et al., 1989c). Treatment with NaOH (1.5% to 3%) decreased the toxicity of karanja (Panda et al., 2008a; Panda et al., 2008b; Panda et al., 2005a). However, even at low inclusion levels (about 6%), some degradation of performance was recorded over the whole growth period (Panda et al., 2005a; Panda et al., 2008a). It is noticeable that expeller cake is still more harmful than solvent-extracted cake, even after alkali treatment (Panda et al., 2008a). Methionine addition could help alleviate the residual effects of detoxified karanja meal (Panda et al., 2008b).

It is concluded that it is not advisable to use karanja meal in broiler diets, even after detoxification.

### Layers

The performance of layers strongly decreased with the use of 10% karanja cake in the diet (Natanam et al., 1989a). The effect of expeller cake was higher than that of solvent-extracted meal. However, in another study, the use of 10% detoxified solvent-extracted meal maintained laying performance and egg quality (Babu et al., 2015).

### Quails

The addition of 6% solvent-extracted karanja meal in the diet of quails decreased growth performance (Krishna et al., 2013). The effect was attenuated by detoxification (with isopropyl alcohol) but there was still a lower growth performance.

## Rabbits

Literature on the use of *Millettia pinnata* to feed rabbits does not seem to exist (October 2015). As karanja oil cake can be detoxified for limited use in ruminants and layers (see **Ruminants** and **Poultry** sections), karanja cake could be potential feed resources for rabbit feeding. However, given the toxicity and unpalatability of the leaves and cake in other species, *in vivo* experiments are necessary before karanja products can be fed to rabbits.

## datasheet citation

Heuzé V., Tran G., Delagarde R., Hassoun P., Bastianelli D., Lebas F., 2016. *Karanja (Millettia pinnata)*. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/636 *Last updated on September 15, 2016, 0:49*

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  - Cereal and grass forages
  - Legume forages
  - Forage trees
  - Aquatic plants
  - Other forage plants
- Plant products/by-products
  - Cereal grains and by-products
  - Legume seeds and by-products
  - Oil plants and by-products
  - Fruits and by-products
  - Roots, tubers and by-products
  - Sugar processing by-products
  - Plant oils and fats
  - Other plant by-products
- Feeds of animal origin
  - Animal by-products
  - Dairy products/by-products
  - Animal fats and oils
  - Insects
- Other feeds
  - Minerals
  - Other products

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- Plant and animal families
- Plant and animal species

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- Broadening horizons
- Literature search
- Image search
- Glossary
- External resources
  - Literature databases
  - Feeds and plants databases
  - Organisations & networks
  - Books
  - Journals

# Karanja (Millettia pinnata)

Description | Nutritional aspects | Nutritional tables | References

## Tables of chemical composition and nutritional value

- Karanja oil cake, expeller
- Karanja oil meal, solvent-extracted

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

### Karanja oil cake, expeller


| Main analysis | Unit | Avg | SD | me | Max | Nb |
|---|---|---|---|---|---|---|
| Dry matter | % as fed | 86.6 | | | | 1 |
| Crude protein | % DM | 26.6 | 2.5 | 24.3 | 29.7 | 5 |
| Crude fibre | % DM | 5.6 | 1.5 | 3.9 | 6.8 | 3 |
| NDF | % DM | 30.4 | 10.3 | 18.2 | 39.9 | 4 |
| ADF | % DM | 11.8 | 2.3 | 10.3 | 15.2 | 4 |
| Lignin | % DM | 2.9 | 0.8 | 2.0 | 3.5 | 3 |
| Ether extract | % DM | 11.0 | 4.0 | 6.4 | 14.5 | 5 |
| Ash | % DM | 4.9 | 0.9 | 3.9 | 6.1 | 6 |
| Gross energy | MJ/kg DM | 20.7 | | | | * |

| Minerals | Unit | Avg | SD | me | Max | Nb |
|---|---|---|---|---|---|---|
| Calcium | g/kg DM | 7.0 | 0.7 | 6.0 | 7.6 | 4 |
| Phosphorus | g/kg DM | 6.2 | 1.9 | 4.8 | 8.9 | 4 |
| Potassium | g/kg DM | 2.3 | | | | 1 |
| Magnesium | g/kg DM | 2.4 | | 2.0 | 2.7 | 2 |
| Manganese | mg/kg DM | 76 | | | | 1 |
| Zinc | mg/kg DM | 199 | | | | 1 |
| Copper | mg/kg DM | 12 | | 2 | 22 | 2 |
| Iron | mg/kg DM | 23 | | 14 | 31 | 2 |

| Amino acids | Unit | Avg | SD | me | Max | Nb |
|---|---|---|---|---|---|---|
| Alanine | % protein | 3.7 | | 2.3 | 5.1 | 2 |
| Arginine | % protein | 4.5 | | 4.3 | 4.6 | 2 |
| Aspartic acid | % protein | 8.6 | | 6.2 | 10.9 | 2 |
| Cystine | % protein | 3.6 | | 1.2 | 6.1 | 2 |
| Glutamic acid | % protein | 15.5 | | 13.5 | 17.6 | 2 |
| wistaria | % protein | 3.6 | | 3.4 | 3.9 | 2 |
| Histidine | % protein | 3.6 | | 2.1 | 5.1 | 2 |
| Isoleucine | % protein | 4.8 | | 3.6 | 6.0 | 2 |
| Leucine | % protein | 7.8 | | 7.7 | 7.9 | 2 |
| Lysine | % protein | 4.5 | | 3.3 | 5.6 | 2 |
| Methionine | % protein | 1.2 | | 1.0 | 1.4 | 2 |
| Phenylalanine | % protein | 4.4 | | 3.6 | 5.2 | 2 |
| Proline | % protein | 4.0 | | 2.9 | 5.0 | 2 |
| Serine | % protein | 4.3 | | 4.0 | 4.5 | 2 |
| Threonine | % protein | 3.4 | | 2.6 | 4.1 | 2 |
| Tyrosine | % protein | 2.5 | | 1.3 | 3.7 | 2 |
| Valine | % protein | 5.9 | | 5.3 | 6.4 | 2 |

| Secondary metabolites | Unit | Avg | SD | me | Max | Nb |
|---|---|---|---|---|---|---|
| Tannins (eq. tannic acid) | g/kg DM | 26.4 | | | | 1 |

| Ruminant nutritive values | Unit | Avg | SD | me | Max | Nb |
|---|---|---|---|---|---|---|
| Nitrogen digestibility, ruminants | % | 85.9 | | | | 1 |

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

References

Chandrasekaran et al., 1989 ; Gowda et al., 2004 ; Kumar et al., 2007 ; Mandal et al., 1975 ; Nagalakshmi and al., 2011 ; Natanam et al., 1989 ; Ravi et al., 2000

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## Karanja oil meal, solvent-extracted


| Main analysis | Unit | Avg | SD | me | Max | Nb |
|---|---|---|---|---|---|---|
| Crude protein | % DM | 30.8 | 2.9 | 26.9 | 33.2 | 4 |
| Crude fibre | % DM | 5.5 | | | | 1 |
| NDF | % DM | 30.1 | 4.6 | 26.8 | 35.4 | 3 |
| ADF | % DM | 17.2 | 4.0 | 12.6 | 20.0 | 3 |
| Lignin | % DM | 3.9 | | 3.6 | 4.2 | 2 |
| Ether extract | % DM | 0.9 | 0.6 | 0.2 | 1.7 | 4 |
| Ash | % DM | 6.0 | 0.6 | 5.4 | 6.9 | 4 |
| Gross energy | MJ/kg DM | 18.5 | | | | * |

| Minerals | Unit | Avg | SD | me | Max | Nb |
|---|---|---|---|---|---|---|
| Calcium | g/kg DM | 7.1 | 1.5 | 5.7 | 8.7 | 3 |
| Phosphorus | g/kg DM | 5.9 | 0.4 | 5.5 | 6.3 | 3 |
| Potassium | g/kg DM | 4.9 | | | | 1 |
| Magnesium | g/kg DM | 2.0 | | | | 1 |
| Manganese | mg/kg DM | 71 | | | | 1 |
| Copper | mg/kg DM | 2 | | | | 1 |
| Iron | mg/kg DM | 18 | | | | 1 |

| Secondary metabolites | Unit | Avg | SD | me | Max | Nb |
|---|---|---|---|---|---|---|
| Tannins (eq. tannic acid) | g/kg DM | 34.1 | | | | 1 |

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

References

Kumar et al., 2007 ; Natanam et al., 1989 ; Ravi et al., 2000 ; Soren et al. 2009

*Last updated on 15/09/2016 00:36:18*

## datasheet citation

Heuzé V., Tran G., Delagarde R., Hassoun P., Bastianelli D., Lebas F., 2016. *Karanja (Millettia pinnata)*. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/636 *Last updated on September 15, 2016, 0:49*

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# Karanja (Millettia pinnata)



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Heuzé V., Tran G., Delagarde R., Hassoun P., Bastianelli D., Lebas F., 2016. *Karanja (Millettia pinnata)*. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/636 *Last updated on September 15, 2016, 0:49*

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