Sesame (Sesamum indicum) seeds and oil meal

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Common names

Sesame, benne, beni, beniseed, benneseed [English]; sésame [French]; ajonjolí, sésamo [Spanish]; gergelim, sésamo [Portuguese]; sesam [Afrikaans]; sezam [Croatian]; Riɗi [Hausa]; wijen [Indonesian]; Indiski sezam [Serbian]; Susam [Turkish]; Vừng [Vietnamese]; [Amharic]; السمسم [Arabic]; [Bengali]; Сусам [Bulgarian]; 芝麻 [Chinese]; کنجد [Farsi]; Σουσάμι [Greek]; [Gujarati]; שומשום [Hebrew]; [Hindi]; ゴマ [Japanese]; 참깨 [Korean]; [Malayalam]; [Marathi]; [Punjabi]; Кунжут индийский [Russian]; [Tamil]; งา [Thai]

- **Product names**: sesame meal, sesame oil meal, sesame oil cake, til oil cake, sesame press cake, expeller sesame oilcake, sesame expeller meal

Species

Sesamum indicum L. [Pedaliaceae]

Synonyms

Sesamum mulayanum N. C. Nair, *Sesamum orientale* L.

Feed categories

- Plant products and by-products
- Oil plants and by-products

Related feed(s)

Description

Sesame (*Sesamum indicum* L.) is a tropical and subtropical plant cultivated for its seeds, which yield about 50% of a high quality edible oil. Sesame oil meal, the by-product of seseame oil extraction, is used as a feed ingredient.

Morphological description

Sesame is an annual or sometimes perennial species, growing 50 to 250 cm tall (Sun Hwang, 2005). Its morphology is extremely variable. The sesame plant can be branched or unbranched. The leaves vary in shape and size, and may be alternate or opposite (Oplinger et al., 1990). The growing fashion is indeterminate and the plant keeps producing leaves, flowers and seeds as long as weather permits. At maturity, leaves and stems turn yellow to red in colour (Oplinger et al., 1990). It normally takes 125 to 135 days for sesame to reach maturity, but it only takes 90-120 days in commercial varieties (Hansen, 2011).

Sesame has an extensive root system that makes it very tolerant of drought. The stems are green, erect, quadrangular, longitudinally furrowed and densely hairy. The leaves are hairy, ovate, 3-17.5 cm long x 1-7 cm broad, dull green in colour (Sun Hwang, 2005). White to pale pink bellshaped flowers develop at the leaf axils along the stems. Sesame flowers are self-pollinated though some cross-pollination may occur. Only flowers borne 30 to 60 cm off ground develop into fruits. The fruit is a deeply grooved capsule, 2.5-3.5 cm long, parallelepipedic in shape and containing 8 rows of seeds (about 100-150 seeds). The fruits of ancient varieties were mostly shattering, splitting open at fruit maturity and releasing seeds. A non-shattering mutant cultivar with reduced seed losses has been developped. Four to six weeks are necessary for seeds to mature. The seeds are variable in colour, small and flat with a point at one end. Thousand seeds weigh about 32 g. The lighter coloured seeds are considered of higher quality (Hansen, 2011; Myers, 2002; Sun Hwang, 2005; Oplinger et al., 1990). White seed varieties are produced in Mexico, Guatemala and El Salvador. Black seed varieties are grown in China and Thailand (Hansen, 2011). Breeding programmes particularly focus on 2 traits: antioxidant factor in sesame oil (sesamol) trait and non-shattering x high yielding trait (Hansen, 2011; Oplinger et al., 1990).

Uses

Sesame seeds

Sesame is primarily grown for its edible seeds and oil. 65% of sesame seeds are used for oil extraction and 35% for food. Sesame seeds have outstanding amounts of oil and a desirable nutty flavour after cooking. For these reasons, sesame seeds are much appreciated in bakery, candy industry and other food specialties (Hansen, 2011).

Sesame oil

Sesame seeds are mainly used for their high oil content. Sesame seeds have a high polyunsaturated fatty acid (PUFA) content and rank 4th after safflower, soybean and maize for their PUFA content. Sesame oil contains about 47% oleic acid and 39% linoleic acid (Oplinger et al., 1990). Sesame oil is rich in tocopherols and in lignans (notably sesamin and sesamolin) that provide exceptional oxidative stability compared with other edible oils (Sun Hwang, 2005). There are two main types of sesame oils: the first one is pale yellow, has a grain-like odour and a nutty taste and is used for salad dressing and deep frying. The second one, obtained from roasted seeds, is amber-coloured and used in cooking as a flavouring agent (Hansen, 2011). Due to its stability, sesame oil can be used in margarine production where refrigeration equipments are lacking (Hansen, 2011). Sesame oil is used in pharmaceutical preparations as a vehicle for drug delivery, in insecticides and in cosmetics. Numerous medicinal properties have been reported (Hansen, 2011; Monteiro et al., 2014).

Sesame oil meal

Sesame oil meal (or sesame oil cake) is the protein-rich by-product obtained after oil extraction. Depending on the way oil has been extracted, sesame oil meal can be food grade (from dehulled sesame seeds) or used as a feed for livestock and poultry (from undecorticated sesame seeds). It is a valuable source of protein for animals (Hansen, 2011; Oplinger et al., 1990). Unlike other oil meals, sesame oil meal is usually obtained by mechanical extraction only (rather by mechanical extraction followed by solvent extraction) and its residual oil content is high.

Sesame seed hulls

The hulls resulting from the dehulling of sesame seeds are discarded and can be used as fodder for ruminants or poultry (Mahmoud et al., 2015; Abdullah et al., 2011).

Distribution

Sesame is one of the oldest oil crop and its use has been recorded in Babylon and Assyria 4000 years ago. It spread from the Fertile Crescent and is now found in many tropical and subtropical areas. It has been cultivated commercially in the USA since the 1950s. The worldwide seed production was 5.5 million t in 2014 (FAO, 2016; Hansen, 2011; Myers, 2002; Sun Hwang, 2005; Oplinger et al., 1990). Sesame is mainly produced in Africa (3.0 million t) and Asia (2.3 million t). India, Sudan, China, Myanmar and Tanzania account for 80% of world production. China, India, Taiwan, Vietnam and Mexico are the main users (FAO, 2016). In Ethiopia, sesame cake is sold in local markets (Gebremedhin et al., 2009).

Sesame grows well in areas with long, warm seasons, from 0 to 40° in both hemispheres, under conditions similar to those of cotton crop (Sheahan, 2014; Sun Hwang, 2005). It does well in most soils but prefers well-drained ones. It is particularly tolerant of drought and extreme heat though it requires good soil moisture for establishment (Sheahan, 2014; Hansen, 2011; Sun Hwang, 2005). A minimal seasonal rainfall of 500 to 700 mm is necessary for optimal seed yield. Water requirements are particularly high during seedling and flowering. Sesame is intolerant of waterlogging. Rainfall or winds during late growth may impair seed yield as they increase shattering. Moisture occuring at maturity increases fungal attacks. Sesame yield and oil content are positively correlated with photoperiod (Hansen, 2011; Myers, 2002; Sun Hwang, 2005; Oplinger et al., 1990). Sesame has moderate tolerance of salinity (Sheahan, 2014; Hansen, 2011; Oplinger et al., 1990). Thanks its deep root system, sesame scavenges nutrients from below most crop root systems: it has low input requirements and often grows under conditions where few other crops can survive. These attributes make sesame an excellent candidate for low-input sustainable food systems (Sheahan, 2014).

Processes

Storage

Sesame seeds have good viability and can be stored about 5 years at room temperature. However it is important to dry them down to 8-6% in order to prevent moist heating and rancidity. Frost might hamper seed quality (Hansen, 2011; Oplinger et al., 1990).

Oil extraction

Several processes exist to extract sesame oil, depending on the end product and region of production. The seed may be dehulled, or cooked or roasted, and the oil extracted by mechanical pressure, resulting in a feed-grade, oil-rich sesame cake. Further extraction with solvent results in a feed-grade, low oil sesame flour. Dehulling is common in India, where sesame meal is an important food, and can be performed manually at village level or mechanically in conventional oil mills. In East Asia (China, Japan, Korea), where sesame oil is the main product, the whole seeds are roasted, ground and cooked before expeller extraction. In North China, seeds are soaked, roasted, dehulled and milled to make sesame paste, and the oil (called small mill sesame oil) is separated by centrifugation or gravitation (Sun Hwang, 2005). In Africa, farm-level extraction is performed by crushing with a grindstone and by adding boiling water to skim off the oil, resulting in a crude, low quality oil. A more sophisticated process uses hand-operated presses and a 3-step extraction: the first extraction is done at room temperature and produce high grade oil ; the resulting press cake is heated and pressed to yield a coloured oil that is later refined ; a third step yields a non edible oil (Mkamilo et al., 2007). Sesame oil meal (usually from non-dehulled seeds) is fed to livestock and poultry (Hansen, 2011; Oplinger et al., 1990).

drilling management

Establishment

Sesame should be planted after the last killing frost when soil temperature is above 21°C. It requires a well-prepared weed-free seedbed and good moisture content. Sowing sesame just after rain or irrigation is recommended. Sesame seeds should be shallow planted at 2-3 kg/ha (Myers, 2002). Careful weeding is necessary for sesame to grow (Hansen, 2011; Myers, 2002; Oplinger et al., 1990). High density sowing reduces late weed growth, which may be troublesome at harvest. Sesame is frequently intercropped in smallholder fields. Strip cropping with maize and sorghum is common, and protects sesame from strong winds (Mkamilo et al., 2007).

Harvest

Sesame is ready to harvest 90 to 150 days after being sown. Because frost is deleterious to seed quality the harvest should be done before the first killing frost (Hansen, 2011). Harvest of the non shattering varieties can be done with a combine harvester provided all holes have been sealed to prevent losses of small seeds. In shattering varieties, it is recommended to swathe the plants when the stems are still green, and then to stack them in vertical piles. As sesame seeds as fragile, it is preferable to use low cylinder speed (half that of cereals) (Hansen, 2011). Seed yields are about 400-500 kg/ha (FAO, 2016).

Environmental impact

Cover crop, soil improver, green manure and weed/pest control

Thanks its extensive root system, sesame provides valuable cover to the soil and has a positive effect on soil structure, moisture retention and tilth (Langham et al., 2008; Myers, 2002). Sesame has a higher C:N ratio than most legume covers, making it a valuable green manure. It vigorously outcompetes weeds (Creamer et al., 2000). In some cases, it has been reported to have some weed potential (Sheahan, 2014). Sesame can successfully reduce root-knot nematode populations in subsequent crops and regulate cotton bollworm/maize earworm (Pimbert, 1991; McSorley, 1999; Sipes et al., 1997; Rodriguez-Kabana et al., 1988).

Wildlife

Sesame attracts beneficial insects and is a source of feed for songbirds, quail and doves (Sheahan, 2014; Creamer et al., 2000).

Phytoremediation

Sesame plants have been reported to accumulate and remove from the soils the organochlorine pesticide lindane, a neurotoxin that can persist in soils for many years (Abhilash et al., 2010).

datasheet citation

Heuzé V., Tran G., Bastianelli D., Lebas F., 2016. *Sesame (Sesamum indicum) seeds and oil meal*. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/26 *Last updated on September 9, 2016, 2:16*

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Nutritional attributes

Sesame oil meal

Sesame oil meal is a protein rich by-product. Expeller sesame meal has a protein content of about 45% DM, ranging from 32 to 53%, whereas solvent-extracted sesame meal contains about 48% protein. Expeller sesame oil meal is rich in residual oil, and thus in energy, though the oil content depends on the process and may be extremely variable, from 5 to 20%. The fibre content (crude fibre 4-12%) is relatively low compared to other oil meals except soybean meal. Lignin content is also low (< 2%). Sesame oil meal from dehulled seeds should have a higher nutritional value but is normally a food product. Sesame oil meal has a peculiar amino acid profile: it is very poor in lysine and rich in sulfur amino acids. Unsaturated fatty acids (mosty oleic acid C16:0 and linoleic acid C18:1) constitute 80% of the total fatty acids.

Sesame seeds

Sesame seeds are mainly characterised by their large oil content (about 50% DM, ranging from 35 to 55%). They are also rich in protein (22-27%). The fibre content appears to be extremely variable: some varieties contain small quantities of fibre (crude fibre 4-8% DM) while others are much more fibrous (13-20% DM) (Sun Hwang, 2005).

Potential constraints

Phytic acid and oxalates

Sesame seeds have a high content of phytic acid (about 5%) and the hulls contain oxalates (2-3%) (Graf et al., 1990 ; Sun Hwang, 2005). As phytic acid reduces calcium availability, diets with significant amounts of sesame hulls, whole sesame seeds or non-dehulled sesame oil meal may need to be supplemented in calcium (Aherne et al., 1985; Göhl, 1982). High amounts of oxalic and phytic acids may have adverse effects on palatability (Ravindran, 1991). Dehulling alleviates the problems raised by oxalates, but it has little effect on phytates (Ravindran, 1991).

Rancidity

Though sesame oil is extremely stable, oil-rich sesame oil meal will eventually become rancid (Göhl, 1982).

ruminants

Sesame oil meal is a valuable protein and energy source for ruminants. Reported *in vitro* OM digestibility is high (83% in ADAS, 1988 ; > 75% in Chandrasekharaiah et al., 2002). However, lower values have been reported (69% *in vitro* DM digestibility, Innaree, 1994). In Egypt, it has been used in control diets for experiments on protein supply in goats (Kholif et al., 2015).

Several processes have been tested to improve the nutritional value for ruminants. Treatment with 1.5-2% formaldehyde decreased ruminal protein degradability with no effect or a positive effect on nutrient intake (Bugalia et al., 2008; Pani et al., 1998) and a positive effect on Ca and P balance (Pani et al., 1998). Formaldehyde treatment increased the digestibility of crude fibre and lipids, as well as indices of post-partum reproductive efficiency (Bugalia et al., 2008). Heat treatment of sesame oil meal at 140°C, 150°C or 160°C during 1h, 2h or 3 h increased bypass protein, and the most efficient heat treatment was at 150°C (Mahala et al., 2007).

Dairy cattle

In Thailand, sesame oil meal introduced at 14 to 42% (substituting for soybean meal) in the diets of lactating crossbred cows decreased diet DM digestibility but did not result in significant differences in milk production, milk constituents, feed consumption and body weight of cows (Innaree, 1994). In Iran, including 15% sesame oil meal in the diets of lactating dairy cow did not affect DM intake, increased milk fat but decreased milk yield and feed efficiency compared to the control diet (soybean/cottonseed meal) (Shirzadegan et al., 2014). In Egypt, sesame oil meal included at 17.5% dietary level was found suitable for feeding lactating dairy buffaloes as it resulted in milk yield similar to that obtained with soybean meal and cottonseed meal (Mahmoud et al., 2014a).

Growing cattle

In Eritrea, in Barka cattle fed on urea-treated sorghum stover based diet, the animals had higher DM intake (6.13 *vs.* 5.81 kg/head/day), higher daily weight gain (741g *vs.* 650 g) and improved feed efficiency when they were supplemented with sesame oil meal rather than with fish meal (Mehari et al., 2010). In Egypt, mixtures of nigella meal (*Nigella sativa*) and sesame oil meal used as total replacement for concentrate in calf diets had higher DM, lipid and crude fibre digestibilities and resulted in higher intake, higher weight daily gain, improved feed conversion ratio, and increased profitability (Mahmoud et al., 2014b). In Gambia, in young grazing N'Dama bull calves, sesame oil meal could be fed as a protein supplement during 4 months at levels up to 400 g/day. Fed at this level, sesame oil meal nt only increased daily weight gain (271 *vs.* 169 g/d in control) during the experiment, but also maintained higher growth (203 g *vs.* 52g/d) after it (Little et al., 1991).

Sheep and goats

In Ethopia, sheep fed a teff straw diet and sesame oil meal up to 30% of the diet had a higher weight gain, enhanced carcass parameters, and overall profitability was increased (Fitwi et al., 2013). In Eritrea, male sheep fed on urea-treated sorghum stover diet had higher DM intake (847 *vs.* 826 g/head/d) and higher daily weight gain (134 *vs.* 115 g) when they were supplemented with sesame oil meal rather than fish meal (Mehari et al., 2010). In Sudan, sesame oil meal and groundnut meal ranked higher than cotton meal or sunflower meal as a supplementary protein for desert sheep lambs during fattening (7 weeks). The animals had higher daily weight gain and a better feed efficiency (Suliman et al., 2007). An earlier experiment done with yearling desert sheep lambs showed that sesame oil meal ranked 2nd after sunflower meal for growth rate (Ahmed et al., 2005). In Egypt, mixtures of nigella oil meal and sesame oil meal used as total replacement of concentrate in lamb diets decreased total digestible nutrients and no significant difference was observed between two rations in final weight, total weight and average daily gain. It was concluded that a mixture of nigella oil meal and sesame oil meal could replace commercial concentrate in growing lambs (Mahmoud et al., 2014b).

In Ethiopia, Abergelle goats grazing on natural pasture were profitably supplemented with different ratios of sesame oil meal:*Faidherbia albida* pods. The 1:1 ratio (105 g of each feed) yielded better intake and daily weight gain (80 g/d) (Weldemariam, 2015).

Pigs

Sesame oil meal

Sesame meal has a high protein and energy content, but its deficiency in lysine, its fibre content and the presence of phytate and oxalates are limitations for its use in pigs. Early trials found that sesame oil meal could be used in growing-finishing pigs up to 15% in the diet with satisfactory results (Squibb et al., 1951) but later studies demonstrated that it is preferable to associate sesame oil meal with a source of lysine such as soybean meal or animal by-products (Ravindran, 1990). Sesame meal may replace only 10% of soybean meal in maize-soybean meal based diets in growing-finishing and sows (Seerley, 1991). Generally, it has been advised to adapt the level of sesame oil meal in diets according to the type and quantity of other protein sources of the diet (Ravindran, 1990; Cunha, 1977). Ileal digestibilities of most of its amino acids tend to decline as the inclusion of sesame oil meal increases in pig diets, and daily weight gains and feed efficiency were hampered as the level of sesame oil meal increased from 0 to 12% (diet DM) (Li et al., 2000). When the formulation of pig diets took into account the apparent ileal digestibility of protein and amino acids, up to 10% sesame oil meal (DM basis) could be included in the diet without causing significant changes in total feed intake, average daily gain and feed conversion ration (Tartrakoon et al., 2001). Due to potential palatability problems caused by oxalates, it has been recommended to limit the use of sesame oil meal to 5% in starter diets (Ravindran, 1990).

Sesame seeds

Sesame seeds are known to have a role as a natural antioxidant. In Vietnam, where small-scale farmers use diets based on non-defatted rice bran, which is very prone to rancidity and to loss of palatability during storage, it was shown that the inclusion of 1-3.5% of ground sesame seeds at limited peroxidation and enhanced feed intake and feed conversion ratio in pigs (Yamasaki et al., 2003).

Poultry

Sesame oil meal is rich in protein and energy but due to its low lysine content and high methionine and cystine contents it is used as a supplementary source of protein with other oil meals such as soybean meal (Yasothai, 2014). High differences in quality and nutritional value of sesame products can be observed (Cheva-Isarakul et al., 1993). Phytates and oxalates are an issue for poultry feeding and can limit its use in practical diets. Amino acid digestibilities are high but processing at excessive temperature can decrease amino acid levels and availability (Yasothai, 2014).

Sesame oil meal

Broilers

Studies on the use of sesame oil meal in broilers tend to conclude that sesame oil meal can be used at moderate levels, usually below 10% (Mamputu et al., 1995; Rahimian et al., 2013; Daghir, 2008). Performance decreased at higher inclusion levels (Mamputu et al., 1995; Rahimian et al., 2013). Some effects on broiler metabolism or intestine mucosa characteristics were observed (Yamauchi et al., 2006; Rama Rao et al., 2008). However, in some cases levels as high as 20% sesame oil meal allowed good performance (Jacob et al., 1996; Rama Rao et al., 2008). Feed intake is generally not affected by sesame oil meal in the diet, suggesting that palatability is not an issue. Adequate values for metabolizable energy and amino acid digestibility should be used since local products can be significantly different from those presented in international feed tables (Kang et al., 1999; Yasothai, 2014). Phytase addition improved performance in some cases (Sterling et al., 2001) although this effect was not constant (Rahimian et al., 2013).

The general recommendation is to take great care on feed formulation when using sesame oil meal in broiler diets since subcarencies in amino acids (lysine) and minerals (Ca, P, etc.) could occur if inappropriate values are considered. In these conditions, the use of relatively low levels (5-8%) could be safe, while higher levels (10-15%) can be tested with high quality sesame oil meal, or with slower growing broilers.

Layers

In layers, laying performance and feed efficiency were affected by levels of sesame oil meal above 4% (Mamputu et al., 1995; Cheva-Isarakul et al., 1993). High levels (15-20%) of sesame oil meal led to significantly reduced laying rates, feed efficiency and weight gain (Jacob et al., 1996). Differences between performances obtained with sesame oil meals of different origins have been observed, possibly due to amino acid content or protein quality (Cheva-Isarakul et al., 1993).

In pullets, the use of sesame oil meal above 5% led to reduced growth and uniformity in the flock, and delayed initiation of lay (Tangtaweewipat et al., 1992).

Sesame oil meal should be used with care in layers, and only at low levels. A particular attention should be paid to feed formulation, particularly amino acid content (lysine).

Quails

In growing japanese quails, up to 15% sesame oil meal was used without adverse effects on growth and carcass characteristics (Sina et al., 2014). In laying quails, the use of sesame oil meal decreased egg production and feed efficiency and is thus not recommended (Tangtaweewipat et al., 1992).

Sesame seeds

Broilers

The use of raw sesame seeds at 5 to 15% in diets for broilers reduced body weight gain and degraded feed efficiency whereas feed intake was less affected but tended to decrease (Olaiya et al., 2015; Ngele et al., 2011). Technological treatments could alleviate this negative effect to a certain extent. Toasting was the most efficient treatment, followed by soaking and boiling (Olaiya et al., 2015). However, even when toasted, sesame seeds led to performance below that obtained with control diets (Jiya et al., 2014; Ngele et al., 2011).

Layers

In layers, the optimal level of soaked sesame seeds was 3%, which allowed improved laying rate with unchanged feed intake. Above 6% sesame seeds, egg production and egg weight decreased, leading to a lower egg mass and feed efficiency. (Diarra et al., 2008).

Quails

The use of 1 to 2% sesame seeds improved laying rate in quails, without affecting body weight and feed intake. Fertility and hatchability were also improved (Al-Daraji et al., 2010).

Sesame hulls

Broilers

In broilers the use of sesame hulls up to 10%, with adequate feed formulation, tended to slightly improve feed intake and growth performance, with unchanged feed efficiency (Nikolakakis et al., 2014; Mahmoud et al., 2015). In chicks, sesame hulls led to a decrease in growth performance, with a stronger effect at 12% inclusion than at 6 to 8% (Farran et al., 2000).

Layers

Egg production decreased above 14% sesame hulls in diets. At 7 to 14% sesame hulls, laying rate slightly decreased but egg weight increased, leading to a constant egg mass and feed efficiency. In all cases, sesame hulls decreased body weight gain in layers (Farran et al., 2000).

Rabbits

Sesame oil meal

Sesame oil meal has been a traditional source of proteins for rabbit feeding for a long time (Templeton, 1937; Benoit et al., 1948). Its high digestibility was established in the 1940s *e.g.* 91% for crude protein and 90% for gross energy, corresponding to 15.05 MJ DE/kg DM (Voris et al., 1940). Sesame oil meal is included at 10-20% in the control diet of many experiments (Roy et al., 2002; Salma et al., 2002; Ibrahim, 2007; Fasiullah et al., 2010). In experimental studies, sesame oil meal has been introduced without any health problem or alteration of performance in growing rabbit diets up to 38-39% (Colin et al., 1977; Colin et al., 1978) and even up to 56% (Lebas, 1973).

If sesame oil meal could be considered as a suitable source of proteins for rabbits (Colin et al., 1974; Colin et al., 1978), it is deficient in lysine and covers only 50% of growing rabbit requirements for lysine (Lebas, 2013). Thus, the utilisation of sesame oil meal in balanced rabbit rations requires a source of lysine, such as legume seeds or industrial lysine.

Sesame seeds

Whole toasted sesame seeds were introduced safely in rabbit diets at up to 12%, but their utilization in balanced diet was limited by the very high lipid content of the seeds (52%). (Njidda, 2010). Best growth and carcass quality results were obtained at 8% dietary level (Njidda, 2010). Due to the lack of experiments at the time of writing, it is not known whether toasting is necessary or not for the use of sesame seeds in rabbit feeding.

Fish

Sesame oil meal has been found to have a value similar to that of soybean meal for carnivorous fish, and has successfully used as a fish meal protein substitute without negatively affecting their growth. About 50% of fish meal could be replaced with sesame oil meal in rainbow trouts (*Oncorhynchus mykiss*) (Nang Thu et al., 2011) and European sturgeons (*Huso huso*) (Jahanbakhshi et al., 2012).

datasheet citation

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Tables of chemical composition and nutritional value

- Sesame meal, mechanical extraction
- Sesame meal, solvent extraction
- Sesame seeds, whole

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

Sesame meal, mechanical extraction

Main analysis	Unit	Avg	SD	me	Max	Nb
Dry matter	% as fed	92.8	1.7	88.7	95.9	48
Crude protein	% DM	44.9	5.0	32.1	53.4	54
Crude fibre	% DM	7.3	2.1	3.9	12.4	50
NDF	% DM	24.6	9.8	18.8	47.7	8
ADF	% DM	13.5	9.4	7.7	36.6	8
Lignin	% DM	1.7	0.2	1.5	2.1	7
Ether extract	% DM	11.3	3.7	5.2	19.6	41
Ash	% DM	11.9	2.2	8.1	16.7	43
Starch (polarimetry)	% DM	1.8	1.6	0.6	4.5	6
Total sugars	% DM	4.3	0.6	3.4	5.3	6
Gross energy	MJ/kg DM	20.6	0.9	18.7	22.0	9 *

Minerals	Unit	Avg	SD	me	Max	Nb
Calcium	g/kg DM	19.7	4.0	11.7	28.4	19
Phosphorus	g/kg DM	12.6	3.2	10.3	23.3	17
Potassium	g/kg DM	10.4	0.6	9.7	11.4	13
Sodium	g/kg DM	0.1	0.1	0.0	0.1	3
Magnesium	g/kg DM	5.9	0.7	4.1	6.6	12
Manganese	mg/kg DM	80	5	72	88	6
Zinc	mg/kg DM	126	8	114	136	6
Copper	mg/kg DM	44	1	43	46	6
Iron	mg/kg DM	1632	686	305	2055	6

Amino acids	Unit	Avg	SD	me	Max	Nb
Alanine	% protein	4.6	0.3	4.3	5.1	8
Arginine	% protein	12.6	0.8	11.1	14.1	9
Aspartic acid	% protein	8.0	0.3	7.5	8.5	7
Cystine	% protein	2.2	0.2	1.9	2.5	8
Glutamic acid	% protein	18.1	1.0	16.3	19.6	8
wistaria	% protein	4.9	0.3	4.5	5.3	9
Histidine	% protein	2.8	0.2	2.5	3.1	8
Isoleucine	% protein	3.7	0.2	3.4	4.0	9
Leucine	% protein	6.6	0.3	6.3	7.5	9
Lysine	% protein	2.5	0.3	2.1	2.9	10
Methionine	% protein	2.7	0.2	2.3	3.1	10
Phenylalanine	% protein	4.5	0.1	4.3	4.7	9
Proline	% protein	3.5	0.2	3.1	3.9	7
Serine	% protein	4.5	0.2	4.2	4.7	8
Threonine	% protein	3.4	0.1	3.2	3.7	9
Tryptophan	% protein	1.3		1.1	1.4	2
Tyrosine	% protein	3.4	0.3	3.0	3.9	7
Valine	% protein	4.5	0.3	4.0	5.0	9

Fatty acids	Unit	Avg	SD	me	Max	Nb
Palmitic acid C16:0	% fatty acids	9.0	0.1	8.8	9.2	5
Stearic acid C18:0	% fatty acids	6.7	0.2	6.5	6.9	5
Oleic acid C18:1	% fatty acids	39.3	0.5	38.6	39.8	5
Linoleic acid C18:2	% fatty acids	44.5	0.6	44.0	45.2	5
Linolenic acid C18:3	% fatty acids	0.5	0.0	0.4	0.5	5

Ruminant nutritive values	Unit	Avg	SD	me	Max	Nb
OM digestibility, ruminants	%	80.3				1
Energy digestibility, ruminants	%	80.3				*
OF ruminants	MJ/kg DM	16.6				*
ME ruminants	MJ/kg DM	12.5				*
Nitrogen digestibility, ruminants	%	78.4				*

Pig nutritive values	Unit	Avg	SD	me	Max	Nb
Energy digestibility, growing pig	%	76.0				*
DE growing pig	MJ/kg DM	15.7				*
MEn growing pig	MJ/kg DM	14.4				*
DO growing pig	MJ/kg DM	9.6				*
Nitrogen digestibility, growing pig	%	88.6				*

Poultry nutritive values	Unit	Avg	SD	me	Max	Nb
AMEn cockerel	MJ/kg DM	11.4	0.2	11.2	11.6	5
AMEn broiler	MJ/kg DM	11.2		10.9	11.5	2

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

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Sesame meal, solvent extraction

Main analysis	Unit	Avg	SD	me	Max	Nb
Dry matter	% as fed	93.7	1.1	92.5	95.6	6
Crude protein	% DM	48.5	3.7	44.0	55.0	7
Crude fibre	% DM	10.1	4.0	6.1	15.2	4
NDF	% DM	45.5				1
ADF	% DM	18.4				1
Ether extract	% DM	2.6	0.9	1.4	3.4	4
Ash	% DM	12.6	2.2	9.7	14.9	4
Gross energy	MJ/kg DM	18.9				*

Minerals	Unit	Avg	SD	me	Max	Nb
Calcium	g/kg DM	9.1				1
Phosphorus	g/kg DM	4.6				1
Potassium	g/kg DM	3.8				1
Magnesium	g/kg DM	2.3				1
Manganese	mg/kg DM	thirty		24	36	2
Zinc	mg/kg DM	60		38	81	2
Copper	mg/kg DM	26				1
Iron	mg/kg DM	55				1

Amino acids	Unit	Avg	SD	me	Max	Nb
Alanine	% protein	4.4				1
Arginine	% protein	12.5				1
Aspartic acid	% protein	8.0				1
Cystine	% protein	1.9				1
Glutamic acid	% protein	18.7				1
wistaria	% protein	4.6				1
Histidine	% protein	2.3				1
Isoleucine	% protein	3.4				1

Leucine	% protein	6.1	1
Lysine	% protein	2.4	1
Methionine	% protein	3.0	1
Phenylalanine	% protein	4.2	1
Serine	% protein	4.8	1
Threonine	% protein	3.6	1
Tyrosine	% protein	2.5	1
Valine	% protein	4.1	1

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

References

AFZ, 2011 ; Dewar, 1967 ; Friesecke 1970 ; Han et al., 1976 ; Krishnamoorthy et al., 1995 ; Nwokolo 1987 ; Yamazaki et al., 1986

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Sesame seeds, whole

Main analysis	Unit	Avg	SD	me	Max	Nb
Dry matter	% as fed	96.6	2.0	91.1	98.4	11
Crude protein	% DM	23.4	1.6	21.9	27.4	11
Crude fibre	% DM	8.9	5.0	5.2	16.8	11
NDF	% DM	14.8				1
ADF	% DM	8.0				1
Lignin	% DM	2.2				1
Ether extract	% DM	49.7	6.2	36.2	55.9	8
Ash	% DM	4.9	1.2	2.6	6.6	11
Starch (polarimetry)	% DM	4.6		3.4	5.8	2
Gross energy	MJ/kg DM	29.1				*

Minerals	Unit	Avg	SD	me	Max	Nb
Calcium	g/kg DM	1.7		1.7	1.8	2
Phosphorus	g/kg DM	6.2	1.2	4.6	7.9	6
Potassium	g/kg DM	5.3	1.1	4.2	6.3	3
Magnesium	g/kg DM	3.3	0.5	2.9	3.9	3

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

References

AFZ, 2011 ; CIRAD 1991 ; CIRAD 2008 ; Nwokolo 1987 ; Ravindran et al., 1994 ; Woodman 1945

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datasheet citation

Heuzé V., Tran G., Bastianelli D., Lebas F., 2016. *Sesame (Sesamum indicum) seeds and oil meal*. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/26 *Last updated on September 9, 2016, 2:16*

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Sesame (Sesamum indicum) seeds and oil meal

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Heuzé V., Tran G., Bastianelli D., Lebas F., 2016. *Sesame (Sesamum indicum) seeds and oil meal*. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/26 *Last updated on September 9, 2016, 2:16*

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