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Cotton seeds

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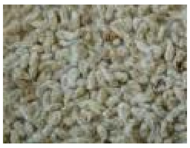
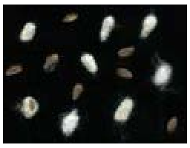

Common names

Cotton seeds, cottonseeds, whole cottonseed, whole cotton seeds, Pima cottonseeds, white cottonseeds, black cottonseeds, slick cottonseeds

Species

Gossypium spp. [Malvaceae]

Feed categories

- Oil plants and by-products

Related feed(s)

- Cotton (general)
- Cottonseed meal
- Cottonseed hulls
- Cotton straw and cotton crop residues

Description

Cotton seeds are the seeds of the cotton plant. Cotton seeds are ovoid, 3.5-10 mm long. They are densely covered with white or rusty, long and woolly hairs, called the lint, which is the main product used to make cotton textiles, and shorter hairs (linters). Commercially available cotton seeds are usually the by-product of the production of cotton fibre by a cotton gin, which separates the lint from the seeds. Consequently, seed production is dominated by factors determining the production of cotton fiber and the seed is about 15-20% of the value of the cotton crop (O'Brien et al., 2005). Depending on the species and variety, cotton lint has different colours (black, brown or red), and may be long and thin (*Gossypium hirsutum*, 90% of world production), longer and finer (*Gossypium barbadense*, also called Egyptian cotton) or shorter and thicker (*Gossypium herbaceum* and *Gossypium arboretum*) (Ikitoo, 2011; Rossin, 2009).

Once ginned, the cotton seed remains covered with linters and called **whole cottonseed** or **fuzzy cottonseed**. The amount of linters left on the seeds varies from 4 to 8%, except for seeds of *Gossypium barbadense* varieties, such as the American Pima cotton, which are naturally without linters (NCPA, 2012). Linters are a valuable fibre used for paper, cellulose acetate, viscose, explosives, plastic or photographic film. Fuzzy cotton seeds are subject to a mechanical delinting process that yields linters and naked seeds called **delinted cottonseed** or **black** or **slick cottonseed** (Hoffman, 1998). Cotton seeds intended for sowing generally undergo chemical (sulphuric acid) treatment in order to remove linters but these delinted seeds (sometimes called **acid cottonseed**) should not be used as feed as they may contain chemicals residues and can have an unpalatable flavour (Smith et al., 1999).

Fuzzy or delinted cotton seeds may be either fed to livestock or submitted to oil extraction, yielding oil, cottonseed meal and hulls. Cotton seeds contain about 20% of valuable cooking oil. A typical cottonseed crushing operation separates the seed into oil (16%), hulls (26%), meal (45.5%) and linters (8.5%) (O'Brien et al., 2005).

Distribution

Cotton seeds are available where cotton fibre is produced. Cottonseed production (both for oil and feed use) was 42 million tons in 2010. In 2009, 9.2 million tons of cotton seed were used for feed (FAO, 2012). Cotton seeds are mainly used locally and only small amounts are exchanged (0.74 million exported and 0.73 million ton imported in 2009). The main producers are China, India, USA, Pakistan, Uzbekistan and Brazil, which represented 96% of cottonseed world production in 2010 (FAO, 2012).

Processes

Storage

Cotton seeds can be stored for one year under favourable conditions. In order to prevent mycotoxin development, the seeds should be dried and their moisture levels kept under 10%. Their high hygroscopic nature requires that the relative air humidity in the storage installation is monitored. An air-cooling system is necessary to prevent seed heating during storage. Overheated seeds must be cooled down to 15.6°C to prevent further deterioration (O'Brien et al., 2005).

Grinding

Coarse grinding of whole cotton seeds is preferred to fine grinding. Coarse grinding enhances seed digestibility while fine grinding results in fat release that may reduce shelf-life, and in breaking of gossypol glands, which releases free gossypol (Calhoun, 2009; Hoffman, 1998).

Environmental impact

Genetically-modified cotton was introduced in 1996 and by 2010 it accounted for 65% of the world cotton crop (notably insect-resistant *Bt* cotton and herbicide-resistant cotton) (O'Brien et al., 2005; USDA, 2010). The main expected environmental benefit of the use of Bt cotton is a reduction in pesticide use and residues (Edwards et al., 2009). Animal studies have failed to demonstrate noxious side-effects from the use of GM cotton (EFSA GMO Panel, 2008). Transgenic whole cotton seeds were found to have the same chemical composition and *in vitro* digestibility as non-transgenic seeds (Mohanta et al., 2011). However, as for other GM crops, both the environmental benefits of GM cotton and its effects on health remain highly controversial and a matter of debate.

Datasheet citation

Heuzé V., Tran G., Hassoun P., Brossard L., Bastianelli D., Lebas F., 2015. *Cotton seeds*. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/742 *Last updated on May 12, 2015, 14:25*

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Cotton seeds

Nutritional attributes

Whole cotton seeds are rich in protein (about 22% DM) and oil (about 20% DM), resulting in a high gross energy content. Combined with their high fibre content (about 28% DM crude fibre), these qualities make them a good feed for ruminant animals. However, for monogastric animals, the high fibre content and the presence of gossypol are limiting factors and, since cotton seeds contain more fibre and free gossypol than cottonseed meal, whole cotton seeds are much less used in pigs and poultry diets than cottonseed meal.

Potential constraints

Gossypol

Gossypol (see the Cotton (general) datasheet for more information) is a toxic polyphenolic compound found mostly in glands localized in the cotton seeds. It exists in a free toxic form and in a bound, non-toxic form (Morgan, 1989). Free gossypol is the more important form in unprocessed cotton seeds. In *Gossypium hirsutum* seeds, total gossypol concentrations ranging from 0.6 to 1.15% DM and free gossypol concentrations from 0.05 to 0.7% DM have been reported (OGTR, 2008). Gossypol content depends on species, cultivars, fertilizer rates, growing conditions and insect pressure (Blasi et al., 2002; Randel et al., 1992; Carter et al., 1966). "Glandless" cotton varieties without gossypol have been developed but these varieties are more sensitive to pests, less productive, and have thus been found less economically viable, though investigations are still ongoing (Rodman, 2006; Bourzac, 2006). The free gossypol content of cotton products may depend on processing: heating, for instance, increases gossypol binding and reduces toxicity, whereas fine grinding breaks the gossypol glands, releasing gossypol in the product (EFSA, 2008). Extrusion was shown to reduce free gossypol by 71 to 78% in cotton seeds (Buser et al., 2001).

Free gossypol causes moderate acute toxicity in animals. Signs of acute gossypol toxicity include constipation, dyspnoea, anorexia and loss of weight while repeated exposure to lower doses of gossypol (in rats and humans) mainly affects the testis in males (reduced sperm motility, inhibited spermatogenesis and depressed sperm counts), and reproductive organs and embryo development in females (EFSA, 2008).

The effects of gossypol on animal health and performance depend on the type of animal. The rumen of mature ruminants detoxifies cotton seeds by exposing gossypol to rumen microorganisms, causing its deactivation, binding, and degradation. Young ruminants with an immature rumen as well as monogastric animals do not benefit from this protection and are thus more sensitive to gossypol (Blasi et al., 2002; Poore et al., 1998). In these species, the use of unprocessed cotton seeds is not recommended, though it is possible to alleviate gossypol toxicity through the addition of iron salts to the diet, which are able to bind gossypol (EFSA, 2008).

Tannins

Whole cotton seeds contain condensed tannins that are located in the hulls where they are mainly bound to proteins and fibres (Yu et al., 1996).

Cyclopropenoid fatty acids

The oil of cotton seeds, particularly those of *Gossypium hirsutum,* contain about 0.5-1% of cyclopropenoid fatty acids such as malvalic, sterculic and dihydrosterculic acids. These fatty acids have been found to have deleterious effects on animal performance and various harmful effects on health (reproductive disorders, growth retardation and altered fat metabolism) in rainbow trout, rodents and poultry (OGTR, 2008; Sebedio et al., 1989; Phelps et al., 1964).

Aflatoxins

Cotton seeds can be contaminated by the fungus *Aspergillus niger*, which produces aflatoxins, a group of mycotoxins deleterious to animal and human health. Aflatoxin levels in cotton seeds should not be higher than 0.02 mg/kg and 0.03 mg/kg in the EU and in the USA respectively (Jouany et al., 2009). Inadequate storage conditions tend to increase aflatoxin contamination and it is recommended that cotton seeds are stored at moisture contents lower than 10% (O'Brien et al., 2005). Aflatoxin contamination can be reduced by processing: for example aflatoxin content was reduced by 50% when the cotton seeds were processed by two stages of extrusion at a temperature of 132°C (Buser et al., 2001).

Ruminants

Cotton seeds are high in energy (due to their fat content), crude protein and fibre, and are consequently a good supplement for dairy and fattening ruminants. Whole cottonseed may be used as a feed for mature cattle, as it's often done where adequate milling equipment is not available. The seedes are usually soaked in water and fed in small quantities as a supplement to green feed (Göhl, 1982). Due to the presence of gossypol (See **Potential constraints**), cotton seeds must not be given to young ruminants before they have a mature functional rumen. However, 2 experiments with calves fed on 15% or 25% cottonseeds reported no detrimental effect on calves performance or health due to gossypol (Bernardes et al., 2007; Anderson et al., 1982). Given the detrimental effects of gossypol on reproduction, cotton seeds must be limited or avoided in diets for reproductive males and females.

Energy source

Because the energy of cotton seeds is mainly provided by their fat content, methane production in the rumen is lower than that obtained with fermentable carbohydrates (Arieli, 1998). Cotton seeds provide by-pass energy in the form of long chain fatty acids that are released in the rumen after oil hydrolysis. The addition of cotton seeds was found to greatly reduce the numbers of protozoa, because excessive fat in the rumen may have a detrimental effect on cellulolytic bacteria (Bird et al., 1987). Because of its high fat content it may be recommended to limit cotton seeds in order not to exceed about 6% of the total fat content in the diet. It can be an interesting source of energy when incorporated at up to 15% of the diet for steers in a hot and humid climate. Those animals show less thermal stress (lower respiration and sweating rates), maintain their body temperature with a lower water consumption and have a better overall performance (Umpapol et al., 2011).

Protein source

Cotton seeds are a protein source. Delinting tends to decrease the fibre content and increase the protein and oil concentrations (Göhl, 1982). Cottonseed protein is highly degradable: soluble proteins (albumin and globulin) make up 75% of total proteins and rumen protein degradability values are usually over 70% (Arieli, 1998).

In vivo digestibility of diets including cotton seeds

When cotton seeds are introduced into a diet, the crude fat digestibility generally increases (Karalazos et al., 1992; Polviset et al., 2010; Silva et al., 2010); and fibre (ADF) digestibility may decrease (Hill et al., 2008; Polviset et al., 2010) or increase (Karalazos et al., 1992). Apparent DM or OM digestibility of the whole diet does not change.

Animal	Experiment	Inclusion rate	Effect on DMD	Effect on OMD	Effect on DMI	Reference
Sheep	Substitute for maize grain in concentrate + hay	175, 355, 530 g/d	Decreases from 74 to 63%		No effect	Karalazos et al., 1992
Dairy goat	Substitute for soybean meal	13% (320 g/d)	Tends to decrease (58 *vs.* 60%)	Decreases (59 vs 62%)	No effect	Silva et al., 2010
Steers	Increasing levels + hay	1.2 kg/d, 2.3 kg/d or *ad lib.*	-	Decreases from 75 to 63% at *ad libitum* (3.7 kg/d)	Hay DMI decreases	Hill et al., 2008
Steers	Increasing levels in TMR	10, 20 or 30%	-	Decreases from 82% (10% inclusion rate) to 75% (20 or 30% inclusion rates		Neill et al., 1989
Steers	Increasing levels in concentrate + straw	15 or 30%	No effect (80%)	No effect (82%)	No effect	Polviset et al., 2010

TMR= total mixed ration; DMD= *in vivo* apparent dry matter digestibility; OMD= *in vivo* apparent organic matter digestibility; DMI= dry matter intake

Dairy cows

The response of dairy cows in terms of DM intake when cotton seeds are used as a supplement depends on climatic conditions, on dietary factors such as fat, fibre and energy content, and possibly on diet protein degradability (Arieli, 1998). Whole cotton seeds included into dairy cows diets up to 25% did not affect DM intake but had a positive effect on milk fat content and a negative effect on milk protein content. Milk fat composition changed, resulting in a decrease in C6-C12 fatty acids and in an increase in stearic and total oleic acids (Coppock et al., 1987). High levels of cotton seeds (3.5 kg/d) offered for a long period (5 months) to supplement the diets of dairy cows (548-557 kg, 25 kg milk) significantly impaired fat and carbohydrate metabolism, measured by liver function. However, this effect was reversible when cotton seed supplementation was stopped for 2 months (Girginov et al., 2008). The following table presents dairy cow trials with cotton seeds included in the diet.

Country	Breed	Experiment	Inclusion rate on DM basis, except where stated	Results	Reference
USA	Holstein	Comparison of cotton seeds or cracked cotton seeds in TMR	3 or 10%	No effect on DMI (24 kg/d), milk yield (34.6 kg/d for primipares, 45 kg/d for multipares) and milk fat (3.5 %)	Santos et al., 2002
USA		Dose comparison in TMR	0 or 15%	DMI increased by 0.7 kg/d, milk yield by 0.9-1.4 kg/d and milk fat by 0.3%	Risco et al., 1998
Greece	Friesian (600kg)	Comparison cotton seeds *vs.* cottonseed meal in concentrate plus maize silage and straw diet	20% on fresh basis	Milk yield increased by 2 kg/d and milk fat by 0.42%	Belibasakis et al., 1995
USA	Holstein	Comparison of cotton seeds or crushed cotton seeds in TMR	12.8%	No effect on DMI (25-28 kg/d), milk yield (38.5-40 kg) and milk fat (3.9-4%) for primipares and multipares respectively. Slight differences in milk fatty acids composition	Prieto et al., 2003
Argentina	Holstein	Comparison of GM cotton seeds and non GM cotton seeds in TMR	10%	No effect on DMI (22-23 kg/d), body weight (540-567 kg), milk yield (27 kg/d) and milk composition	Castillo et al., 2004
USA	Holstein	Comparison of cotton seeds to cottonseed meal or SBM in TMR	13.50%	No effect on DMI (20.7-22.7 kg/d), milk yield (28.6-30.8 kg/d) and milk composition	Mena et al., 2004
China	Holstein	Comparison TMR with or without cotton seeds	10%	No effect on DMI (18–21 kg/d) and milk yield (23-30 kg/d); milk protein increased (3.2 *vs.* 3.4%). Milk fat tended to increase	Chen et al., 2008
Turkey	Holstein (500 kg)	Increasing cotton seeds levels in a diet based on maize silage and concentrate	0, 12.5, 25, or 37.5%	No effect on milk yield (18.3-20.5 kg/d) and milk fat (4-4.1%)	Oguz et al., 2006
Thailand	Holstein Friesian (450 kg)	Comparison of cracked or not cotton seeds in TMR	10%	No effect on DMI (15.2-15.9 kg/d), milk yield (16.2-16.6 kg/d) and milk composition	Wongnen et al., 2009
India	Lactating Murrah buffaloes	Comparison between transgenic (Bt) and non-transgenic cotton seeds in a concentrate (4.5 kg/d) with forage	Up to 40%	No effect on forage DM intake (11.8-12 kg/d) and body weight gain (426-494 g/d)	Singh et al., 2003

Beef cows

In dry pregnant cows (520-580 kg BW) fed tropical hay and cotton seeds offered *ad libitum* (average intake 4 kg cotton seed DM), or relative to body weight (0.25% or 0.5%), hay DMI was higher at *ad libitum* and 0.5% BW level than at 0.25% BW level (11.5 *vs.* 9.5 kg). No diarrhea or other adverse effects were observed even when the cotton seeds were offered *ad libitum*. The average daily weight gain increased from 360 g/d to 590 g/d with increasing cotton seeds intake. Beef cows offered hay supplemented with cotton seeds at 0.5% BW from the end of gestation to 90 days after calving had higher BW gains than when not supplemented and calves were not affected (birth weight and weight gain) by their mother's diet (Hill et al., 2008).

Growing cattle

The following table presents growing cattle trials with cotton seeds included in the diet.

Country	Animal	Experiment	Inclusion rate on DM basis	Main results	Reference
Brazil	Calves	From birth to 3 months	15%	No clinical evidence of gossypol intoxication. Same daily weight gain and DMI than for diets without cotton seeds	Bernardes et al., 2007
USA	Calves	From birth to 3 months	25%	No health problems. Higher daily weight gain and DMI than for diets without cotton seeds	Anderson et al., 1982
USA	Holstein steers (379-394 kg)	Comparison of cotton seeds and various cotton seeds processed (cracked, roasted, cracked + roasted, extruded) in TMR	15%	No difference in DMI (9.6-10.3 kg/d) or ADG (1410-1890 g/d) excepted with roasted and cracked cotton seeds resulting in lower rate of gain (1290 g/d)	Santos et al., 2005
USA	Holstein steers (423-432 kg)	Comparison of various cotton seeds and cottonseed meal levels in TMR	7 or 14%	No difference in DMI (9.2-10.3 kg/d) or ADG (1040-1400 g/d)	Santos et al., 2005
USA	Holstein steers (473-497 kg)	Comparison of two genus of cotton seeds cracked or not	15%	No difference in DMI (9.1-10.1 kg/d) or ADG (1000-1500 g/d)	Santos et al., 2005
Australia	Brahman-cross steers (350 kg)	Comparison of various levels of cotton seeds in finishing diet	10, 20 or 30%	No difference in OMI (5,3-6,5 kg/d) and ADG (810-860 g/d)	Neill et al., 1989
USA	Crossbred (340 kg)	Comparison of cotton seeds to cottonseed meal and husk in TMR	30%	DMI tended to decrease with cotton seeds (5.0 vs 6.3 kg/d)	Moore et al., 1986
USA	Angus x Polled Hereford (457 kg)	Hay based diet supplemented at various cotton seeds levels	0.25, 0.30 % BW or ad libitum	Increasing levels of cotton seeds intake decreased hay DMI from 5.9 kg/d (0 cotton seeds) to 4.5 kg/d (ad libitum cotton seeds). Maximum cotton seeds DMI was 3.7 kg/d	Hill et al., 2008
Thailand	Crossed Charolais (425 kg)	Comparison of various levels of cotton seeds in concentrate offered at fixed amount with rice straw	0, 5, 10, 15%	No effect on straw DMI (6.58 kg/d). ADG and carcass dressing % increase from 621 g/d (0%) up to 700-720 g/d (10 and 15%) and from 56.5% to 64% respectively	Umpapol et al., 2011

TMR= total mixed ration; DMI= dry matter intake; OMI= organic matter intake; ADG= average daily weight gain; BW= body weight

Sheep

The following table presents sheep trials with cotton seeds included in the diet.

Country	Animal	Experiment	Inclusion rate on DM basis	Results	Reference
Iran	Lambs, 30 kg	In a complete TMR containing cotton seeds	8% and 18%	At 8%: increased diet DMI, daily weight gain and slaughter results (hot carcass, dressing percentage) with no adverse effect on internal organs. At 18% all results decreased ()	Absalan et al., 2011
Brazil	Santa Ines lambs	In a complete diet containing cotton seeds	Up to 40%	No effect on daily weight gain, slight change of meat fatty acid profile	Madruga et al., 2008
Brazil	Santa Ines lambs	In a complete diet containing cotton seeds	Up to 40%	Better meat quality (physical and sensory parameters) with no adverse effect	Vieira et al., 2010

Goats

The following table presents goats trials with cotton seeds included in the diet.

Country	Animal	Experiment	Inclusion rate on DM basis	Results	Reference
Australia	Dairy goats	Protected cotton seeds replacing up to 80% of a mixture of rapeseed meal and soybean meal	Up to 80%	Changes in milk fatty acid: increase in linoleic (C18:2) and stearic (C18:0) acids, and decrease in oleic (C18:1) acid	Gulati et al., 1997
Niger	Dairy goats, local breed, 32.7 kg	During the first 8 weeks of lactation	400 g/d	Average milk yield of 447 g/d, milk fat 5.2%, milk protein 3.9%	Djibrillou et al., 1998
Burkina Faso	Dairy goats	8 weeks after the 1st week of lactation	0 to 33%	No effect on DM (1-1.1 kg/d) and milk yield (0.7-0.8 kg/d), but an increase in milk fat (4.6% without cotton seeds to 6.1% with 33% cotton seeds) and a decrease in milk protein (3.8 to 3.2%)	Ouedraogo et al., 2000
Brazil	Dairy goats, Saanen	Partial replacement for soybean meal	13%	No effect on milk yield (1.1 kg/d) but increase in milk fat (3 to 3.4%)	Silva et al., 2010

Effect of gossypol

Ruminants with a well developed microbial rumen population are able to detoxify gossypol by binding it to amino acids in the rumen (Santos et al., 2002). However, the detoxifying mechanism can be overwhelmed when excessive gossypol content is combined to a low protein concentration in the rumen (Risco et al., 1998). As a result, gossypol may have detrimental effects on health and reproduction (see below). Free gossypol content can be significantly reduced (from 63 to 85%) by various processes such as roasting, cracking and roasting or extrusion. Iron also has a detoxifying effect and adding Fe as iron sulphate (up to 500 mg/g DM of the diet) to steer diets decreased gossypol in plasma (Santos et al., 2005).

Because the rumen becomes functional between 6 and 8 weeks, young ruminants with undeveloped rumen such as lambs and calves should not be fed with cotton seeds (Martin, 1990). Ruminants from 8 to 24 weeks old can tolerate up to 200 mg/kg of dietary free gossypol and older animals can tolerate up to 600 mg/kg without adverse effects (Risco et al., 1998).

Gossypol has no marked effect on production (milk, growth) in adult animals except when very high levels of cotton seeds are used. However, gossypol has a negative effect on gonads and reproduction, primarily in male ruminants but females can also be affected (Randel et al., 1992).

Females

Most of the studies conducted on dairy cows at various lactation stages showed no effect of gossypol on DMI or on milk production and composition, though plasma gossypol increased with increasing levels of gossypol in the diet (Mena et al., 2004). Gossypol was found to decrease hemoglobin content in adult dairy cows (Risco et al., 1998). It increased erythrocyte fragility in young heifers given 30% whole cotton seeds for a long period (over 200 days) (Colin-Negrete et al., 1996) and in adult dairy cows fed 13.5% cotton seeds (corresponding to 20.1 g/d of total gossypol intake) for a shorter duration (84 days) (Mena et al., 2004).

Ruminant females seem to be relatively insensitive to the negative effects of gossypol on fertility (Randel et al., 1992). In growing dairy heifers fed 15% or 30% cotton seeds for a long period (over 400 days), there was no effect of the cotton diet on body weight at onset of puberty and on pregnancy rates (Colin-Negrete et al., 1996). Dairy cows receiving a diet with 15% cotton seeds (20 g/d total gossypol) did not show reproduction problems after 120 days (Risco et al., 1998). However, dairy cows fed for more than 170 days after calving with a diet containing 10% of cotton seeds or a mixture of cotton seeds and cracked cotton seeds (22.8 and 17.5 g/d of free gossypol respectively) showed lower fertility, conception rate and higher abortions when plasmatic gossypol was high (Santos et al., 2003b). Dairy heifers fed 33% to 67% cotton seeds (14.7 g/d of free gossypol) showed a lower quality and viability of embryo and reduced embryo development (Villaseñor et al., 2008). Globally, gossypol has a negative effect on early embryo development and survival (Zirkle et al., 1988; Galvao et al., 2006).

Males

Gossypol may have detrimental effects on male reproduction with marked testicular and spermatogenic epithelium damage (Randel et al., 1992; Chase et al., 1994; Arshami et al., 1988; Risco et al., 1998). When cotton seeds are removed from the diet, animals partly recovered their testicular normality after 2 months damage (Arshami et al., 1988). Young Brahman bulls fed with 41% cotton seeds reach puberty later than those fed with soybean meal (613 *vs.* 550 days) but with no difference in quality and quantity of semen (Chase et al., 1994). However, adult Holstein bulls fed a diet containing 25 or 35% cotton seeds for 120 days showed abnormalities in terms of semen volume, concentration and other criteria (Smith et al., 1991). In growing male lambs, cotton seeds fed for about 8 months at 20, 30 or 40% did not affect daily weight gain, testis formation and weight, and semen volume and concentration. However, sperm motility and vigour decreased when the diet contained 20% or more cotton seeds, and total sperm defects also increased with increasing cotton seeds levels (Cunha et al., 2012).

Pigs

Cotton seeds are not a good feed for pigs, due to the presence of gossypol (LD_{50} is 550 mg/kg for pigs, European Commission, 2003), and to their high fibre content, which reduces their energy density compared to other oilseeds. Cotton seeds contain 16% less net energy (for growing pigs) than soybean seeds and 43% less than rapeseeds (Noblet et al., 2002). For those reasons, there are very limited data available on the use of cotton seeds for pigs. Feral swine have been observed readily feeding on whole cotton seeds but alsoconsuming them in lethal amounts, causing their deaths (Campbell et al., 2010). Glandless (gossypol-free) cottonseed kernels could be fed to starter, grower and finisher pigs and could replace 50% of soybean meal in a maize-soybean meal based diet provided that they were supplemented with lysine. Processing cottonseed kernels through pelleting, mild autoclaving or extrusion did not improve their feeding value (LaRue et al., 1987).

Poultry

Whole cotton seeds have a high fibre level and thus dehulled seeds (kernels) should be preferred for poultry feeding. The presence of free gossypol also limits their use in poultry diets. However, the high energy level due to the oil content of cotton seeds can be valuable in poultry feeds.

Broilers

The inclusion of cottonseed kernels in broiler diets significantly decreased feed intake and growth performance even at levels as low as 6.25% in the diet (Diaw et al., 2010b). Even though iron or lysine addition could alleviate the effects of gossypol (review of Diaw et al., 2011), it is not advisable to use whole cotton seeds in practical conditions. However, cottonseed kernels from glandless (gossypol-free) varieties did not impair broiler performance up to 20% inclusion rate (Diaw et al., 2010a; Yo, 1991). In hot and humid conditions, performance was even increased in diets with cotton seeds (Diaw et al., 2010a).

Rabbits

Bibliographical references on the use of cotton seeds in rabbit nutrition are scarce and (as of 2013), only one paper (Johnston et al., 1985) had been published on the utilization of extruded cotton seeds for lactating does and fattening rabbits. The single inclusion rate (43%) tested was very high and resulted in performance comparable to those obtained in similar conditions with other extruded seeds (soybean, flax seed and safflower seed) and soybean meal. Milk production was estimated through the average individual weight of 3 week-old kits and growth rate was studied until the young were 8 weeks old. While differences were not significant (6 does and their litters per treatment), it can be noted that the use of cotton seeds reduced the weight of 3-week-old kits and their subsequent growth rate by 11% when compared with the soybean meal control. This slight reduction of performance could not be attributed to the presence of cotton oil, since this source of lipids is considered suitable for rabbit feeding (Abdelhamid, 1989). However, the intrinsic deficiency of cotton protein (Carabaño et al., 1992) was not taken into account and may explain the minor alteration of performance. It can be noted that extrusion can reduce significantly the free gossypol content (Buser et al., 2001), which could explain the relatively mild negative effect of the seeds, but the authors did not provide data on the gossypol content of the tested feed. More investigations would be necessary before recommending the utilization of cotton seeds in rabbit feeding.

Datasheet citation

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Feed categories
All feeds
Forage plants
- 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

Latin names
Plant and animal families
Plant and animal species

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

Cotton seeds

Description | Nutritional aspects | Nutritional tables | References

Tables of chemical composition and nutritional value

- Cotton seeds, whole
- Cotton seeds, dehulled

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

Cotton seeds, whole

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	92.3	1.8	88.7	95.0	143
Crude protein	% DM	21.8	2.0	17.8	25.8	170
Crude fibre	% DM	28.1	3.4	21.2	36.0	137
NDF	% DM	48.6	2.5	39.8	51.3	41 *
ADF	% DM	36.1	2.7	31.1	40.6	47 *
Lignin	% DM	10.6	2.0	8.0	15.6	40 *
Ether extract	% DM	19.7	3.0	13.2	24.7	138
Ash	% DM	4.4	0.3	3.7	5.2	152
Starch (polarimetry)	% DM	2.1		0.3	3.9	2
Total sugars	% DM	2.1		1.6	2.6	2
Gross energy	MJ/kg DM	23.8		22.6	24.6	2 *

Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	1.5	0.3	1.0	2.5	120
Phosphorus	g/kg DM	5.9	0.8	4.5	7.8	121
Potassium	g/kg DM	12.0	1.2	10.0	14.9	109
Sodium	g/kg DM	0.1	0.1	0.0	0.3	17
Magnesium	g/kg DM	3.6	0.3	3.0	4.5	107
Manganese	mg/kg DM	16	1	14	18	19
Zinc	mg/kg DM	35	4	29	42	19
Copper	mg/kg DM	10	2	8	12	19
Iron	mg/kg DM	70	35	46	183	13

Secondary metabolites	Unit	Avg	SD	Min	Max	Nb
Tannins (eq. tannic acid)	g/kg DM	3.2	4.2	0.3	11.4	6
Tannins, condensed (eq. catechin)	g/kg DM	8.9	4.2	6.0	17.0	6

Ruminant nutritive values	Unit	Avg	SD	Min	Max	Nb
OM digestibility, ruminants	%	62.8	14.0	46.7	71.0	3
Energy digestibility, ruminants	%	64.0				*
DE ruminants	MJ/kg DM	15.2				*
ME ruminants	MJ/kg DM	12.0				*
Nitrogen digestibility, ruminants	%	70.2	4.0	61.5	70.2	3 *
a (N)	%	77.6				1
b (N)	%	16.1				1
c (N)	h-1	0.156				1
Nitrogen degradability (effective, k=4%)	%	90				*
Nitrogen degradability (effective, k=6%)	%	89		78	89	2 *

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

References

AFZ, 2011; Arieli et al., 1989; Arieli, 1992; Ashes et al., 1978; Belyea et al., 1989; Beran et al., 2005; CIRAD, 1991; CIRAD, 2008; Clark et al., 1993; Clark et al., 1997; Combellas et al., 1993; DePeters et al., 2000; FUSAGx/CRAW, 2009; Henderson et al., 1984; Karalazos et al., 1992; Lanham et al., 1992; Leonardi et al., 2005; Maan et al., 2003; Masoero et al., 1994; Patel, 1966; Pena et al., 1986; Pozy et al., 1996; Stutts et al., 1988; Woodman, 1945

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Cotton seeds, dehulled

Dehulled cotton seeds contain less fibre than whole cotton seeds, but the fibre content depends on the level of dehulling, which may be highly variable.

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	93.6	1.8	90.4	95.5	10
Crude protein	% DM	32.5	2.9	27.2	37.9	11
Crude fibre	% DM	13.2	6.7	2.8	20.5	10
NDF	% DM	27.5				*
ADF	% DM	18.2				*
Lignin	% DM	6.2				*
Ether extract	% DM	31.5	7.3	18.4	38.0	8
Ash	% DM	5.6	0.8	4.7	6.7	10
Gross energy	MJ/kg DM	26.2				*

Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	1.9	0.5	1.4	2.3	3
Phosphorus	g/kg DM	8.6	1.8	6.8	10.3	3
Potassium	g/kg DM	11.8				1
Magnesium	g/kg DM	5.2				1

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

References

AFZ, 2011; Ashes et al., 1978; CIRAD, 1991; CIRAD, 2008

Last updated on 17/01/2013 13:39:28

Datasheet citation

Heuzé V., Tran G., Hassoun P., Brossard L., Bastianelli D., Lebas F., 2015. *Cotton seeds*. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/742 *Last updated on May 12, 2015, 14:25*

English correction by Tim Smith (Animal Science consultant) and Hélène Thiollet (AFZ)

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- Denis Bastianelli (CIRAD)
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Cotton seeds

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Heuzé V., Tran G., Hassoun P., Brossard L., Bastianelli D., Lebas F., 2015. *Cotton seeds*. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/742 *Last updated on May 12, 2015, 14:25*

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