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# Short Communication

# Noug Seed Cake Quality and Safety

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## Abstract

*Niger (***Guizotia abyssinica***) is an oil-seed crop cultivated in the highland areas of Ethiopia. It is known locally as noug, and its seed is a major source of edible oil. The by-product that remains after extraction of oil from noug seed is called noug seed cake and serves as the main protein supplement and as a moderate source of energy for livestock production in Ethiopia. Noug seed cake has a high concentration of protein which varies from 25.2 to 38%. However, its nutritional contents are highly variable depending on the environmental factors, variety of the seed, extraction methods, etc. In addition, different physical, chemical, and biological factors were reported to affect the nutritional quality and feed safety of noug seed cake. A visible fungal growth is an indicative of spoilage of noug seed cake, and noug seed cake contamination and moulding are the main source of aflatoxin contamination. Some of the common malpractices that cause the accumulation of moulds and aflatoxin production in noug seed cake include storage of noug seed cake indoors in plastic bags or on the floor without bags, in bags stacked without aeration, absence of raised platforms and store for longer time. It is therefore very important to protect mycotoxin production and contamination and keep the feeding value of noug seed cake safe. Furthermore, adulteration of noug seed cake with other types of oil seed cakes is also a common feed safety issue. Prevention of noug seed cake aflatoxin contamination and keeping it safe requires an on-going and thorough sampling and testing program and strict adherence to guidelines since its contamination is critical to animal health and productivity and also to public health. This is because animal feed is an essential channel for transmission of contaminants to the human food chain. A key area of attention is awareness creation using different tools such as media outlets, public gatherings, and social medias about the dangers of aflatoxin B1 contamination of noug seed cake and its adverse effects on animals and humans. It is also especially important to strengthen nationwide surveillance, increase frequent feed inspections to ensure feed safety, and to increase local education and assistance to ensure that animal feeds are harvested and processed correctly, dried completely, and stored properly.*

**Keywords**: Noug seed cake, feed safety, mould, aflatoxin

# Introduction

Niger (*Guizotia abyssinica*) is an oil-seed crop cultivated in the highland areas of Ethiopia and locally known as noug. It is a strong, upright annual herbaceous plant with hairy stems reaching up to a height of 2 m (**Figure 1**). The stems are soft, hollow with a diameter of up to 2 cm, and branched. Its root system is well developed, with a taproot that has many lateral roots, particularly in the upper 5 cm (Getinet & Sharma, 1996; Wayessa, 2007). The color of the plant is pale green, often stained or dotted with purple, and becomes yellow with age. Noug leaves are usually dark green, but the lower ones have a distinct yellow color.

Figure 1. Noug plant

Noug is a variable species adapted to different environments. It can be grown from sea level up to an altitude of 2500 m above sea level where average daily temperatures range from 13°C to 23°C. It requires optimal annual rainfall of about 1000 - 1300 mm, but more than 2000 mm of rainfall depresses its seed yield (Wayessa, 2007). Noug does well on a wide range of soils, from poor sandy soils to heavy black cotton soils, at a pH varying from 5.2 –7.3. Noug can withstand waterlogged areas where there is poor oxygen supply. Noug plants also have some tolerances to soil salinity (Getinet & Sharma, 1996). Noug flowers are capitulate, ranging from 15 to 50 mm in diameter, bright yellow (**Figure 1**) and becoming golden yellow as they mature.

Noug seeds resemble other oil crop seeds such as sunflower seeds. However, noug seed is smaller in size and black in color, angular and elongated (**Figure 2**). The seeds have a thick, adherent seed coat and can be stored for up to a year without deterioration under appropriate dry conditions. Noug seed contains proteins, oil and soluble sugars. In Ethiopia, noug seed is a major source of edible oil. Oil from noug seed is pale yellow, with a nutty taste and a pleasant odor and mostly used for cooking.

Figure 2. Noug seeds

The by-product that remains after extraction of oil from noug seed is called noug seed cake and serves as the main protein supplement and as a moderate source of energy for livestock production (dairy, beef cattle and small ruminants) in Ethiopia. However, different physical, chemical, and biological factors were reported to affect its feed safety and nutritional quality. These factors were also shown to be used to assess the quality and safety of noug seed cake.

## Characteristics of Noug Seed Cake

### Physical attributes

Noug seed cake (**Figure 3**) is the by-product obtained after the extraction of most of the oil from noug seeds. It is one of the oil seedcakes commonly used as a protein supplement in the diet of different farm animals (dairy, beef cattle and small ruminants). Because of its high nutrient content noug seed cake is increasingly used in Ethiopia for its effect on animal productivity in small- or large-scale livestock production systems. Noug seed cake produced in fine form is preferred as compared to coarse form. It is popular because users think it is easy to mix with other feed ingredients like wheat bran and does not need to be ground for immediate feeding or mixing with other ingredients like wheat bran.

Users assess the quality of noug seed cake by visual observation. Fresh noug seed cake is shiny but turns greyish or dull as it is exposed to moisture. Fresh noug seed cake has a pleasant odor, but it turns rancid as it ages, especially under poor storage conditions. In addition, visible mould (fungal growth) is indicative of spoilage of noug seed cake. Recent studies have identified noug seed cake contamination and moulding as the main source of Aflatoxin contamination in feeds. A level of contamination of Aflatoxin B1 up to 290-397 µg/kg has been detected in noug seed cake samples collected from farms and feed millers around

Addis Ababa (Gizachew *et al*., 2016). It is, therefore, important to recognize the characteristics of a contaminated noug seed cake to avoid feeding aflatoxin contaminated diets to animals.

Figure 3. Noug seed cake

## Chemical composition

Noug seed cake has a high concentration of protein which varies from 25.2 to 38%, with most values lying between 30 and 35%, as well as non-starch polysaccharides, fat content varying from 2.1 to 12.6% with an average of 8.4% and a metabolizable energy value of 2.37 Mcal/kg DM (**Table 1**). However, as indicated in Table 1 the nutritional contents of noug seed cake are highly variable mainly due to environmental factors, variety of the seed, extraction methods, etc. For instance, noug seed cake produced by mechanical extraction of the oil from the seeds is reported to contain more fat (7-14% DM) than those produced by solvent (chemical) extraction leaving only around 1-2% in the cake but with a higher NDF content (31.6 - 51.8 %). Noug seed cake also has a moderate *in vitro* DM digestibility of 61.7 - 67.3% (**Table 1**).

**Table 1**. Chemical and nutritional value of noug seed cake

| Nutritional parameter | Value | References |
|---|---|---|
| Dry matter (g/Kg) | 91.9 – 92.3 | Gashaw & Defar, 2017; Feyissa *et al*., 2015; Mekuriaw *et al*., 2018; Gebermariam *et al*., 2016; Yigzaw *et al*., 2019; Mengistu et al., 2020 |
| CP (%) | 25.2 – 38.0 | Tolera, *2008*; Mekuriaw *et al*., 2018; Gebermariam *et al*., 2016; Yigzaw *et al*., 2019; Mengistu *et al*., 2020 |
| NDF (%) | 31.6 – 51.8 | Gashaw & Defar, 2017; Mekuriaw *et al*., 2018; Gebermariam *et al*., 2016; Yigzaw *et al*., 2019; Mengistu *et al*., 2020 |
| ADF (%) | 22.7 – 35.6 | Gashaw & Defar, 2017; Feyissa *et al*., 2015; Mekuriaw *et al*., 2018; Gebermariam *et al*., 2016; Yigzaw *et al*., 2019; Mengistu *et al*., 2020 |
| Fat (%) | 2.1 – 12.6 | Tolera, 2008; Feyissa *et al*., 2015 |
| DM digestibility (%) | 61.7 - 67.3 | Tolera, 2008; Mekuriaw *et al*., 2018 |
| ME (Mcal/Kg DM) | 2.37 | Tolera, 2008 |

## Biological features

Noug seed cake needs proper storage and transportation. The cake should be aerated when stored, as its shelf life is shortened when it becomes too damp. A study by Gizachew *et al*., (2016) suggest that the optimal storage conditions for avoiding growth of aflatoxin producing fungi on noug seed cakes would be a dry well aerated room with average room temperature less than 20°C and equilibrium relative humidity of 86%.

Common storage malpractices that cause the accumulation of moulds and aflatoxin production in noug seed cake include storage of noug seed cake indoors in plastic bags or on the floor without bags, in bags stacked without aeration, absence of raised platforms (**Figure 4**), storage for more than 3 months, etc. These storage conditions can cause heating and shorten its shelf-life. Noug seed cake should be packed in moisture-proof bags or in similar suitable moisture-proof clean and pathogen/contaminant-free containers. Moisture contamination during transportation or storage can allow fungal growth which can predispose noug seed cake to contamination with mycotoxins, particularly aflatoxins. Mycotoxins are poisonous chemical compounds produced by fungus or moulds. Those mycotoxins that occur in feedstuffs have great significance in the health and productivity of livestock. Since they are produced by fungi, mycotoxins can be associated with diseased or mouldy crops, although they can also be present in visually healthy crops and grains.

Figure 4. Poor storage conditions that are favorable to the accumulation of moulds and production of aflatoxins

## Mycotoxin Production and Safety of Noug Seed Cake

Factors that affect mycotoxin production and contamination can be categorized as physical, chemical, and biological factors. Physical factors include environmental conditions favorable for fungal colonization and mycotoxin production such as temperature, relative humidity, and insect infestation. In general, moulds can grow at a temperature range of 10 - 40°C, under high moisture, and oxygen (above 20% dry matter and above 70% equilibrium relative humidity), and a pH range of 4.0 - 8.0 (Negash, 2020). Because feedstuffs can be contaminated during pre- or post-harvest, control of additional mould growth and mycotoxin formation is dependent on storage management such as poor air circulation. After harvest, temperature, moisture content, and physical damage (by insects, rodents) and/or the stress of hot dry conditions are the major factors influencing mycotoxin contamination of noug seeds. Chemical factors include the use of fungicides and/or fertilizers. Biological factors are based on the interaction between the colonizing toxigenic fungal species and substrate. In addition, like chemical properties, the biological quality of noug seed cake is affected by type of oil extraction method and adulteration.

Aflatoxin in animal feedstuffs has been a growing concern in the dairy industry due to the prevalence of aflatoxin M1 (hydroxylated form of AFB1) in dairy

products from animals consuming AFB1-contaminated feed. Concentrate animal feedstuffs can have elevated levels of mycotoxin contamination. For instance, the highest level of aflatoxin B1 contamination detected in noug seed cake was 419 µg/kg (De Boevre *et al*., 2012). In fact, noug seed cake has been found to be the main source of aflatoxin contamination among animal feeds by different studies (Tola and Kebede, 2016). It is important to note, however, that there is a difference between aflatoxin B1 which is the aflatoxin in feeds, with aflatoxin M1 which is the one excreted in the milk of a cow that consumed a feed contaminated with aflatoxin B1 (Gizachew *et al*., 2016). Aflatoxin M1 is considered a detoxified by-product of Aflatoxin B1 and, therefore, has only 10% of the toxicity and mutagenicity of Aflatoxin B1 (Wogan and Paglialunga, 1974).

In addition, adulteration of noug seed cake with other types of oil seed cakes is also a common feed safety issue. In Ethiopia it is quite common that diverse types of oil seed cakes are mixed for livestock feeding. For instance, noug seed cake can be adulterated with rapeseed, mustard seed, or safflower seed during extraction and yet the mixture can be sold as pure noug seed cake. When adulterated with rapeseed the mixture often reduces DM intake, weight gain and may cause health problems for animals because of the toxic glucosinolates (and their derivative) in rapeseed that causes physiological changes in the thyroid gland, liver, spleen, and other organs (Lajolo *et al*., 1991; Knutsen *et al*., 2016).

## Control and Prevention of Mould Growth in Noug Seed Cake

Animal feed is an essential channel for transmission of contaminants to the human food chain; therefore, hazards present in animal feeds pose a threat to human health. Prevention of mycotoxin contamination of feed, particularly noug, is critical to animal health and productivity and public health. A combination of technology solutions, effective regulations, and standards could bring about mitigation and prevention of aflatoxin contamination of feeds. The latter includes prevention of mould or fungus growth on feedstuffs, decontamination of mycotoxin contaminated feeds as a secondary strategy, and continuous surveillance for mycotoxins in animal feedstuffs. Prevention can be achieved by following strict hygienic safety measures during harvesting, threshing, storage, and processing of noug seeds. In addition, proper drying, and storage of seeds and noug seed cake are effective tools for reducing mould growth and mycotoxin production.

Decontamination of mycotoxin can be attained by physical, chemical, and biological techniques. Mycotoxin binders mainly used as feed additives could be a reliable option for sequestering mycotoxin in feeds and preventing their absorption after ingestion. Adsorbents/binders that are usually added to compound animal feed have been confirmed to reduce mycotoxins, and examples include naturally occurring specific clays (e.g., bentonite) as well as activated charcoal, and certain

yeasts, bacteria, and enzymes (Ogunade *et al*., 2018; Vila-Donat *et al*., 2018). Physical approaches include sorting out contaminated grains and de-hulling. Chemical approaches include applying fungicides that inhibit mould growth, and biological approaches depend on the development of atoxigenic fungi that compete with toxigenic fungi in the environment.

Preventing noug seed cake aflatoxin contamination requires an on-going and thorough sampling and testing program and strict adherence to the following guidelines:

- Purchase noug seed cake from reputable persons and companies with a proven record of properly monitoring the quality and safety of their feed products.
- Do not buy poor quality noug seed cake as it is likely to have been adulterated.
- Noug seed cake should be packed in moisture proof bags or in similar suitable moisture-proof clean and pathogen/contaminant-free containers.
- Store noug seed cake at proper moisture levels (70% equilibrium relative humidity), temperature of 10 - 40°C with adequate aeration for no longer than 3 months.
- Feed processors and sellers should develop a systematic inspection and clean-up program to keep bins, delivery trucks and other equipment free of adhering or caked feed ingredients.
- Minimize dust accumulation in milling and mixing areas.
- Keep all feed equipment free of caked feed.
- Check feed storage bins for leaks.
- Implement effective rodent and insect control programs in storage areas.

## Summary

Adverse animal health can result from consumption of aflatoxin-contaminated feeds, particularly noug seed cake and handling of such feeds by humans may pose additional health risks. However, risks of cancer from human consumption of milk from cows fed aflatoxin-contaminated noug seed cake are likely overstated as recent findings have challenged the notion that milk aflatoxin M1 is carcinogenic (Turna *et al*., 2022). A key area of need is awareness creation about the dangers of aflatoxin B1 contamination of feed and its adverse effects on animals and humans. It is also especially important to strengthen nationwide surveillance, increase feed inspections to ensure feed safety, and to increase local education and assistance to ensure that animal feeds are harvested correctly, dried completely, and stored properly. These could be achieved through awareness creation using tools such as media outlets, public gatherings, and social learning. However, equal attention should be paid to correcting the myth that milk from

different places including Ethiopia is unsafe due to aflatoxin contamination (typically due to consumption of aflatoxin-contaminated noug seed cake), given the recent publication (Turna *et al*., 2022) showing that US FDA and EU standards for safe levels of aflatoxin in milk are probably misleading.

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