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Chemical Composition and Nutritional Characterization of Cotton Seed as Potential Feed Supplement

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Abstract: The potential of cotton seeds to serve as animal feed in reducing feed-food competition between humans and animals was examined in this research. Proximate analysis, mineral characterization, and fatty acid composition of the seed were determined using standard analytical techniques. The protein content of cotton seeds found to be 24.81 ± 0.42% was observed to be above the protein requirement of 18% by rabbits and chicken and 12% for goats and sheep. The combination source of carbohydrates, protein, and fat in which cotton seed is endowed offers an adequate nutritional diet for animals. Carbohydrate and crude fat accounted for 19.30 ± 0.1% and 24.81 ± 0.42%, respectively, making cotton seed a valuable source of lipids, protein, and carbohydrate, all major nutrients needed to maintain animals' proper maintenance. The most abundant mineral was potassium (K), at 126.70 ± 5.77 mg/g, which can help maintain body weight. It could assist in the modulation of electrolyte and water balance in the system. Quality assessments indicate that cotton seed, when properly processed, can serve as an affordable alternative to soybean, maize, and groundnut and is currently used as the major sources of animal protein and energy, thereby reducing the competition between feed and food.

Keywords: Feed food, proximate analysis, mineral characterization, fatty acid composition.

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INTRODUCTION

The increasing world population has set the pace for competition for food between humans and animals, thereby deepening the global food shortage crisis (1). In addition, major food-producing countries such as Nigeria and India are experiencing low agricultural yields due to banditry, kidnapping of farmers, uncontrolled grazing on farmland, and unfriendly agricultural government policies. These burdens increase the demand for food crops such as soybeans, a vital source of protein, which are hugely craved by animal production farmers and human beings.

To meet the increasing global demand for food, it is essential to explore the inherent potential in underutilized and undervalued nutritionally dense lesser-known plant sources (2). Nah and Chau (2010) (3) reported that there is a thousand lesser-known biomass that might substantially add to the array of available nutrient sources, particularly animal protein needs.

It is already established globally that human needs for food and animal feed production compete for the already limited resources available (4). To eradicate this competition for the same resources and avoid increasing the pressure on natural resources, alternative raw materials needed for animal feed production need to be researched. One strategy is the use of underutilized waste seeds. Hence, the current work explores the potential of cotton seeds to serve as an alternative to animal protein and fat requirements.

Cotton seed, an often-discarded waste material after cotton fiber has been removed from the pod, is readily available and affordable locally. Hence, the reason for characterizing them in animal production, especially in developing countries where protein needs are a problem, and demand for food often drives the price of goods.

In this regard, recent studies have shown that underutilized plant materials are a potentially sustainable and suitable source of food, particularly for animal production (2). Nweze *et al.* (2011) (5) reported that the performance of broiler chickens fed African porridge fruits (*Tetrapluera tetraptera*) and the dressed weight of broilers fed a *Tetrapluera tetraptera* feeding regime were better than those fed other diets.

Similarly, Ade-Omowaye *et al.* (2015) (6) carried out research into the nutritive potential of some underexplored legumes in Nigeria. *Mallotus subulatus* was found to be rich in protein, making it an alternative source of protein for animal feeding. Harouna *et al.* (2018) (7) exploited the use of different species of wild *Vigna* plants in animal feed production; their findings indicate that the species can be judiciously used as a food replacement in animal feedstocks. Research further reported that the species are underutilized because their potential is still obscured.

With a dearth of information on available alternative sources of animal feed ingredients, this study hopes to evaluate the proximate, mineral, and fatty acid contents of underutilized seeds of cotton seed (*Gossypium hirsutum*).

MATERIALS AND METHODS

Sample Preparation

A fully matured sample of cotton seed was collected fresh from a farm in Ogbondoroko, Afon area of Kwara State, Nigeria. The plant material was identified at the Herbarium of Plant Biology, University of Ilorin, Ilorin, Nigeria, where a voucher specimen was deposited. The seeds were deshelled, pulverized, dried, and kept safe until needed for analysis.

Methods

Proximate analyses

Proximate analysis was carried out to determine the moisture content, ash content, crude fiber, crude fat, crude protein, and carbohydrate contents. The standard procedure of the Association of Official Analytical Chemists was used to determine the listed parameters (8).

Mineral Characterization

The mineral contents of cotton seed were determined by atomic absorption spectrophotometry (AAS) according to the methods of Birt *et al.,* 2002 (8).

The digested sample was analyzed for mineral contents by an atomic absorption spectrophotometer (Hitachi model 170-10). The absorption measurement of the elements for cotton seed was read out.

Extraction and Physicochemical Analysis of the Seed Oil

Oil extraction was carried out using n-hexane (1000 mL) according to the method of Atolani *et al.* (2016). Two hundred grams of sample material of ground dried seeds was extracted using a Soxhlet extractor at 55 °C for 7 hours. The oil was obtained using a rotary evaporator at 40 °C, according to standard methods described by Zubair *et al.* (2018) (9).

GC-MS Characterization of the Seed Oils

The esterified oil from the seeds was analyzed using a gas chromatograph (6890N, Agilent Technologies Network) coupled to an Agilent technology inert XL EI/CI mass selective detector (MSD) (5975B, Agilent Technologies Inc., Palo Alto, CA). Constituents were identified primarily based on the comparison of retention time with those of the authentic standards and further confirmed by comparing mass fragmentation patterns with those of the NIST library (10).

RESULT AND DISCUSSION

Proximate Analysis

In this research, we obtained data that point to the potential of underutilized cotton seeds in Nigeria as an alternative plant feed ingredient to reduce feed-food competition between animals and humans for scarce, limited food crops such as soybean and groundnut seeds.

The proximate analysis results of cotton seed are presented in Table 1. The oil content was found to be 24.81± 0.42%, this is very close to the value of 30.31% reported for soya beans by Bayero *et al.,* (2019) (11) and 48.33 ± 0.14% for ground nut as reported by Kamuhu *et al.,* (2019) (12), this implies the seeds can equally serve as a major source of fat and oil for industry, freeing up the convectional groundnut oil and soybean oil consumed at home, thereby reducing home-industrial competition for vegetable oil. Fat and oil are one of the primary energy sources available to humans and animals and a source of fat-soluble vitamins A, D, E, and K (13). The seed has a moisture content of 7.49 ± 0.21% and falls within the range of the WHO/FAO recommended standard; the low moisture content implies that the seed's shelf life would be high (14).

The food ash content indicates that the mineral composition of food, macro-, and micronutrients aids proper digestion of food; the ash content was found to be 5.85 ± 0.00, this was also more than the ash content in soybean (4.61 %), groundnut (2.37 ± 0.04 %) and maize (1.35 %) (12) indicating the seed is rich in minerals. Ruminant animals need highly desirable fiber-rich plants for proper gut functions. The high fiber content (18.71 ± 0.26) justifies cotton seed as an alternative source of feed ingredients, particularly in ruminant animals such as cattle, goats, sheep, and rabbits. This value is higher than the 3.7 ± 0.03 reported value by Atasie *et al.* (2009) (15) and 9.80 ± 0.19 by Kamuhu *et al.,* (2019) (12) for groundnut seed, commonly used in animal feeds but coveted by humans.

The available protein in the body complements the restoration of damaged tissue and the supply of energy. The high protein level in soya and groundnut seeds is a significant reason for animal feeding as a source of protein, thereby creating the problem of feed-food competition that this research hopes to solve. The protein content of cotton seed was found to be 24.81 ± 0.42%, which is more than the enough protein requirement of 18% by rabbits, (16), 12% for goats and sheep (17), and 18% for chicken (18). The combination source of carbohydrates, protein, and fat will offer an adequate nutritional diet for animals. Carbohydrates accounted for 19.30 ± 0.1%, making cotton seed a valuable source of lipids, protein, and carbohydrates, all major nutrients needed to maintain proper animal maintenance. This clearly indicates that cotton seed, when properly processed, can serve as an alternative to soybean, the primary current source of animal protein, helping to reduce the tension between feed-food competition.

Table 1: The proximate composition of cotton seed.

Class of food	**% Composition**		
	Cotton seed	**Soybean**	**Ground nut**
Moisture	7.49 ± 0.21	8.13	5.11 ±0.05
Crude Protein	24.37 ± 0.28	39.24	22.02 ± 0.23
Crude Fiber	18.71 ± 0.26	6.84	9.80 ± 0.19
Ash	5.85 ± 0.00	4.61	2.37 ± 0.04
Lipid	24.81 ± 0.42	30.31	48.33 ± 0.14
Carbohydrate	19.30 ± 0.10	5.08	12.37 ± 0.44
	This study	Ref (11)	Ref (12)

Mineral Characterization

Table 2 shows the values obtained for mineral characterization of the seed. The seeds were analyzed for minerals such as Mg, K, Na, Zn, Ca, and Fe. Minerals are known for their vital roles in enhancing the proper utilization of food by both plants and animals (19).

The most abundant minerals were found to be potassium (K) at 126.7 ± 05.77 mg/g. Potassium assists in regulating water and electrolyte balance in the body system (20). The sodium content was 12.5 mg/g. Low sodium content helps to regulate acid-base balance and prevent nerve and muscle contraction. High sodium content has been reported to induce hypertension (21).

Magnesium (Mg) plays a crucial role in the stability of the nucleic acid structure. A moderate level of Mg content (7.45 mg/g) will aid in the absorption of electrolytes in the body (22).

Calcium (Ca) is needed for strong bone and dental formation: proper blood clotting and normal functioning of the nervous system. Deficiency of calcium has been reported to include rickets and decaying of the teeth. Excess calcium affects phosphorus usage in the body of animals, another final vital nutrient; hence, a moderate level of the content found in the seed (7.4 ± 0.02 mg/g) is desirable for animals (23).

Iron (Fe) aids oxygen binding to hemoglobin and control of infection (24). Fe and zinc were found in trace amounts (0.1 ± 0.01 mg/g and 0.1 ± 0.00 mg/g, respectively). Zinc (Zn) assists in wound healing. Excess zinc can induce anemia, and deficiency can cause dermatitis (25).

These mineral compositions of cotton seed further show its nutritive potential as a replacement feed ingredient in animals.

Physicochemical Characterization of Cotton seed

Physicochemical characteristics are vital in determining the appropriate use of seeds. Crucial traits such as the acid value are often used to judge the edibility potential of uncommon seeds. Table 3 gives the quality assessment of cotton seed. The percentage yield of 24.81 ± 0.42% indicates that it is a vital source of oil. The acid value was found to be 41.14 ± 0.32 mg KOH/g, which compared favorably to the value of 65.50 mg KOH/g for maize seed oil (26). This further indicates that cotton seed oil can serve as a replacement for feed ingredients, thereby helping to reduce the food-feed competition that has currently been seriously experienced. The saponification value of cotton seed oil was 183.40 ± 0.12 mg/KOH, which is below the standard stated by the International Codex for edible oils compared with a reference standard of 196-205 mg/KOH. This implies that the oils obtained would not be an excellent feedstock for soap-making but somewhat reserved for dietary needs. The iodine value shows the extent of the degree of unsaturation in a molecule. A high degree of unsaturation is desired in edible oils. Polyunsaturated fatty acid-rich oil was reported to mitigate several health challenges, as it prevents clogging of the arteries. Cotton seed shows an iodine value of 157.2 ± 1.55 $I_2$100 g^{-1} oil; these high iodine values mean that the oils contained highly unsaturated fatty acids. The level of unsaturation was further confirmed by GC-MS characterization (Table 4), with a total unsaturation level of 58.54%. Physicochemical analysis revealed that the oil is stable and rich in phytochemicals, as evidenced by the lower free fatty acid content. Higher free fatty acids have been associated with the autooxidation of fat and oil. The lower free fatty acids also indicate a longer shelf life of cotton seed oil and make it an ideal candidate ingredient to reduce food-feed competition between humans and animals.

Table 2: The Mineral Characterization of Cotton seed oil.

Minerals	% Composition
Na	12.60 ± 0.10
K	126.70 ± 5.77
Ca	6.9 ± 0.06
Mg	7.4 ± 0.02
Zn	0.1 ± 0.00
Fe	0.1 ± 0.01

Table 3: Quality parameters of cotton seed oil.

Parameter	Cotton seed oil
% Yield	24.81±0.42
Saponification value (mg KOH/g)	183.40±0.12
Acid value (mg KOH/g)	41.14±0.32
% Free fatty acid	2.11±0.01
Peroxide value (meq kg^{-1})	4.16±0.04
Iodine value ($I_2$100 g^{-1} of oil)	157.2±1.55
Physical state at ambient temperature (25°C)	Liquid

Fatty Acid Methyl Ester Composition of Cotton seed oil

Gas chromatography-mass spectrometry (GC–MS) analysis of cotton seed oil revealed the presence of ten (10) compounds, as shown in Table 4.

The relative abundances of the compounds were in the order linoleic acid (30.22%) > palmitic acid (25.32%) > vaccenic acid (22.27%) > oleic acid (4.92%) > stearic acid (4.19%). The least abundant fatty acids were 7,10-hexadecadienoic acid (0.73%), myristic acid (0.53%), stearolic acid (0.24%), 7-hexadecenoic acid (0.19%) and tridecanoic acid (0.18%) (Table 4). Literature appraisals have revealed the crucial roles these fatty acids play in nutrition.

Linoleic acid, a polyunsaturated fatty acid, is credited to prevent food spoilage (27). Field *et al.* (2009) (28) reported that vaccenic acid, another PUFA found in cotton seed oil, demonstrated a beneficial reduction in cell and tumor growth.

Sales-Campos *et al.* (2013) (29), in a mini-review, attributed the reduction of inflammation enhancement of bactericidal and fungicidal action and inhibition of cancer proliferation amongst other bioactive functions to the presence of oleic acid.

The role of cotton seed oil rich in polyunsaturated fatty acid (PUFA) PUFAs in the management of cardiovascular-related ailment cannot be overemphasized (6, 30). The high prevalence of PUFAs in cotton seed oil implies a positive health benefit to the animals.

Table 4: Fatty acid composition of cotton seed oil.

S/N	Fatty acid	Saturation	% Composition
1	Tridecanoic acid	13:0	0.18
2	Oleic acid	18:1	4.92
3	Palmitic acid	16:0	25.32
4	7,10-Hexadecadienoic acid	16:2	0.73
5	Stearolic acid	18:1	0.24
6	Linoleic acid	18:2	30.22
7	Vaccenic acid	18:1	22.27
8	Stearic acid	18:0	4.19
9	Myristic acid	14:0	0.53
10	7-Hexadecenoic acid	16:1	0.19
	Total Saturation		**41.46**
	Total Monounsaturation		**27.62**
	Total Polyunsaturation		**30.95**
	Total Unsaturation		**58.54**

CONCLUSION

This study indicates that cotton seed, if properly processed, can serve as an alternative to soybean, maize, and groundnut currently used as the primary sources of animal protein and energy, thereby reducing the tension between feed-food competition. Many seeds are available cheaply in Nigeria and many other tropical countries and are often discarded as waste after the fiber has been removed. Processing the seeds into animal feed is viable, as cotton seed possesses many nutritional benefits, making it a good alternative in animal feed. The seed is an endowed source of carbohydrates, protein, and fat with other nutritional benefits. Carbohydrates and crude fat accounted for 19.30 ± 0.1% and 24.81 ± 0.42%, respectively, making cotton seed a valuable source of lipids, protein, and carbohydrates, all significant nutrients needed to maintain proper animal maintenance. The combination source of carbohydrate, protein and fat demonstrated by cotton seed will offer adequate nutritional diet for animals. This clearly indicate that cotton seed when properly processed can serve as alternative to soybean, groundnut and maize currently been used as the major source of animal protein, thereby reducing the tension between feed-food competition.

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