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Proximate and Mineral Compositions, Amino-acid Profile and Anti-nutritional Factors of White Sesame (*Sesamun indicum*) Seed Meal

* Unwana A. Ukpanah, Usen I. Michael, Ofoninyene O. Usoro

Department of Animal Science, Faculty of Agriculture, Akwa Ibom State University, Akwa Ibom State, Nigeria. P. M. B.1167

*Corresponding Author Email: unwanaukpanah@yahoo.com

Abstract

White sesame seed meal is the by-product of sesame oil industry. It has numerous desirable features and can be a significant source of protein as functional feed ingredient or as dietary supplements, this study is designed to bring an update to the existing knowledge on the proximate composition, mineral composition, essential and non-essential amino acids, anti-nutritional factors such as tannin, hydrogen cyanide (HCN) trypsin inhibitors, phytate and haemagglutinin of sesame seed meal. Result showed that the crude protein content of sesame seed meal was $40.99 \pm 0.10\%$, ether extract was 7.63, and crude fiber was 5.84 ± 0.07 . These values fell within the range of values reported by previous researchers. The result of mineral composition (both macro and micro) showed that the values obtained for Ca (0.23%), Mg (0.27%), K (0.77%), P (0.38%) and Na (0.22%) in the present study were lower than the values obtained in previous studies, this may be influenced by species diversity, region, soil nutrient and acidity. The values obtained for the different anti-nutritional factors were, tannin ($0.05 \pm 0.01\%$), hydrogen cyanide ($7.44 \pm 0.48\text{mg/kg}$), trypsin inhibitors ($5.76 \pm 0.00\text{mg/g}$) phytate ($0.03 \pm 0.00\%$). These values fell within the recommended ranges.

Keywords: White sesame seed meal, proximate and mineral compositions, amino-acid profile, anti-nutritional factors.

1.0 Introduction

Sesame (*Sesamun indicum* L) seed is referred to as the 'Queen of oil seeds' because of its high oil yield and quality (Achouri *et al.*, 2012). Sesame seeds are frequently used as a raw material for oil extraction. It has an oil content of about 48–55%; and it is a suitable source of protein, yielding about 20–25% of protein depending on the variety (Heuze *et al.* 2021). White sesame seed meal is the by-product of sesame oil industry. It has numerous desirable features; it serves as a protein-rich functional feed ingredient or as a dietary supplement.

White sesame seed meal is a good source of sulfur-containing amino acids, including methionine, cysteine and tryptophan (Achouri *et al.* 2012) although, when compared with soybean meal, it is

low in lysine, isoleucine, leucine, and valine. Soybean meal (SBM) has higher digestibility and a relatively well-balanced amino acid profile, which makes it widely used as a feed ingredient for livestock (Ukpanah, *et al.*, 2022^a; Ogunwole *et al.*, 2014). However, wider utilization and availability of this conventional protein source for livestock feed is limited by the increasing demand for human consumption and by other animal feed industries (Ukpanah, *et al.*, 2022^b; Essien *et al.*, 2022; Owosibo *et al.*, 2017; Ali *et al.*, 2019), hence the need to focus on using a less expensive and readily available plant protein source such as white sesame seed meal to replace soybean meal without reducing the nutritional quality of livestock feed.

The objective of this study was to determine the proximate and mineral compositions, amino-acid profile and anti-nutritional factors (tannin, trypsin inhibitor, hydrogen cyanide (HCN), phytate and haemagglutinin) of white sesame seed meal.

2.0 Materials and Methods

2.1 Location of the Experiment

This study was carried out at the Department of Animal Science, Faculty of Agriculture, Akwa Ibom State University Obio Akpa Campus, Akwa Ibom State, Nigeria. Obio Akpa is located between latitudes 5°17'N and 5°27'N and between longitudes 7°27'E and 7°58'E. The area is characterized with an annual rainfall ranging from 3500mm – 5000mm and average monthly temperature of 25°C. Akwa Ibom State is a coastal state lying between latitudes 4°30'N and 5°30'N and between longitudes 7°30'E and 8°00'E, with a relative humidity between 60-90%. It is in the tropical rainforest zone of Nigeria (AKSG, 2012).

2.2 Experimental Material

White sesame seed meal was procured from Fidelity Agro Services (NIG), Owerri, Imo State, Nigeria for the experiment.

The following parameters were measured; the proximate and mineral compositions, amino-acid profile, anti-nutritional factors such as tannin, hydrogen cyanine, trypsin inhibitors, phytate and haemagglutinin of sesame seed meal.

2.3 Proximate and Mineral Composition

The crude protein, crude fibre, dry matter, ether extract, ash, nitrogen free extract and gross energy of sesame seed meal were determined.

The white sesame seed meal was subjected to wet digestion with hydrochloric and nitric acids by the AOAC (2005) method. Following the digestion, the mineral elements, Na, K, Ca, Mg, were determined by flame photometry using the Jenway Digital Flame photometer. In addition, Zn, Fe, I, Mn, Co was determined with an Atomic Absorption Spectrophotometer using buck 600 AAS. Phosphorus was determined by using the spectronic ZID digital spectrophotometer.

2.4 Amino Acid Profile

A modified ninhydrin colorimetric analysis method (Rosen, 1997) was used following the extraction of white sesame seed meal for amino acid analysis. 1ml of diluted extracts of each amino acid was added to 0.5ml cyanide - acetate buffer pH (5.4) and 0.5ml 3% (w/v) ninhydrin in methycellosolve. The mixture was heated in a boiling water bath at 100°C for 15 minutes. Immediately after the mixture was removed from the water bath, 50ml iso-propyl alcohol-water

mixture (ratio 1:1) was added as diluents and mixed by shaking vigorously, then cooled to room temperature (25%). The amino acid profile was estimated by determining the optical density at respective wave length corresponding to each amino acid using UV/visible spectrophotometer.

2.5 Anti-nutritional Factors

2.5.1 Tannin

Tannin in the white sesame seed meal was determined as stated by Maga (1982). 2g of the sample was soaked with 80ml of acetone and 20ml of glacial acetic acid to extract tannin. The sample was filtered after four hours through a double layer filter paper to obtain the filtrate. A set of standard solution of tannic acid was prepared ranging from 10ppm to 50ppm. The absorbance of the standard solution as well as that of the filtrate was read at 500nm on a spectronic 20. The percentage tannin was calculated using the formula.

$$\% \text{ Tanin} = \text{Absorbance} \times \text{Average gradient} \times \text{Dilution factor} \div 10,000$$

.....Equation 2.1

2.5.2 Hydrogen Cyanine

Using Markham distillation apparatus, 5g of the sample was weighed into 250ml conical flask. The sample was soaked with 25ml of distilled water for 3 hours, incubated for another 16 hours at a temperature of 38°C and after, the extraction and filtration were carried out using double layer or hardened filter paper (Bradbury *et al.*,1999). The extract was moved to a 500ml flask and was steam distilled with saturated solution of sodium bicarbonate in a 50ml flask for 60 minutes. 1ml of starch indicator was added to 20ml of the distillate which was then titrated with 0.02ml of iodine solution. The color change to blue determined the end point. The percentage hydrocyanide was calculated.

$$\text{Hydrocyanide acid} = \text{titre} \times 100 \times \frac{0.27}{10} \times \frac{100}{1000}$$

.....Equation 2.2

2.5.3 Trypsin Inhibitors

The procedures outlined by Kakade *et al.* (1974) were adapted for trypsin inhibitor measurement. 0.2g of the white sesame seed meal was measured into centrifuge tubes. 10ml of 0.1m phosphate buffer was added to the tubes at room temperature. The suspension gotten was then centrifuged at 500rpm for 5 minutes and then filtered through a Whatman No. 42 filter paper. 2ml of casein solution was added to all the tubes which were previously kept at 37°C. 6ml of TCA solution was added and incubated for 20 minutes and filtered through Whatman No.42 filter paper. Absorbance of filtrate and trypsin standard solutions was read at 28nm. The trypsin inhibitor in mg/g was calculated.

$$\text{Trypsin inhibitor mg/g} = \frac{A \text{ standard} - A \text{ sample} \times \text{Dilution factor}}{0.1g \times \text{Sample weighting} \times 1000 \times \text{Sample size}}$$

.....Equation 2.3

2.5.4 Phytate

The phytate content was determined according to the procedure by Lucas and Markakas (1975), 2g of white sesame seed meal was weighed into a 250ml conical flask. The sample was soaked for 3 hours using 100mls of 2% concentrated hydrochloric acid in the conical flask. 50mls of each filtrate was placed in a 250ml beaker and 107mls of distilled water was added. 10mls of 0.3% ammonium thiocyanate solution was introduced. This was titrated with a standard iron chloride solution. The end point was slightly brownish – yellow.

$$\% \text{ Phytic acid} = X1.19 \times 100$$

.....Equation 2.4

Where:

$$X = \text{titre value} \times 0.00195\text{g}$$

2.5.5 Haemagglutinin

The haemagglutinin was determined using the procedure described by Seidman and Moore (2000). One percent solution of the sample was used for the measurement. 50ml of allantoic fluid was taken out of the sample using a micropipette and dispensed into a well of a microwell plate. The negative and positive control allantoic fluid samples were added on one of the plates, and 50ml of Phosphate Buffered Saline (PBS) dispensed into it. The sides of the of the plate was taped gentle to mix and the cover placed on it. The plate was allowed to stand for 45 minutes at room temperature, it was observed and the result recorded.

3.0 Results and Discussion

3.1 Proximate Composition of Sesame Seed (*Sesamum indicum*) Meal

The proximate composition of white sesame seed meal is presented in Table 3.1. Result showed that the crude protein content of sesame seed meal was $40.99 \pm 0.10\%$. This value is similar to the values reported by previous authors, 42.21%, (Fagbenro *et al.*, 2010), 40.04%, (Sangkhom and Ekasit, 2015) and 42.00% (INRAE, 2021) for white sesame seed meal. The crude protein value reported in this study also fall within the values reported for conventional plant protein sources such as groundnut (34.88-45%) and soya bean meal (38-43%) (Aduku, 1993; Olomu, 1995). Hence, white sesame seed meal can serve as a potential protein source for broiler production with a crude protein content of $40.99 \pm 0.10\%$.

The ether extract value ($7.63 \pm 0.00\%$) obtained in this study was lower than that reported by Fagbenro *et al.* (2010) (15.92%); Yasothai (2014) (9.20%) and INRAE (2021) (11.10%). This was however higher than that reported by Sangkhom and Ekasit (2015) (3.46-4.15%) for black, white and red sesame seed meals. The ether extract (EE) values of white sesame seed meal were higher than those of the conventional protein sources such as soybean (3.50%) and groundnut cake (GNC) (3.60%) (Aduku, 1993, Olomu, 1995). In terms of energy yielding protein, fat is not an essential dietary ingredient and may be replaced by carbohydrate. However, in the nutrition of farm animals, the high energy density fat is advantageous. The hydrolysis of triglycerides yields glycerol and fatty acids, which serves as concentrated sources of energy (Esonu, 2006).

The crude fibre value for white sesame seed meal obtained in this study was $5.84 \pm 0.07\%$, the value falls within the range of values of 4.70-7.10% reported by several researchers (Fagbenro *et al.*, (2010); Yasothai (2014); INRAE (2021)). There is evidence that dietary fibre has a number of

beneficial effects related to its indigestibility in the small intestine (Aremu *et al.*, 2015). It is well known that the dietary fibre plays an important role in the maintenance of internal distention in the intestinal tract as its physiological effect. Adequate consumption of dietary fibre from a variety of feeds helps for bulk provision in feeds (Aremu *et al.*, 2015). When compared with the conventional grain legumes such as groundnut cake and soyabean meal with 5.0 and 6.5% crude fibre, respectively (Aduku, 1993), the value obtained for sesame seed meal falls within the range.

The ash content of white sesame seed meal was $11.80 \pm 0.00\%$, which was higher than the value of 7.27% (Fagbenro *et al.*, 2010), 10.35% (Yasothai, 2014) and 11.10% (INRAE, 2021), but compared favourably with the values 11.69 - 11.87% reported by Sangkhom and Ekasit (2015). Olomu (1995) reported ash contents for conventional grain legumes such as groundnut cake and soybean meal with 6.4% and 8.0% respectively being lower than the 11.80% value reported for sesame seed meal. The value obtained in this study is an indication that white sesame seed meal may improve the bioavailability of minerals to enhance proper bone and teeth development, better membrane functions and carbohydrate metabolism (NRC, 1994; McDonald *et al.*, 2002; Agbara, 2010) when incorporated into mono-gastric diets.

The nitrogen free extract (NFE) which represent the readily available carbohydrate in white sesame seed meal was $23.84 \pm 0.00\%$. This compares favorably with the acceptable range values of legumes (20-60%) (Nwafor *et al.*, 2017). The result is higher than the report of Fagbenro *et al.*, (2010) (20.73%), but lower than the earlier reports (Yasothai, 2014 = 34.30% and Sangkhom and Ekasit, 2015 = 39.61-41.89%). When compared with the conventional grain legume such as soya bean meal with 33.20-34.30% (NRC, 1998; Poultry Feeding Standards, 2005), the value obtained in the present study was lower. The carbohydrate content of white sesame seed meal suggest that the seed meal could be a good supplement to scarce cereal grains as sources of energy for feed formulation for poultry birds.

The dry matter content was found to be $90.09 \pm 0.07\%$ in this study. This falls within the range of values reported by Fagbenro *et al.*, (2010) (91.61%); Yasothai (2014) (90.70%) and INRAE (2021) (93.10%). When compared with the conventional grain legumes such as groundnut cake and soyabean meal with 90.00% and 92.00%, respectively (Adejero, 2004), sesame seed meal falls within the range. The high dry matter content suggests high TDN (Total Digestible Nutrients) value.

The gross energy content of white sesame seed meal in this study was $4.04 \pm 0.07\text{kcal/g}$. This is slightly lower than that reported earlier by INRAE (2021) (4.62kcal/g). Notwithstanding, the gross energy content in this study qualifies sesame seed meal as a potential energy source.

Table 3.1: Proximate Composition of Sesame seed (*Sesamum indicum*) meal

Nutrient	Composition (%)/S.E
Dry matter	90.09 ± 0.07
Crude protein	40.99 ± 0.10
Ether extract	7.63 ± 0.00
Crude fibre	5.84 ± 0.07
Ash	11.80 ± 0.00
Nitrogen free extract	23.84 ± 0.00
Gross energy (kcal/g)	4.04 ± 0.07

S.E = Standard error of mean

3.2 Mineral Composition of Sesame Seed Meal

The result of mineral composition (both macro and micro) of sesame seed meal is as shown in Table 3.2. The values obtained for Ca (0.23%), Mg (0.27%), K (0.77%), P (0.38%) and Na (0.22%) in the present study were lower than the values obtained in previous studies by Yasothai (2014) for K (1.29%) and Mg (0.80%), respectively and INRAE (2021) for Ca (18.60g/kg), P (11.50g/kg), Mg (5.50g/kg) and K (9.60g/kg), respectively.

However, the value obtained for Na 0.22% in the present study was higher than the value reported in INRAE (2021) for Na (0.06g/kg). The varying compositions reported by various researchers as different from the present study may be influenced by species diversity, different stages at which the plant is harvested, differences in region, soil nutrients and acidity. The value obtained for calcium in this study was comparable to the value of 0.20% reported for conventional grain legumes such as groundnut cake and soya bean meal (Aduku, 1993). Phosphorous content revealed a lower value to that reported for groundnut and soya bean meal (0.60%) (Aduku, 1993). This implied that diet formulation based on sesame seed cake will require calcium and phosphorous supplementation for proper bone and teeth development, better membrane functions and carbohydrate metabolism (NRC, 1994; McDonald *et al.*, 2002, Agbara, 2018).

Sodium values fall within the range (0.18-0.33%) reported for mechanically extracted and solvent extracted soybean meal by Aduku (1993) and Van Eys *et al.*, (2004). Table salt is added to broiler rations at the maximum rate of 0.25% or 0.35% (Aduku, 1993; Olomu, 2011), which serves as a source of sodium. Therefore, utilizing sesame seed cake in broiler rations will lead to the reduction in the quantity of table salt used thereby reducing the cost of production of broiler chickens as reported by Ekpo (2019). The importance of sodium in broiler production cannot be over emphasized; Olomu (2011) outlined the side effect of Na deficiency in poultry production as follows: reduced appetite and growth rate, decreased egg production and egg size, increase cannibalism, depraved appetite, muscular dystrophy and poor bone growth. In agreement with the macro minerals, the values obtained for zinc (55.65mg/kg), manganese (29.77mg/kg) and iron (86.41mg/kg) were lower than the values reported by previous studies by Yasothai (2014) for zinc (107.50ppm), manganese (51.61ppm) and Iron (100ppm) respectively, and INRAE (2021) for zinc (124.00mg/kg), manganese (63.00mg/kg) and iron (1519.00mg/kg), respectively.

However, values obtained for iodine (5.88mg/kg) and Cobalt (1.91mg/kg) in this study was higher than the value reported by INRAE (2021) for iodine (0.20mg/kg) and cobalt (0.70mg/kg), respectively. As reported earlier, the differences observed in their compositions may be influenced by species diversity, different stages at which the plant is harvested, differences in region, soil nutrients and acidity. The level of iron, manganese and zinc obtained for sesame seed cake was lower than the values obtained for conventional grain legumes such as soya bean meal for iron (125mg/kg), manganese (36mg/kg) and zinc (60mg/kg) (Aduku, 1993). This implied that diet formulation based on sesame seed cake will provide sufficient iodine for synthesis of thyroid hormones in order to prevent iodine deficiency which may result in goiter (an enlargement of the thyroid glands) (NRC, 1994), enhance the synthesis of vitamin B₁₂ because of the presence of cobalt (McDonald *et al.*, 2002; NRC, 1994).

3.3 Amino Acid Profile

3.3.1 Essential Amino Acids (%) of Sesame Seed Meal

The result of essential amino acid composition of sesame seed meal is as shown in Table 3.3. The values of essential amino acids obtained in this study were higher than that reported in previous studies by Yasothai (2014) and INRAE (2021). The use of sesame seed meal shall avert the problem of depigmentation of the wing feathers in poultry birds which is caused by inadequate

lysine content (NRC, 1994), foot pad dermatitis in poult which is caused by methionine deficiency (NRC, 1994; Banerjee, 2007).

The result obtained also revealed that sesame seed meal could enhance availability of limiting amino acids especially lysine (7.88%) and methionine (2.12%) which were higher than values reported for conventional protein sources such as groundnut cake with lysine value of (1.54%) and methionine value of (0.54%) and soybean with lysine value of (2.69%) and methionine value of (0.62%) (NRC, 1994; Adejoro, 2004). This makes it a potential protein source which would supply adequate amount of essential amino acids required for proper development of broiler birds.

Table 3.2: Mineral composition of *Sesamum indicum* seed meal

Minerals	Composition/S.E
Macro minerals (%)	
Calcium	0.23 ± 0.00
Magnesium	0.27 ± 0.00
Potassium	0.77 ± 0.00
Phosphorous	0.38 ± 0.07
Sodium	0.22 ± 0.07
Micro minerals (mg/kg)	
Zinc	55.65 ± 0.28
Iron	86.41 ± 0.00
Iodine	5.88 ± 0.00
Manganese	29.77 ± 0.56
Cobalt	1.91 ± 0.00

S.E = Standard error

Table 3.3 Essential amino acids of sesame seed meal

Parameters	Composition (%) / S.E
Arginine	5.70 ± 0.00
Histidine	2.78 ± 0.07
Isoleucine	2.90 ± 0.07
Leucine	6.41 ± 0.07
Lysine	7.88 ± 0.00
Methionine	2.12 ± 0.00
Phenylalanine	10.88 ± 0.00
Threonine	2.85 ± 0.00
Tryptophan	1.77 ± 0.00
Valine	4.23 ± 0.07

S.E = Standard error

3.3.2 Non-essential amino acids (%) of sesame seed meal

The result of non-essential amino acids compositions of sesame seed meal is presented in Table 3.4. The values of non-essential amino acids obtained in the present study were higher than that reported for the same plant by Yasothai (2014) and INRAE (2021). This imply that dietary formulations with sesame seed meal revealing high composition of non-essential amino acids in this study will prevent protein deficiencies associated with non-essential amino acids in poultry

nutrition (NRC, 1994). A variety of abnormalities in feather development occur with deficiencies of tyrosine and cystine in growing chicks (Banerjee, 2007).

However, high amounts recorded in the present study may prevent deficiencies of these amino acids. The level of proline, serine glycine, alanine and tyrosine were higher than values obtained for conventional grain legumes such as soyabean meal for proline (24.70g/kg), serine (23.80g/kg), glycine (20.90g/kg), alanine (21.60g/kg) and tyrosine (17.50g/kg), respectively (NRC, 1994). This reveals its potential as a protein source that would supply adequate amounts of these non-essential amino acids in the diets of broiler birds. In contrast, the values obtained for glutamic acid and aspartic acid for sesame seed cake were lower than the values obtained for conventional grain legumes such as soybean meal for glutamic acid (88.2g/kg) and aspartic acid (55.70g/kg), respectively, (NRC,1994). This implies that dietary formulations with sesame seed meal will require glutamic acid and aspartic acid supplementation for the supply of adequate amounts of these non-essential amino acids to ensure proper development of broiler birds.

Table 3.4: Non-essential amino acids (%) of sesame seed meal

Parameters	Composition (%) /S.E
Alanine	4.03 ± 0.28
Aspartic acid	4.48 ± 0.23
Cysteine	1.56 ± 0.00
Glutamic acid	3.36 ± 0.00
Glycine	3.84 ± 0.00
Proline	4.64 ± 0.10
Tyrosine	7.10 ± 0.07
Ornithine	0.54 ± 0.14
Cystine	0.70 ± 0.07
Serine	3.47 ± 0.07

S.E = Standard error

Table 3.5: Anti-nutritional factors of sesame seed meal

Anti-nutritional factors	Levels/S.E	Normal range
Tannin (%)	0.05 ± 0.01	≤ 1%
Phytate (%)	0.03 ± 0.00	0 - 50%
Hydrogen cyanide (mg/kg)	7.44 ± 0.48	≤ 50mg/kg
Trypsin inhibitor (mg/g)	5.76 ± 0.00	0.4 - 6.8mg/g
Haemagglutinin (Hu/mg)	38.24 ± 0.14	< 4.10-5.0HU/mg

S.E = Standard error.

3.4 Anti-nutritional Factors of Sesame Seed Meal

The values of the different anti-nutritional factors obtained for sesame seed meal in this study is as shown in Table 3.5. Tannin (0.05 ± 0.01%), Phytate (0.03 ± 0.00%), hydrogen cyanide (7.44 ± 0.48mg/kg) and trypsin inhibitor (5.76 ± 0.00mg/g) values reported in white sesame seed meal fell within the recommended range of ≤ 1.00% for tannin (Adekunle and Oyerinde, 2004), 0-50 % for phytate (Mohamed *et al.*, 2003a), ≤ 50mg/kg for hydrogen cyanide (Udedibie *et al.*, 2004; Okoli *et*

al., 2012) and 0.4-6.8 mg/g for trypsin inhibitor (Probert, 2004). However, haemagglutinin value was observed to be higher than the 4.10 - 5.0 HU/mg range reported as normal range for poultry birds by Akanji (2015). This is an indication that sesame seed meal could have the tendency to disrupt normal digestion and absorption in poultry birds. Henry *et al.*, (2018) reported that haemagglutinin are a group of naturally occurring glucoproteins that cause red blood cells (erythrocytes) to agglutinate, or clump together. The anti-nutrient is also responsible for binding viruses to cells in the upper respiratory tract (Akanji, 2015; Ashiba *et al.*, 2015). Pan *et al.* (2014) reported that the presence of haemagglutinin on influenza viruses enables the viruses to bind to sialic acid on the surfaces of cells in host animals. This binding facilitates host infection, therefore contributing to the virulence of the viruses (Pan *et al.*, 2014; Ashiba *et al.*, 2015).

4.0 Conclusion

The proximate and mineral compositions, amino-acid profile and anti-nutritional factors of white sesame seed meal revealed that white sesame seed meal can serve as a protein source in livestock diet. White sesame seed meal is recommended as a valuable protein ingredient for livestock feed production. The high level of haemagglutinin in this study indicates that white sesame seed meal should not be included as a sole protein source for poultry birds.

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