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Effects of boiling method on Nutritional and Anti-nutritional contents of Sheri variety of Mango Seed Kernel

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ABSTRACT

Mango fruit wastes contribute significantly to environmental pollution in many African countries. Consequently, there is growing interest in converting mango by-products into value-added products for human consumption and using them as an alternative feed resource for sustainable livestock production. This study assessed the effects of boiling on the proximate composition, vitamins, anti-nutritional factors, amino acids, and fatty acid contents of the Sheri variety of mango seed kernels. The dried kernels were divided into two equal portions. One portion was boiled by immersing the kernel in clean portable water at a kernel to water ratio of 1:5 (w/v) and heating at 100°C for 30 minutes. The boiled kernels were then dried in a hot air oven at 60-65°C until a constant weight was achieved. The other portion was left unprocessed, and served as the control. Boiling significantly ($p < 0.05$) reduced all the proximate composition parameters except ether extract. Nitrogen-free extract (NFE) decreased from 76.59 to 70.95%; protein, from 10.92 to 6.95%; fiber, from 8.38 to 5.67%; and ash, from 3.52 to 0.66%, while ether extract increased from 10.41 to 11.59%. The highest percentage reduction of 81.25% was recorded in ash for proximate composition indices, 31.40% for vitamin B1 among the vitamins, 25.43% for phytate amongst the anti-nutrients, 57.58% for calcium amongst the minerals, 49.16% for alanine amongst the amino acids, and 42.86% for arachidonic acid amongst the fatty acids. The Sheri variety of mango seed kernel has the potential for use in poultry diets as an energy source; however, boiling the kernel at 100°C for 30 minutes is necessary to reduce anti-nutritional factors to a minimum level.

Keywords: Boiling, nutritional, anti-nutritional, mango, seed kernel.
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INTRODUCTION

During mango processing, large quantities of bio-waste, primarily peels and seeds are generated. According to reports, between 35% and 60% of the fruit weight (seed and peel) is thrown away every year worldwide (Joseph et al., 2020; Mwaurah et al., 2020; Yadav and Paudel, 2022). These wastes are frequently discarded without adequate treatment, resulting in environmental pollution and associated economic losses (Torres-León et al., 2021). Consequently, increasing attention has been directed toward converting mango by-products into value-added products for human use and as alternative feed resources for livestock and poultry. Among these by-products, mango seed kernels have gained attention as a potential alternative energy source in poultry diets, particularly in the ongoing search for substitutes for maize, which is increasingly expensive and highly competitive due to its demand for human consumption and industrial use (Adewale et al., 2016). Beyond their energy value of 453 kcal reported by Fowomola (2010), mango seeds contain bioactive compounds with documented antioxidant, anti-inflammatory, and immune-modulatory properties (Torres-León et al., 2021; Lebaka et al., 2021; Castro-Muñoz et al., 2024). They also provide appreciable levels of essential minerals, including iron, sodium, calcium, magnesium, potassium, and phosphorus, as well as vitamins (Rai et al., 2020). Furthermore, mango seed kernels have been reported to possess a nutrient profile comparable to that of maize; however, this composition varies depending on the mango cultivar (Beyene and Araya, 2015; Shehabeldin et al., 2021). These attributes underscore the potential of mango seed kernels as a non-conventional feed ingredient in poultry nutrition. Despite growing interest in mango seed kernels as alternative feed resources, most available studies present their nutrient and anti-nutritional composition in a generalized manner, with limited emphasis on varietal differences. Mango cultivars differ markedly in their genetic makeup, agronomic characteristics, and environmental growing conditions, which can significantly influence nutrient density and the concentration of anti-nutritional compounds (Akin-Idowu et al, 2020). Mango farming in Nigeria is distributed across various regions, particularly in states that provide a favorable dry season condition for flowering and sufficient moisture during the fruit development phase, resulting in ideal production conditions. Sheri mangoes are characterized by their elliptical shape, yellow skin when ripe, remarkable juiciness, and smooth texture. This variety of mango is widely available across the country (Frutplanet, n.d). The lack of variety-specific information, therefore, constrains accurate evaluation and the safe inclusion of mango seed kernels in poultry feed formulation. In addition, different processing methods have been reported to modify nutrient availability and reduce anti-nutritional factors (Dakare et al, 2012). Boiling is a simple, cheap, and effective technique for reducing anti-nutrient contents in mango seed kernels (Diarra and Usman 2008; Diarra et al. 2011; Dakare et al. 2012; Joseph et al. 2020; Fomowola 2025). However, the degree of anti-nutritional decrease is influenced by boiling duration and temperature (Fomowola, 2025). Data on the effects of such processing method on specific mango varieties remain scarce. In particular, there is limited documented information on the nutritional and anti-nutritional composition of the Sheri mango variety and on how boiling influences the quality of its seed

Figure 1: Sheri mango fruits.

kernel. Therefore, this study aimed to determine the effects of boiling on nutrient and anti-nutrients composition of Sheri mango seed kernels.

Materials and Methods

Experimental site

The experiment was conducted in the Animal Science Department of Federal University Gashua. Yobe State, Nigeria. Gashua is situated in the Sahel savanna zone of Nigeria at latitude 12^0c52.547/12.8758^0 N and longitude 11.0120^0 ^{c} /11^0.00.719 E (Oyimaps, 2024). The study was carried out under standard laboratory conditions in June 2025.

Sample collection and processing

The Sheri variety of mango fruits (Figure 1) were purposely procured from mango farmers in Lafia, Nasarawa State, Nigeria, between February and March 2025. The seeds were thoroughly washed to remove any adhering debris, sun-dried, and then cracked to extract the kernels. The dried kernels were divided into two equal portions. One portion was processed by boiling, following the method of Olaposi et al. (2017). Boiling was performed by immersing the kernels in a container with clean potable water at a kernel-to-water ratio of 1:5 (w/v) and heating at 100 °C for 30 minutes. After boiling, the kernels were immediately drained and rinsed with clean water to remove soluble anti-nutritional compounds. The boiled kernels were then dried in a hot air oven (UNISCOPE SM 9053, England) at 60-65 °C until a constant weight was achieved, ensuring both storability and prevention of microbial spoilage. Both the boiled and raw kernels were milled using a Marlex Excella grinder (Marlex Appliances PVT, Daman) and sieved through a 2 mm mesh to obtain uniform flour. The resulting flours were stored in airtight containers and refrigerated at 4 °C until further analyses.

Determination of Proximate Composition

The proximate composition of both raw and boiled mango seed meal samples was determined using the standard procedures of the Association of Official Analytical Chemists (AOAC, 2019). All measurements were performed in triplicate to ensure accuracy.

Determination of Mineral Content

Calcium (Ca) and magnesium (Mg) were determined using atomic absorption spectrophotometry (AAS) according to AOAC (2005), following ashing of 1 g of sample at 550 °C and dissolution of the ash in 10% HCl. Phosphorus (P) was determined calorimetrically using the vanadomolybdate method after wet digestion with nitric and perchloric acids. Potassium (K) and sodium (Na) were quantified using flame photometry, while iron (Fe) was analyzed by Atomic Absorption Spectroscopy (AAS) following acid digestion. All measurements were performed in triplicate, and the results were expressed as mg per 100 g of dry matter.

Evaluation of Amino Acid

One hundred milligrams (100 mg) of the ground samples were weighed and defatted. Next 10 mls of 6N hydrochloric acid containing 0.1% phenol was added to hydrolyze the samples. The tubes were flushed with nitrogen, sealed tightly and incubated at 110°C for 24 hours. After hydrolysis, the mixtures were allowed to cool at room temperature and neutralized with 6N Sodium hydroxide until they reached a pH of 7. The hydrolysates were filtered, centrifuged, and then diluted to a final volume of 25 ml using citrate buffer. For the Sulphur containing amino acids, methionine and cysteine were oxidized before hydrolysis, resulting in methionine sulfone and cysteic acid, respectively. Tryptophan was analyzed separately through alkaline hydrolysis, where samples were treated with 4N Sodium hydroxide. Hydrolysis was performed under nitrogen, and incubated at 110 $^{\circ C}$ for 20 minutes. Portions of the prepared hydrolysates were injected into a cation – exchange high performance liquid chromatography (HPLC) column. Amino acids were then detected using post column ninhydrin derivatization with primary amines measured at 570 nm and secondary amines at 440 nm. Calibration curves were constructed using amino acid standard at concentration ranging from 50 to 200um. Amino acids were quantified by comparing the peak areas of the samples to those of the standards, and the results were expressed as gram of amino acid per 100g of the feed samples.

Determination of Vitamins

The concentrations of vitamins C, A, E, and K in mango seed kernel were determined following the method of Sambucetti

Table 1: Proximate Composition of raw and processed mango seed kernel.

Parameters, %	Raw	Boiled	SEM	P-value	% Reduction and increase
Dry matter	96.98[a]	94.62[b]	0.01	<.0001	2.43
Protein	10.92[a]	6.95[b]	0.11	<.0001	36.35
Ether extract	10.41[b]	11.59[a]	0.02	<.0001	11.33
Fiber	8.38[a]	5.67[b]	0.01	<.0001	32.34
Ash	3.52[a]	0.66[b]	0.01	<.0001	81.25
Nitrogen free extract	76.59[a]	70.95[b]	0.10	<.0001	7.37

Means within the same row bearing different superscripts (a, b) are significantly different (P<0.05). SEM=standard error of mean.

and Zuleta (1996). Ten grams of mango seed meal were extracted with 50 mL of ethanol, left to stand for 30 minutes, and then filtered through Whatman filter paper. The filtered extract was saponified by adding 25 mL of 0.5 N sodium hydroxide (NaOH) and gently heating for 30 minutes with continuous stirring. After cooling, the mixture was neutralized with hydrochloric acid (HCl) to pH neutrality. Vitamins A and E were extracted with hexane, evaporated at 40 °C using a rotary evaporator, and the residue dissolved in methanol for analysis. Vitamin A (retinol) was measured using HPLC with a UV detector at 328 nm, while vitamin E (α-tocopherol) was detected using a fluorescence detector (excitation 290 nm, emission 330 nm). Vitamin C was determined by dissolving an aliquot of the mango seed kernel in distilled water and measuring absorbance at 265 nm using a spectrophotometer, according to AOAC (2016). Vitamin K was quantified by saponification of the extracts, followed by acetone extraction and analysis using high-performance liquid chromatography (HPLC) with fluorescence detection, as described by Sambucetti and Zuleta (1996). All analyses were performed in triplicate, and vitamin concentrations were calculated from standard calibration curves.

Determination of anti-nutritional factors

The phytochemical and anti-nutritional constituents of the samples, including alkaloids, flavonoids, tannins, phlobatannins, triterpenes, steroids, saponins, oxalates, phytates, quinones, phenols, and trypsin inhibitors were determined using standard procedures. Alkaloids were determined following Harborne (1973), flavonoids using the aluminium chloride colorimetric method, tannins using the Folin–Denis method (AOAC, 2016), and phlobatannins by acid precipitation. Triterpenes and steroids were screened using the Liebermann–Burchard test, saponins by the froth method, oxalates by acid extraction and permanganate titration (AOAC, 2016), and phytates using the Wade reagent assay. Quinones were detected via chloroform extraction followed by a sulfuric acid reaction, phenols were determined using the Folin–Ciocalteu method, and trypsin inhibitor activity was assessed by inhibition of BAPNA hydrolysis (Kakade et al., 1974). All analyses were performed in triplicate, and results were expressed on a dry matter basis.

Determination of Fatty Acids

The fatty acid composition, including stearic, oleic, palmitic, linoleic, arachidonic, and linolenic acids was determined using gas chromatography according to the method described by the Association of Official Analytical Chemists (AOAC, 1996). Lipid extraction was carried out using the Folch method with a chloroform–methanol mixture (2:1 v/v), as described by Folch et al. (1957). The extracted lipids were saponified with alcoholic potassium hydroxide to release free fatty acids and subsequently methylated to form fatty acid methyl esters (FAMEs) using boron trifluoride methanol reagent. The FAMEs were analyzed using a gas chromatograph (GC) equipped with a flame ionization detector (FID) and a capillary column (SP-2560, 100 m × 0.25 mm × 0.2 µm film thickness). The injector and detector temperatures were maintained at 250°C, while the oven temperature was programmed to increase from 150°C to 230°C at a rate of 4°C per minute. Nitrogen was used as the carrier gas. Identification of individual fatty acids palmitic (C16:0), stearic (C18:0), oleic (C18:1), linoleic (C18:2), linolenic (C18:3), and arachidonic (C20:4 was performed by comparing retention times with those of known FAME standards. The relative concentration of each fatty acid was expressed as a percentage of the total identified fatty acids based on the chromatographic peak areas.

Determination of Nutrient Losses

Percentage nutrient losses due to processing were calculated by comparing the nutrient values of processed samples to those of the raw sample using the formula below:

$$Nutrient\ loss\ (\%) = \frac{Nr - Np}{Nr} x\ 100$$

Where:
Nr= Nutrient concentration in raw mango seed meal
Np= nutrient concentration in processed mango seed meal

Statistical Analysis

Data obtained from the boiled treated and raw samples were subjected to one-way analysis of variance (ANOVA**)** using the Statistical Analysis System **(**SAS, version 15.1, SAS, 2018**),** according to the procedure described by Snedecor and Cochran (1987). Differences among treatment means were separated using Duncan's multiple range tests, and significance was accepted at *P*< 0.05.

RESULTS AND DISCUSSION

The proximate composition of raw and boiled Sheri variety of mango seeds is presented in Table 1. The dry matter contents of 96.98% (raw) and 94.62% (boiled) were higher than the corresponding values of 85.23% and 85.50% reported by Falola et al. (2025) for raw and boiled mango seed kernels, respectively. The crude protein content of the raw sample (10.92%) was comparable to the value of 10.90% reported by Falola et al. (2025), but higher than the values of 6.36 %, 7.40%, 8.75% and 8.5% reported by Nzikou et al.(2010), Dakare et al (2012), Diarra et al.(2014) and Iman et al (2025), respectively. The crude protein value of the boiled mango seed kernel was 6.95%, showing a significant reduction (p<0.05) from the raw sample. The decrease in crude protein due to boiling is supported by earlier reports of Diarra and Usman (2008), Dakare et al. (2012), and Yatnatti et al. (2014), which attributed the reduction to leaching of soluble protein and denaturation. The crude fiber content of the raw kernel (8.38%) differed from the values of 2.02%, 2.20%, 2.82%, and 9.55% reported by Nzikou et al. (2010), Yatnatti et al. (2014), Dakare

Table 2: Vitamin compositions of raw and processed mango seed kernel (mg/100 g).

Parameters	Raw	Boiled	SEM	P-value	% reduction
Vitamin A	32.78[a]	27.03[b]	0.15	<.0001	17.54
Vitamin C	51.27[a]	44.15[b]	0.05	<.0001	13.89
Vitamin E	8.14[a]	6.69[b]	0.03	0.0074	17.81
Vitamin K	2.20[a]	2.06[b]	0.03	<.0001	6.36
Vitamin B1	0.86[a]	0.59[b]	0.02	<.0001	31.40
Vitamin B2	0.74[a]	0.55[b]	0.03	0.0014	25.68
Vitamin B3	2.33[a]	2.22[b]	0.03	0.0315	4.72
Vitamin B6	3.20[a]	3.07[b]	0.03	0.0080	4.06
Vitamin B9	1.66[a]	1.45[b]	0.03	0.0012	12.65
Vitamin B12	1.24[a]	1.14[b]	0.02	0.0073	8.06

Means within the same row bearing different superscripts (a, b) are significantly different (P<0.05). SEM=standard error of mean.

Table 3: Mineral compositions of raw and processed mango seed kernel (mg/100g).

Parameters	Raw	Boiled	SEM	P-value	% Reduction
Calcium	165.00[a]	70.00[b]	7.91	<.0001	57.58
Magnesium	480.00[a]	385.00[b]	7.57	0.0013	19.79
Sodium	1870.00[a]	1585.00[b]	17.34	<.0001	15.24
Potassium	4165.00[a]	4115.00[b]	15.00	0.0151	1.20
Iron	162.10[a]	125.95[b]	0.18	<.0001	22.30
Copper	5.27[a]	4.47[b]	0.05	<.0001	15.18
Zinc	31.40[a]	23.75[b]	0.19	<.0001	24.36

Means within the same row bearing different superscripts (a, b) are significantly different (P<0.05). SEM=standard error of mean.

et al. (2014), and Falola et al. (2025), respectively. The differences in crude fiber values recorded in this study compared to those reported may be attributed to several factors including varieties used, cultivation conditions, as well as the methods of drying and extraction. Ether extract contents of 10.41% (raw) and 11.59% (boiled) were comparable to the values of 10.80% and 11.40% reported by Falola et al. (2025), but higher than the range of 1.61–3.66% reported by Das et al. (2022). The nitrogen-free extract content of the raw sample (76.59%) was higher than 69.93% reported by Dakare et al. (2012) and 70.95% by Falola et al. (2025). The reduction in NFE values in boiled samples recorded in this study is not consistent with earlier reports by Falola et al. (2025) and Amao and Siyanbola (2013), whose studies indicated non-significant and significant increases in the NFE contents of boiled and dry heat-treated mango seed kernels. The ash content of the raw kernel (3.52%) was comparable to the value of 3.10% reported by Falola et al. (2025), but higher than the 2.19% reported by Dakare et al. (2014). Variations in nutrient composition among studies may be attributed to the variation in soil, climate, and varietal differences. Overall, boiling significantly altered the proximate composition of Sheri mango seed kernel, resulting in reductions in most components except ether extract.

As presented in Table 2, boiling significantly reduced all the vitamin components of Sheri mango seed kernels analyzed. Vitamins A, E, K, and C declined from 32.78, 8.14, 2.20, and 51.27 mg/100g in raw kernels to 27.03, 6.69, 2.06, and 44.15 mg/100g, respectively. B-complex vitamins (B_1, B_2, B_3, B_6, B_9, and B_{12}) similarly decreased from 0.86, 0.74, 2.33, 3.20, 1.66, and 1.24 mg/100g to 0.59, 0.55, 2.22, 3.07, 1.45, and 1.14 mg/100g following boiling. The observed reductions are attributable to thermal degradation and aqueous leaching of heat-labile, water-soluble vitamins. This agrees with the report of Falola et al. (2025), who observed reductions in vitamin contents in a similar trial.

Table 3 shows the mineral contents of the raw and boiled Sheri mango variety. The values of 165, 480, and 1,870 mg/100 g recorded for calcium, magnesium, and sodium, respectively, were higher than the values of 55.77, 18.52, and 111.3 mg/100 g observed for calcium, magnesium, and sodium in the raw mango seed kernel (Fowomola 2010 and Dakare et al. 2014). The current study's findings showed that Sheri variety has noticeably high concentrations of potassium, sodium, magnesium, calcium, and iron, respectively. These are important macro minerals needed for the body's essential processes. The potassium, iron, copper and zinc values of 4165, 162.10, and 31.40 mg/100 g recorded for the raw mango seeds in this study were higher than the values reported for raw mango seed kernel reported by Fowomola (2010) and Dakare et al.(2014), which were 1.10 mg/100 g, 82.01 mg/100 g, and 77.34 mg/100 g, respectively. The copper value (5.27 mg/100 g) recorded in this study was lower than 8.6 mg/100g reported by Yatnatti et al. (2014). The variation in value reported in this study and that reported by Fowomola (2010) and Dakare et al. (2014) may be attributed to varietal differences. The reduction in mineral content in boiled mango seed kernel may be due to leaching into the boiling water. Boiling typically lowers the concentration of certain minerals, especially those that are water-soluble such as potassium, magnesium, and calcium (Diarra and Usman, 2008, Falola et al., 2025). Boiling time, temperature, water volume, and variety all affect the observed decrease in mineral content.

Table 4 summarizes the amino acid profile of raw and boiled Sheri mango seed kernels. The most predominant amino acids recorded in this study are phenylalanine, proline, and glutamic acid, with values of 225.49, 10.92, and 6.68 mg/100g, respectively in the raw samples. The values of proline and glutamic acid in the raw samples were higher than the values of 2.55 and 8.94 mg/100g reported by Dakare et al. (2014). However, the values of lysine glycine and isoleucine (3.08, 3.12 and 3.84) recorded in the raw samples were consistent with the values of 3.35, 3.01, and 3.11 mg/100g reported for raw mango seed kernel (Dakare et al. 2014). Boiling has been shown to alter amino acid profile, leading to a decrease in certain heat-sensitive amino acids (Diarra and Usman, 2008, Falola et al 2025). The essential amino acid profile of the Sheri variety of

Table 4: Amino acid compositions of raw and processed mango seed kernel (mg/100g).

Parameters	Raw	Boiled	SEM	P-value	% Reduction
Arginine	3.07[a]	1.82[b]	0.05	<.0001	40.72
Alanine	4.17[a]	2.12[b]	0.04	<.0001	49.16
Aspartic Acid	5.04[a]	3.12[b]	0.05	<.0001	38.10
Cysteine	0.36	0.27	0.04	0.0522	25.00
Glutamic Acid	6.68[a]	4.16[b]	0.04	<.0001	37.72
Glycine	3.12[a]	2.83[b]	0.04	0.0010	9.30
Histidine	1.44[a]	1.31[b]	0.04	0.0168	9.03
Isoleucine	3.84[a]	2.14[b]	0.04	<.0001	44.27
Leucine	5.17[a]	3.62[b]	0.03	<.0001	29.98
Lysine	3.08[a]	2.65[b]	0.03	<.0001	13.96
Methionine	1.09[a]	0.95[b]	0.03	0.0117	12.84
Ornithine	0.11	0.08	0.03	0.2936	27.27
Phenylalanine	225.49[a]	178.07[b]	0.98	<.0001	21.03
Proline	10.92[a]	6.95[b]	0.11	<.0001	36.37
Serine	2.04[a]	1.12[b]	0.03	<.0001	45.10
Threonine	1.42[a]	0.91[b]	0.04	<.0001	35.92
Tyrosine	1.91[a]	1.14[b]	0.03	<.0001	40.31
Tryptophan	0.91[a]	0.73[b]	0.04	0.0053	19.78
Valine	3.19[a]	2.55[b]	0.03	<.0001	20.06

Means within the same row bearing different superscripts (a, b) are significantly different (P<0.05). SEM=standard error of mean.

Table 5: Fatty acid compositions of raw and processed mango seed kernel (%).

Parameters	Raw	Boiled	SEM	P-value	% Reduction
Stearic (C18;0	1.85[a]	1.55[b]	0.04	0.0005	16.22
Oleic (C18;1)	15.14[a]	13.87[b]	0.04	<.0001	8.39
Palmitic (16:0)	19.28[a]	18.18[b]	0.03	<.0001	5.71
Linoleic(18:2)	4.15[a]	3.18[b]	0.04	<.0001	23.37
Arachidonic(20:0)	0.14[a]	0.08[a]	0.03	0.1136	42.86
Linolenic(18:3)	0.69[a]	0.47[b]	0.04	0.0035	31.88

Means within the same row bearing different superscripts (a, b) are significantly different (P<0.05). SEM=standard error of mean.

mango seed kernel indicates good protein quality. The reduction in the value of the boiled mango seed kernels may be due to denaturation of proteins and the Maillard reaction, which can reduce the availability of amino acids (Parsons et al., 1992). Additionally, soluble amino acids may leach into the boiling water, further reducing their concentration in the kernel. Despite these reductions, some amino acids, such as glutamic acid and aspartic acid, are relatively heat-stable and show minimal changes. The variation in amino acid content is also influenced by the duration of boiling, seed variety, and initial protein composition, which explains the differences reported across studies (Oladele and Aina, 2007)

The fatty acid profile is a critical parameter for assessing oil quality. Table 5 presents the proportions of fatty acids identified in this study. Palmitic and oleic acids are the predominant fatty acids, with values of 19.28% and 15.14%. These values are lower than those reported for three Nigerian mango cultivars (Glenn, Alphonso, and Fazli), in which palmitic acid contents of 34.60%, 27.06%, and 24.08%, respectively, were recorded (Paschal et al., 2022). Similarly, the oleic acid value of 15.14% obtained in this study was lower than the values of 34.64%, 28.90%, and 21.20% respectively, reported for the same cultivars. The linoleic acid content (4.15%) was comparable to the value of 4.30% reported for the Glenn cultivar. Furthermore, the arachidonic and linolenic acid contents (0.14% and 0.69%, respectively) were lower than those reported by Paschal et al. (2022) for Nigerian mango seed cultivars. The relatively high proportion of palmitic acid observed in this study indicates that the oil is rich in saturated fatty acids. High palmitic acid content enhances the suitability of the oil for cosmetic product manufacturing and for use as a reaction intermediate in the synthesis of alkali salts, which serve as lubricants, emulsifiers, and emollients in various commercial applications (Agu et al., 2018). This observation is consistent with the findings of Paschal et al. (2022), who also reported palmitic acid as one of the dominant fatty acids in Nigerian mango cultivars. Variations in fatty acid composition between this study and previous reports may be attributed to varietal differences.

Table 6 summarizes the anti-nutritional composition of raw and boiled Sheri mango seed kernels. In this trial, phenol was found to have the highest content (225.49 mg/100 g) in the raw samples, while oxalate had the lowest content (7.17 mg/100 g). Boiling resulted in a general reduction in the concentrations of anti-nutrients. The reduction in the values of anti-nutrients due to boiling confirms the earlier report of Joseph et al. (2020). The highest percentage reduction was recorded in phytates (25.43%), while the least reduction was observed in flavonoids (4.64%). The oxalate content observed in this study was lower than the value of 30.65 mg/100 g reported by Falola et al. (2025). The tannin, saponin, and phytate contents were higher than those reported by the same authors. Diarra et al. (2014) reported that mango seed kernels contain several anti-nutritional factors, including tannins, phytates, oxalates, saponins, and cyanogenic glycosides. The presence of these compounds has been shown to impair growth performance and reduce nutrient bioavailability in animals (Gemade et al., 2014). For example, Amah et al. (2022) observed that administration of high levels of mango seed kernel extract significantly

Table 6. Anti-nutritional factor compositions of raw and processed mango seed kernel (mg/100 g).

Parameters	Raw	Boiled	SEM	P- value	% Reduction
Phenol	225.49[a]	178.07[b]	1.98	<0.0001	21.03
Flavonoid	79.92[a]	76.21[b]	0.05	<0.0001	4.64
Tannins	55.66[a]	46.58[b]	0.42	<0.0001	16.31
Quinone	27.59[a]	21.80[b]	0.19	<0.0001	20.99
Oxalate	7.17[a]	5.56[b]	0.08	<0.0001	22.45
Saponin	67.25[a]	63.53[b]	1.13	<0.1145	5.53
Steroids	71.41[a]	66.55[b]	0.21	<0.0001	6.81
Triterpene	54.51[a]	48.88[b]	0.24	<0.0001	10.33
Alkaloids	9.50[a]	7.39[b]	0.22	<0.0003	22.21
Phytate	97.80[a]	72.93[b]	0.38	<0.0001	25.43
Trypsin inhibitors	32.22[a]	27.93[b]	0.43	<0.0003	13.31

Means within the same row bearing different superscripts (a, b) are significantly different (P<0.05). SEM=standard error of mean.

reduced haemoglobin concentration, red blood cell count, and white blood cell count, indicating potential adverse haematological effects. Phytate, in particular, is known to chelate essential minerals such as Zn2+, Fe2+/3+, Ca2+, Mg2+, Mn2+, and Cu2+ in diet, thereby limiting their absorption and utilization. However, Gemede and Ratta (2014) also noted that at low concentrations, certain anti-nutritional compounds may exert beneficial physiological effects, including reductions in blood glucose and cholesterol levels, as well as a possible protective role against cancer. Furthermore, processing methods have been demonstrated to markedly reduce the levels of anti-nutritional factors in mango seed kernels. Dakare et al. (2012) reported reductions of up to 95.8% in tannin content and complete elimination (100%) of trypsin inhibitors following appropriate processing. This suggests that effective processing can enhance the nutritional suitability of mango seed kernels for animal feeding.

Conclusions and Recommendations

The boiling method has significantly reduced the proximate, vitamins, minerals, amino acids, fatty acids and anti-nutritional factors contents of the mango seed kernel samples analyzed. The highest losses in proximate components were recorded in ash (81.25%), protein (36.35%), and fiber (32.34%). Other nutrients affected by boiling include vitamin B1 (31.40%), vitamin B2 (25.68%), calcium (57.58%), zinc (24.36%), arachidonic acid (42.86%) and iron (22.30%). Significant anti-nutritional factors including phytate, oxalate, alkaloid, phenol, and quinone experienced notable reductions in the boiled samples. Thus, the total nutritional quality and safety for consumption of Sheri mango kernel were improved due to the reductions in anti -nutritional factors. Boiling the seed kernel at 100^{o}C for 30 minutes is recommended as a suitable processing method; however, optimization of boiling time and conditions is necessary to minimize nutrient losses and maximize the health benefits of the Sheri variety of mango seed kernel.

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REFERENCES

Adewale RT, Odunsi AA, Akinwumi AO, Olakanlo OD, Anwo OJ (2016). Response of broiler chicken to parboiled mango seed kernel meal (PMKM) based diet fortified with vitamins. International Journal of Livestock Research, eISSN: 2277-1964.

Agu CM, Chukwuma HK, Albert CA, Ozioma OA, Ijeoma EA, Joy NE (2018). Nonlinear Kinetics, Thermodynamics, and parametric studies of Colocynthis vulgaris Shrad seeds oil extraction. Industrial Crops and Products, 123: 386-400.

Akin-Idowu PE, Ademoyegun OT, Olagunju YO, Aduloju AO and Adebo UG (2017). Phytochemical content and antioxidant activity of five grain Amaranth species. Am. J. Food Sci. Technol., 5(6):249–255. doi: 10.12691/AJFST-5-6-5.

Amao O, Siyanbola W (2013). Carcass and physiological response of broilers fed dry heat treated mango (*Mangifera indica*) kernel based diet. International Journal of Livestock Production, 4(3):30–34.

Amah AK, Chris AW, Iheukwumere CB, Melford UE (2022). Evaluation of the proximate and anti-nutrient composition of methanol extract of *Mangifera indica* (mango) seed kernel and impact of its consumption on haematological parameters. Research Journal of Biology and Pharmacy, 6(2):070–074. DOI:10.53022/oarjbp.2022.6.2.0078

AOAC (1996). Official methods of analysis (16th Ed.). Association of Official Analytical Chemists, Washington DC.

AOAC (2005). Official methods of analysis (18th Ed.). Association of Official Analytical Chemists.

AOAC (2016). Official methods of analysis of the Association of Official Analytical Chemists (20th Ed.). AOAC Inc., Washington DC.

AOAC (2019). Official methods of analysis of the Association of Official Analytical Chemists (21st Ed.). AOAC, Washington DC.

Beyene G, Araya A (2015). Review of Mango (Mangifera indica) Seed Kernel Waste as a Diet for Poultry. Journal of Biology, Agriculture and Healthcare, 5 (11): 156-160.

Castro-Muñoz R, Cabezas R, Plata-Gryl M (2024). Mangiferin: A comprehensive review on its extraction, purification, and uses in food systems. Advances in Colloid and Interface Science, 329:103188.

Dakare MA, Danladi AA, Abel AS, Sunday EA (2012). Effects of processing technique on the nutritional and antinutritional contents of mango (*Mangifera indica*) seed kernel. World Journal of Young Researchers, 2(3):55–59.

Dakare MA, Danladi AA, Abel SA, Sunday EA (2014). Chemical composition and anti-nutrient contents of yellow maize, raw and processed composite mango (*Mangifera indica*) seed kernel from Zaria, Kaduna State Nigeria. International Journal of Advanced Research, 2(7):90–97.

Das K, Pathak K, Baishya S (2022). Mango seed kernel: Nutrient composition and quality characteristics of oil. Agricultural Research Journal, 59:1130–1136.

Diarra SS (2014). Potential of mango (*Mangifera indica* L.) seed kernel as a feed ingredient for poultry: A review. World's Poultry Science Journal, 70(2):279–288. https://doi.org/10.1017/S0043933914000294

Diarra SS, Usman BA (2008). Growth performance and some blood variables of broiler chickens fed raw or boiled mango kernel meal. International Journal of Poultry Science, 7:315–318. https://doi.org/10.3923/ijps.2008.315.318

Diarra SS, Saleh B, Kwari ID and Igwebuike JU (2011) Evaluation of boiled mango kernel meal as energy source by broiler chickens in the semi-arid zone of Nigeria. International Journal of Science and Nature 2 (2): 270-274.

Falola OO, Fasuan TO, Adedeji OY (2025). Effect of processing techniques on nutrient and anti-nutrient contents of mango seed

kernel. Research Journal of Botany, 20(1):14–17. https://doi.org/10.3923/rjb.2025.14.17

Folch J, Lees M, Sloane-Stanley GH (1957). A simple method for the isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry, 226(1):497–509. https://doi.org/10.1016/S0021-9258(18)64849-5

Fowomola MA (2010). Some nutrients and anti-nutrients contents of mango (*Mangifera indica*) seed. African Journal of Food Science, 4(8):472–476.

Frutplanet. (n.d.). Nigeria mango season and varieties: Complete timing and quality guide. https://frutplanet.com(Retrieved June 11, 2026)

Gemede HF, Ratta N (2014). Anti-nutritional factors in plant foods: potential health benefits and adverse effects. International Journal of Nutrition and Food Science, 3:284-289.

Harborne JB (1973). Phytochemical methods: A guide to modern techniques of plant analysis. Chapman and Hall Ltd.

Iman S, Rasheed MU, Zahran HA, Rashid H, Fatima M, Saleem Z, Bano Y, Gull S, Akbar R, Khan A, Mohamed Ahmed IA, Zongo E, Rahim MA, Castro-Muñoz R (2025). Comprehensive analysis of mango (*Mangifera indica* L.) seed: Phytochemical profile, bioactivity, and nutraceutical potential. Food Science and Nutrition, 13(6):e70390. https://doi.org/10.1002/fsn3.70390

Joseph R, Chacha M, Ndabikunze B, and Raymond J (2020). Effect of lactic acid fermentation, boiling and soaking on selected nutrients and health promoting components of mango seed kernels. International Journal of Biosciences, 17 (6): 26–39.

Kakade ML, Rackis JJ, McGhee JE, Puski G (1974). Determination of trypsin inhibitor activity of soy products: A collaborative analysis of an improved procedure. Cereal Chemistry, 51:376–382.

Lebaka VR, Wee YJ, Ye W, Korivi M (2021). Nutritional composition and bioactive compounds in three different parts of mango fruit. International Journal of Environmental Research and Public Health, 18(2):741. https://doi.org/10.3390/ijerph18020741

Mwaurah PW, Kumar S, Wainaina I (2020). Extraction and nutritional characterization of mango kernel oil. Journal of Food Measurement and Characterization, 14(1):291–300.

Nzikou JA, Kimbonguila L, Matos L, Loumouamou B, Pambou-Tobi N, Ndangui C, Abena A, Silou T, Scher J, Desobry S (2010). Extraction and characteristics of seed kernel oil from mango (*Mangifera indica*). Research Journal of Environmental and Earth Sciences, 2(1):31–35.

Olaposi RA, Oladipupo QA, Olumide SF, Gbeminiyi O (2017). Effect of Soaking and Boiling on Anti-nutritional Factors, Oligosaccharide Contents and Protein Digestibility of Newly Developed Bambara Groundnut Cultivars. Turkish Journal of Agriculture - Food Science and Technology, 5(9): 1006-1014.

Oladele AK and Aina JO (2007). Chemical composition and functional properties of flour produced from two varieties of tigernut (Cyperus esculentus). African Journal of Biotechnology, 6 (21): 2473-2476.

Parsons CM, Hashimoto K, Wedekind KJ, Han Y, Baker DH (1992). Effect of over processing on availability of amino acids and energy in soya bean meal. Poultry Science, 71:133–140.

Paschal EO, Ogonna JN, Chijioke EO, Emeka MM, and Nonye JO (2022). Solvent Extraction of Oil from Three Cultivars of Nigerian Mango Seed Kernel: Process Modeling, GA-Optimization, Nonlinear Kinetics and Comparative Characterization. Applied Food Research 2 (2): 100227. https://doi.org/10.1016/j.afres.2022.100227

Rai AK, Das H, Dash SR, Behera S (2020). Mango seed: A potential source of nutrition from waste. Indian Farmer, 7(3):244-248.

Sambucetti ME, Zuleta A (1996). Resistant starch in dietary fiber values measured by the AOAC method in different cereals. Cereal Chemistry, 73(6):759-761.

SAS Institute Inc. (2018). SAS/STAT® 15.1 User's Guide. Cary, NC: SAS Institute Inc

Shehabeldin A, El-Esawy G, El-Sanafawy H (2021). Effect of Dietary Partial Replacement of Corn Grains by Mango Seeds on Productive and Reproductive Characterization of Damascus Goat Bucks at Prepubertal Stage. Journal of Animal and Poultry Production, 12 (2):61–69. https://doi.org/10.21608/jappmu.2021.153289

Snedecor GW and Cochran WG (1987) Statistical Methods. 5th Edition, Iowa State University Press, p.456.

Torres-León C, Ascacio-Valdés JA, Chávez-González ML (2021). Valorization of Ataulfo mango seed byproduct based on its nutritional and functional properties. In: Bioprocessing of Agri-Food Residues for Production of Bio-products. Apple Academic Press. Pp.233-251.

Yadav SPS and Paudel P (2022). The Process Standardizing of Mango (*Mangifera indica*) Seed Kernel for Its Value Addition: A Review." Reviews in Food and Agriculture 3(1): 6-12.

Yatnatti S, Vijayalakshmi D and Chandru R (2014). Processing and nutritive value of mango seed kernel Flour. Curr. Res. Nutr. Food Science 2(3): 170-175.