

# Impact of processing methods on the quality characteristics of *Parkia biglobosa* (locust beans)

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**ABSTRACT:** *Parkia biglobosa*, commonly known as African locust bean, is an essential food source in West Africa, valued for its cultural and nutritional significance. This study evaluates the effects of different processing methods—unprocessed, boiled, re-cooked, and fermented—on the nutritional and anti-nutritional properties of *P. biglobosa* locust beans. Using a completely randomised design (CRD) and standard AOAC methods, the proximate composition and anti-nutritional factors of the beans were analysed. The findings reveal that fermentation significantly improves the nutritional content, with notable increases in crude protein (34.10%), fat (25.23%), and pH (7.60), while preserving a high moisture content (55.6%). Boiling and re-cooking also enhance the nutritional profile, but to a lesser degree. All processing methods reduced anti-nutritional factors such as oxalates, phytic acid, and tannins, with fermentation yielding the most significant reductions. Statistical analysis indicates that variations in proximate composition have a significant effect on quality parameters ( $p < 0.000$ ), while processing stages in isolation do not ( $p = 0.641$ ). However, processing stages did significantly impact anti-nutritional factors ( $p = 0.028$ ). The results highlight fermentation as the most effective method for improving the nutritional and sensory qualities of locust beans. This study underscores the importance of optimising processing conditions to enhance the quality and safety of *P. biglobosa*, providing valuable insights for producers and stakeholders aiming to maximise the nutritional potential of this vital crop.

**Keywords:** Boiled, fermentation, *Parkia biglobosa*, proximate, re-cooked.

## INTRODUCTION

*Parkia biglobosa* plays a crucial role in the diets of many West African communities, serving as a vital source of protein and traditional seasoning. It is particularly esteemed not only for its sensory appeal but also for its socioeconomic and cultural significance. Nutritional importance in West African societies. The seeds of this tree are processed into various forms, such as fermented products, which serve as essential flavouring agents in local cuisines. These processed locust beans are not only valued for their distinct taste but also for their nutritional richness, containing substantial amounts of protein, fat, carbohydrates, and essential micronutrients (Campbell-Platt, 2010). The processing stages employed in preparing locust beans play a crucial role in determining their final quality attributes. Traditionally, locust beans undergo several processing steps, including fermentation, boiling,

and sometimes roasting, each of which can impact the beans' nutritional composition, sensory properties, and safety profile. Fermentation is a prevalent processing stage in the production of locust beans. It involves the action of microorganisms on the beans, leading to biochemical changes that enhance their flavour, aroma, and nutritional value. Fermentation also reduces antinutritional factors present in the beans, making them more digestible and nutritious (Achi, 2005). Boiling is another essential processing stage for locust beans. This step helps soften the beans and remove unwanted substances, improving their texture and taste. Boiling can also contribute to the reduction of antinutritional factors, although it may lead to some nutrient loss due to heat sensitivity (Achi, 2005).

Fermentation is a traditional method used to enhance

the nutritional and sensory properties of locust beans. The process involves the action of natural microorganisms, which transform the beans' biochemical composition. Studies have shown that fermentation significantly increases protein digestibility and reduces antinutritional factors such as tannins and phytates (Achi, 2005; El Hag *et al.*, 2002). Furthermore, fermented locust beans develop a complex flavour profile that is highly valued in West African cuisine (Enujiugha, 2009). Recent research by Ajiboye and Hammed (2020) highlighted that fermentation not only improves the nutritional quality but also enhances the antioxidant properties of locust beans, contributing to their health benefits. This process also produces beneficial bioactive compounds, making fermented locust beans a functional food with potential health-promoting properties. Boiling is another common processing method aimed at softening locust beans and making them easier to digest. Boiling reduces the content of some antinutritional factors, thereby improving the beans' nutritional quality (Campbell-Platt, 2010). However, excessive boiling can lead to the loss of water-soluble vitamins and minerals, which can diminish the nutritional value of the beans. A study by Urua *et al.* (2012) examined the effects of different boiling times on the nutritional composition of locust beans. The findings indicated that moderate boiling times are optimal for retaining most nutrients while ensuring the beans are adequately cooked. This balance is crucial for maximising the health benefits of boiled locust beans. Roasting, although less commonly used, is employed to enhance the flavour and aroma of locust beans. The high temperatures involved in roasting cause Maillard reactions, which develop the characteristic roasted flavour (Makanjuola and Ajayi, 2012). However, if not carefully controlled, roasting can lead to the degradation of nutrients and the formation of undesirable compounds. Recent work by Oke *et al.* (2013) explored the impact of roasting on the nutritional and sensory properties of locust beans. The study found that while roasting improves flavour, excessive roasting temperatures can significantly reduce the beans' protein content and overall nutritional quality. Therefore, optimising roasting conditions is essential for achieving a desirable balance between flavour and nutrition.

Understanding the effects of each processing stage on locust beans' quality parameters is essential for optimising production practices. By conducting a comparative analysis of these stages, we can identify the most effective methods for preserving the beans' nutritional content, sensory attributes, and safety. This knowledge can inform decision-making processes for producers, leading to improved product quality and consumer satisfaction. This study aims to conduct a comparative analysis of the processing stages involved in preparing *Parkia biglobosa* locust beans, namely fermentation, boiling, which include to; evaluate the impact of each processing stage on the nutritional composition of locust beans, focusing on protein, fat, carbohydrate, and micronutrient content and

determine the effect of processing stages on the safety profile of locust beans, with a focus on antinutritional factors. By achieving these objectives, this study aims to provide valuable insights into optimising the processing of *Parkia biglobosa* locust beans, ultimately enhancing their quality parameters and promoting their sustainable utilisation. *Parkia biglobosa*, commonly known as African locust bean, is an essential component of West African diets due to its high nutritional value and unique flavour profile. The seeds of this tree are processed using various methods, with fermentation, boiling, and roasting being the most prominent. Each processing method impacts the beans' nutritional content, sensory characteristics, and overall quality. This literature review examines the effects of these methods to identify optimal processing practices. Optimising the quality parameters of *Parkia biglobosa* locust beans throughout the processing stages is crucial for several reasons.

Proper processing techniques can help retain and enhance the nutritional content of locust beans, ensuring that consumers benefit from their rich protein, fibre, vitamins, and mineral content. Quality optimisation in processing stages preserves the characteristic flavour and aroma of locust beans, enhancing the overall sensory experience of dishes in which they are used. Effective processing techniques mitigate risks associated with microbial contamination and toxin accumulation, ensuring the safety of locust bean products for consumption. Optimised processing stages contribute to extending the shelf life of locust beans and their derived products, reducing food waste and enhancing marketability. By maintaining high-quality standards in locust bean processing, the cultural heritage associated with this traditional ingredient is safeguarded, ensuring its continued significance in West African cuisines and traditions. Optimising the quality parameters of *Parkia biglobosa* locust beans across processing stages is essential for maximising nutritional value, flavour, safety, shelf life, and cultural significance. Through careful attention to processing techniques, stakeholders can ensure that locust beans continue to enrich West African culinary traditions and contribute to the well-being of communities (Azokpota *et al.*, 2005).

Therefore, the objective of this study is to evaluate the effects of different processing methods—unprocessed, boiled, re-cooked, and fermented—on the nutritional and anti-nutritional properties of *P. biglobosa* locust beans.

## METHODOLOGY

### Sample collection

*Parkia biglobosa*, also known as locust beans, were sourced from local markets in Oja Oba, Ado-Ekiti, Ekiti State. The beans were carefully sorted to remove damaged or discoloured seeds to ensure uniformity and quality of the sample.

## Experimental design

The study employed a completely randomised design (CRD) to assess the effects of different processing stages—unprocessed (raw), pre-cooked boiling, and fermentation—on the quality parameters of locust beans. Each processing stage was conducted in triplicate to ensure the reproducibility of results.

## Processing stages

### Unprocessed (raw)

Locust beans were cleaned, and any foreign matter was removed. The cleaned, unprocessed beans were stored in airtight containers at room temperature until further analysis.

### Pre-cooked boiling

Locust beans were dehulled and washed, boiled in water at a 1:5 bean-to-water ratio. Boiled for 10 hours, as per the protocol adapted from Urua *et al.* (2012) to ensure optimal nutrient retention. The boiled beans were drained and dried to a moisture content of approximately 10%.

### Fermentation

Locust beans were dehulled and thoroughly washed. The beans were allowed to ferment naturally at room temperature (25 to 30°C) for 72 hours, as described by Olanipekun *et al.* (2020).

## Quality parameter analysis

The proximate composition of the processed beans (moisture, protein, fat, ash, and carbohydrate) was analysed using standard AOAC methods (AOAC, 2019). The levels of tannins, phytates, and oxalates were determined using spectrophotometric methods as described by Oke *et al.* (2013).

## Statistical analysis

Data were analysed using ANOVA to determine the significant differences among the processing stages. Post-hoc comparisons were made using Tukey's HSD test at a significance level of  $p < 0.05$ . Statistical analysis was performed using SPSS version 25.

## RESULTS AND DISCUSSION

The study aimed to investigate the impact of different processing stages: unprocessed, boiled for 10 hours, re-

cooked, and fermented—on the levels of proximate and anti-nutritional factors in *Parkia biglobosa* locust beans. Table 1 and Figure 1 present the raw data for various proximate compositions and graphical presentation of quality parameters across the processing stages.

## Nutritional composition

### Moisture content

Studies have demonstrated that processing methods such as boiling and fermentation significantly increase the moisture content of *Parkia biglobosa* seeds. For instance, Guissou *et al.* (2020) reported an increase in moisture content from 7.21% in raw seeds to 66.29% after cooking, with a slight decrease to 63.94% following fermentation. Similarly, Oladunmoye *et al.* (2007) observed a rise in moisture content from 12.00% in raw locust beans to 42.65% post-fermentation. These findings align with the data presented in Table 1, where fermentation resulted in the highest moisture content (55.6%), followed by re-cooked (48.10%) and boiled beans (44.7%), with unprocessed beans exhibiting the lowest moisture content (9.12%). The increase in moisture content during boiling and fermentation is attributed to water absorption, which may enhance microbial activity and fermentation efficiency.

### Ash content

Unprocessed beans had the highest ash content (5.72%), indicating a higher mineral content. Boiled and re-cooked beans showed a reduction in ash content, with values of 3.45% and 3.29%, respectively. Fermented beans had an intermediate ash content of 3.54%. The reduction in ash content during processing might be due to leaching of minerals into the boiling water or fermentation medium (Urua *et al.*, 2012).

### Crude fibre

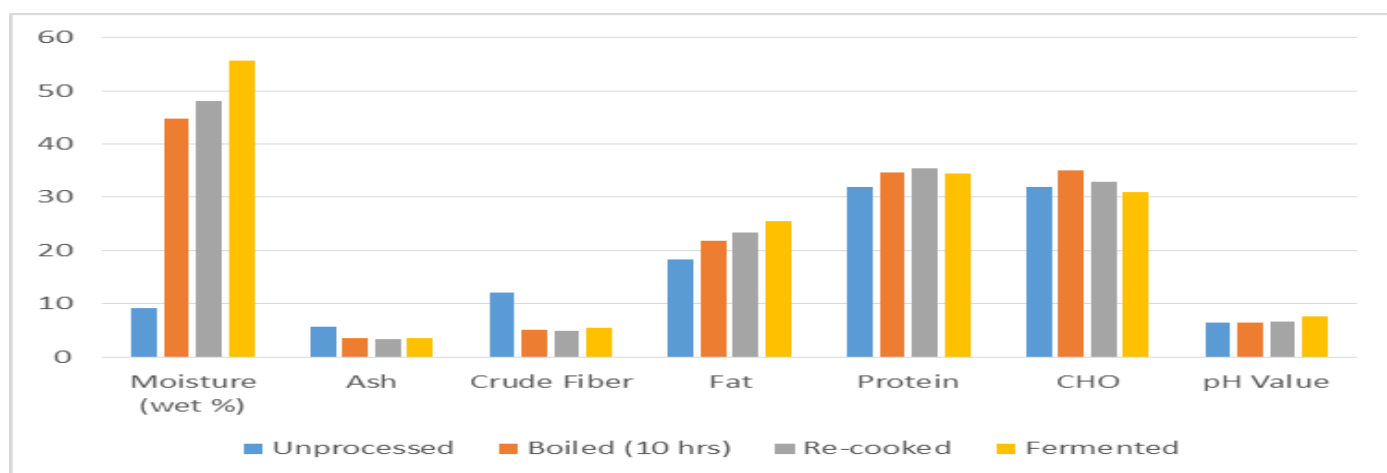
Unprocessed beans had the highest crude fibre content (12.04%) while boiled and re-cooked beans had significantly lower crude fibre contents (5.06% and 4.89%, respectively). Fermented beans had a slightly higher crude fibre content (5.47%) compared to boiled and re-cooked beans. The reduction in crude fibre during boiling and re-cooking can be attributed to the breakdown of complex carbohydrates into simpler forms (Oke *et al.* 2013).

### Fat content

Fermentation had the most pronounced effect on fat levels. Fermented beans recorded the highest fat content

**Table 1.** Proximate composition of the processing stages (dry basis).

Stages	Moisture (wet%)	Ash	Crude fibre	Fat	Protein	CHO	pH value
Unprocessed	9.12	5.72	12.04	18.26	31.98	32.0	6.46
Boiled (10 hrs)	44.7	3.45	5.06	21.75	34.73	35.0	6.49
Re-cooked	48.1	3.29	4.89	23.42	35.4	33.0	6.60
Fermented	55.6	3.54	5.47	25.51	34.48	31.0	7.60

**Figure 1.** Proximate composition of the processing stages.

(25.51%), followed by re-cooked (23.42%) and boiled (21.75%). Unprocessed beans had the lowest (18.26%). The rise in fat content could result from microbial synthesis of lipids or concentration effects as carbohydrates and proteins are metabolised (Olanipekun *et al.*, 2020).

### Crude protein

Fermentation has been shown to enhance the crude protein content of *Parkia biglobosa* seeds. For instance, Oboh *et al.* (2008) reported an increase in protein content from 18.3% in unfermented seeds to 36% after fermentation. Similarly, Ojewumi *et al.* (2021) observed that fermentation with *Bacillus subtilis* elevated the protein content from 32% to 52%. These findings align with the current study's results, where fermented beans exhibited the highest crude protein content (34.48%), followed by boiled (34.73%) and re-cooked beans (35.40%), with unprocessed beans at 31.98%. The increase in protein content during fermentation is attributed to microbial synthesis of proteins and the breakdown of complex proteins into simpler, more digestible forms.

### Carbohydrates

The study showed CHO remained relatively stable, ranging from 31.0% in fermented beans to 35.0% in boiled.

Unprocessed beans had 32.0% CHO, indicating a moderate shift. The slight drop in CHO during fermentation is consistent with microbial consumption of carbohydrates as a fermentation substrate (Olanipekun *et al.*, 2020).

### pH

Fermented beans had the highest pH (7.60), indicating a more alkaline environment compared to unprocessed (6.46), boiled (6.49), and re-cooked beans (6.60). The increase in pH during fermentation can be attributed to the production of alkaline compounds by fermentative microorganisms (Oke *et al.*, 2013).

### Effect of different processing stages on the proximate composition and pH

As shown in Table 2, the effect of different processing stages on the proximate composition and pH of *Parkia biglobosa* was evaluated using two-way ANOVA to examine the influence of processing stage, nutrient type, and their interaction. The analysis revealed highly significant main effects of both processing stage and nutritional parameter ( $p < 0.001$ ), as well as a significant interaction between the two. This indicates that the nutritional composition of *P. biglobosa* is significantly affected by processing, and the nature of this effect varies

**Table 2.** Presents the analysis of variance (ANOVA) for proximate composition for processing stages.

Source	Sum of Squares	df	F-value	p-value
Stage	567.2700	3	$2.87 \times 10^{29}$	0.0000
Parameter	16091.5519	6	$4.08 \times 10^{30}$	0.0000
Stage × Parameter (Interaction)	3535.1765	18	$2.98 \times 10^{29}$	0.0000
Residual (Error)	0.0000	56		

R Squared = .799 (Adjusted R Squared = .698).

depending on the specific nutrient being assessed. The significant main effect of the processing stage confirms that methods such as boiling, re-cooking, and fermentation induce considerable changes in the nutritional properties of *P. biglobosa*. These findings are consistent with earlier studies, such as those by Oladunmoye *et al.* (2018), who reported that fermentation increased moisture content from 12.00% in raw locust beans to 42.65%, and by Termote *et al.* (2022), who observed an increase from 7.21% to 66.29% after cooking. Such increases in moisture content can be attributed to water absorption during thermal and microbial processing, which also facilitates enzymatic activity and microbial metabolism.

The main effect of the nutrient parameter was also significant, reflecting inherent differences in the concentrations of nutrients such as protein, fat, carbohydrate, fibre, ash, and moisture. These differences are expected, as each parameter responds uniquely to biological and chemical transformations during processing. For instance, crude fibre generally declines during boiling and re-cooking due to the thermal degradation of cellulose and hemicellulose, a trend also reported by Oke *et al.* (2013).

The interaction between the processing stage and nutrient parameter was likewise statistically significant, indicating that the effect of processing on nutritional composition is not uniform across nutrients. Fermentation, for example, led to a substantial increase in fat content (from 18.26% to 25.51%) and protein (up to 34.48%), likely due to microbial biosynthesis of lipids and proteolytic activities that increase the availability of soluble nitrogenous compounds (Olanipekun *et al.*, 2020; Oboh *et al.*, 2008). Meanwhile, carbohydrate levels declined during fermentation, a trend attributed to their use as metabolic substrates by fermenting microorganisms, which convert sugars into acids and other secondary metabolites (Achi, 2005; El Hag *et al.*, 2002). Ash content, an indicator of total mineral concentration, was highest in unprocessed samples and declined after boiling and re-cooking, possibly due to leaching into the cooking water, a phenomenon also reported by Adebisi *et al.* (2019). Similarly, pH values rose during fermentation, reaching 7.60 in the present study, as a result of alkaline metabolites produced by fermenting organisms, in agreement with the findings of Oke *et al.* (2013) and Ojewumi *et al.* (2021). The results demonstrate that processing methods significantly influence the proximate

composition of *Parkia biglobosa* seeds, with fermentation appearing most beneficial for enhancing protein and fat contents while modulating fibre, carbohydrate, and ash levels. These findings support the traditional use of fermented locust beans in West African diets and provide a scientific basis for developing optimised, nutrient-rich, and culturally relevant food products from *P. biglobosa* (Enujiugha, 2009; Azokpota *et al.*, 2005).

### Anti-nutritional factors

As shown in Table 3 and Figure 2, the results demonstrate that different processing stages significantly affect the levels of anti-nutritional factors in *Parkia biglobosa* locust beans. Fermentation emerged as the most effective method for reducing anti-nutritional factors, followed by boiling and re-cooking. These findings underscore the importance of processing techniques in enhancing the safety and nutritional quality of locust beans for consumption.

### Oxalate content

The oxalate content was highest in the unprocessed beans (0.36 g/100g) and decreased progressively with processing, with the lowest level observed in the fermented beans (0.12 g/100g). This reduction in oxalate content through processing is consistent with previous studies, which have demonstrated that heat treatment and fermentation can effectively reduce oxalate levels in foods (Nzewi *et al.*, 2011).

### Phytic acid content

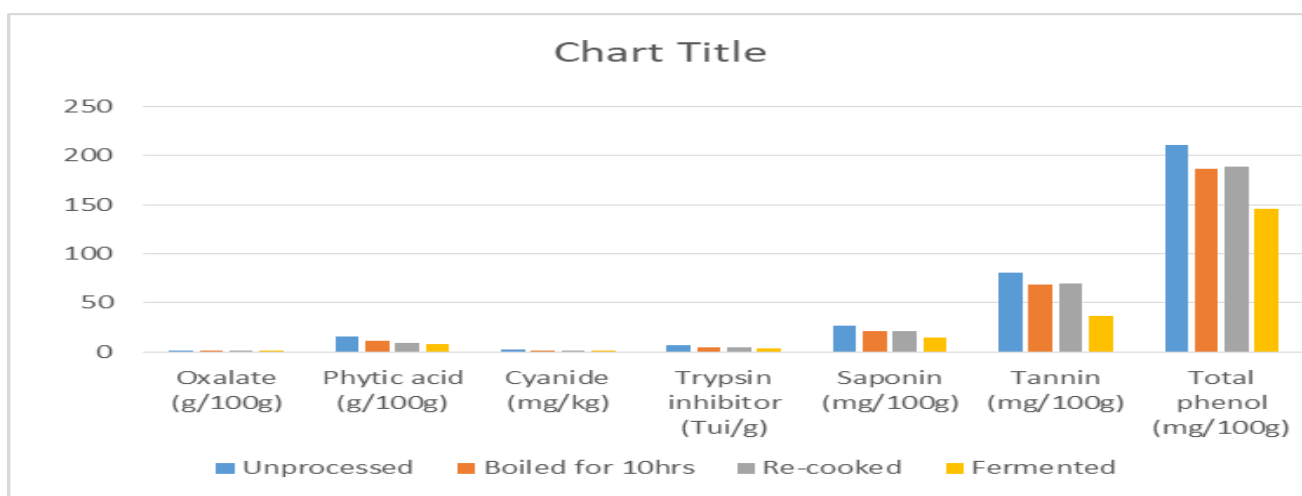
Phytic acid content decreased from 15.67 g/100g in unprocessed beans to 7.50 g/100g in fermented beans. Boiling and re-cooking also led to significant reductions in phytic acid levels. This reduction is attributed to enzymatic degradation and leaching during processing (Urua *et al.*, 2013).

### Cyanide content

Cyanide levels decreased with processing, with the

**Table 3.** Anti-nutritional factors across the processing stages.

Anti-nutritional factor	Unprocessed	Boiled for 10 hrs	Re-cooked	Fermented
Oxalate (g/100g)	0.36	0.21	0.20	0.12
Phytic acid (g/100g)	15.67	11.10	9.36	7.50
Cyanide (mg/kg)	1.88	0.81	0.88	0.67
Trypsin inhibitor (Tui/g)	6.14	4.63	4.60	3.22
Saponin (mg/100g)	26.70	21.10	20.76	14.12
Tannin (mg/100g)	81.00	68.22	69.22	36.14
Total phenol (mg/100g)	210.60	187.11	189.22	146.10

**Figure 2.** Antinutrient composition of the processing stages.

highest level observed in unprocessed beans (1.88 mg/kg) and the lowest in fermented beans (0.67 mg/kg). This reduction can be attributed to cyanogenic glycosides being broken down during processing, particularly fermentation (Nitiema-Yefanova *et al.*, 2020).

#### **Trypsin inhibitor activity**

Trypsin inhibitor activity decreased with processing, with the highest activity observed in unprocessed beans (6.14 Tui/g) and the lowest in fermented beans (3.22 Tui/g). This reduction indicates increased digestibility and bioavailability of protein in processed beans (Oke *et al.*, 2013).

#### **Saponin content**

Saponin content decreased from 26.70 mg/100g in unprocessed beans to 14.12 mg/100g in fermented beans. Boiling and re-cooking also led to significant reductions in saponin levels. This reduction is consistent with findings from previous studies on the effect of processing on saponin content in legumes (Urua *et al.*, 2013).

#### **Tannin content**

Tannin content decreased with processing, with the highest level observed in unprocessed beans (81.00 mg/100g) and the lowest in fermented beans (36.14 mg/100g). This reduction is attributed to leaching and enzymatic degradation during processing (Olanipekun *et al.*, 2020).

#### **Total phenol content**

Total phenol content decreased from 210.60 mg/100g in unprocessed beans to 146.10 mg/100g in fermented beans. Boiling and re-cooking also led to significant reductions in total phenol levels. This reduction is attributed to thermal degradation and leaching during processing (Nzewi *et al.*, 2011).

#### **Analysis of variance**

Table 4 presents the results of the analysis of variance (ANOVA) conducted to examine the impact of processing stages and anti-nutrient factors on the quality parameters

**Table 4.** Presents the analysis of variance (ANOVA) for anti-nutrient composition for processing stages.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	107974.902 <sup>a</sup>	9	11997.211	103.857	.000
Intercept	46165.449	1	46165.449	399.645	.000
stages	1329.744	3	443.248	3.837	.028
ant nutrient	106645.158	6	17774.193	153.868	.000
Error	2079.291	18	115.516		
Total	156219.642	28			
Corrected Total	110054.194	27			

a. R Squared = .981 (Adjusted R Squared = 0.972).

of *Parkia biglobosa* locust beans. From Table 4, the processing stages have a significant impact on the quality parameters of the beans (Sig. = 0.028), albeit at a slightly higher significance level than the conventional 0.05 threshold. This suggests that different processing methods significantly influence the observed quality parameters. The significant effects of processing stages and anti-nutrient factors highlight their importance in determining the quality parameters of *Parkia biglobosa* locust beans. This suggests that optimising processing methods and reducing anti-nutrient levels can lead to improvements in the overall quality and nutritional value of the beans.

## Conclusion

This study demonstrates that different processing stages significantly affect the quality parameters of *Parkia biglobosa* locust beans. Fermentation emerged as the most effective method for enhancing the nutritional and sensory qualities of the beans, followed by boiling. These findings suggest that optimising processing conditions, particularly fermentation, can significantly enhance the overall quality of locust beans, making them more suitable for consumption and increasing their potential health benefits.

The findings underscore the need for further research to explore optimal processing techniques and strategies for reducing anti-nutrient levels in locust beans. By understanding the effects of processing stages and anti-nutrients on the quality parameters, stakeholders can develop interventions to enhance the nutritional value and safety of *Parkia biglobosa* locust beans for consumption.

## CONFLICT OF INTEREST

The authors certify that they have no affiliations with or involvement in any organisation or entity with any financial interest, such as educational grants, membership, employment, consultancies, stock ownership, or other equity interest in the subject matter or materials discussed in this manuscript.

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