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Higher amounts of proximate and minerals in composite biscuit made from African locust beans pulp

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Food insecurity (FI) is still endemic in most parts of Low and Middle Income Countries (LMICs), including Ghana. This study was a quasi-experimental design carried out in the Wa Municipality. We assessed the proximate and minerals in African locust fruit pulp (*Parkia biglobosa*) and biscuits made from composite flours. We also did sensory evaluation on the formulated biscuits. We also assessed the acceptability of biscuits manufactured. We performed proximate analysis and used two treatments: control sample, wheat flour (WF) and ALFPF at 100, 75, 25, and 0%. A total of 100 respondents randomly selected, sensory evaluate the products based on appearance, texture, scent, taste, and acceptability, based on a nine-point hedonic scale questionnaire. Generally, the mineral and nutrient quantities were higher in the composite biscuit compared to the control except for fat and oil. Protein, fibre, carbohydrate content was statistically significantly ($p < 0.001$) higher for the sample with 25% flour and 75% ALFPF compared to the control and 50/50 and 75/25. Probably, this consumption can improve food insecurity and the consumption of this can improve food insecurity, hidden hunger levels among the population.

Key words: *Parkia biglobosa*, African locust bean, proximate, minerals, Wa municipality, Ghana.

INTRODUCTION

Hunger and malnutrition persist in many parts of Ghana, especially the zone of influence which is made up of the regions in the northern part. About 18% of the food insecure live in the Upper East region; in the Northern region it is 17%; and in the Ashanti region it was found to be 13%. Nationally, Upper East region records 49% food insecurity and this is the highest prevalence in the country (CFSVA Ghana, 2020). Stunting is endemic in the Northern egion (where approximately 33% of children are short-for-their-age) (GSS, GHS and ICF, 2015). There have been many calls for the use of biodiversity as a means to reduce FI and improve nutritional status (Burlingame et al., 2012; Charrondière et al., 2013; Chhikara et al., 2018). Although, the African locust bean tree (*Parkia biglobosa*) is perennial, it is is a rich source of plant protein (Quansah et al., 2019). This leguminosae

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Table 1. Proportion of Dankote wheat flour to *Parkia biglobosa* flour (ALFPF) used to produce composite biscuits.

Treatment	Wheat flour (g)	Parkia biglobosa flour (g)
A	100	100
B	125	75
C	75	125
D (Control)	100	0

Source: Authors

is one of Northern Ghana's most popular trees (Zakari et al., 2015). And there is the need to use it in the use of low-cost local commodities (Awogbenja and Ndife, 2012). Essential eatable wild fruits improve health, food security, and income generation (Aworh, 2015; Bvenura and Sivakumar, 2017). Maroyi and Cheikhyoussef urged millions of people worldwide to take advantage of the local available edible fruits (Maroyi and Cheikhyoussef, 2017).

According to Ikhimalo(2019)., the fruits of African locust bean are mostly used as condiment, but it is a legume and its nutrients can be exploited. *P. biglobosa* fruit pulp exploitation is limited, aside from its application in cooking local delicacies (Adeloye and Agboola, 2022) with just a few uses for porridge and fresh meals (Amoa-Awua et al., 2014). The *tree* is available in Northern parts of Ghana (Alrayyes, 2018). The fruits are plucked when it is season and the yellow pulp is sucked and the seed which is high in minerals and nutrients is thrown away (Adeloye and Agboola, 2022). The avenue for exploiting the potential of the beans of the tree by making it part of a meal has not been exploited. Although Ghana is struggling to achieve the Sustainable Development Goal 2 of zero hunger. Although this wild fruit has been available in the Northern section of Ghana, food insecurity and malnutrition is highest there. It is important to harness the potential of this plant as a way of diversifying food consumption to reduce food insecurity and improve nutritional status (Ikhimalo, 2019). Cereal-based products are nutritious and can reduce food insecurity (Alrayyes, 2018). Wild fruits such as African locust beans have the potency of curing multiple disorders because of their rich fiber and antioxidant components (Ajayi et al., 2018; Alissa and Ferns, 2017; Shaheen et al. 2017). Cereal fortification with legumes (Singha and Muthukumarappan, 2018) has proven to be incredibly advantageous since both cereals and beans supplement each other in terms of unobtainable indispensable amino acids (Yu et al., 2016)..

The use of the flour from *P. biglobosa* as composite flour for preparing biscuits remains a warm area in the quest to reduce food security and improve nutritional status in Ghana. Previous studies advocated for increase use of the fruit without formulating any food product. This study determined the levels of proximate and minerals and consumer acceptance of biscuits formulated from African locust bean pulp powder composite through sensory evaluation.

MATERIALS AND METHODS

Study area

The study was conducted at Upper West Region of Ghana specifically, Wa Municipality at the time the fruit was in season. The Wa Municipality is bounded to the south by the Northern Region of Ghana and to the west by the Black Volta. The distance of Wa from the capital city of Ghana, Accra, is about 560 km.

Study design

The quasi-experimental research design is employed since this enables us to determine the physico-chemical characteristics of the study materials.

Sources of raw material

The local raw materials used for the development of the biscuits include ALBFP from dried fruits, fresh eggs, sugar, butter, and milk powder. The ALBFP for the biscuit formulation was obtained from the Upper West Region Wa. The other materials were bought from the super market in Wa.

Formulation of blends

The study adopted a completely randomized design with two treatments made up of commercially available flour made from wheat (Dankote brand) and the flour made from *P. biglobosa*. Table 1 shows the percentages of *P. biglobosa* flour used to replace Dankote brand flour at 100, 75, 25, and 0%. Composite biscuits were made from the formulations according to the method described in Vaclavik et al. (2021).

Preparation of *P. biglobosa* African locust bean fruit pulp flour

The fruit was harvested when it was in season in August-September. Maturity of the fruit was determined through its brownish colour and the sound it makes when the fruit is shaken. The method described by Vaclavik et al. (2021) was used in the formulation of *P. biglobosa* flour. The pods were de-husked manually followed by the removal of seeds from the yellow fruit pulp. The pulp was then desiccated for 9 h at 60°C (Genlab Widnes, Model T1211) to a moisture content of 10% at the research laboratory of School/Faculty of Agriculture and Natural Sciences, University of Cape Coast. The dried fruit was then milled with a hammer mill (Christy Hunt, England), thereafter, we sieved this with a 0.5 mm mesh. This flour was then wrapped in polythene bags and kept at room temperature at the same research laboratory (Stone

and Sidel, 2004).

Preparation of the composite biscuit from *P. biglobosa*

This was made using the creaming method (Akubor et al., 2017; Awotedu et al., 2018) with components being margarine, *P. biglobosa* flour, sugar, salt, eggs and milk powder. All ingredients were weighed before use.

Preparation of the composite biscuit

The ingredients for the composite biscuit were mixed kneaded into stiff dough for 10 min. After this, though was careened out on a even surface to a sheet of even breadth of about 0.5 cm. Weighed amounts were then consigned on greased baking salvers, masked, left for about 15 minutes and heated for 20 min at 180°C in an oven. There after, the composite biscuits were then taken out of the oven packaged in an air-tight container after it was allowed to cool.

Sample size and sampling approach for sensory evaluation

As is consistent with the standards of the hedonic method of sensory evaluation, a total of 100 staff and students from the Home Science Department were randomly sampled in Wa Senior High Secondary School with sensory evaluation of the new products.

Proximate analysis of WF and ALBFP

Moisture, ash, protein, dry matter, fats/oils, and fibre contents were determined using AOAC recommended techniques (AOAC, 2019).

Mineral analysis of ALBFP and composite biscuits

The minerals were determined through methods that led to acid oxidation before a complete elemental analysis was carried out. A flame photometer was used to determine the amounts of potassium and sodium in the digested samples. The calculation of the amount of minerals was based on the method described (Ifesan et al., 2017). The calcium and magnesium were determined by the method that involves chelation of the cations with ethylene diaminetetra-acetic acid (EDTA). Amount of mineral was calculated using the procedure of Ifesan et al. (2017), phosphorus was assessed by applying the ascorbic acid procedure by D'souza et al. (2014).

Sensory evaluations

This assessment of the sampled biscuits was performed within 24 h of baking by 100 untrained people from Wa Technical Secondary Senior High School. Samples of the prepared biscuits with varying codes were arranged in a suitable area. Each biscuit was presented on its own plate. Before going on to the next coded biscuit, the assessors were provided with bread which they ate and rinse their mouths with water afterwards. The texture, appearance, acceptability and taste were accessed (Stone and Sidel, 2004). A nine-point hedonic scale was used to rate the parameters for the sensory evaluation. The items were scored as: 1 = liked extremely; 2 = liked very much; 3= liked moderately; 4= liked slightly; 5= liked or disliked, 6 = disliked slightly; 7= disliked very much; 8= disliked moderately; and 9= disliked extremely (Dahouenon-Ahoussi et al., 2012).

Statistical analysis

One way analysis of variance (ANOVA) was used to analyse the data generated from the study. Proportions and numbers were presented for the proximate, minerals and sensory results. The statistical significance between the means of the dependent variables were determined at 5%. Tukey post hoc test procedure was applied to determine where the differences in the averages of the estimates assessed exist.

Ethical consideration

Approval for the sensory evaluation study was provided granted by the Department of Vocational and Technical Education research committee, University of Cape Coast. Written consent was provided by all who took part in the study. Permission was also sought from the School of Agriculture and Natural Science where laboratory analysis was done. Institutional Review Board of the University of Cape Coast (UCCIRB/CES/2021/95) gave approval for the study.

RESULTS

Proximate constituents of wheat locust pulp flour and composite flour

Compared to the control (WF), locust pulp fruit had the highest amount of protein (12.06%), and fibre (6.2%). Among the composites, protein and fibre were highest in the blend of 25% wheat flour and 75% of locust pulp flour (25/75) proportion. Statistical significances observed were denoted with different letters at the 5% probability level (Table 2).

Mineral composition of wheat locust flour and composite flour

The locust pulp had the greater quantities of all five minerals determined in relation to the wheat flour (control). The proportions of the minerals were higher than blend of 25 parts of wheat flour and 75% of locust pulp flour. Means with similar variables are insignificant, while means with different variables are statistically significant at 5% probability level (Table 3).

Proximate composition proportions of composite biscuit

It was noticed that even after blending the proportion of the protein in the 25/75 was higher compared to all other mixtures and the control. Similar observation was made for the proportion of fibre, however, the fat/oil proportion was higher in the 75/25 proportion. Means with similar variables are insignificant, while means with different variables are significant at the 5% probability level (Table 4).

The amounts of phosphorus, potassium, sodium (µg/g), and the proportions of calcium and magnesium were

Table 2. Proximate constituents of wheat, locust pulp flour and composite flour.

Sample	Dry matter (%)	Moisture (%)	Ash (%)	Protein (%)	Fat/Oil (%)	Fibre (%)	Carbohydrate (%)
Wheat flour	89.21^{a}	10.79^{e}	0.57^{a}	10.24^{d}	0.99^{e}	0.428^{a}	85.95^{e}
Locust Pulp	92.59^{e}	7.41^{a}	1.91^{c}	12.06^{b}	0.28^{a}	6.202^{e}	81.37^{b}
50/50	90.93^{c}	9.07^{c}	2.66^{d}	11.48^{e}	0.39^{b}	5.099^{d}	78.06^{a}
75/25	90.00^{b}	10.00^{d}	1.56^{b}	8.21^{c}	0.85^{d}	3.238^{b}	82.87^{c}
25/75	91.57^{d}	8.43^{b}	3.59^{e}	13.79^{a}	0.65^{c}	3.577^{c}	83.98^{d}
ANOVA							
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
l.s.d.	0.2937	0.2937	0.1279	0.2305	0.01568	0.2083	0.3172
Cv	0.2	1.8	3.4	1.1	1.4	3.1	0.2

50/50 = blend of 50% of locust pulp flour and 50% of wheat flour; 75/25 = blend of 75% of wheat flour and 25 parts of locust pulp flour; 25/75 = blend of 25% of wheat flour and 75% of locust pulp flour; in a row and column, the percentages denoted by the alphabets are not statistically different at P< 0.05.
Source: Authors

Table 3. Mineral composition of wheat locust flour and composite flour.

Sample	Phosphorus (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Calcium (%)	Magnesium (%)
Wheat flour	136^{a}	1058^{a}	461.0^{a}	0.78^{a}	0.051^{ab}
Locust Pulp	168^{d}	6509^{e}	974.6^{d}	0.98^{c}	0.054^{b}
50/50	154^{c}	4427^{c}	958.6^{cd}	0.86^{b}	0.052^{ab}
75/25	143^{b}	2975^{b}	908.7^{b}	0.76^{a}	0.050^{a}
25/75	155^{c}	5477^{d}	933.2^{bc}	0.85^{b}	0.052^{ab}
ANOVA					
p-value	<0.001	<0.001	<0.001	<0.001	0.043
l.s.d.	20.4	84.4	26.5	0.017	0.0024
cv (%)	0.7	1.1	1.7	1.1	2.5

50/50 = Blend of 50% of locust pulp flour and 50% of wheat flour , 75/25 = blend of 75% of wheat flour and 25 parts of locust pulp flour, 25/75 = blend of 25%of wheat flour and 75% of locust pulp flour. In rows and columns, the percentages denoted by the alphabets are not statistically different.
Source: Authors

higher in the 25/75 blend of composite biscuits. Generally, the values of these minerals increased above the level of non-biscuit levels. Means with similar variables are insignificant while means with different variables are significant at 5% probability level (Table 5).

Sensory analysis

Appearance

Biscuit prepared from wheat as well as composite biscuits was scored for appearance. More than half of the respondents (53.4%) satisfied with the appearance of biscuits prepared with 100% wheat, While 42.2 and 38.5% immensely liked the appearance of 50/50 and 25/75 biscuit samples, respectively (Figure 1).

Texture

The composite biscuit with locust wheat flour obtained the greatest texture score (47.9) (Figure 2). Among the composite biscuits, 25/75 had the highest score of 46% compared to 50/50 and 75/25 which had lower values of 34.2 and 31.5%, respectively.

Taste

The results showed 38.8% of panelists liked sample 25/75 very much, 45.2% liked sample 50/50 slightly, 20.4% neither liked nor disliked sample 25/75, 8.2 disliked sample 50/50 and 11 disliked the biscuit prepared form25/75 flour blend (Figure 3).

Table 4. Proximate estimates of composite biscuits.

Sample	Dry matter (%)	Moisture (%)	Ash (%)	Protein (%)	Fat/Oil (%)	Fibre (%)	Carbohydrate (%)
Wheat flour	95.32^{c}	5.32^{b}	2.57^{a}	7.04^{b}	18.19^{b}	1.34^{a}	69.81^{c}
50/50	93.06^{a}	6.71^{c}	3.17^{b}	7.72^{a}	16.32^{a}	1.72^{b}	68.25^{b}
75/25	95.32^{c}	4.68^{a}	2.69^{a}	7.16^{b}	22.08^{d}	1.24^{a}	66.27^{a}
25/75	93.30^{a}	6.94^{c}	3.32^{b}	8.09^{c}	19.11^{c}	2.28^{c}	71.63^{d}
ANOVA							
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
l.s.d.	0.22	0.22	0.13	0.098	0.199	0.096	0.324
Cv	0.1	2	2.3	0.7	0.6	3.1	0.2

50 = Blend of 50% of locust pulp flour and 50% of wheat flour , 75/25 = blend of 75% of wheat flour and 25 parts of locust pulp flour, 25/75 = blend of 25% of wheat flour and 75% of locust pulp flour. In rows and columns, the percentages denoted by the alphabets are not statistically different.
Source: Authors

Table 5. Mineral composition of composite biscuits.

Sample	Phosphorus (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Calcium (%)	Magnesium (%)
Wheat flour	1528^{b}	1326^{a}	859.1^{a}	0.70^{b}	0.048^{a}
50/50	1680^{c}	2776^{c}	885.8^{a}	0.69^{b}	0.051^{ab}
75/25	1376^{a}	1942^{b}	862.7^{a}	0.64^{a}	0.049^{a}
25/75	1697^{c}	3259^{d}	990.5^{b}	0.81^{c}	0.054^{b}
ANOVA					
p-value	<0.001	<0.001	<0.001	<0.001	0.004
l.s.d.	41.5	98.4	32.24	0.031	0.003
Cv	1.4	2.2	1.9	2.3	3.2

50 = Blend of 50% of locust pulp flour and 50% of wheat flour, 75/25 = blend of 75% of wheat flour and 25 parts of locust pulp flour, 25/75 = blend of 25% of wheat flour and 75% of locust pulp flour. In rows and columns, the percentages denoted by the alphabets are not statistically different.
Source: Authors

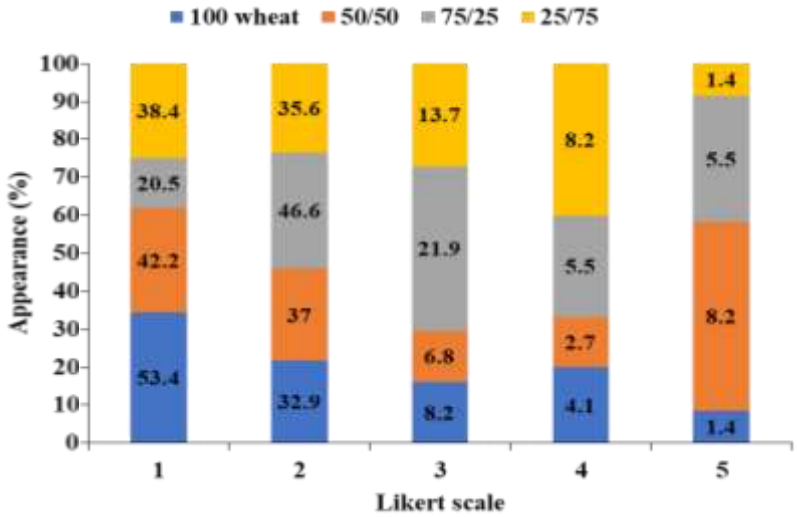

Figure 1. Results of sensory evaluation of the appearance of composite biscuit.
Source: Authors

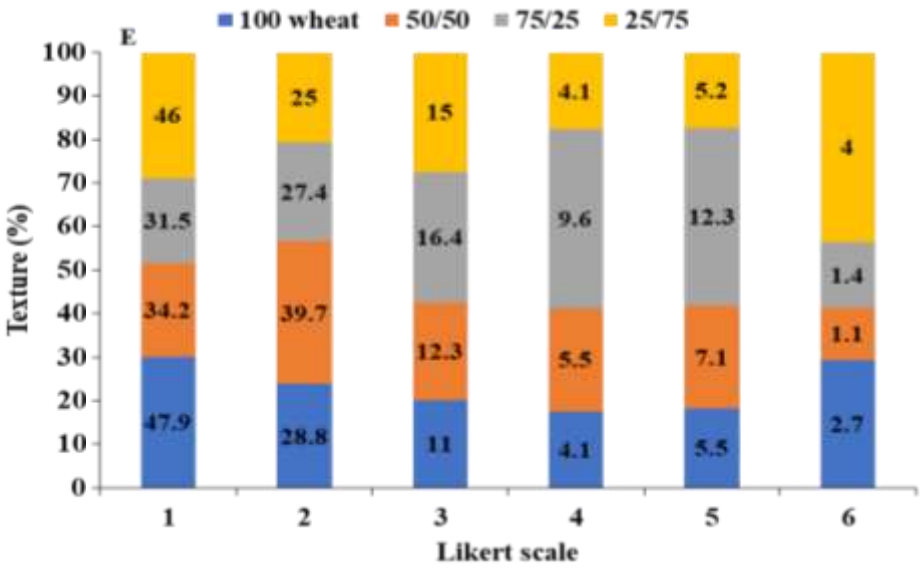

Figure 2. Results of sensory evaluation of the texture of composite biscuits.
Source: Authors

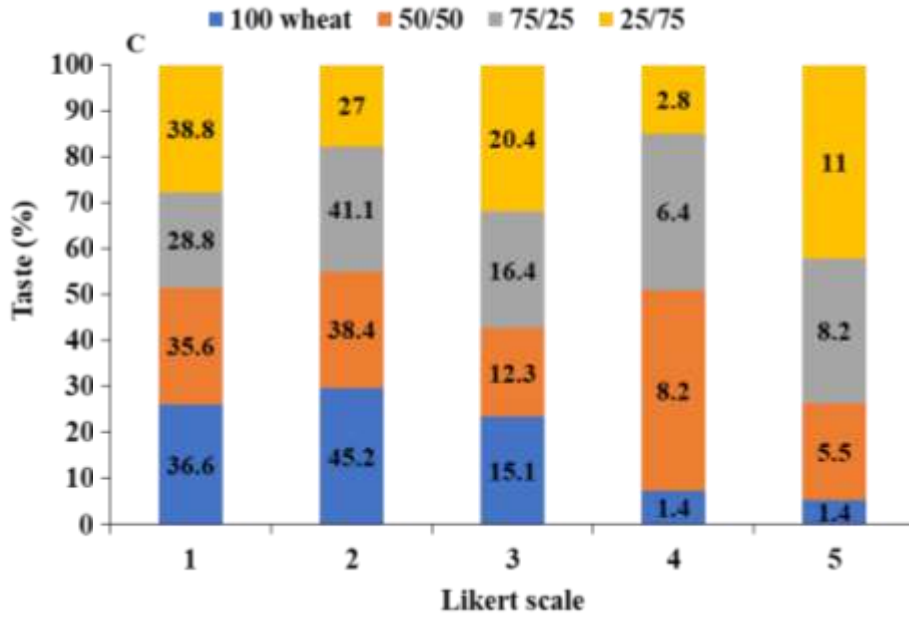

Figure 3. Taste of composite biscuits.
Source: Authors

Overall acceptability

The overall acceptability of the samples increased as the quantities of parkia flour content increased. Almost half of the panelist (46.5%) liked biscuits prepared from 25/75 parts of wheat and parkia flour and 43.8% liked biscuits prepared with equal proportion 50/50 of flour (Figure 4).

DISCUSSION

Physicochemical characteristics of wheat locust pulp and composite flour

The proximate and minerals in African Bean locust fruit pulp (*P. biglobosa*) and biscuits made from composite

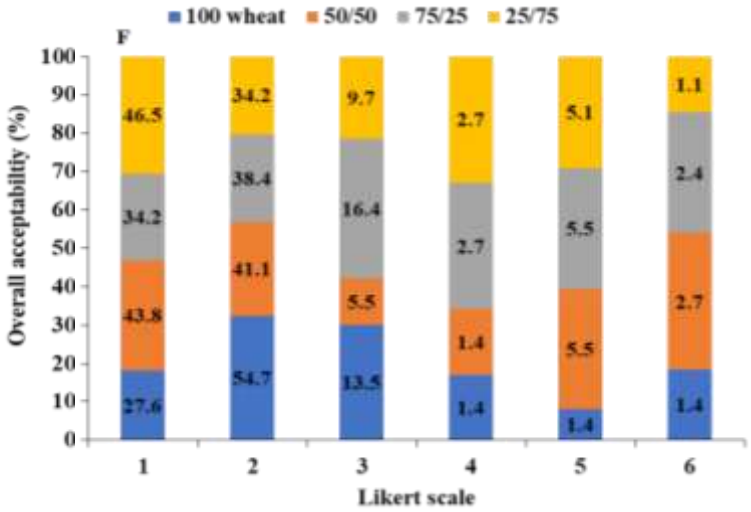

Figure 4. Overall acceptability of composite biscuit.
Source: Authors

flours were assessed. The nutrients and mineral proximate were generally higher in locust pulp flour in relation with the control sample (wheat flour). The protein found in the locust pulp flour and composites was more than 4.29% indicated by Dahouenon-Ahoussi et al. (2012) and akin to 6.56% found by Egbebi et al. (2016). Parkia pulp is a Leguminosae fruit therefore contains a high amount of lysine with about 22.56% crude protein and a rich source of indispensable amino acids (Nyadamu et al., 2017). This biscuit may improve protein intake among populations that need to improve protein nutrition. The composite biscuits had higher crude fibre content compared to wheat flour (WF) and this was similar to that reported by Olujobi (2012). They indicated that the increase in these proximal characteristics including fibres may be attributable to their abundance in parkia flour Olujobi (2012). The dry matter content is similar to the study of Kusuma (2015) and Ogunyinka et al. (2017), who during their study reported dry matter for parkia flour within 77 to 81% and 90.48 to 91.1% (Iheke at al., 2017).

Mineral composition of prepared wheat locust pulp and composite flours

Generally, locust pulp has been reported to have a high mineral content, including calcium, magnesium, potassium, phosphorus, and iron (Ogunyinka et al., 2017). The phosphorus content in the parkia pulp flour obtained was higher than that reported by (2017) and may be due to the variety used for the study and the amounts increased in biscuits as the quantity of parkia flour used augmented. The same pattern was observed for potassium and this has also been reported by Nyadanu et al. (2017) and Iheke et al. (2017)

Jide et al. (2018) indicated sodium composition of 1795 mg/kg for parkia fruit pulp which is greater than the amount of sodium obtained in the study. Iheke et al. (2017) claimed that locust flour is a good source of calcium during their study. Our results agree with the aforementioned since locust pulp flour had 0.98% calcium, which was significantly greater than the calcium content of wheat flour. A direct relationship was observed between the magnesium content of composite flour with augmenting proportion of locust pulp flour.

Mineral content of composite biscuits

Phosphorus matter of the biscuit increased with augmenting content of locust pulp flour substitution. That was because the mineral is high in the pulp flour (Table 3). This could be because of the big initial amount of phosphorus in the locust pulp flour used in blends. The finding is consistent with that reported by Ndekwe and Solomon (2017). Processing into the biscuit did not reduce the amount of the mineral. An increase in potassium content of the biscuit was observed with increasing percentage locust pulp flour as well. Increasing amount of potassium content of the composite with increasing locust pulp flour content could be due to the high amount of potassium in the flour (Ndukwe and Solomon, 2017). Olatoye et al. (2019) reported a substantial amount of potassium in a biscuit prepared from cassava, wheat, and parkia flour blends. The results suggest that processing did not reduce the amount of minerals and therefore these minerals could be available to the body after consumption.

Composite biscuits contained significantly higher

amounts of magnesium and calcium than biscuits prepared from wheat flour. This mineral content of composite bread increases when wheat flour is partially replaced with flour from locally cultivated grain legumes (Kennedy et al., 2017).

Sensory attributes

The yellow colour of parkia flour enhanced the overall appearance of the composite biscuits. This finding corroborates those of Adeloye and Agboola (2022) who posited that the yellow colour of parkia makes the product attractive and appealing to consumers. They observed appearance scores increased with increased parkia concentration in a product. Similarly, an observation was made by Ogunyinka et al. (2017) who reported increase in the appearance of parkia based cookies with increasing parkia concentration. The taste score of the parkia blended biscuit increased with increased parkia flour content probably due to highly digestible carbohydrates, such as natural sugars and this was also observed by Stone and Sidel (2004). The overall acceptability of the prepared biscuit samples was high for biscuits prepared with an increased proportion of parkia flour. This might be attributed to the appearance, taste, and texture of the parkia wheat blend biscuit. Such observation could be due to the sweetness of parkia, which improves the taste of the biscuit (Adeloye and Agboola, 2022).

Conclusions

The African locust bean pulp is suitable for composite biscuits with wheat flour. The minerals and nutrients were not lost during processing. Composite biscuits had higher nutrient composition compared to the control sample. Phosphorus, calcium, sodium, and magnesium content increase with increased African locust bean pulp flour, with sample 25/75 recording the highest mineral content. The acceptability of composite biscuit samples was high and this increases for biscuits prepared with an enhanced percentage of African locust bean pulp flour. It is believed that encouraging consumers to patronize the formulated composite biscuits would improve food insecurity and improve nutritional status.

CONFLICT OF INTERESTS

The authors declare no conflict of interests regarding the publication of this manuscript.

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