

EFFECTS OF FERMENTATION ON THE NUTRITIONAL COMPOSITION OF BANANA AND GROUNDNUT FLOUR BLENDS

ABSTRACT

The study was carried out to determine the effect of fermentation on the nutritional composition of banana and groundnut flour blends. Four blends of banana and groundnut flour was composed (50:50, 60:40, 100:0 and 0:100(banana:groundnut)). Each blend was fermented naturally at room temperature for 72 hours. The pH and total titratable acidity (TTA) were monitored at 24hour interval during fermentation. Mineral and antinutrient composition were also assessed using standard techniques. The pH of the fermenting samples decreased as fermentation progressed while total titratable acidity increased. Total microbial load of the samples decreased during fermentation. Antinutrients decreased while minerals increased after fermentation. From the research, it was observed that fermentation reduced the antinutrient contents of the samples while the minerals were enhanced, therefore food products from legume and carbohydrate blends should be fermented in order to increase the nutritional composition.

INTRODUCTION

Banana is a seed plant that produces edible fruits, usually seedless which belong to the specie *Musa acuminata* or are hybrids of *Musa acuminata* and *Musa balbisiana*. It is an edible fruit produced by several kinds of large herbaceous flowering plants in the genus of *Musa*. It is highly nutritive and very delicious. It contains about 74% water, 23% carbohydrate and 1% protein. Bananas are a valuable source of vitamin B₆, vitamin C, potassium and fibre (USDAARS, 2018). Banana is monocarpic, flowering and setting fruit once before it dies. A healthy banana plant will have 8-12 leaves, fruits mature in 60-100 days after flowers first appears depending on the season and cultivar. New banana plants arise as suckers from an underground rhizome. As old plants die and new suckers are formed the rhizome expands and is called a mat. Bananas are propagated by suckers, pieces of the rhizome and by tissue culture (Ploetz, 2004).

Groundnut (*Arachis hypogaea*) is an herbaceous annual plant in the family Fabaceae grown for its oil and edible nuts. Peanut plants are small, usually erect, thin stemmed plants with feather-like leaves. The groundnut pods can reach up to 10 cm in length and can contain between 1 and 5 seeds. The peanut plant can reach 0.6 m in height depending on the variety and as an annual plant. It is a rich source of protein, niacin, and vitamins E, vitamin B₁, copper, zinc, vitamin B₆, foliate, iron and has a high lysine content which makes it a good complement for cereal protein which is low in lysine (Okaka, 2005).

Fermentation has been known as one of the oldest food processing techniques. Fermentation has been known to improve food quality through biosynthesis and bioavailability of vitamins (Ojokoh and Fagbemi, 2016; Ijarotimi, 2012). This research is therefore focused on the effects of fermentation on the nutritional composition of banana and groundnut.

METHODOLOGY

COLLECTION OF SAMPLES

43 Fresh groundnut (*Arachishypogaea*) and fresh ripe banana (*Musaacuminata*) were locally
44 obtained in Arena market, Oshodi, Lagos State, Nigeria. They were all transported to the
45 laboratory in clean polyethylene bags.

46 **PREPARATION OF THE SAMPLES**

47 The groundnut was thoroughly cleaned by picking all the dirt present in them. It was dried,
48 peeled and milled into flour. The groundnut flour was defatted by using a soxhlet extractor.
49 The ripe bananas were cleaned with water to remove the sand particles present on the peel after
50 which it was peeled. The banana pulp was cut into small slices and oven dried. It was then
51 milled into flour. The flour was sieved and stored in an air tight container.

52 **PREPARATION OF COMPOSITE FLOUR**

53 The banana (B) and groundnut (G) were formulated in ratio 50:50, 60:40, 100:0, 0:100
54 (banana: groundnut)

55 **FERMENTATION OF SAMPLES**

56 Sterile water was added to the flour blends in covered containers. The samples were allowed
57 to ferment naturally at room temperature for 72 hours.

58 **MICROBIOLOGICAL ANALYSIS**

59 Microorganisms were isolated at 24hr interval during fermentation. The samples were
60 subjected to microbiological analysis to monitor the growth and the changes in the population
61 of microorganisms responsible for the fermentation of the samples. The organisms were
62 characterized based on biochemical and morphological observations according to the
63 methods of Cheesebrough (2006).

64 **pH Determination**

65 The pH of the samples was determined according to the method of A.O.A.C (2012).
66 Two grams of sample was mixed in 20ml distilled water. The mixture was allowed to stand
67 for 15 minutes, shaken at 5 min interval and filtered with Whatman No. 1 filter paper. The pH
68 of the filtrate was measured using a pH meter (Model HM-305, Tokyo, Japan). The pH meter
69 was standardized using standard buffer of pH 4.0 and 7.0.

70 **Total Titratable Acidity**

71 A 10 ml of the filtrate was measured into a beaker and 2 drops of phenolphthalein was added
72 into it. This was titrated with 0.1 M sodium hydroxide (NaOH) solution and the titre value
73 was read. Total titratable acidity was expressed as percent (%) lactic acid.

74 **Mineral Analysis**

75 The mineral analysis was determined by the method described by AOAC (2012). The
76 samples were ashed at 550°C. Sodium (Na) and potassium (K) were determined using the
77 standard flame emission photometer. Phosphorus was determined calorimetrically while
78 calcium (Ca), magnesium (Mg), and iron (Fe) were determined using an atomic absorption
79 spectrophotometer; all values were expressed in mg/100 g.

80 **Determination of Anti-nutritional Factors**

81 The anti-nutrients saponin, calcium oxalate, trypsin inhibitors, tannins, and phytate levels in
 82 the fermented and unfermented samples were determined using the method of A.O.A.C
 83 (2012).

84 RESULTS

85 The changes in pH of each sample during fermentation decreased with the days of
 86 fermentation. 100% banana flour had the highest pH value of 6.66 at 0hour while 50%
 87 banana: 50%groundnut flour formulation had the lowest pH value of 4.08 at 72 hours. This is
 88 illustrated in table 1.

89 Table 2 shows the change in temperature of each sample during fermentation which
 90 decreased with the days of fermentation. 60% banana: 40%groundnut flour formulation had
 91 the highest temperature value of 31.2⁰C at 0hour while 100%groundnut flour formulation had
 92 the lowest temperature value of 22.4⁰C at 72hours.

93 Table 3 shows the result of total titrable acidity during fermentation which values increases as
 94 the pH decreases. 100% banana flour formulation had the highest titrable value of 6.53 at
 95 72hours while 100% groundnut flour formulation had the lowest titrable value of 4.13 at
 96 0hour.

97 **Table 1: Changes in pH During Fermentation of Banana-Groundnut Blends**

SAMPLE	Fermentation Period			
	0 HOUR	24 HOURS	48 HOURS	72 HOURS
A	4.57±0.02	4.44±0.05	4.21±0.10	4.08±0.01
B	6.01±0.05	5.91±0.02	5.64± 0.11	5.43±0.01
C	5.78±0.01	5.42±0.01	5.21±0.02	5.02±0.06
D	6.66±0.00	6.15±0.00	5.51±0.05	5.28±0.00

98 A = Banana flour (50g) + Groundnut flour (50g) B = Banana flour (60g) + Groundnut flour (40g)
 99 C = Banana flour (0g) + Groundnut flour (100g) D = Banana flour (100g) + Groundnut flour (0g)

100

101 **Table2: Changes in Temperature During Fermentation of Banana-Groundnut Blends**

SAMPLE	Fermentation Period			
	0 HOUR (⁰ C)	24 HOURS (⁰ C)	48 HOURS (⁰ C)	72 HOURS (⁰ C)
A	30.3±0.00	27.1±0.01	26.4±0.00	25.2±0.01
B	31.2±0.01	25.3±0.00	24.9±0.01	22.8±0.00
C	27.4±0.00	24.4±0.02	23.0±0.10	22.4±0.00
D	30.8±0.00	29.6±0.02	28.3±0.15	27.6±0.00

102 A = Banana flour (50g) + Groundnut flour (50g) B = Banana flour (60g) + Groundnut flour (40g)
 103 C = Banana flour (0g) + Groundnut flour (100g) D = Banana flour (100g) + Groundnut flour (0g)

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105 **Table 3:Changes in Titrable AcidityDuring Fermentation of Banana-Groundnut Blends**

SAMPLE	FERMENTATION PERIOD			
	0HOURS	24HOURS	48HOURS	72HOURS
A	5.20±0.05	5.22±0.01	5.31±0.00	5.46±0.10
B	5.72±0.01	5.78±0.05	6.01±0.02	6.27±0.05
C	4.13±0.03	5.80±0.02	5.91±0.01	6.43±0.03
D	5.83±0.03	6.20±0.02	6.31±0.00	6.53±0.05

106 **Keys:**

107 **A = Banana flour (50g) + Groundnut flour (50g)** **B = Banana flour (60g) + Groundnut flour (40g)**
 108 **C = Banana flour (0g) + Groundnut flour (100g)** **D = Banana flour (100g) + Groundnut flour (0g)**

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 110

TABLE 4: Microbial Count During Fermentation of Ripe Banana-Groundnut Blend

Sample	Bacteria (cfu/ml) ($\times 10^4$)				Lactic Acid Bacteria (cfu/ml) ($\times 10^4$)				Fungi (sfu/ml) ($\times 10^4$)			
	0hr	24hr	48hr	72hr	0hr	24hr	48hr	72hr	0hr	24hr	48hr	72hr
A	8.0	1.0	6.0	2.4	4.0	0.4	4.0	1.6	8.0	1.0	0.9	1.2
B	5.0	1.7	1.3	1.9	6.0	0.6	4.0	0.5	9.0	4.0	1.0	0.6
C	7.0	1.0	1.2	2.2	4.0	0.7	1.0	1.8	9.0	4.0	1.0	0.3
D	9.0	1.0	0.8	2.2	8.0	0.5	0.9	0.8	10.0	3.0	1.2	1.0

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Keys:

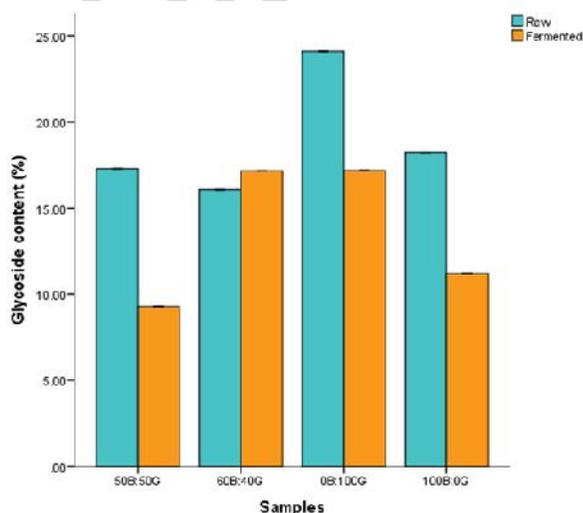
A = Banana flour (50g) + Groundnut flour (50g) **B = Banana flour (60g) + Groundnut flour (40g)**
C = Banana flour (0g) + Groundnut flour (100g) **D = Banana flour (100g) + Groundnut flour (0g)**

115 Figure 1-5 shows the antinutrient composition of raw and fermented ripe Banana-
 116 Groundnut blend. Glycosides, Flavonoid and Tannin values decreased after fermentation
 117 while Phytic acid and Alkaloid increased after fermentation.

118 Glycosides recorded the highest value in 100% formulation of unfermented groundnut
 119 (C) (24.09 ± 0.03) and the lowest in fermented 50% Banana: 50% Groundnut (A) formulation
 120 (9.28 ± 0.01). Phytic acid recorded highest value in fermented 60% Banana: 40% Groundnut
 121 (B) formulation (27.93 ± 0.01) and the lowest in unfermented 60% Banana: 40% Groundnut
 122 formulation (12.54 ± 0.01).

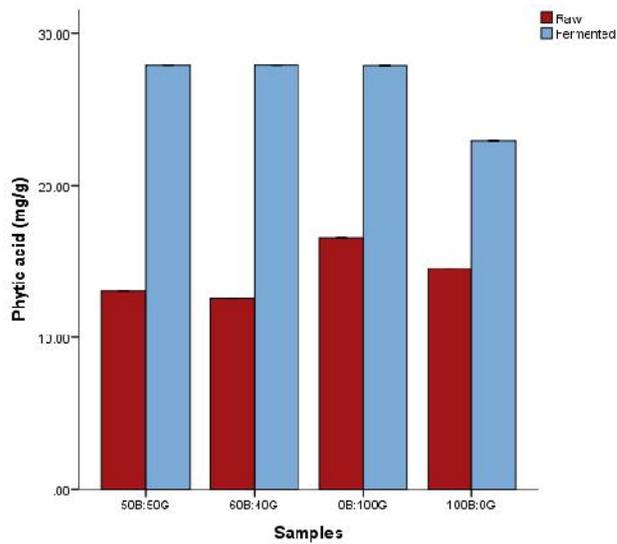
123 Flavonoid recorded the highest value in 100% formulation of unfermented groundnut
 124 (21.29 ± 0.01) and the lowest value in fermented 50% Banana: 50% Groundnut formulation
 125 (4.23 ± 0.01). Tannin recorded the highest value in unfermented 100% Groundnut formulation
 126 (4.68 ± 0.01) and the lowest value in fermented 60% Banana: 40% groundnut formulation
 127 (0.05 ± 0.00) while Alkaloid recorded the highest value in unfermented 60% Banana: 40%
 128 Groundnut formulation (34.18 ± 0.01) and the lowest value in unfermented 100% formulated
 129 Groundnut concentration (3.19 ± 0.01).

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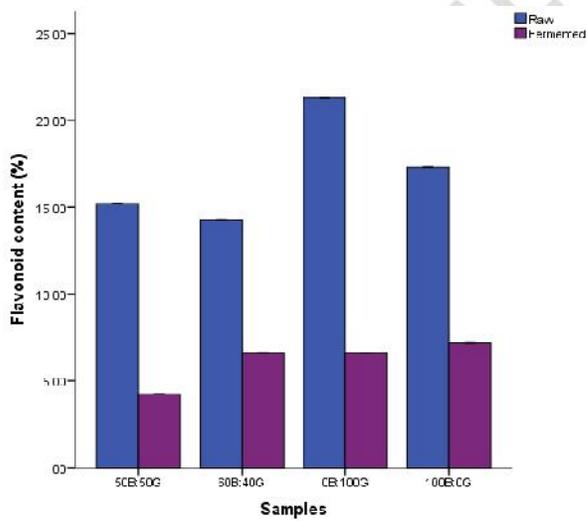
132 **Figure 1: Percentage Glycoside Content of Fermented and Unfermented Ripe Banana-**
133 **Groundnut blend**



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135 **Figure 2: Phytic acid (mg/g) Content of Fermented and Unfermented Ripe Banana-**
136 **Groundnut blend**

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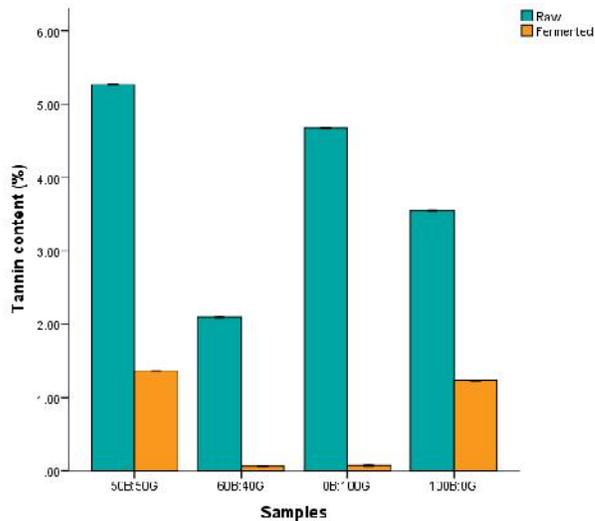
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139 **Figure 3: Percentage Flavonoid Content of Fermented and Unfermented Ripe Banana-**
140 **Groundnut blend**

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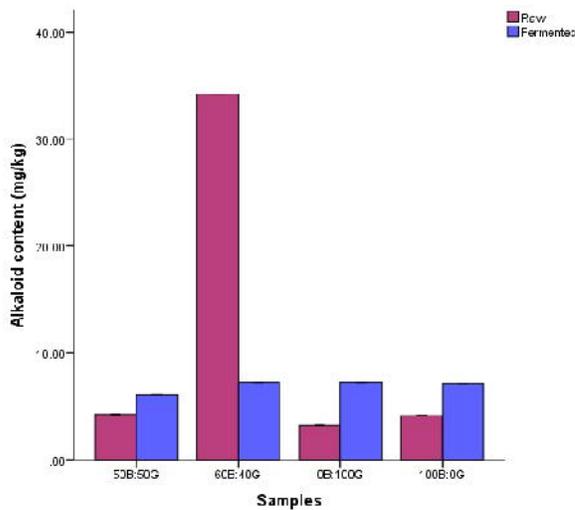
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145 **Figure 4: Percentage Tannin Content of Fermented and Unfermented Ripe Banana-**
 146 **Groundnut blend**

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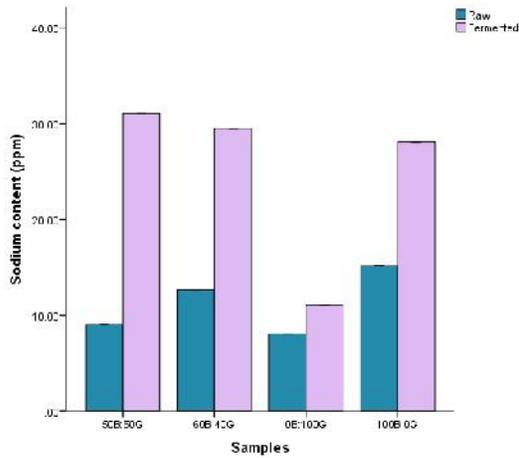
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149 **Figure 5: Alkaloid (mg/g) Content of Fermented and Unfermented Ripe Banana-**
 150 **Groundnut blend**

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152 The mineral composition of ripe Banana-Groundnut blends increased after fermentation
 153 process. Sodium recorded the highest value of 31.03 ± 0.01 in fermented 50%Banana: 50%
 154 Groundnut formulation and the lowest value of 8.06 ± 0.02 in unfermented 100% groundnut
 155 formulation while Potassium recorded the highest value of 22.64 ± 0.01 in fermented 50%
 156 Banana: 50% Groundnut formulation. Calcium recorded the highest value of 31.08 ± 0.01 in
 157 unfermented 100% banana formulation and the lowest value of 7.31 ± 0.02 in unfermented
 158 60% Banana: 40% Groundnut formulation while Magnesium recorded the highest value of
 159 43.22 ± 0.01 in fermented 50% Banana: 50% Groundnut formulation and the lowest value of

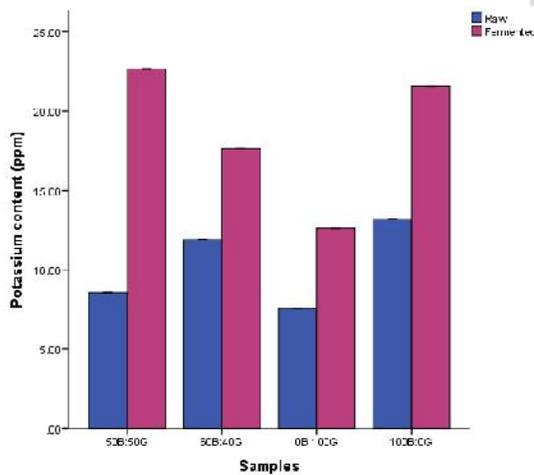
160 19.69±0.02 in unfermented 50% Banana : 50% Groundnut formulation. Iron recorded the
 161 highest value of 45.05±0.01 in fermented 50% banana; 50% Groundnut formulation and the
 162 lowest value of 21.14±0.02 in unfermented 50% Banana: 50% Groundnut formulation.



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164 **Figure 6: Sodium (ppm) Content of Raw and Fermented Ripe Banana-Groundnut**
 165 **blend**

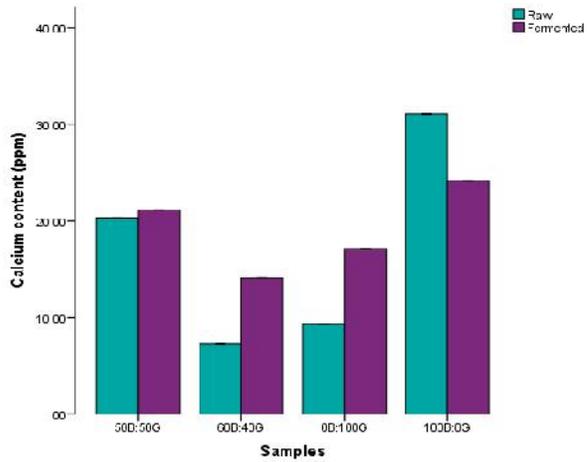
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168 **Figure 7: Potassium (ppm) Content of Raw and Fermented Ripe Banana-Groundnut**
 169 **blend**

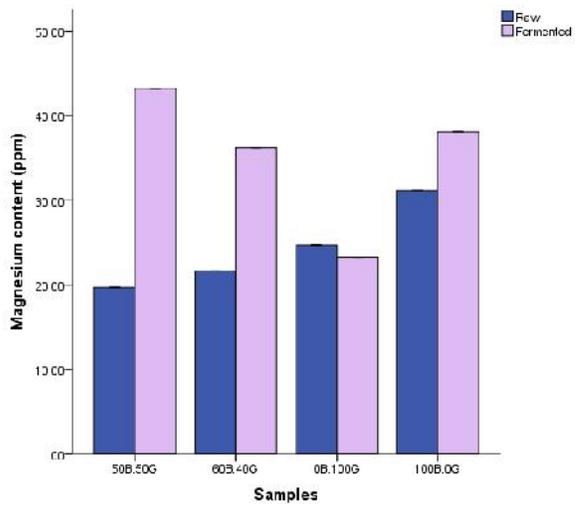
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172 **Figure 8: Calcium (ppm) Content of Fermented and Unfermented Ripe Banana-**
 173 **Groundnut blend**

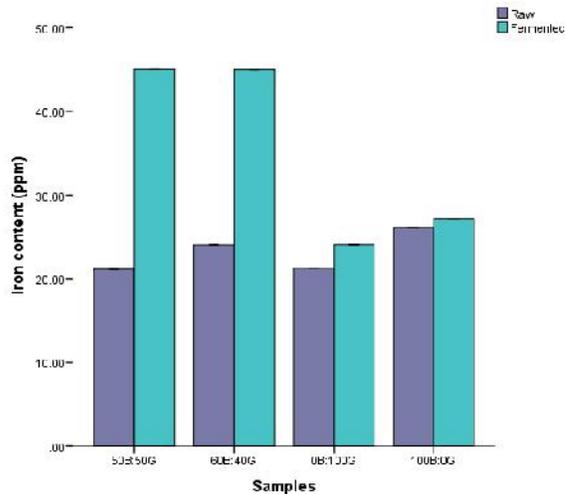
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176 **Figure 9: Magnesium (ppm) Content of Fermented and Unfermented Ripe Banana-**
 177 **Groundnut blend**

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180 **Figure 10: Iron (ppm) Content of Fermented and Unfermented Ripe Banana-**
 181 **Groundnut blend**

182 **Key:**

183 **50B:50G** = 50%Banana flour: 50% Groundnut flour

184 **60B:40G** = 60%Banana flour: 40% Groundnut flour

185 **0B:100G** = 0%Banana flour: 100% Groundnut flour

186 **100B:0G** = 100%Banana flour: 0% Groundnut flour

187

188 **DISCUSSION**

189 Decrease in pH and increase in total titratable acidity (TTA) as fermentation progressed is in
 190 agreement with the findings of Mbateet *al.*, (2007) and Ojokoh and Fagbemi (2016). Increase
 191 in titratable acidity could be due to the presence of lactic acid bacteria in the environment
 192 which degrade carbohydrates resulting in acidification (Noutet *al.*, 1989). The fermenting
 193 samples had high initial microbial load which later decreased as fermentation progressed.
 194 This is contrary to the report of various researcher who reported initial increase of microbial
 195 load followed by a decrease in the microbial load.

196

197 There was reduction in the antinutrient composition of the samples after fermentation.
 198 Glycoside content of sample A decreased significantly after fermentation. Sample B showed
 199 no significant difference after fermentation. It was observed that unfermented sample C had
 200 the highest glycoside content which was greatly reduced after fermentation. There was also
 201 significant decrease in sample D after fermentation. From the results, it was observed that
 202 fermentation had no positive impact on the phytic acid content of the blends. The flavonoid
 203 content of all the samples was greatly decreased after fermentation. There was significant
 204 decrease in the tannin content of the fermented blends when compared with the unfermented
 205 blends. However, samples B and C recorded the least tannin content after fermentation.
 206 Alkaloid only decreased significantly in sample B after fermentation, other samples recorded
 207 no significant difference after fermentation. Decrease in the antinutrient contents of the
 208 samples may be due to the ability of the fermenting organisms to break down these
 209 antinutrients. Fetuga (2013) reported that different processing methods such as cooking,
 210 autoclaving and soaking have an influence in reducing the antinutritional factors of foods.

211

212 The sodium and potassium contents of all the samples increased significantly after
213 fermentation. There was increase in the calcium content of samples A, B, and C after
214 fermentation. However, sample D recorded a lower calcium content. Magnesium content
215 increased after the fermentation of samples A, B and D, while there was no significant
216 difference in sample C. there was significant increase in the iron content of samples A and B
217 after fermentation, while slight increase was recorded for samples C and D. Increase in the
218 mineral composition of the samples may be due to the reduction in the antinutrients. It has
219 been reported that antinutrients tie up minerals in food thereby making them unavailable in
220 the food. Hence, the reduction of these antinutrients could be responsible for increase in the
221 mineral composition. Potassium was the most abundant mineral present in the sample
222 formulation. This result was consistent with the findings of Lewuet *al.*, (2010); Osagie (1998)
223 and Onyeka (2008).

224 **CONCLUSION**

225 Considering the mineral and antinutrient properties of the food blends (raw blends and
226 fermented blends), fermentation had considerable impact on the nutritional composition of
227 the banana and groundnut flour blends. Furthermore, fermentation could be explored more by
228 food processing industries to improve the overall acceptability of food blends.
229

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