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Evaluation of Organoleptic, pH and Pasting Properties of Blends from Unripe Plantain, Soybean and Ginger

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Authors' contributions

This work was carried out in collaboration among all authors. Author II designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AJ and MS managed the analyses of the study. Author II managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To evaluate the organoleptic, pH and pasting properties of unripe plantain (*Musa paradisiaca*), soybeans (*Glycine max*) and ginger (*Zingerber officianale*) as edible sources of food which can be processed into flour for several purposes.

Methodology: The plant materials (unripe plantain, soybean and ginger) used in this study were processed separately into flours. The flours were then formulated into different proportions i.e. composite flour blends; A (100%), B(80:14:6)%, C(70:26:4)%, D (60:38:2)% and E(50:50)% and analyzed for pasting properties, pH and sensory properties using standard procedures for 12weeks. Data generated were subjected to one-way analysis of Variance (ANOVA) in randomized block to test significant variations (P<0.05) among mean values obtained.

Results: The results showed that the peak viscosity of the blends which is the ability of starch to swell freely before their physical breakdown ranged from 651 RVU to 2766 RVU. The highest value (2766 RVU) was recorded in blend A, follow by B (1916 RVU), C (1383 RVU), D (972 RVU) while the lowest value (651 RVU) was recorded in E. The highest trough value (2462 RVU) was recorded

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in blend A and followed by B (1687 RVU), C (1224 RVU), D (875 RVU) and the lowest was E (550 RVU). This implies that the higher the quantity of soybean substituted, the lesser the trough. Trough which measures the ability of paste to withstand breakdown during cooling was significantly different (P<0.05) in the blends. There were significant differences (P<0.05) in the aroma of the various blends at week 0. Blend B with 6% ginger inclusion had the highest score (8.83) at 0 week, followed by blend C (8.50) with 4% ginger. Blends A and E without ginger inclusion had the lowest scores (6.25 and 6.75 respectively) at 12 weeks. The highest pH blend E (6.98) was observed at 12 weeks storage. The pH of the various blends remained acidic throughout storage of 12 weeks, an indication of shelf stability of products.

Conclusion: It was evident that supplementing unripe plantain flour adequately improved the pasting properties, pH and organoleptic properties which is a useful application in pastries like cakes and other snacks

Keywords: Pasting; organoleptic; plantain; soybean; ginger.

1. INTRODUCTION

The need for strategic development and use of inexpensive local resources in the production of popular foods has been promoted by organizations such as Food and Agriculture Organization, International Institute for Tropical Agriculture, Nigerian and Federal Institute for Industrial Research, Nigeria. This led to the initiation of composite flour program. The objective was to seek ways of substituting flours, starches and protein concentrates from indigenous crops, such as wheat used in baked products [1]. Alternative source of food production was advocated by Oke and Adeyemi [2] in tackling food crises. The prospect of blending tubers, roots and plantain with cereals and legumes for the production of household food products is receiving considerable attention [3]. This makes the products to be nutritious, relatively cheap and affordable to the rural dwellers reducing hunger and malnutrition [3].

Formulation of foods from low-lysine staples fortified with legumes has been proposed as a practical and sustainable approach to improving the protein nutritional value of foods for young children in developing countries [4].

The first historical indication places the appearance of soybean as a food crop in North-eastern China around 1700-1100 B.C. By the 16th century, soybean was used in Buma, India, Indonesia, Japan, Korea, Malaysia, Philippines, Nepal, Thailand and Vietnam. The first record of soybean in Europe was in England in 1790 [5] Soybean is one of the most important oil and protein crops of the world, Soybean contains 30 to 45% protein with a good source of all indispensable amino acid, and the protein content of soybean is about 2 times of other pulses, 4 times of wheat, 6 times of rice grain, 4 times of egg and 12 times of milk. Soybean has 3% lecithin, which is helpful for brain development. It is also rich in calcium, phosphorus and vitamin A, B, C and D. It has been referred to as "the protein home of the future" [6]. Moreover, isoflavones contained in soybeans are effective cancer - preventive agents for lowering risks of various cancers. Evidences also point to the beneficial effects of soy isoflavones in the prevention of cardiovascular diseases [6]. Compositing with soy is expected to substantially improve the protein efficiency ratio (PER), *in-vitro* protein digestibility (IVPD), lysine and isoflavone content [1].

Plantain is the common name for herbaceous plants of the genus Musa Plantain (*Musa paradisiaca*), plantain is grown in 52 countries with world production of 33 million metric tonnes. In the agricultural sector, plantain is ranked fourth in Ghana. Total annual national production is 2 million tonnes with per capita consumption of 101.8kg [7]. It is an important staple food in Central and West Africa. It is a basic food crop and cheap source of energy in Nigeria [3]. An average plantain has about 220 calories and is a good source of potassium and dietary fiber. The nutritious food is ideal for diabetics, children and pregnant women. It can also be good supplement for marasmus patients. Plantain contains small amount of serotonin which has the ability to dilate the arteries and improve blood circulation. Its regular consumption helps to cure anemia (low blood level) and maintain a healthy heart. A diet of unripe plantain can also be a good inclusion in a weight loss diet plan [3].

Ginger (*Zingiber officinale*) is a root or underground stem (rhizome) know to contain gingerols (oleoresins) with several health benefits. It reduces the risk of colon cancer, obesity, diabetes, cardiovascular diseases, cold related – diseases and arthritis. Considering the health benefits of soy, unripe plantain and ginger powder, their incorporation as blend in the preparation of cookies may enhance nutritional and health status of consumers. Several studies have reported the use of wheat based composite flour [8,9].

The possibility of producing bakery/pastry products from wheat/plantain composite flour has been assessed. With the progressive increase in the consumption of bakery/pastry products in Nigeria, the composite flour program if adopted has the potential to add values to indigenous crops like plantain and at the same time conserve foreign exchange spent on wheat importation. The objective of this study was to improve the sensory attributes, usage and shelf stability of unripe plantain, soybean and ginger as blends.

2. MATERIALS AND METHODS

2.1 Materials

Unripe plantain and ginger roots were bought from Jattu market in Auchi, Edo State Nigeria; defatted soy bean flour (Variety TGX 1448-2E) was purchased from Benin City in Edo State Nigeria. Every other chemical used were bought from Promise laboratory in Ekpoma, Edo State Nigeria. This study was conducted in Auchi polytechnic Auchi, Edo State, Nigeria.

2.1.1 Processing of plantain flour

Fresh matured unripe plantain was peeled, sliced using slicer and dried in an oven (Galenkamp) at 60^{o}C for 48hours to remove moisture. Dried sample was ground into powder (plantain flour).

2.1.2 Processing of soybeans to defatted flour

Soybean seeds were cleaned and sorted manually to remove dirt, leaves and stones. The clean soybean seeds were coarsely milled to separate the coat from the cotyledon. The dehulled seeds were milled to fine soybean flour using an attrition mill. The fine soybean flour was then defatted using cold extraction with n-hexane. The defatted flour was then air-dried (Galenkamp) and the clumps broken into fine flour, then sieved through a mesh screen.

2.1.3 Processing of ginger powder

Fresh ginger roots were sorted and washed to remove soil and other foreign materials then sliced to thin layers and dried in an oven (Galenkamp) at 60˚C for 24 hours to remove moisture before milling to powder.

2.1.4 Formulation of unripe plantain, soybeans and ginger flour blends

Five samples were prepared from the combinations of unripe plantain, defatted soybean and ginger as blends mixed in different proportions using Nutri-survey linear programming software version 2007 to obtain the formulations;

A = 100% unripe plantain
B = 80% unripe plantain, 14% soybean, 6% ginger
C = 70% unripe plantain, 26% soybean, 4%ginger
D = 60% unripe plantain, 38% soybean, 2% ginger
E = 50% unripe plantain, 50% soybean

2.1.5 Determination of the pasting properties

The pasting properties of the flour samples were determined using Rapid Visco Analyzer (RVA) as described by [10]. The pasting properties of flours namely peak viscosity, break down viscosity, final viscosity, trough viscosity setback viscosity, peak time and pasting temperature were analyzed.

2.1.6 Sensory Evaluation

The organoleptic properties of flour blends were evaluated by 10 trained panelists (five males and 5 females) within the age range of 20-45years, consisting of staff and students of the Department of Food Technology, Auchi Polytechnic Auchi, Edo State, Nigeria. Samples were coded for colour, flavor, texture, taste and general acceptability using Nine-Point Hedonic Scale (1=dislike extremely, 2= dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6= like slightly, 7=like moderately, 8=like very much and 9=like extremely)

2.1.7 pH Assessment

The method of [11] modified by Liang and King [12] was used. A 10% weight per volume suspension of the samples was prepared in distilled water and was mixed thoroughly in a blender (Lapriva model) and then the pH (pHep pocket-sized pH meter) of the sample was measured by inserting the electrodes into the suspension.

2.2 Design and Data Analysis

Data generated were subjected to one-way analysis of Variance (ANOVA) in randomized block to test significant variations (P<0.05) among mean values obtained. The values used for each treatment were in triplicate. Where significant differences existed Duncan's multiple range test was applied to indicate where the differences occurred using Genstat statistical package 2005, 8th edition (Genstat Procedure Library Release PL16). Where blend A=100% unripe plantain; B=80% unripe plantain, 14% soybean, 6% ginger; C=70% unripe plantain, 26% soybean, 4% ginger; D=60% unripe plantain, 38% soybean, 2% ginger and blend E=50% unripe plantain, 50% soybean.

3. RESULTS AND DISCUSSION

3.1 Pasting Properties of Flour Blends

The pasting properties of flour blends namely peak viscosity, break down viscosity, final viscosity, trough viscosity, set back, peak time and pasting temperature were analyzed and the results are shown in Figs. 1-5 below. There were significant differences (P<0.05) in the pasting properties of the various blends.

The peak viscosity of the blends which is the ability of starch to swell freely before their physical breakdown [13] ranged from 651 RVU to 2766 RVU and were significantly (P<0.05) different. The highest value (2766 RVU) was recorded in blend A, follow by B (1916 RVU), C (1383 RVU), D (972 RVU) while the lowest value (651 RVU) was recorded in E. It was observed that the higher the quantity of soybean substituted in the blends the lower the peak viscosity. This is an indication of the strength of pastes, formed from gelatinization during processing in food applications. It reflects the extent of granule swelling [14]. It also provides an evidence of the viscous load likely to be encountered during mixing.

The highest trough value (2462 RVU) was recorded in blend A and followed by B (1687 RVU), C (1224 RVU), D (875 RVU) and lowest was E (550 RVU). This implies that the higher the quantity of soybean substituted, the lesser the trough. Trough which measures the ability of paste to withstand breakdown during cooling was significantly different (P<0.05) in the blends.

The breakdown viscosity which is an index of the stability of the paste during processing was significantly (P<0.05) different and the highest value (304 RVU) was recorded in blend A, follow by B (229 RVU), C (159 RVU), E (101 RVU) while the least was recorded in blend D (97 RVU). The higher the breakdown in viscosity the lower the ability of the starch in the flour samples to withstand heating and shear stress [15]. It was reported by [16] that high breakdown value indicates relative weakness of the swollen starch granules against hot shearing while low breakdown values indicate the starch in question possesses cross-linking properties.

Final viscosity (FV) is important in determining ability of the flour sample to form a gel during processing. There was significant difference (P<0.05) in the FV of the blends. The highest FV value (3668 RVU) was observed in blend A, followed by B (2295 RVU), C (1607 RVU), D (1146 RVU) and E (770 RVU) in that decreasing order. This depicts that FV increased with increasing amount of unripe plantain inclusion in the blend.

There was significance difference (P<0.05) in the setback viscosity of the blends. Setback viscosity indicates gel stability and potential for retro gradation [15]. The highest setback viscosity value (1206 RVU), this was followed by B (608 RVU), C (383 RVU) D (271 RVU) and the least was observed in blend E (220 RVU). Chinma et al. [16] reported that high setback value is an indicative of the propensity of the starch molecules to disperse in hot paste and re-associate readily during cooling. The lower the setback viscosity during the cooling of the paste indicates greater resistance to retro degradation.

The peak time (PT) which is a measure of the cooking time was significantly different (P<0.05) among the blends. Blends C, D and E had same PT value (7 minutes) and were not significantly different (P>0.05). While, blend A had B had 6.13 minutes and 6.53 minutes respectively.

The pasting temperature is the measure of the minimum temperature required for cooking a given food sample [17]. The attainment of the pasting temperature is essential in ensuring sweeting, gelatinization and subsequent gel formation during processing. The pasting temperature (PTT) is the temperature at which the viscosity starts to rise [14]. In this study the pasting temperature of the blends was significantly different (P<0.05). The highest temperature was observed in blend E (94.50˚C), followed by D (86.95˚C), C (85.15˚C), B (84.40 ^{o}C) and A (84.15˚C) in that decreasing order. This depict that PTT decreased with increasing unripe plantain inclusion.

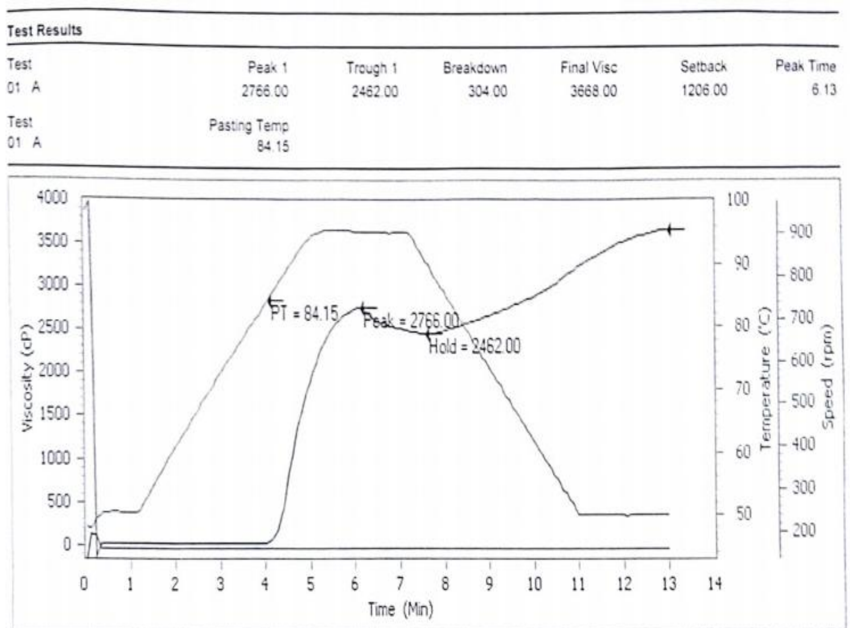

Fig. 1. Pasting properties of blend A (100% unripe plantain)
BD = Breakdown, PT = Pasting time, PV = Peak viscosity, PTT = Pasting temperature, FV = Final viscosity, RVU = Visco analyzer units

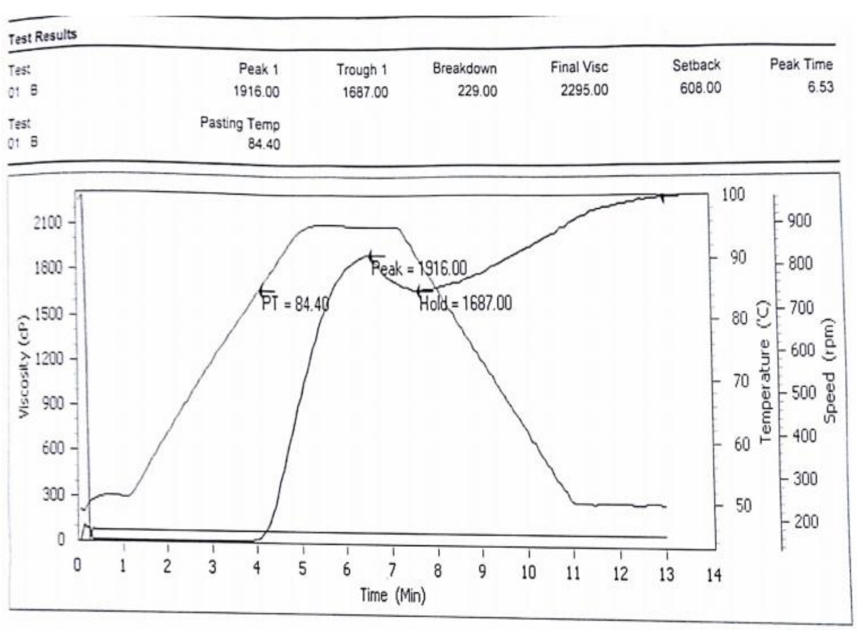

Fig. 2. Pasting properties of Blend B (80% unripe plantain, 34%Soybean and 6% Ginger)
BD = Breakdown, PT = Pasting time, PV = Peak viscosity, PTT = Pasting temperature, FV = Final viscosity, RVU = Visco analyzer units

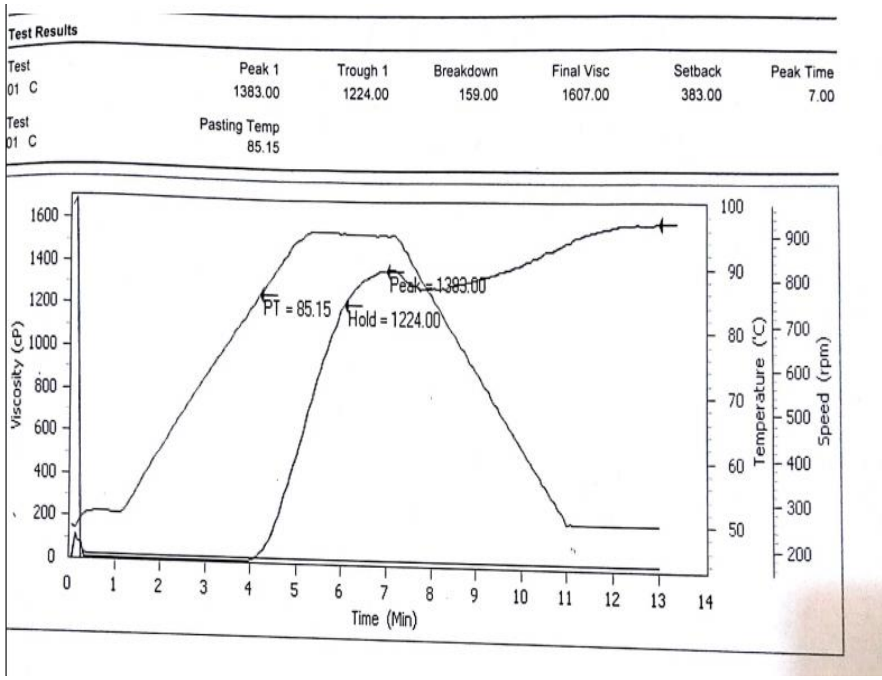

Fig. 3. Pasting properties of blend C (70% unripe plantain, 36% Soybean and 4% Ginger)
BD = Breakdown, PT = Pasting time, PV = Peak viscosity, PTT = Pasting temperature, FV = Final viscosity, RVU = Visco analyzer units

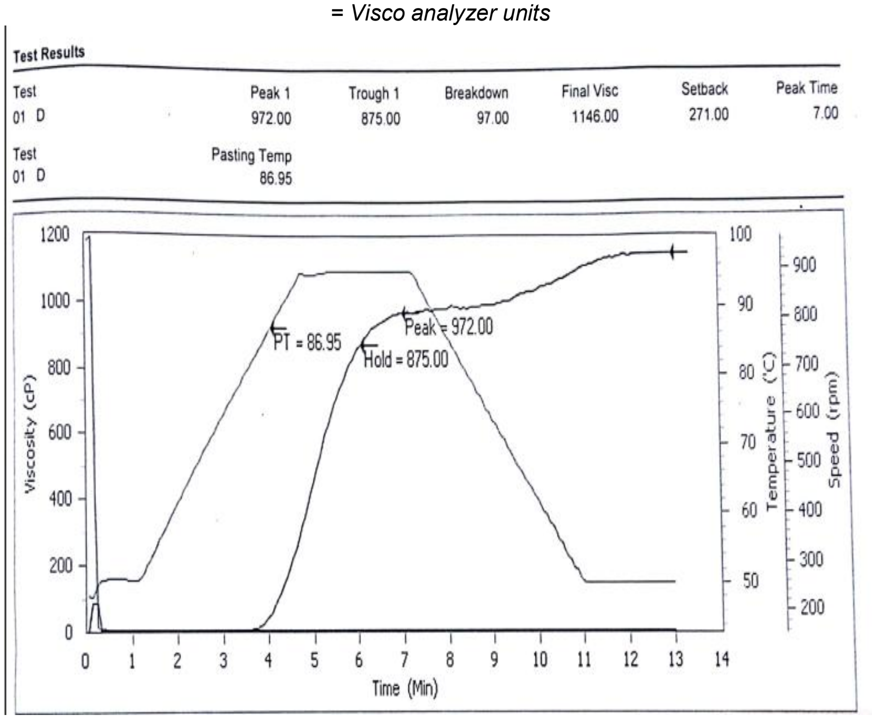

Fig. 4. Pasting properties of blend D (60% unripe plantain, 38% Soybean and 2% Ginger)
BD = Breakdown, PT = Pasting time, PV = Peak viscosity, PTT = Pasting temperature, FV = Final viscosity, RVU = Visco analyzer units

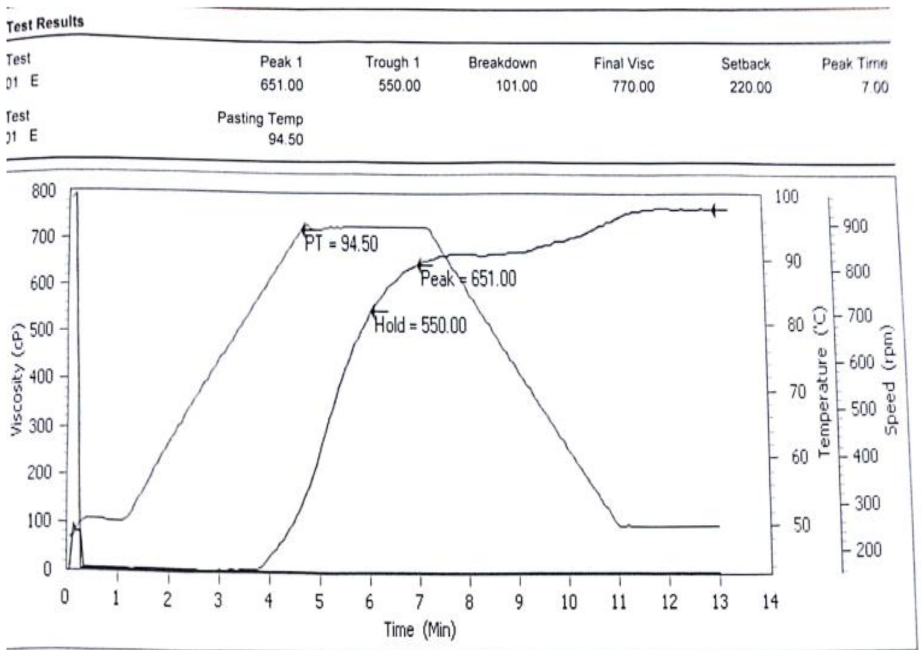

Fig. 5. Pasting properties of Blend E (50% unripe plantain: 50% soybean)

BD = Breakdown, PT = Pasting time, PV = Peak viscosity, PTT = Pasting temperature, FV = Final viscosity, RVU = Visco analyzer units

3.2 Organoleptic Assessment of Blends

3.2.1 Colour

There was significant difference (P<0.05) among the blends for all the attributes of sensory evaluation which are colour, taste, texture, aroma and acceptance. From the results (Table 1) it was observed that there was no significant difference (P>0.05) in the colour of the various blends throughout the storage period. However, blends A and E without ginger had higher score (7.83) at 12 weeks than the other blends. Colour is one of the most important attributes by which consumers judge the quality of food products and deterioration is one of the main factors that limit storage life [18].

3.2.2 Taste

The results on taste of the various blends (Table 2) showed that from 0 - 4 weeks there was no significant difference (P>0.05) among blends A, B and E. There was also no significant difference (P>0.05) between blends C and D throughout the storage period. According to Iwanegbe and Igene [18] taste and colour is a perfect combination for judging the standard of food product quality.

3.2.3 Texture

Table 3 showed the results for texture of the blends throughout storage period. There was no significant difference (P>0.05) in the texture of all the blends at 0 week. There was also no significant difference (P>0.05) between blends A and B from week 0 - 8. However, significant differences occurred among blends C, D, and E throughout storage. The texture quality of all the blends decreased at week 12. Blends A with 0% ginger had the lowest score (7.17) at 12^{th} week and was followed by blend E (7.50) also with 0% ginger. This may be an indication that ginger enhances texture quality of food.

3.2.4 Aroma

Aroma has important impact on food processing as it influences the judgment of consumer even before the food is eaten [18]. The analysis of variance showed that there was significant differences (P<0.05) in the aroma of the blends based on formulation and storage period. The results for aroma of all the blends are shown in Table 4. There were significant differences (P<0.05) in the aroma of the various blends at week 0. Blend B with 6% ginger inclusion had the highest score (8.83) at 0 week, followed by blend

C (8.50) with 4% ginger. Blends A and E without ginger inclusion had the lowest scores (6.25 and 6.75 respectively) at 12 weeks. This is an indication that ginger enhances aroma of food.

3.2.5 Acceptance

There were significant differences among the blends throughout storage period (Table 5) in terms of acceptability. Blend D (60% unripe plantain: 38% soybean: 2% ginger) was most preferred, and was followed by blend C (70% unripe plantain: 26% soybean: 4% ginger). The results depict that the interactive inclusion of unripe plantain, soybean and ginger could positively influence the level of acceptance of the blends.

Table 1. Sensory evaluation (colour) of unripe plantain, defatted soybean and ginger flour blends

	Storage period (weeks)				
Blend	**0**	**4**	**8**	**12**	**SEM**
A	7.42^{c}	7.75^{abc}	7.75^{abc}	7.83^{abc}	
B	8.08^{a}	7.58^{abc}	7.92^{abc}	7.58^{abc}	
C	7.83^{abc}	8.08^{a}	8.0^{ab}	7.75^{abc}	0.15
D	7.58^{abc}	7.67^{abc}	7.75^{abc}	7.42^{c}	
E	8.00^{ab}	7.58^{abc}	7.50^{bc}	7.83^{abc}	

Means with the same superscript are not significantly different (P>0.05)

Table 2. Sensory evaluation (taste) of unripe plantain, defatted soybean and ginger flour blends

	Storage period (Weeks)				
Blends	**0**	**4**	**8**	**12**	**SEM**
A	6.67^{c}	6.25^{cde}	7.50^{b}	6.58^{cd}	
B	6.42^{cd}	6.17^{de}	6.58^{cd}	6.17^{de}	
C	8.25^{a}	8.58^{a}	7.67^{b}	8.33^{a}	0.15
D	8.17^{a}	8.17^{a}	8.33^{a}	8.33^{a}	
E	6.42^{cd}	6.33^{cde}	7.42^{b}	5.92^{e}	

Means with the same superscript are not significantly different (P>0.05)

Table 3. Sensory evaluation (texture) of unripe plantain, defatted soybean and ginger flour blends

	Storage period (Weeks)				
Blends	**0**	**4**	**8**	**12**	**SEM**
A	8.00^{cd}	8.00^{cd}	8.00^{cd}	7.17^{g}	
B	8.00^{cd}	8.08^{bc}	7.83^{cde}	7.75^{def}	
C	8.00^{cd}	8.83^{a}	8.33^{b}	7.58^{ef}	0.15
D	8.00^{cd}	9.00^{a}	8.33^{b}	7.83^{cde}	
E	8.00^{cd}	8.83^{a}	7.83^{cde}	7.50^{f}	

Means with the same superscript are not significantly different (P>0.05)

Table 4. Sensory evaluation (Aroma) of unripe plantain, defatted soybean and ginger flour blends

	Storage period (Weeks)				
Blends	**0**	**4**	**8**	**12**	**SEM**
A	6.67^{fg}	6.67^{fg}	6.50^{fgh}	6.25^{gh}	
B	8.83^{a}	8.50^{ab}	8.25^{bc}	8.25^{bc}	
C	8.08^{bcd}	8.50^{ab}	7.83^{cde}	7.83^{cde}	0.15
D	6.17^{h}	7.75^{de}	7.58^{e}	7.58^{e}	
E	5.67^{i}	6.42^{fgh}	6.75^{f}	6.75^{f}	

Means with the same superscript are not significantly different (P>0.05)

Table 5. Sensory evaluation (Acceptance) of unripe plantain, defatted soybean and ginger flour blends

	Storage period (Weeks)				
Blends	**0**	**4**	**8**	**12**	**SEM**
A	6.67^{def}	6.75^{def}	6.83^{de}	6.83^{de}	
B	6.17^{g}	6.17^{g}	6.42^{efg}	6.42^{efg}	
C	8.50^{ab}	7.83^{c}	7.42^{c}	7.75^{c}	0.15
D	8.75^{a}	8.58^{ab}	8.33^{ab}	8.25^{b}	
E	7.00^{d}	6.42^{efg}	6.50^{efg}	6.33^{fg}	

Means with the same superscript are not significantly different (P>0.05)

Table 6. pH assessment of unripe plantain, soybean and ginger flour blends

	Storage period (Weeks)							
Blends	**0**	**2**	**4**	**6**	**8**	**10**	**12**	**SEM**
A	6.26^{k}	6.26^{k}	6.38^{jk}	6.70^{f}	6.81^{def}	6.81^{def}	6.81^{def}	
B	6.31^{jk}	6.37^{jk}	6.52^{h}	6.87^{cdef}	6.92^{abc}	6.92^{abc}	6.80^{f}	
C	6.34^{j}	6.38^{jk}	6.42^{ij}	6.80^{f}	6.83^{def}	6.83^{def}	6.88^{bcd}	0.03
D	6.37^{jk}	6.47^{hi}	6.62^{g}	6.90^{bcd}	6.94^{abc}	6.95^{ab}	6.96^{ab}	
E	6.37^{jk}	6.47^{hi}	6.62^{g}	6.90^{bcd}	6.95^{ab}	6.95^{ab}	6.98^{a}	

Means with the same superscript are not significantly different (P>0.05)

3.3 pH Assessment of Blends

The pH of the blends was within the range of 6.26-6.98 (Table 6). There was significant difference (P<0.05) in the pH value of the blends stored for total duration of 12 weeks (3 months). However, at 0 and 2 weeks, there was no significant difference (P>0.05) in the pH values of the blends except for blends D (6.47) and blend E (6.47). At 4 weeks the pH range was 6.38-6.62 with blend A having the least (6.38) and the highest were blends D (6.62) and E (6.62). The highest pH blend E (6.98) was observed at 12 weeks storage. The pH of the various blends remained acidic throughout storage of 3 months, an indication of shelf stability of products

4. CONCLUSION

The result obtained from this study has shown that the inclusion of 2 – 4% ginger flour to plantain and soybean flour improved the pasting properties, pH and organoleptic properties which are useful application in pastries like cakes and other snacks. The pH of the various blends remained acidic throughout storage of 3 months, an indication of shelf stability of products.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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