Quality Characterization of Biscuit Baked from Acha-Ripe Plantain.

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Abstract

Biscuits were produced form six (6) flour blends of acha and ripe plantain. The pasting properties, mineral and vitamin contents, functional properties were evaluated. Data were subjected to analysis of variance (ANOVA), mean values were separated using Duncan multiple range test (DMRT). The peak viscosity, trough viscosity, final viscosity, set back and temperature ranged from 8.54-64.45RVU, 7.47-25.39RVU, 12.89-40.36RVU, 5.30-5.77 min and 58.26-60.12^{o}C. The calcium, sodium, potassium, iron and magnesium ranged from 25.98-42.80mg, 21.15-51.14mg, 273-292mg, 3.53-4.05mg and 72.27-72.30mg respectively. The vitamin A,B_6, B_{12} and C contents ranged from 0.01mg/g, 5.11mg/g, 8.61-10.34mg and 2.03-5.32mg/g respectively. The bulk density, WAC, OAC, emulsifying capacity, swelling capacity and glycemic index ranged from 0.70-077 MI/g, 90.8-110.67 MI/g, 84.13-101.00 MI/g, 43.30-45.91 MI/g, 0.62-1.32 MI/g and 61.93-68.17%.

Introduction

Biscuits are flour confections produced from dough and baked to very low moisture content within a short period of time to make them flaky and crispy. The consumption of biscuits and other western styled bakery products such as bread and cakes prepared from wheat flour has become very popular in Nigeria, especially, among children (Ayo and Nkama, 2003).

Biscuits are prominent ready-to- eat baked snack among the people, globally. The association of wheat consumption with such health problems as celiac disease makes it pertinent to utilize composite flour in biscuit manufacture (Kiin-Kabari and Giami, 2015). Composite flour is desirable in this regard because it improves the nutritional value of food products such as bakery products, especially when blended with legumes such as pigeon pea (Preedy *et al.*, 2011). In fact, biscuits have been suggested as better use for composite flour than bread due to their ready-to- eat form, wide consumption, relatively long shelf life, and good eating quality (Bala *et al.*, 2015; Noorfarahzihah *et al.*, 2014).

Acha (*Digitaria exilis*), commonly known as fonio or hungry rice is a cereal grain in the family *gramineae* (Alamu *et al.*, 2001; Ayo and Nkama, 2004). It is grown in some areas of Bauchi, Plateau and Kaduna states. It is considered as rich source of minerals, vitamins fiber, proteins, carbohydrate, amino acids it contains cysteine and methionine.

The production of food quality biscuit would depends on the selection of correct flour for each type and appropriate processes involving steps such as mixing, aeration, fermentation, machining including laminating, baking, cooking and packaging (Okaka and Okaka, 2005). Introduction of composite flour into bakery world has brought about different changes in baked product.

Baking technique is probably the earliest and oldest of all other techniques and is still going steady over food processing field. Bakery products have played a key role in the development of mankind, being a principal source of convenience, variety and a healthy nutrition component to modern lifestyles (Uptal *et al.*, 2015). Bakery biscuits are very popular, ready to eat, convenient, inexpensive and also an important product in human diet and are usually eaten with tea and are also used as weaning food for infants (Uptal *et al*, 2015). It is also used as a snack in school for the school going children who are often underweight. It may be used as a nutrient supplement during emergency situation (Baljeet et al., 2010). Not only long shelf-life of biscuits makes large scale production and distribution possible but also good eating quality makes biscuits more attractive for protein fortification and other nutritional improvements (Hooda and Jood, 2005).

Materials and Method

Source of Raw Materials

Acha (*Digitaria exilis*) and ripe plantain were purchased from the Sabon-Gari Market, Zaria Kaduna State. The other ingredients like margarine, sugar, baking powder and eggs were bought the same market. All chemicals used were of analytical grade.

Preparation of Samples

Preparation of Acha Flour

Acha flour was produced using the method of Ayo, (2001) Acha grains were winnowed to remove chaff and dust. Adhering dust and stones were removed by washing in water (sedimentation) using local calabashes. The washed and destoned grains were dried in a cabinet drier at 45°C to a moisture content of about 12%. The dried grains were milled using attrition milling machine and the flour sieved to pass through a 0.4mm mesh size. The acha flour was packaged in air tight containers for use.

Preparation of Ripe Plantain Flour. Ripe plantain was washed with cleaned water and peeled with stainless knife to separate skin from the fruit. The peeled fruit was sliced to equal size dried under the sun. After which it was milled and sieved. The flour was then packaged in a clean polythene bag and stored at a low temperature (Agu *et al*, 2014).

Formulation of Composite Flour

Composite flour of acha, and ripe plantain flour was prepared as shown in Table 1. One hundred percent acha was the control and designated as sample A. Sample B consisted of 90% acha and 10% ripe plantain. Sample C consisted of 80% acha and 20% ripe plantain. Sample D consisted 70% acha and 30% ripe plantain. Samples E and F consisted of 60% acha, 40% of ripe plantain and 50% acha, 50% ripe plantain respectively. The blends were thoroughly mixed using a Kenwood blender to achieve uniform blending.

Preparation of biscuit

The modified recipe of Onabanjo and Ighere (2014) adopted after preliminary experimentation was as follows: flour (250 g), fat (63 g),sugar (63 g), salt (1 g), whole egg (20 ml), powdered milk (5 g), nutmeg(1.5 g), baking powder (1 g), and water (20–60 ml).Biscuit was prepared using the traditional creaming method described by Chinma et al. (2011).The fat and sugar were mixed in a mixer until the mixture was fluffy. Eggs and milk were added, while mixing continued. Baking powder, ground nutmeg, composite flour, and salt were introduced into the mixture to form a soft dough. The dough was removed from the bowl and kneaded one flat surface to obtain a uniform mix. The kneaded dough was rolled out into sheets using a rolling pin and cut into the desired shape using a cutter. The cut mass was transferred to a greased baking tray. Baking was carried out at 180°C for 17 min. Biscuit made from 100% acha flour served as the control sample.

Pasting properties

Pasting characteristics were determined using a Rapid Visco Analyzer. About 2.5g of the sample was weighed into a previously dried canister and 25ml of distilled water was dispensed into the canister containing the sample. The suspension was thoroughly mixed, and the canister was fitted into the Rapid Visco Analyser as recommended. Each suspension was kept at 50^{o}C for 1min and then heated up to 95^{o}C with a holding time of 2min followed by cooling to 50^{o}C with 2min holding time. The rate of heating and cooling were at a constant rate of 11.85^{o}C per min. Peak viscosity, trough, breakdown, final viscosity, set back, are read from the pasting profile with the aid of thermocline for windows software connected to a computer.

Minerals and vitamin analyses

Total calcium (Ca^{2+}) and magnesium (Mg^{2+}) contents were determined by EDTA versanate complexometric titration method as described by Harbourne. Sodium (Na^{+}) and potassium (K^{+}) ion contents were determined by flame photometry as described by Onwuka (2005), phosphorus (P) and sulphur were determined using AOAC method. Duplicate solutions were prepared for each sample and a minimum of three separate readings were taken to minimize error. The mean values were used to calculate the concentrations. The vitamin B2 B3, Folacin, C and vitamin D were determined using the methods described by AOAC (2012) methods.

Functional properties

Water absorption capacity:

The method of Onwuka (2005) was adopted in the determination of water absorption capacity. One (1g) gram of sample was weighed into a conical graduated centrifuge tube and thoroughly mixed with 10ml distilled water for 30seconds using a warring whirl mixer. The sample was then allowed to stand for 30 minutes at room temperature and then centrifuged at 5,000rpm for 30 minutes. The volume of free water (supernatant) was read directly from the graduated centrifuge tube. Absorption capacity is expressed as grams of water absorbed (or retained) per gram sample.

Water absorption capacity = Amount of water absorbed (total-free) × density (water).

Oil absorption capacity:

The method of Onwuka (2005) was adopted in the determination of oil absorption capacity. One (1g) gram of sample was weighed into a conical graduated centrifuge tube and thoroughly mixed with 10ml of oil for 30seconds using a warring whirl mixer. The sample was then allowed to stand for 30minutes at room temperature and then centrifuged at 5,000rpm for 30minutes. The volume of free oil (supernatant) was read directly from the graduated centrifuge tube. Absorption capacity is expressed as grams of oil absorbed (or retained) per gram sample.

Oil absorption capacity = Amount of oil absorbed (total)-free × density (oil)

Emulsifying capacity: The method of Onwuka (2005), was adopted in the determination of emulsifying capacity. Two (2g) gram of the flour sample was blended with 25ml distilled water at room temperature for 30seconds in a warring blender at 1600rpm. 25ml of vegetable oil was gradually added after complete dispersion with continued blending for another 30seconds, and then transferred into a centrifuge tube at 1,600rpm for 5minutes. The volume of oil separated from the sample after centrifuging is read directly from the tube. Emulsion capacity is expressed as the amount of oil emulsified and held per gram of sample.

Bulk density:
The method of Onwuka (2005), was adopted in the determination of bulk density. Bulk densities of samples were determined by weighing 25ml capacity graduated measuring cylinder, gently filling the cylinder with the sample and tapping the bottom of the cylinder on the laboratory bench several times until there is no further diminution of the sample level after filling the 25ml mark. The final volume is expressed as g/ml.

2.6. Statistical Analysis
The means and standard deviation of duplicate samples for the nutritional, chemical and sensory properties of the cookies were calculated. The data obtained was then subjected to Analysis of variance (ANOVA) (Steele, 1980) where significance difference existed, Tukey's test was employed in separating the means as described by (Ihekoronye and Ngoddy, 1985).

Results.
Table 1: Pasting Properties of Biscuits Samples.

SAMPLE	PEAK VISCOSITY	TROUGH VISCOSITY	FINAL VISCOSITY	SET BACK	PEAK TIME	PASTING TEMPERATURE
A	8.54±0.03[a]	7.47±0.08 [a]	12.89±0.00[a]	5.77±0.04[b]	5.80±0.01[e]	58.26±0.19[a]
B	20.13±0.11[b]	10.04±0.19[b]	19.17±0.10[b]	5.43±0.21[a]	5.64±0.01[d]	58.24±0.02[a]
C	31.17±0.15[c]	14.12±0.10[c]	23.63±0.13[c]	5.60±0.00[b]	5.51±0.01[c]	58.45±0.02[ab]
D	43.00±0.27[d]	18.02±0.09[d]	29.31±0.06[d]	5.44±0.03[a]	5.46±0.05[c]	58.70±0.01[b]
E	54.11±0.11[e]	21.34±0.22[e]	34.98±0.07[e]	5.40±0.06[a]	5.21±0.01[b]	58.68±0.22[b]
F	64.43±0.34[f]	25.39±0.01[f]	40.36±0.04[f]	5.30±0.00[a]	5.09±0.01[a]	60.12±0.01[c]
P-VALUE	0.000*	0.000*	0.000*	0.000*	0.000*	0.002*

Mean ± SE, analysis of variance (ANOVA), Duncan Multiple Range Test (DMRT). A=100% Acha, B=90% acha+10% ripe plantain, C=80% acha+20% ripe plantain, D= 70% acha+30% ripe plantain, E=60% acha+40% ripe plantain, F= 50% acha +50% ripe Plantain.

The pasting properties of the biscuit samples are presented in Table 1. The peak viscosity value ranged from 8.54- 64.43RVU. The highest value was recorded for 50% acha with 50% ripe plantain while the lowest value was recorded for 100% acha flour. There was a significant difference between the biscuit samples ($p < 0.05$) and it was observed that on increasing the concentration of the ripe plantain the peak viscosity of the flour samples increases. The peak viscosity indicates the strength of pastes formed from gelatinization during food processing. It also reflects the extent of granule swelling (Giami, 2004) and could be indication of the viscous load likely to be encountered during mixing.
The trough value ranged from 7.47 to 25.39RVU. The highest value of the trough was recorded for 50% acha with the addition of 50% ripe plantain flour while the lowest value of the trough was recorded in 100% acha only. There was significant differences among the flour samples at ($p > 0.05$) which means that the higher the ripe plantain flour, the higher the trough of the flour samples. Trough thickness measures the smallest capacity of the paste to resist collapse during the period of cooling (Adegunwa *et al.*, 2005).
Also the setback value ranged from 5.30-5.77RVU. The highest set back value was recorded for 100% acha and the lowest set back value was recorded for 50% acha and 50% ripe plantain. There was a significant difference between the setback values of the biscuits. It was observed that on increasing the concentrations of the ripe plantain the setback value decreases.
The peak time value of ranged from 5.09-5.80RVU. The highest peak time was recorded for 100% acha and the lowest peak time was recorded for 50% acha and 50% ripe plantain. There was significant ($P<0.05$) differences between the peak time of the biscuits samples. As the concentration of ripe plantain increases and acha reduces the peak time increases. The pasting

temperature ranged from 58.24-60.12^{0}C. There was significant difference pasting temperature. As the ripe plantain concentration increases the pasting temperature increases.

Table 2; Mineral Contents of Biscuits Samples

SAMPLE	CALCIUM	SODIUM	POTASSIUM	IRON	MAGNESSIUM
A	25.98±0.26^a	21.15±0.14^a	292.20±1.68b	3.53±0.35^a	77.27±6.27^a
B	29.47±0.23^b	28.16±0.09^b	289.87±0.39b	3.64±0.32^b	71.20±0.09^a
C	31.91±0.57^c	35.14±0.56^c	287.26±0.13ab	3.77±0.03^c	71.48±0.02^a
D	36.30±0.24^d	41.80±0.42^d	274.13±9.24a	3.87±0.15^d	71.74±0.01^a
E	38.99±0.15^e	49.12±0.52e	280.03±1.42a	3.93±0.03^d	71.96±0.04^a
F	42.08±0.17^f	56.14±0.13f	273.63±4.77a	4.05±0.05^e	72.30±0.00a
P-VALUE	0.000*	0.000*	0.037*	0.000*	0.570

Mean ± SE, analysis of variance (ANOVA), Duncan Multiple Range Test (DMRT). A=100% Acha, B=90% acha+10% ripe plantain, C=80% acha+20% ripe plantain, D= 70% acha+30% ripe plantain, E=60% acha+40% ripe plantain, F= 50% acha +50% ripe Plantain.

The minerals and vitamins composition of biscuits samples is shown in Table 2 show that there was significant (P<0.05). The calcium contents ranged from 25.98mg-29.47mg. The highest calcium contents was recorded for 50% and 50% ripe plantain additional and lowest calcium contents was recorded for 100% acha. The samples were significantly (P<0.05) different.
The sodium contents ranged between 21.15-56.14mg. The highest sodium content was recorded for 50% acha with 50% ripe plantain addition and the lowest sodium content was recorded for 100% acha. The samples were significantly (P<0.05) different for sodium contents. Also the potassium contents for the samples was higher for 100% acha and the lowest sample was recorded for 50% acha and 50% ripe plantain. The value was lower than the 1086.67 to 5350mg/kg for potassium content of high protein fibre snacks reported by Opeoluwa et al. (2015). The difference might be due to variation in flour and other ingredients used. Potassium is an essential nutrient and has important role in the synthesis of amino acid and protein in man. The samples were significantly (P<0.05).

The iron contents ranged from 3.53mg/g-4.05mg/g of the biscuit samples. The highest iron contents was observed in in 50% acha with addition of 50% of ripe plantain. The samples were significantly (P<0.05) different. The magnesium contents ranged between 71.20mg/g-77.27mg/g. the highest magnesium contents was recorded for 100% acha and the lowest was recorded for 90% acha with addition of 10% ripe plantain. The samples were not statistically significant (P>0.05). The biscuit samples had considerable amount of magnesium this agrees with report of some researchers (Anuonye *et al.*, 2012; Inyang and Ekop, 2015; Ohizua *et al.*, 2017). Magnesium is a cofactor in more than 300 enzyme systems that regulate diverse biochemical reactions in the body, including protein synthesis, muscle and nerve function, blood glucose control, and blood pressure regulation. Magnesium keeps bones strong and heart rhythm steady (Wardlaw and Kessel, 2002).

Table 4; Vitamin Contents of Biscuit Samples.

	Vitamin A	Vitamin B_6	Vitamin B_{12}	Vitamins C
A	0.01 ± 0.00^a	5.11 ± 0.89^a	8.61 ± 0.23^b	2.03 ± 0.11^a
B	0.06 ± 0.00^b	4.83 ± 1.00^a	8.55 ± 1.23^b	2.00 ± 0.41^a
C	0.12 ± 0.00^c	4.63 ± 3.23^a	8.52 ± 0.56^b	2.97 ± 0.34^b
D	0.19 ± 0.00^d	4.33 ± 0.98^a	8.47 ± 2.34^b	$4.12^b\pm0.32^c$
E	0.22 ± 0.01^e	4.37 ± 1.45^a	9.56 ± 2.11^a	$4.61\pm0,37^c$
F	0.29 ± 0.16^f	4.12 ± 2.11^a	10.34 ± 2.14^a	5.32 ± 0.21^d
P-Value	0.00	0.00	0.01	0.030

Mean ± SE, analysis of variance (ANOVA), Duncan Multiple Range Test (DMRT). A=100% Acha, B=90% acha+10% ripe plantain, C=80% acha+20% ripe plantain, D= 70% acha+30% ripe plantain, E=60% acha+40% ripe plantain, F= 50% acha +50% ripe Plantain.

The vitamin A content of the biscuit sample ranged from 0.01mg/g-0.29mg/g. The samples were significantly different vitamin A contents, however the highest vitamin A was observed in 50% acha with 50% ripe plantain and the lowest was observed in 100% acha. As the acha concentration reduces and the concentration of the plantain increases, the vitamin A contents of sample increases. The vitamin B_6 contents ranged from 4.12g/mg-5.11mg. The samples were significantly different for vitamin B_6 contents. The highest vitamin B_6 content was observed in 100% acha and the lowest was observed in 50% acha with 50% ripe plantain powder. The Vitamin B_6 content reduces as the concentration of acha reduces and ripe plantain increases. The vitamin B_{12} contents for the biscuit sample ranged from 8.52mg/g-10.34mg/g. The samples were significantly different for vitamin B_{12}. The vitamin B_{12} contents were highest in 50% acha with 50% ripe plantain and the lowest was observed in 70% of acha with 30% ripe plantain. The vitamin C contents for the biscuits sample ranged from 2.00mg/g-5.32mg/g. The samples were significantly different for the biscuit samples. The highest vitamin C content was observed in 50% acha with 50% ripe plantain and the lowest vitamin C contents in 90% acha with 10% ripe plantain. The glycemic index of the biscuit samples ranged from 1.38-3.24. The samples were significantly different for glycemic index. However the highest glycemic index was observed in 3.24 in 50% acha with 50% ripe plantain and the lowest was observed in 90% acha with 10% ripe plantain.

Table 3: Functional Properties of Biscuits Samples

SAMPLE ID	Bulk Density	Water Absorbing Capacity (MI/G)	Oil Absorbing Capacity (MI/G).	Emulsifying Capacity (MI/G)	Swelling Capacity (MI/G)	GI (%)
A	0.70 ± 0.02^a	110.67 ± 1.33^b	101.00 ± 0.58^c	45.91 ± 0.07^b	0.62 ± 0.03^a	61.93 ± 0.08^a
B	0.74 ± 0.04^b	106.40 ± 0.37^b	97.21 ± 0.41^{bc}	45.30 ± 0.10^b	0.73 ± 0.03^a	62.13 ± 0.08^a
C	0.76 ± 0.01^{bc}	104.23 ± 0.26^{ab}	95.50 ± 0.32^{bc}	44.93 ± 0.12^b	0.91 ± 0.00^a	62.53 ± 0.12^{ab}
D	0.76 ± 0.01^{bc}	101.67 ± 0.23^{ab}	91.07 ± 0.13^b	44.50 ± 0.00^b	1.12 ± 0.01^{ab}	62.76 ± 0.03^{ab}
E	0.74 ± 0.01^b	103.16 ± 0.26^{ab}	88.00 ± 1.00^{ab}	43.73 ± 0.17^a	1.20 ± 0.01^b	64.76 ± 0.26^b
F	0.77 ± 0.03^c	90.83 ± 7.01^a	84.13 ± 0.57^a	43.30 ± 0.06^a	1.32 ± 0.06^b	65.17 ± 0.12^b
P-Value	0.02	0.01	0.00	0.00	0.00	0.00

Mean ± SE, analysis of variance (ANOVA), Duncan Multiple Range Test (DMRT). A=100% Acha, B=90% acha+10% ripe plantain, C=80% acha+20% ripe plantain, D= 70% acha+30% ripe plantain, E=60% acha+40% ripe plantain, F= 50% acha +50% ripe Plantain.

The functional properties of biscuit samples are presented in Table 3. The bulk density of the biscuit sample ranged from 0.70-0.77%. The samples were significantly ($P<0.05$) different. The highest bulk density was recorded for 50% acha with 50% of ripe plantain. The bulk density increases as ripe plantain powder increases and acha reduces. The bulk density of flour depends on combined effects of factors such as intensity of attractive inter-particle forces, geometry, particle size and method of preparation. The bulk density of acha flour and ripe plantain indicated that flours have similar particle size which is economical in terms of packaging cost. The low bulk density of flours could be an advantage in the formulation of baby foods where high nutrients density to low bulk is desired. However, high bulk density is a good physical attribute for determining mixing quality of flour. The result agrees with the reported values for starch foodstuff (Onuh and Abdulsalam, 2009). Bulk density is significant in package design, storage and transport of foodstuff. The least gelation concentrations of the blends were significantly higher than that of cowpea flour alone but lower than that of acha flour (Akpata and Akubor, 1999).

The water absorbing characteristics ranged from 90.83-110.67RVU. The highest water capacity of 100% acha was recorded and the 50% of acha and 50% of ripe plantain had the lowest water capacity. Flours with high WAC have more hydrophilic constituents, such as polysaccharides. The WAC is the ability of a product to associate with water under limiting conditions in order to improve its handling characteristics and dough making potentials (Singh *et al.*, 2001; Giami, 2004; Yasumatsu *et al.*, 1972). Also Water absorption capacity defines the ability of a product to associate with water under conditions where water is limited (Singh *et al.*, 2001). The highest water absorption capacity of the 100:0% acha samples could be attributed to the presence of higher amount of carbohydrates (starch) and fibre in this flour. Water absorption capacity is a critical function of protein in various food products like soups, dough and baked products (Adeyeye and Aye, 1998).
The oil absorption capacity of the samples ranged from 84.13-101.00. The samples were statistically significant ($p<0.05$) different. The highest oil absorbing capacity was observed in 100% acha and lowest was on served in 50% acha and 50% ripe plantain. Products with high OAC have the advantage of improving mouth feel and retention of flavour of the food products in which they are incorporated. However, high OAC would be undesirable in some food applications such as those involving deep frying of legume-based products like bean ball (akara).

The emulsifying capacity of samples were statistically ($P<0.05$) significant. The emulsifying capacity ranged from 43.30-45.91. However the highest emulsifying capacity of 100% acha was observed and the lowest emulsifying capacity was observed 50% acha and 50% plantain. Also the swelling capacity of the samples were statistically ($P<0.05$) different. The highest swelling capacity was recorded in 50% acha with the addition of 50% ripe plantain, the lowest swelling capacity was recorded for 100% acha. The glycemic index of the sample were statistically significant. However the highest glycemic index ranged from 61.93-65.17. The highest glycemic index was observed in 50% acha with the addition of 50% ripe plantain. And the lowest was observed for 100% acha.

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