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Utilization of Breadfruit in Low Fat Cookie Formulation

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Abstract Breadfruit (*Artocarpus altilis*) flour was processed and used to substitute margarine at levels of 0, 10, 20 and 30% labelled A – D samples in the production of low fat cookies. Proximate and functional properties of the flour were studied, as well as the proximate, physical and sensory properties of the cookies made from the flour. The result showed that the breadfruit flour had moisture content of 3.24%, fat 10.20%, protein 9.88%, ash 2.56%, fibre 1.79% and carbohydrate 71.15%. Functional properties of the flour had values of 0.22g/ml, 0.01%, 2.50%, 0.86%, 44.40% and 2.01% for bulk density, foaming capacity, water and fat absorption capacity, emulsion capacity and least gelation concentration, respectively. Substitution of margarine with breadfruit flour increased the moisture content of the produced cookies from 3.4 – 4.9% (B and D samples), crude protein 7.8 – 9.5%, ash 1.0 – 1.2% and carbohydrate 48.5 – 60.7% while fat successively decreased from 39.2 – 23.4% for A and D samples. Physical properties of the cookies showed weight range of 31.25 – 39.30g, 1.98 – 2.70cm diameter, 1.63 – 1.98cm height and 1.00 – 1.66 spread ratio. Control cookie sample was highly preferred in all the sensory parameters analysed. Other samples were accepted up to 20% level of breadfruit flour substitution. From these analyses, low fat cookies can be produced using up to 30% breadfruit flour in place of fat and labelled low fat and improved protein for health conscious consumers. The sensory attributes of the cookies require improvement for better acceptability.

Keywords: *breadfruit, low fat, cookies, proximate, functional, physical, sensory properties*

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1. Introduction

Reducing fat in every-day diet has become a public health issue and a concern for most consumers. In some product sectors, reduced fat alternatives are both widespread and acceptable to consumers, while other sectors such as bakery are generally behind in producing successful reduced fat alternatives. From nutrition point of view, excessive consumption of bakery products is not recommended, as it is linked with the intake of saturated fatty acids (SFA) and trans fatty acids (TFA) [1] which are known to provoke an increase of LDL/HDL-cholesterol ratio, with a consequent increase in the risk of cardiovascular diseases [2]. Zoulias *et al.*, [3] stated that high intake of dietary fat are implicated in coronary heart disease, high blood cholesterol, obesity, gallbladder disease, diabetes and dental caries. Dietary Guideline for Americans suggested that people that choose a diet low in fat comprised of more than 30% of daily energy intake for healthy adults [4]. The use of fat modified foods was ranked as the easiest and most preferred strategy to reduced fat intake in long term in order to prevent diseases associated with high consumption of bakery products. As consumers have attempted to reduce their fat intake, the demand and consumption of reduced/low fat foods has increased.

Cookies are one of the bakery products regarded as snack food, acceptable and widely consumed by children and adults because of its sweetness, convenience, low cost and palatability not for its nutritional quality. They are usually high in fat and sugar but low in protein, fibre, vitamin and minerals [5]. Fat as an important ingredient of cookies contributes to texture, pleasing mouthfeel and positively impacts to flavour intensity and perception. Many cookies and especially soft-type cookies contain large amounts of fat. However, according to Dietary Guideline, fats should be consumed in moderation [5]. As a result, cookies are regarded as unhealthy and are rejected by weight conscious consumers because of their high sugar and fat content [3]. In an attempt to improve the fibre, protein, vitamin and mineral content of cookies while reducing its fat content; several studies have been carried out. Ebere *et al.,* [6] incorporated cashew apple residue in cookie formulation as a source of fibre. Emelike *et al.,* [7] produced cookies enriched with *Moringa* leaf powder as a plant protein source, while Kiin-Kabari and Giami [8] fortified cookies with Bambara groundnut protein concentrate. Several studies using a variety of fat replacers to produce cookies have also been conducted and judged acceptable. Partial replacement of fat by inulin in cookies in order to decrease their caloric value was studied by Zbikowska and Rutkowska [9] and textural properties of low fat cookies were equally researched by Zoulias *et al.,* [10]. All these were done to reduce the use of fat from animal origin in cookie formulation which has led to the availability of cookie products labelled non-fat, low fat and reduced fat for health conscious consumers in recent years.

Breadfruit (*Artocarpus altilis*) seed has been reported to contain 13% fat, ash, fibre, 20% crude protein and 3.8%

crude fibre [11,12] and can be used as fat replacer in cookie formulation. It belongs to the Mulberry family *Moraceae* [13]. The plant grows in the tropics where it is used in a variety of food preparations. It is a fruit tree that is propagated with the root cuttings and the average age of bearing fruit crop is between 4 – 6 years [14]. Breadfruit is native to Africa and Malay Peninsula known as "Ukwa" in Igbo, "Barafuta" in Hausa while among Yoruba's, it is known as "Gberebutu" or "Jaloke" which is very popular in Ile-Ife. It can also be found in other parts of the continents [15]. Breadfruit is not a fruit as the name implies rather it is a leguminous seed described as an important staple food of a high economic value [16]. The breadfruit pulp is made into various dishes using different cooking methods such as pounding, frying, boiling or mashing to make porridge [14]. Breadfruit is regarded as poor man's food in Nigeria. Its production is faced with several problems including short shelf life, poor yield due to diseases and poor awareness of its nutritional value [15]. The fruits are thus utilized in Nigeria within 5 days of harvesting because of their short shelf lives. Hence, there is a need to process it into flour with long lasting ability which can be used to substitute wheat flour in the formulation of low fat bakery products. Therefore, the aim of this research was to evaluate the quality characteristics of breadfruit flour and low fat cookies produced from it.

2. Materials and Method

2.1. Materials

Breadfruit (*Artocarpus altilis*) used for this study were purchased from mile 3 market in Diobu Area of Port Harcourt. Wheat flour and ingredients such as margarine (g), sugar (g), nutmeg (g), fresh eggs (whole), salt (g), powdered milk (g), vanilla essence (ml) and sodium bicarbonate (g) (baking powder) were purchased from Next-Time Supermarket in GRA Phase I. They were taken to the laboratory of Food Science and Technology, Rivers State University of Science and Technology, Port Harcourt, Nigeria for processing and analyses.

2.2. Processing of Breadfruit Flour

The breadfruit seeds were thoroughly washed to remove any dirt and unwanted materials. They were boiled for 1h, peeled, sliced into 0.3cm thick using stainless steel knife and dried in an oven (Gallenkamp, England) at 105^{o}C for 3h, after which they were dried milled into flour using FOSS, Cyclotec 1093 (Sweden) milling machine. The flour was sieved through a 150µm mesh sieve to obtain flour of uniform size. The flour was then packed in an air-tight container and stored at room temperature (28±2°C).

2.3. Formulation and Preparation of Cookies

Low fat cookies were formulated and prepared using the method described by Arisa *et al.*, [17] with some modifications. Breadfruit flour was used to substitute margarine at levels of 0%, 10%, 20% and 30% as shown in Table 1. Margarine and sugar were thoroughly mixed in a Kenwood Mixer at a medium speed until light and fluffy. Whole egg was added to the mixture and mixing continued for about 5min. Sifted wheat flour, breadfruit flour, milk powder, salt and nutmeg (grated) were mixed thoroughly in a bowl to ensure uniformity and added into the mixture gradually while mixing was still going on. Vanilla essence and water were added gradually to form dough. The dough was rolled out on a floured surface board and cut into uniform shapes and sizes of about 5.6 – 6.0cm with cookie cutter. The cut dough was prick on the surfaces with a fork to prevent the dough from rising. It was placed in greased baking sheets and baked in a pre-heated oven at 175°C (350^{o}F) for 15 min. Cookies were removed from the oven and allowed to cool, before packaging in an air-tight container.

Table 1. Formulation of Low Fat Breadfruit Cookies

	Samples			
Ingredients	**A**	**B**	**C**	**D**
Margarine (g)	100	90	80	70
Breadfruit Flour (g)	0	10	20	30
Wheat Flour (g)	150	150	150	150
Sugar (g)	50	50	50	50
Milk Powder (g)	20	20	20	20
Baking Powder (g)	3	3	3	3
Nutmeg (g)	2	2	2	2
Salt (g)	1.5	1.5	1.5	1.5
Whole Egg	1	1	1	1
Vanilla Essence (ml)	5	5	5	5
Water (ml)	50	50	50	50

2.4. Analysis of Proximate Composition

The proximate composition of breadfruit flour and the low fat cookie samples were analysed for moisture, protein, ash, fat and fibre using the Standard Assay method as described by AOAC [18]. Total carbohydrate was determined using the Anthrone Reagent method as reported by Osborne and Voogt [19].

2.5. Analysis of Functional Properties

Functional properties of the breadfruit flour determined included the bulk density, foaming capacity, water and fat absorption capacity, emulsion capacity and least gelation concentration. Bulk density (g/ml) was determined using the method described by Narayana and Narayana-Rao [20]. Foaming capacity (%) was determined with Coffman and Garcia [21] method with some modifications. Water absorption capacity (%) of the cookie samples was determined using Sosulski *et al.*, [22] method. Lin *et al.*, [23] method was used in the determination of fat absorption capacity (%). Emulsion capacity (%) was studied using the method described by Beuchat [24] while least gelation concentration (%) was prepared between 2.2% w/v with 5ml of water inside test tubes. The test tubes were heated in a water bath for 1h at 65^{o}C. They were brought out, cooled for 2h in a refrigerator (4^{o}C) and the test tubes was then reweighed to obtain the least gelation concentration capacity.

2.6. Analysis of Physical Properties

Physical properties such as weight (g), diameter (cm), height (cm) and spread ratio (D/H) of low fat formulated cookies were measured using the method described by

Zoulias *et al.*, [10] and reported by Giami and Barber [25] for fluted pumpkin cookies.

2.7. Sensory Evaluation

Sensory evaluation of the low fat cookie samples were conducted after baking using the method described by Giami and Barber [25] for fluted pumpkin cookies with some modifications. A panel of twenty consumers comprising of staff and student from Department of Food Science and Technology, Rivers State University of Science and Technology, Port Harcourt, Nigeria were used. Criteria for selection were that panelist were 18 years of age, regular consumers of cookies and were neither sick nor allergic to any food. They were trained in the use of sensory evaluation procedures. Samples were served on white disposable plates at each session, properly coded with 3-digit random numbers to prevent bias. The organoleptic attributes such as; colour, texture, taste, flavour and overall acceptability of the cookie samples were evaluated using a 9-point hedonic scale as described by Iwe [26], where 9 denote the highest score (like extremely) and 1 denote the least score (dislike extremely). Necessary precautions were taken to prevent transfer of flavour during the analysis by ensuring that panelist rinse their mouth with potable water after each evaluation.

2.8. Statistical Analysis

Analyses were conducted in triplicate and all data obtained were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Science (SPSS) version 20.0 software 2011. Duncan's New Multiple Range test was used to identify significant difference at 5% level of probability according to the method described by Wahua [27].

3. Results and Discussion

3.1. Proximate Composition of Breadfruit Flour

The result showed that the breadfruit flour had moisture value of 3.24% and fibre 1.79% as presented in Table 2. Moisture content is low compare to 8.01% reported by Osabor *et al.*, *[28]* and in agreement with the report of Nwaigwe and Adejumo [29]. It falls within the range of 3.65 – 5.60% for moisture content of breadfruit seed species from some countries [30]. Omobuwajo [15] stated that breadfruits are utilized in Nigeria within 5 days of harvesting because of their short shelf lives. Processing it into flour drastically lowered the moisture content and it is assumed to have prolong shelf life as moisture levels of foods is usually a measure of the stability and susceptibility to microbial contamination [31]. Breadfruit flour could have longer storage advantage over Brebra seed flour with moisture content of 4.24% as reported by Berhanu and Amare [32] as moisture content in this study is lower. Breadfruit flour has fat content of 10.20% and according to literature; it is a rich source of plant fat [12]. Osabor *et al.*, [28]; Nwaigwe and Adejumo [29] reported lower and higher fat value of 4.23% and 15.67%, respectively for breadfruit seed flours. These differences in fat values could be attributed to the geographical location where the breadfruit seed were grown. Fat value of breadfruit flour observed in this research is lower compared to that of Brebra seed flour (48.5%) reported by Berhanu and Amare [32], Cashew kernel roasted with sand and gari also had higher fat values of 50.0 % and 51.0%, respectively [33]. The protein content (9.88%) of breadfruit flour in this study was quite low compare to those reported by Osabor *et al.*, [28]; Nwaigwe and Adejumo [29] with values of 12.47% and 25.62%, respectively. It is equally low compare to that of cowpea and soybean (20.05 and 30.65%), respectively, as reported by Basman *et al.*, [34]. The processing methods applied might have affected the levels of protein content of the breadfruit flour as defatting increases the availability of protein in food materials. This statement agreed with the work of Emelike *et al.*, [35] who observed an increase in the protein content of cashew kernel flour from 19.8% (undefatted) to 34.0% for the defatted flour. The ash content is in agreement with that reported by Osabor *et al.*, [28]. Ash content of seeds is a reflection of their mineral composition [36]. Carbohydrate value of 71.15% is in close agreement with that recorded by Osabor *et al.*, [28] and high compare to that of Nwaigwe and Adejumo [29] with the values of 73.26% and 46.74%, respectively. Breadfruit seed maybe ranked as carbohydrate rich seed due to its high value observed in this study. Thus, it could serve as a good source of energy when used in the formulation of snack products to the consumers.

Table 2. Proximate Composition of Breadfruit Flour

Parameters	Composition (%)
Moisture	3.24
Fat	10.20
Protein	9.88
Ash	2.56
Fibre	1.79
Carbohydrate	71.15

Values are means of duplicate determinations.

3.2. Functional Properties of Breadfruit Flour

Analysis of the functional properties showed that the breadfruit flour had bulk density and foam capacity values of 0.22g/ml and 0.01%, respectively, as presented in Table 3. This is in agreement with the work of Emelike *et al.*, [35] who reported that undefatted cashew kernel flour bulk density value of 0.2g/ml. Hussain *et al.*, [37]; Adepeju *et al.*, [38] reported flaxseed and breadfruit flours with higher bulk density and foam capacity values as against the ones in this research. Water absorption is the ability of flours to absorb more water and swell for improved consistency in foods. Osundahunsi *et al.*, [39] stated that water absorption capacity is desirable in food systems to improve yield, consistency and give body to the food. Water absorption capacity of breadfruit flour (2.50%) in this study is low compare to that of maize flour 271.7%, yam flour 88.48% and breadfruit flour with the value of 264.7% reported by Fasasi *et al.*, [40]; Jimoh and Olatidoye [41]; Adepeju *et al.*, [38] while it is high compare to that of undefatted cashew kernel flour (0.8%) reported by Emelike *et al.*, [35]. Fat absorption capacity and emulsion capacity of 0.86% and 44.40%, respectively was observed. Odoemelam [42] stated that fat absorption is an important property in food formulations because fat improves flavour and mouthfeel in foods. Breadfruit flour had least gelation concentration value of 2.01% and it was low compare to 10.00% reported by Adepeju *et al.*, [38]. Lower the least gelation concentration, better the gelling ability of a food component [38]. This implies that the flour reported here have better gelling ability. It was observed that all the functional properties of breadfruit flour reported by Adepeju *et al.*, [38] had higher values than those in this research. This could be attributed to variation in cultivars and the analytical procedures adopted.

Table 3. Functional Properties of Breadfruit Flour

Parameters	Composition
Bulk Density (g/ml)	0.22
Foaming Capacity (%)	0.01
Water Absorption Capacity (%)	2.50
Fat Absorption Capacity (%)	0.86
Emulsion Capacity (%)	44.40
Least Gelation Concentration (%)	2.01

Values are means of duplicate determinations.

3.3. Proximate Composition of Low Fat Breadfruit Cookies

From the analyses, increase in breadfruit flour significantly ($P \leq 0.05$) increased the moisture content of the produced cookies from 3.4% to 4.9% with no significant difference between C and D samples, as well as samples A and B as shown in Table 4. The value in this research is in agreement with the report of Ojinnaka *et al.*, [43] for moisture content of breadfruit-wheat based cookies. There was no significant difference ($P \leq 0.05$) in ash content of the cookies in all the samples. Though, a slight increase was observed at 30% level of breadfruit flour substitution which is in agreement with the report of Ojinnaka *et al.*, [43]. Olaoye *et al.*, [44] equally reported an increase in ash content of cookies with increased proportion of breadfruit flour. Ash is an inorganic compound containing mineral component of food and nutritionally aid in the metabolism of other organic compounds such as fat and carbohydrate [45]. Fat and carbohydrate maintained same trend of no significant difference ($P \leq 0.05$) between A and B, as well as C and D samples. It was observed that increasing levels of breadfruit flour substitution significantly increased protein value from 7.8 – 9.5% and carbohydrate from 48.5 – 60.7% while it decreased fat content of the cookies from 39.2 – 23.4% for samples A and D, respectively. Though, wheat flour is a good source of protein, from this research, it is observed that breadfruit flour improved the protein content of the produced cookies. According to literature, breadfruit has been reported to be a rich source of plant protein [12]. Fat plays significant role in the shelf life of food product as fat have the ability of promoting rancidity in foods leading to development of unpleasant and odorous compounds. Min and Boff [46] reported that the yield of fat from tropical crop depends on numbers of factors while the storage ability of fat is largely affected by the type of fatty acid present. From this research, it is evident that cookies produced from 30% level of breadfruit flour substitution greatly lowered the fat content of the cookies showing its ability of been stored for a longer period than those produced from 100% level of margarine and can be labelled low fat cookies for health conscious consumers.

Table 4. Proximate Composition of Low Fat Breadfruit Cookies

Samples	Moisture (%)	C Protein (%)	Ash (%)	Fat (%)	CHO (%)
A	3.5^{b}	7.8^{b}	1.0^{a}	39.2^{a}	48.5^{b}
B	3.4^{b}	7.9^{b}	1.0^{a}	36.8^{a}	49.8^{b}
C	4.3^{a}	8.9^{a}	1.0^{a}	26.6^{b}	58.7^{a}
D	4.9^{a}	9.5^{a}	1.2^{a}	23.4^{b}	60.7^{a}

^{a,b,c} Means with same superscript along the column are not significantly different at $P \leq 0.05$

Key: CHO = Carbohydrate, C = Crude, A = Margarine/Breadfruit Flour (100:0), B (90:10), C (80:20), D (70:30).

3.4. Physical Properties of Low Fat Breadfruit Cookies

Physical properties of breadfruit flour substituted cookies such as weight (g), diameter (cm), height (cm) and spread ratio (D/H) is presented in Table 5. The result showed that breadfruit flour substitution did not significantly affect ($P \leq 0.05$) the weight of all the cookie samples. Though, a gradual decrease in weight from 39.30g (A) to 31.25g (D) was observed as the level of substitution increased. This is not in agreement with the report of Kiin-Kabari and Giami [8] who observed a significant difference in all the cookie samples enriched with Bambara groundnut protein concentrate. This difference may be associated with the utilization of different food materials. There was no significant difference between samples A, C and D in terms of the diameter of the cookies while there was between sample B compare to other samples. Samples B and C was observed to have slight significantly higher height and lower spread ratio values. Sample A had the highest spread ratio of 1.66 and a corresponding highest diameter of 2.70cm and lowest height of 1.63cm. Same trend was observed in sample B with lowest diameter (1.98cm) and spread ratio (1.00) and higher height of 1.98cm. This is in agreement with the report of Emelike *et al.*, [7]; Adepeju *et al.*, [38] for cookies substituted with *Moringa* leaf powder and breadfruit flour. This trend could be related with the calculation of spread ratio as diameter divided by height is equal to spread ratio.

Table 5. Physical Properties of Low Fat Breadfruit Cookies

Samples	Weight (g)	Diameter (cm)	Height (cm)	Spread Ratio (D/H)
A	39.30^{a}	2.70^{a}	1.63^{ab}	1.66^{a}
B	34.85^{a}	1.98^{b}	1.98^{a}	1.00^{ab}
C	33.10^{a}	2.28^{a}	1.93^{a}	1.18^{ab}
D	31.25^{a}	2.31^{a}	1.68^{ab}	1.38^{a}

^{a,b,c} Means with same superscript along the column are not significantly different at $p<0.05$

Key: A = Margarine/Breadfruit Flour (100:0), B (90:10), C (80:20), D (70:30).

3.5. Sensory Properties of Low Fat Breadfruit Cookies

Sensory evaluation of the breadfruit flour substituted cookies showed that sample A with 100% margarine had significantly (P≤0.05) higher acceptability in all the attributes analysed as presented in Table 6. This is in agreement with the report of Ebere *et al.,* [6]; Kiin-Kabari and Giami [8] where the control cookie samples were preferred by the panelists. Scores for colour, texture, taste, flavour and overall acceptability ranged from 8.46 – 4.86, 8.46 – 4.32, 8.87 – 4.50, 7.92 – 4.50 and 8.64 – 4.68, respectively, with no significant difference (P≤0.05) between samples B and C while C had significantly lower scores compare to other samples. Colour and flavour is a very important parameter in judging properly baked products that not only reflect in the suitability of raw materials used for the preparation but also provides information about the quality of the product [47]. Sensory score of cookies up to 6.48 indicated moderately liked by the panelists and it is evident that breadfruit flour can be substituted up to 20% to margarine in the production of low fat cookies that will be acceptable by the consumers.

Table 6. Sensory Properties of Low fat Breadfruit Cookies

Samples	Colour	Texture	Taste	Flavour	O Acceptability
A	8.46[a]	8.46[a]	8.87[a]	7.92[a]	8.64[a]
B	5.76[b]	5.22[b]	5.58[b]	5.94[b]	5.58[b]
C	5.94[b]	5.58[b]	6.48[b]	5.74[b]	5.22[b]
D	4.86[c]	4.32[c]	4.50[c]	4.50[c]	4.68[c]
LSD	0.63	0.88	0.23	0.67	0.18

[a,b,c] Means with same superscript along the column are not significantly different at p<0.05

Key: O = Overall, A = Margarine/Breadfruit Flour (100:0), B (90:10), C (80:20), D (70:30).

4. Conclusion

Substitution up to 30% level of breadfruit flour to margarine successfully decreased the fat and increased the protein content of the cookies without significant effect (P≤0.05) in other proximate composition of the samples compare to the control sample. Physical properties of the cookie samples were not also distorted by the substitution of breadfruit flour up to 30%. In terms of the sensory properties, cookies were accepted by the panelists up to 20% level of substitution while control sample had significantly higher (P≤0.05) sensory scores in all the parameters analysed.

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