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Comparative Studies on the Physicochemical Attributes of Biscuit from African Yam Bean, Brown Rice and Soyabean Flours

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ABSTRACT

This paper presents a comparative study on the physical and proximate composition of biscuits made from different flour sources including wheat, African yam bean, brown rice, and soybeans. The aim of the study was to assess the nutritional value and quality attributes of biscuits derived from alternative flour sources, in comparison to the conventional wheat-based biscuits. Flours of African yam bean, brown rice and soybean were produced using conventional methods. Biscuits were further produced from the flours of African yam bean, soybean and brown rice using the creamy method. The physical characteristics such as weight, thickness, diameter and spread ratio as well as the proximate composition including moisture content, protein, fat, ash, fibre and carbohydrate content of the formulated biscuits as well as the control (wheat flour biscuit) were analyzed and compared among the different biscuit samples. The results on the biscuit samples revealed the following ranges: physical properties: weight 13.31-20.15g, thickness 0.68-0.81cm, diameter 5.03-5.90cm, and spread ratio 7.65-11.15; proximate parameters: moisture 4.70-7.70%, ash 3.50-4.90%, fibre 0.15-7.50%, protein 11.50-30.50%, fat 10.84-22.75% and carbohydrate 40.30-63.50%. The findings suggest that these alternative flour sources offer promising opportunities for the development of nutritious and sustainable biscuit products. The findings of the study further provide valuable insights into the potential of alternative flour sources in biscuit production and their implications for nutrition and food security.

Keywords: Biscuits, physical properties, proximate composition, comparative analysis

INTRODUCTION

Human nutrition is a complex multifaceted scientific domain indicating how substances in foods provide essential nourishment for the maintenance of life [1]. Nutrients, however, are essential dietary factors or substances in foods that provide nourishment for the maintenance of life [2]. Their absence in the diet has been experimentally or epidemiologically demonstrated to be associated with the development of poor health in man. Among these are some of the proximate compositions of food such as carbohydrate, proteins, fats, water, etc. Certain risk factors for many diet related non communicable diseases like diabetes, cardiovascular diseases (CVD), hypertension, stroke and their complications exist [3]. There is therefore, need for the understanding of the nutritional compositions of certain food products which in turn informs the choice of diets especially for the special need. Biscuits are widely consumed snack foods, appreciated for their convenience, portability, and palatability. According to Nwosu [4], biscuit is defined as a small thin crispy cake made from dough. Biscuits are an important baked product in human diet and are usually eaten with tea and are also used as weaning food for infants. The ingredients are simple; which contain soft wheat flour, sugar, fat, eggs [4]. Biscuit is widely accepted by all age group due to its longer shelf life, better taste and its position as snacks; it is also considered as a good product for protein fortification and other nutritional improvement ([5]. In Nigeria, consumption of biscuit is continually growing and there has been increasing reliance on imported wheat [6]. The importance of wheat flour in the production of biscuits is mainly due to its unique ability to form a cohesive gluten network when worked with water. This simple discovery set the stage for the development of many yeast breads, biscuits, pastries, cakes, cookies and other baked products [7].

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However, efforts were aimed on steps to identify those non wheat sources that could be used in tropical countries to minimize the usage of wheat flour, thus affect savings in foreign exchange by limiting wheat importation. Such non wheat flours are obtained from other cereals, legumes, tubers, and root crops, for example maize, sorghum, rice, soybean, sorghum, cassava, sweet potato, potato, plantain etc. Quite matter of concern is the association of wheat consumption with such health problems as celiac disease which makes it pertinent to utilize non-gluten or composite flour in biscuit manufacture [8].

Rice *(Oritza sativa)* is a principal leading food crop of the world and a staple food of over approximately half of the world's population [9]. Rice varieties are classified by grain size and shape into three types; long, medium and short grain. Each variety has distinct cooking, eating and processing qualities. White or polished (WR) rice is the popular form of rice consumed; it is produced by milling rough rice to remove the bran and germ. The brown rice (BR) is unpolished rice obtained by removing the husk from the rough rice. Rice flour is made from finely milled rice, which may be either from white rice or brown rice. Rice milling which removes the bran and germ reduces the nutrients significantly in white rice. This calls for a global campaign for consumption of brown rice (BR). In spite of its nutritional value and health benefits, brown rice is not widely consumed because of its reduced shelf life, nutty flavor, longer cooking time, hard to chew texture due to high fibre content present in the bran and poor taste. Rice flour is considerably lower in protein content compared with wheat flour and does not contain gluten, hence, it is good source of flour for people who are gluten intolerant. Extruded snack with high nutritional and antioxidant properties have been developed from rice-based composite flour [10].

Soybean *(Glycine max)* is a remarkable source of protein for both animals and human consumption and is also a leading source of edible oils and fats [11]. Soybean is the only source that contains all the amino acids, it is used in the production of bread, cookies and other composite flour has been reported. Soybean is cheap and this with its advantage of high nutrient makes it widely accepted and used for various forms of meals and snacks [11].

African yam bean (*Sphenostylis stenocarpa*) is a hard-to-cook under exploited leguminous plant grown extensively in Western Africa [12]. African yam bean is regarded as a security crop for fallow farm lands in the preparation for new planting season and primarily consumed as staple crops. The plant when harvested gives an edible seed which is widely consumed in the south-eastern part of Nigeria and other part of West Africa and though rich in nutrient, it is still largely under exploited [13]. Nutritionally, the seed is rich in protein with values ranging between 17 and 30%, it's also rich in carbohydrate (48.88-63.51%), while other components such as ash (1.86-5.35%), fat (1.39-7.53%), and fibre (2.47-9.57%) are present in relatively small amount [13]. Several factors including different seed accession, planting location, agronomic practices as well as seasons of the year when the bean was planted may influence the proximate composition. Though biscuits are originally made from wheat flour; however, there is a growing interest in exploring alternative flour sources to diversify the nutritional profile and enhance the sustainability of biscuit production. In this regard, African yam bean, brown rice, and soybeans have emerged as promising alternatives due to their nutritional richness and availability. This study aims to compare the physical and proximate composition of biscuits made from these alternative flour sources with those made from wheat flour, to evaluate their potential as nutritious and sustainable alternatives.

MATERIALS AND METHODS

PROCUREMENT OF RAW MATERIALS

Rice *(Oritza sativa)* seeds, Soybean *(Glycine max)* seeds and African yam bean (*Sphenostylis stenocarpa*) seeds were purchased from Eke market, Afikpo, in Afikpo North Local Government Area of Ebonyi State. Wheat flour (Golden Penny brand) and other ingredients such as skimmed milk, granulated refined sugar, fat (butter), baking powder, egg, skimmed milk, salt, nutmeg, vanilla flavour, were purchased from Eke market Afikpo, Ebonyi state. Every other material of interest was obtained from the Department of Food Technology, Akanu Ibiam Federal Polytechnic, Unwana Ebonyi State.

Production of Rice Flour: The rice paddy were cleaned, sorted, and winnowed to remove dirt and extraneous materials. The second portion was also parboiled and sun dried for 2 days. They were dehulled with a commercial machine and thereafter milled into powder using an attrition machine (Globe p44, China) to obtain brown rice flour (BRF). The flour sample was sieved with 100 µm mesh size, packaged in an airtight plastic container for further use.

African yam bean flour: African yam bean was processed into flour according to the procedures described by Enwere [14]. The African yam bean was sorted, soaked in cold water for 24 hours to loosen the seed coats. The seeds were removed by floatation in water. The seeds were cooked for about 10 minutes and dried at 60^{0}C for 10 hours after which they were dehulled and milled into fine flour. The flour sample was sieved with 100 µm mesh size, packaged in an airtight plastic container for further use.

Soybean flour: The dry seeds of Soya bean seeds were processed according to Akubor method [15]. The Soybean seed were weighed 505g initially before sorted, cleaned and were reweighed 500g before washing with clean portable water. The pre-processed soybean seeds were kept to be drained of water before sun drying for about (12

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h). They were roasted and cracked into smaller sizes, winnowed and dry milled. The soybean flour was sieved with 0.5mm mesh size to obtain fine flour and was reweighed (300g) before packaged in plastic plate and labeled.

Production of Biscuit: The modified recipe of Chinma *et al.* [16] was adopted 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). Biscuits were prepared using the traditional creaming method described by Chinma *et al.* [16]. The fat and sugar were mixed in a Kenwood mixer (HM 430) until the mixture was fluffy. Eggs and milk were added, while mixing continued. Baking powder, ground nutmeg, flour, and salt were introduced into the mixture to form soft dough. The dough was removed from the bowl and kneaded on a flat surface to obtain a uniform mix. The kneaded dough was rolled out into sheets using a rolling pin and cut into circular shapes using a cutter. The cut mass was transferred to a greased baking tray. Baking was carried out at 120^{0}C for 30 min. Biscuit made from wheat flour served as the control sample. The biscuits were cooled and packaged in low-density polyethylene bags and kept in a plastic container at ambient temperature.

Analysis of the Samples

Determination of Physical properties

The diameter (D) and thickness (T) of the biscuits were determined using the method of Bala *et al.* [17]. Thickness of biscuits was determined by measuring the diameter of four biscuit samples placed edge to edge with a vernier caliper. An average of six values was taken for each set of samples. Diameter of biscuits was determined by placing four cookies samples edge to edge and measuring with a vernier caliper. An average of six values was taken for each set of samples. Weight of biscuits was measured as average values of six individual biscuits with the help of an analytical weighing balance. Average value for weight was reported in grams. The spread ratio (SR) was calculated by dividing diameter by thickness as in the formula:

SR = D/T

Proximate Composition of Cookies

The proximate composition (Moisture, protein, fat, ash and fibre) of the cookies samples were determined according to the standard methods described by AOAC, [18] while carbohydrate content was determined by difference.

Sensory Evaluation of Cookies

The basic sensory qualities considered were, appearance, taste, aroma, crispness, mouth feel and general acceptability as described by Iwe, [19]. Semi trained panelists consisting of both genders 20 judges of different age groups having different eating habits were constituted to evaluate the quality. Samples were served to the panelists in white plates who were asked to rate the acceptability of the product through sense of organs. The biscuits were rated on a 9- point hedonic scale ranging from 1 (extremely dislike) to 9 (extremely like).

Statistical Analysis

All the data obtained from this study were subjected to statistical analysis using analysis of variance (ANOVA) with statistical package for the social sciences (SPSS) 23.0 software.

Duncan's new multiple range tests (DNMRT) was used to separate the means obtained from triplicate analysis (Duncan, 1955). Statistical significance was accepted at $p < 0.05$.

RESULTS AND DISCUSSION

Physical properties of biscuit samples

The results of the physical properties of biscuit samples as shown in table 1 revealed significant ($p<0.05$) variations in the weight, thickness, diameter and spread ratio parameters among the biscuit samples. The weight of the biscuit samples ranged from 13.31 – 20.15g which was within the range of 12.33-16.18g reported by Makinde and Adeyemi, [20] for biscuits produced from composite flours of wheat, corn, almond and coconut. African yam bean sample (BAF) had the highest weight (20.15g) followed by brown rice sample (BRF) 18.05g and wheat sample (BWF) (the control) 16.49g while the least weight was recorded by soybean sample (BSF) 13.31g. The higher weight observed in biscuit samples (BAF and BRF) when compared to the control (BWF) could be attributed to increased moisture absorption and less retention of carbon dioxide gas in the blended dough, resulting in heavy dough [21]. The biscuits thickness ranged from 0.68 cm in sample BSF to 0.81 cm in sample BAF. The values were lower than the range of 1.30-1.75cm reported by Nwatum *et al.* [22] for the thickness of Cookies produced from wheat, defatted peanut and avocado flour blends.

Table 1: Physical properties of biscuit samples

Samples	Weight (g)	Thickness (cm)	Diameter (cm)	Spread ratio
BWF	$16.49^{c}\pm0.01$	$0.70^{c}\pm0.01$	$5.10^{c}\pm0.01$	$8.50^{b}\pm0.03$
BAF	$20.15^{a}\pm0.02$	$0.81^{a}\pm0.03$	$5.90^{a}\pm0.01$	$7.65^{d}\pm0.01$
BSF	$13.31^{d}\pm0.02$	$0.68^{d}\pm0.02$	$5.03^{d}\pm0.01$	$11.15^{a}\pm0.02$
BRF	$18.05^{b}\pm0.01$	$0.77^{b}\pm0.01$	$5.50^{b}\pm0.03$	$8.15^{c}\pm0.01$

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Values are means of 3 replicates ± standard deviations. Means within a column with the same superscript were not significantly (P>0.05) different.
Legend: BWF = 100%wheat flour (control); BAF = African yam bean flour; BSF = Soybean flour
BRF = Brown rice flour

The diameter of the biscuit samples ranged from 5.03cm for sample (BSF) to 5.90cm for sample (BAF). The highest diameter was observed in sample BAF (5.90cm) and sample BRF (5.50cm) followed by sample BWF (5.10cm). Makinde and Adeyemi, [20] reported that low dough viscosity results in high flow rate (spread rate) of the dough and contributes to large diameter of composite flour biscuits. The spread ratio ranged from 7.65 (BAF) – 11.15 (BSF). The values were comparable to the values 6.44 – 7.00 for mushroom-wheat composite biscuits [23]. High fat biscuits always tend to spread more. The spread factor is an indicator of biscuit and cookie quality [22]. It is considered as one of the most important quality parameters of biscuits. There is a relationship between the spreadability, height (thickness) and the breaking strength. The higher the spread ratio of biscuits the more desirable it is [24].

Proximate composition of biscuit samples

The moisture content of the biscuits ranged from 4.70 to 6.70% and the samples were significantly different ($p<0.05$). Samples (BSF) and (BAF) had the highest percentage moisture content of 6.70% and 5.90% respectively followed by sample (BRF) 5.00% while the least value was recorded for sample (BWF) with percentage value of 4.70%. The moisture content was significantly lower than the moisture content range of 13.32 to 13.77% reported by Tanko *et al.* [25] for biscuits produced from composite flour of sweet potato and cashew nut flour blends and favorably compared with 4.25 - 6.67% range reported by Chigbo *et al.*, [26]. The moisture contents of the cookies were within the range (5 - 10%) set by the Protein Advisory Group reported as not having adverse effect on the quality attributes of the product. The lower the moisture contents of a product, the better the shelf stability of such product because low moisture ensures shelf stability in dried products. Thus, low moisture content in confectionaries such as cookies is of advantage as it brings about reduction in microbial spoilage and prolonged storage life if stored an appropriate packaging material under good environmental condition. The ash content ranged from 3.50 – 4.90% with samples (BRF and BAF) having higher ash content of 4.90% and 4.80% respectively, followed by sample (BWF) 3.38% and the least being sample (BSF) 3.50%. The high ash content of the biscuits was an indication of high presence of minerals in biscuit samples. Ash is a non- organic compound containing mineral content of food and nutritionally it aids in the metabolism of other organic compounds such as fat and carbohydrate [27] The protein content of the biscuits ranged from 11.50 to 30.50% and samples were significantly different ($p<0.05$). Sample (BSF) had the highest percentage protein content of 30.50% while the least value was recorded for sample (BWF) with percentage value of 11.50%.

Table 2: Proximate Composition of Biscuit Samples

Samples	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fibre (%)	Carbohydrate (%)
BWF	4.70±0.01^{d}	3.84±0.01^{c}	11.50±0.01^{d}	17.25±0.01^{b}	0.15±0.03^{d}	63.50±0.01^{b}
BAF	5.90±0.01^{b}	4.80±0.01^{b}	20.54±0.01^{b}	10.84±0.03^{d}	7.50±0.01^{a}	58.29±0.01^{c}
BSF	6.70±0.02^{a}	3.50±0.02^{d}	30.50±0.03^{a}	22.75±0.01^{a}	3.70±0.01^{b}	40.30±0.02^{d}
BRF	5.00±0.01^{c}	4.90±0.02^{a}	12.50±0.01^{c}	15.50±0.02^{c}	2.70±0.02^{c}	61.30±0.01^{a}

Values are means of 3 replicates ± standard deviations. Means within a column with the same superscript were not significantly (P>0.05) different.
Legend: BWF = 100%wheat flour (control); BAF = African yam bean flour; BSF = Soybean flour
BRF = Brown rice flour

The protein contents were similar to the results (15.00 – 26.64%) reported by Nwatum *et al.*, [22] Paper 3. The highest percentage of protein content in sample (BSF) might be as a result of the high protein content of soybean flour. The result implies that the biscuits samples were high in protein content and could be used as alternative protein source in protein deficiency. The fat content of the samples ranged from 10.84 – 22.75% with sample (BSF) having the highest fat content of 22.75% and sample (BAF) having the least fat content. The high fat content recorded by Soybean sample (BSF) 22.75% portrays soybean as a good source of fat more than the rest. This report is however higher than (16.82-19.30%) for three varieties of soybean by Eshun, [28] and lower than (0.37-2.38%) reported by Adegboyega *et al.*, [29] on the fat content of processed African yam bean flours. Fat helps in support of cell growth and in production of hormones. The fat content of the biscuits was however, within the

standard value (15%–20%) for soft dough biscuits [30]. Fat plays a role in determining the shelf-life of foods. A high amount of fat could accelerate spoilage by promoting rancidity which could lead to the production of off flavors and odors. The crude fibre content in biscuit samples ranged from 0.15 to 7.50%. There was significant ($p < 0.05$) difference in fibre content of the samples with sample (BAF) having the highest fiber content (7.50%) this might be as a result of high fiber content African yam bean. Sengev *et al*., [31] also reported similar values (2.10 to 3.0 %) for cookies from wheat and composite of sweet potato and mango mesocarp. The high fiber content of biscuit samples has several health benefits, as it will aid in the digestion in the colon and reduce constipation often associated with whole wheat product [20]. Studies have indicated the role of crude fibre in lowering blood cholesterol levels and lowering plasma glucose in some diabetic patients [32, 33]. The studies also showed that crude fibre contributes to the health of the gastro-intestinal system and metabolic system in man. The carbohydrate content ranged from 40.30 – 63.50% with the wheat flour biscuit sample (BWF) having the highest content of 63.50%. It has been that the higher the protein fat, ash content, the less the carbohydrate [34] hence the least carbohydrate content recorded by sample (BSF). The carbohydrate content suggests that all the biscuit samples were good sources of energy needed for normal body metabolism.

CONCLUSION

This comparative study has provided valuable insights into the physical and proximate composition of biscuits made from alternative flour sources including African yam bean, brown rice, and soybeans, in comparison to conventional wheat-based biscuits. The findings of this study suggest that biscuits made from alternative flour sources such as African yam bean, brown rice, and soybeans exhibit distinct physical characteristics and proximate composition profiles compared to wheat-based biscuits. This offers promising opportunities for the development of nutritious and sustainable biscuit products. Further research is hereby needed to optimize formulations and processing techniques to enhance the quality and acceptability of biscuits made from alternative flour sources, thereby promoting their adoption in the food industry.

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