Quality Assessment of Bread Made from Whole Wheat Flour and Beetroot Powder

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ABSTRACT
Background: Bread is one of the most popular bakery products whose consumption is increasing in many countries, including Nigeria, as a result of urbanization. This can be leveraged to develop bread with improved nutritional and health benefits.
Objective: The study aimed to produce and analyze the nutritional and sensory qualities of bread made from wheat flour and beetroot powder.
Materials and Methods: The research design was experimental. Samples were analyzed chemically according to the Association of Official Analytical Chemists (AOAC) methods. All analyses were carried out in Triplicate. Data were analyzed using IBM SPSS statistics version 20 while ANOVA was used to compare different variables together.
Results: The results showed significant differences ($p < 0.05$) in the proximate, mineral, and antioxidant content of the bread samples. However, there was no significant difference ($p < 0.05$) in the sensory attributes of the bread samples. Moisture content was lowest while crude fibre was highest in sample B. Sample A had the highest moisture ($30.34 \pm 0.12\%$) and carbohydrate content ($49.00 \pm 0.18\%$). The highest amount of crude protein ($10.59 \pm 0.04\%$), crude fibre ($1.08 \pm 0.04\%$), and total ash ($2.39 \pm 0.02\%$) was found in Sample D. Zinc, iron, β-Carotene and lycopene (mg/100 g) were highest in sample A while sample D had the highest vitamin C content. Sample C had the most preferred colour (6.87 ± 1.63) and aroma (6.33 ± 1.61) but the least preferred taste (5.77 ± 1.61). Sample A had the most preferred texture (6.60 ± 1.52), taste (6.07 ± 1.36), and overall acceptability (6.57 ± 1.17).
Conclusion: Bread produced from whole wheat flour and beetroot powder has improved nutritional value and can be consumed by healthy individuals and people requiring high fibre diets to maintain good nutritional status.

Keywords: Quality Assessment, Bread, Wheat Flour, Beet Root Powder

INTRODUCTION

Bread is a cereal-based staple meal that is a good source of micronutrients, fibre, and protein (1). It is high in carbohydrates but low in protein and other micronutrients (2). It is enjoyed by both young and old in Nigeria as part of the diet and even as a snack. Hence, bread, a versatile food with a variety of flavours and nutrients, remains the foundation of our daily diet (3). Bread consumption is increasing in many countries, particularly in Sub-Saharan Africa, as a result of urbanization, but matching bread supply and demand to consumers' eating habits is difficult. As customer demand for high-quality, health-conscious bakery products grows, the baking industry faces the challenge of developing bread with improved nutritional, physicochemical, and sensory properties (2).

Wheat flour is widely used in bread production because its storage proteins have the ability to form a viscoelastic dough after wetting and kneading (4). Wheat is the most abundant food crop in terms of the

planted area, yielding roughly the same amount as rice. The unique flavour of wheat and the light, leavened texture of the products produced are the reasons for its almost universal appeal as a food. Other cereal-based products lack the same light texture (5). Wheat is a good source of protein, minerals, B vitamins, and dietary fibre. However, the nutritional makeup of wheat grains, with their vital coating of bran, vitamins, and minerals, can be affected by environmental factors (6).

Beetroot (*Beta vulgaris L.*) is a root vegetable that is also known as red beet, garden beet, table beet, or simply beet (7). The taproot of the beet plant forms the beetroot and it is high in vitamins and minerals. Minerals such as iron, phosphorus (8), and calcium (9, 10, 11) are abundant in beetroot powder. It contains a lot of antioxidants and vitamins like A, B, and C, it is high in dietary fibre and has phenolic chemicals that act as antioxidants. Beetroot has become one of the most important functional foods in recent years due to its numerous health benefits.

This vibrantly coloured vegetable serves as a food, a medicinal plant, and a food colouring agent (9).

Iron deficiency is a common cause of anaemia, accounting for half of all cases of anaemia in women and children around the world. Anaemia is a major concern for women and children. In children, it can impair cognitive development and have long-term health and economic implications. For women, it contributes to increased maternal mortality, poor birth outcomes, as well as decreased work productivity. More than half (58%) of women aged 15 to 49 have anaemia and 68% of children aged 6 to 59 months have anaemia (12). In Nigeria, several regional studies on the nutritional status of school-age children have been conducted. These studies from a systematic review conducted from 2005 to 2015 in Nigerian school-aged children revealed high rates of zinc (63%) and iodine deficiency (59%) and lower rates of vitamin A (16%), iron deficiency (12%), and iron deficiency anaemia (14%). Studies have revealed that more than 60% of 4–8-year-old children in Ibadan, Nigeria, were deficient in calcium, copper, iron, folate, and vitamins A, D, and E (13).

Bread is a staple food in Nigeria, so assessing the quality of bread made from wheat flour and beetroot powder, will aid in the development of a new bread product as well as broaden the ranges of bread available for consumption, allowing consumers to easily assess the benefits present, in order to improve anaemia and hypocalcaemia. Incorporating beetroot powder with wheat flour to make it healthier and more nutritious may help to compensate for bakery products (such as bread) lack of fibre, iron, calcium, phosphorus, and antioxidants (14). Beetroot powder has been found to have a higher protein, dietary fibre, and ash content than wheat flour (14, 15). Furthermore, beetroot is not a well-known, common, or widely studied vegetable in Nigeria. As a result, incorporating it into a staple food such as bread will raise awareness of the vegetable and its distinct health benefits.

MATERIALS AND METHODS
Study design
The study was experimental.
Collection of Raw Materials
The beetroots (*Beta vulgaris*) were gotten from Jos, Plateau State while all other materials such as margarine, yeast, salt, granulated sugar, and wheat flour were obtained from D.S.C (Delta Steel Company) market, Delta State. The baking equipment was provided by the Department of Nutrition and Dietetics laboratory at Babcock University in Ilishan-Remo, Ogun State, and includes a weighing scale, an air-dry oven, a blender, a stainless steel knife, a chopping board, bowls, measuring cups, and a muslin cloth.
Preparation of Beetroot Powder
Raw beetroot purchased locally was thoroughly cleaned to remove any extraneous contaminants. It was then trimmed and sliced into thin (1-3mm) pieces with a sharp kitchen knife. Thereafter, they were dried in a hot air circulated oven at 60-70°C for 7-10 hours. After the beetroot slices have dried completely, they were ground in an electric grinder. The pulverized powder was then sieved using a sieve with a mesh size of 60-65 before placing in sealed coloured glass bottles or HDPE bags for later use (14, 8, 11).

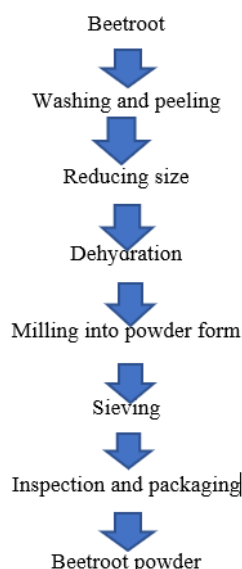Figure 1 below depicts the beetroot powder preparation process.

Beetroot

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Washing and peeling

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Reducing size

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Dehydration

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Milling into powder form

↓

Sieving

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Inspection and packaging

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Beetroot powder

Fig. 1: **Flow chart for the preparation of beetroot powder**

The straight dough method described by Kohajdova and Karovicova (16) was used to prepare the bread samples. The following is the recipe for each bread sample (Table 1):

Production of Beetroot Bread

Table 1: Recipe for the bread samples

Ingredients	Sample A	Sample B	Sample C	Sample D
Whole wheat flour (g)	100	95	90	85
Beetroot powder (g)	0	5	10	15
Yeast (g)	4	4	4	4
Butter (g)	2.5	2.5	2.5	2.5
Sugar (g)	1	1	1	1
Salt (g)	2	2	2	2
Vanilla flavour (g)	1	1	1	1

Sample A (control- 100% whole wheat flour)
Sample B (95% whole wheat flour with 5 % beetroot powder)
Sample C (90% whole wheat flour with 10% beetroot powder)
Sample D (85% whole wheat flour with 15% beetroot powder)

In an electric mixing bowl, the ingredients were combined for 6 minutes. After 20 minutes of fermentation, the dough was formed on a dough former, proofed for 45 minutes, and baked for 12 minutes at 230°C in an electric oven. Cooling was done for 1 hour, followed by packaging.

Chemical Properties

The Association of Official Analytical Chemists (AOAC) technique was used to determine the moisture and ash content (17). Fat content was determined using the Soxhlet extraction method, protein content was determined using the Kjeldahl method (18), and total dietary fibre was determined using the enzymatic–gravimeter method (19). Deducting the sum of the moisture, total ash, crude fat, crude fibre, and crude protein values (per 100 g) from the total was used to yield the carbohydrate content. The AOAC (17) standard method was also used to determine the iron, zinc, vitamin C, lycopene, and β-carotene content.

Sensory Evaluation

A panel of 30 semi-trained judges assessed the sensory qualities of the four bread samples. For the evaluation, the nine-point hedonic scale method was used.

Statistical Analysis

Data was analyzed using IBM SPSS statistics version 20. Descriptive statistics for mean, standard deviation, frequency and percentage was used in describing the data that was obtained. Analysis of Variance (ANOVA) was used to compare different variables together at $p < 0.05$.

RESULTS

Table 2 shows the proximate composition of the bread samples per 100 g. There were significant differences in the moisture, crude protein, crude fat, crude fibre, total ash and carbohydrate contents ($p < 0.05$) of all the four samples of bread. The moisture content ranged from ($30.34 \pm 0. 12\%$) to ($23.64 \pm 0.16\%$). Moisture content was lowest in sample B ($23.64 \pm 0.16\%$) however it had the highest crude fat ($9.72 \pm 0.07\%$) followed by sample D ($9.05 \pm 0.04\%$). The carbohydrate content ranged from ($55.88 \pm 0.05\%$) to ($49.00 \pm 0.18\%$) with sample D having the lowest ($49.00 \pm 0.18\%$) followed by sample C ($52.97 \pm 0.46\%$) while sample A had the highest moisture content ($30.34 \pm 0.12\%$). Although sample D had the lowest carbohydrate content, it contains the highest amount of crude protein ($10.59 \pm 0.04\%$), crude fibre ($1.08 \pm 0.04\%$), and total ash ($2.39 \pm 0.02\%$).

Table 2: Proximate composition (%) of the bread samples

Variables	Sample A	Sample B	Sample C	Sample D
Moisture (%)	$30.34^a \pm 0.12$	$23.64^d \pm 0.16$	$27.01^c \pm 0.28$	$27.89^b \pm 0.23$
Carbohydrate (%)	$55.88^a \pm 0.05$	$53.59^b \pm 0.13$	$52.97^c \pm 0.46$	$49.00^d \pm 0.18$
Crude protein (%)	$9.63^d \pm 0.12$	$10.07^b \pm 0.09$	$9.86^c \pm 0.05$	$10.59^a \pm 0.04$
Crude fat (%)	$2.08^d \pm 0.11$	$9.72^a \pm 0.07$	$6.78^c \pm 0.28$	$9.05^b \pm 0.04$
Crude fibre (%)	$0.68^d \pm 0.04$	$0.79^c \pm 0.02$	$0.98^b \pm 0.04$	$1.08^a \pm 0.04$
Total ash (%)	$1.39^d \pm 0.04$	$2.20^c \pm 0.03$	$2.32^b \pm 0.03$	$2.39^a \pm 0.02$

Means with different superscripts in the same row are significantly different ($p < 0.05$)
Values are mean $\pm$ standard deviation of triplicate samples
Sample A: Control – 100% whole wheat flour
Sample B: 95% whole wheat flour with 5 % beetroot powder
Sample C: 90% whole wheat flour with 10% beetroot powder
Sample D: 85% whole wheat flour with 15% beetroot powder

Table 3 shows the iron and zinc content of the bread samples. There was a significant difference in the iron content of the samples with sample A having the highest amount (2.20 ± 0.03 mg/100 g) and sample C having the least amount of iron (1.94 ± 0.02 mg/100 g), however, there was no significant difference in the iron content of sample B and D. The zinc content differed significantly in all the samples with the values ranging from (0.23 ± 0.00 mg/100 g) in sample A and (0.19 ± 0.00 mg/100 g) in sample B.

Table 3: Iron and Zinc content (mg/100 g) of the bread samples

Variables	Sample A	Sample B	Sample C	Sample D
Iron (mg/100 g)	$2.20^a \pm 0.03$	$2.11^b \pm 0.00$	$1.94^c \pm 0.02$	$2.08^b \pm 0.02$
Zinc (mg/100 g)	$0.23^a \pm 0.00$	$0.19^d \pm 0.00$	$0.20^c \pm 0.00$	$0.22^b \pm 0.00$

Means with different superscripts in the same row are significantly different ($p<0.05$)
Values are mean $\pm$ standard deviation of triplicate samples
Sample A: 100% whole wheat flour
Sample B: 95% whole wheat flour with 5 % beetroot powder
Sample C: 90% whole wheat flour with 10% beetroot powder
Sample D: 85% whole wheat flour with 15% beetroot powder

The antioxidant properties of the bread samples are shown in Table 4. There was significant difference ($p < 0.05$) in the vitamin C content which ranged from (0.95 ± 1.52 mg/100 g) to (7.96 ± 0.27 mg/100 g). The result shows that the value of β-carotene in the bread samples differed significantly and ranged from (0.18 ± 0.00 mg/100 g) to (0.10 ± 0.00 mg/100 g) with sample A having the highest and sample D having the least amounts. There was a significant difference ($p < 0.05$) in the lycopene content of all the samples with the highest amount in sample A (1.52 ± 0.05 mg/100 g).

Table 4: Antioxidant properties (mg/100 g) of the bread samples

Variables	Sample A	Sample B	Sample C	Sample D
Vitamin C (mg/100 g)	$0.95^a \pm 1.52$	$3.78^b \pm 0.53$	$5.85^c \pm 0.39$	$7.96^d \pm 0.27$
β-Carotene (mg/100 g)	$0.18^a \pm 0.00$	$0.15^b \pm 0.01$	$0.14^c \pm 0.00$	$0.10^d \pm 0.00$
Lycopene (mg/100 g)	$1.52^a \pm 0.05$	$0.53^b \pm 0.01$	$0.39^c \pm 0.02$	$0.27^d \pm 0.01$

Means with different superscripts in the same row are significantly different ($p < 0.05$)
Values are mean $\pm$ standard deviation of triplicate samples
Sample A: 100% whole wheat flour
Sample B: 95% whole wheat flour with 5 % beetroot powder
Sample C: 90% whole wheat flour with 10% beetroot powder
Sample D: 85% whole wheat flour with 15% beetroot powder

The result of the sensory evaluation of the bread samples is shown in Table 5. The result shows that there was no significant difference in the sensory attributes of the bread samples ($p < 0.05$) in terms of

colour, aroma, texture, taste, and overall acceptability. Sample C had the most preferred colour (6.87 ± 1.63) and aroma (6.33 ± 1.61) but the least preferred taste (5.77 ± 1.61). Sample A had the most preferred texture (6.60 ± 1.52), taste (6.07 ± 1.36), and overall acceptability (6.57 ± 1.17). However, it had the least preferred aroma while sample B had the least acceptable colour.

Table 5: Sensory attributes of the bread samples

Sensory attributes	Sample A	Sample B	Sample C	Sample D
Colour	6.70[a] ± 1.42	6.53[a] ± 1.17	6.87[a] ± 1.63	6.77[a] ± 1.55
Aroma	6.10[a] ± 1.19	6.33[a] ± 1.24	6.33[a] ± 1.61	6.33[a] ± 1.49
Texture	6.60[a] ± 1.52	6.30[a] ± 1.71	6.47[a] ± 1.59	6.43[a] ± 1.65
Taste	6.07[a] ± 1.36	5.83[a] ± 1.53	5.77[a] ± 1.61	5.83[a] ± 1.53
Overall acceptability	6.57[a] ± 1.17	6.50[a] ± 1.20	6.33[a] ± 1.37	6.20[a] ± 1.40

Means with similar superscripts in the same row are not significantly different ($p < 0.05$)
Sample A: 100% whole wheat flour
Sample B: 95% whole wheat flour with 5 % beetroot powder
Sample C: 90% whole wheat flour with 10% beetroot powder
Sample D: 85% whole wheat flour with 15% beetroot powder

DISCUSSION

Bread is a popular baked product consumed by most Nigerians and it is a major part of our daily diet. Hence, it can serve as a vehicle for improving the nutritional value of bread. The proximate composition of the bread samples shows that the moisture content ranged from (30.34 ± 0. 12%) to (23.64 ± 0.16%). Moisture content was lowest in sample B (23.64 ± 0.16%). This was higher than the result of Awasthi (10) where the moisture content of cakes enriched with beetroot powder ranged from 6.80 to 10.20%. It can be observed from the result that carbohydrate content decreased as the amount of beetroot powder increased with sample D having the lowest (49.00 ± 0.18%) and sample A having the highest carbohydrate content (55.88a ± 0.05%). However, the crude protein, crude fat, crude fibre, and total ash increased as the quantity of beetroot powder increased. This is similar to the result from other works (10, 20, 21) where the protein, fat, fibre, and total ash also increased as the ratio of beetroot powder incorporated food products was increased. In the same vein, Lucky *et al.* (14) recorded an increase in protein, fibre, and ash but a decrease in fat as beetroot powder increased in cakes enriched with beetroot. The increasing nutritional quality of bread resulting from an increase in the ratio of beetroot can be explained by the fact that beetroot powder contains more protein, ash, and fibre than wheat flour (14). Therefore, the addition of beetroot powder to bread improved the overall nutritional value of the bread. The increased fibre and reduced carbohydrate content of the beetroot bread make it a better option for the management of obesity and diabetes. Whole wheat was used for producing the bread as it has been shown that consumption of wheat bran can help prevent and control diabetes mellitus, be used for weight management, and reduces the risk of cardiovascular diseases (22, 23, 24). Also, beetroot powder has been found to have a higher protein, dietary fibre, and ash content than

wheat flour (14, 15), low calories of about 45 Kcal per 100 g, and contain zero cholesterol (11).

The result of the iron and zinc analysis showed that the bread samples contained iron and zinc. However, there was no significant difference in the iron content of the samples with sample A having the highest amount (2.20 ± 0.03 mg/100 g) and sample C having the least amount of iron (1.94 ± 0.02 mg/100 g). There was also no significant difference in the zinc content of the samples with the values ranging from (0.23 ± 0.00 mg/100 g) in sample A and (0.19 ± 0.00 mg/100 g) in sample B. This is different from the results from similar studies where food products enriched with beetroot had higher iron and zinc contents (8, 9, 10, 11, 20). However, it was similar to the study of Ingle *et al.* (11) where the zinc content decreased as more beetroot powder was added to cookies. This disparity could be due to a variety of factors such as soil acidity as acidic soils are more likely to cause nutrient deficiencies in beetroot (25). Peeling and application of fertilizer can also affect the iron content as it has been shown that the peels of beetroot and beetroots treated with fertilizer contain more iron than other parts of beetroot (26). Zinc is involved in the regulation of the cardiovascular and reproductive system, and the wound healing process (27). Iron is a component of many enzymes that takes part in hormone and DNA synthesis (26, 28), cholesterol metabolism, detoxification, and immune function (29, 30).

The result for the antioxidant properties reveals that the bread samples contain vitamin C. It also shows that beetroot is a rich source of vitamin C as the vitamin C content of the bread samples was noticed to increase with the increase in beetroot powder. This agrees with results from other studies where the incorporation of beetroot in food products increased their vitamin c content (8, 20). Vitamin C is a potent antioxidant and cofactor that contributes to immune defense and protects against environmental

oxidative stress, its deficiency can cause immune impairment and increase susceptibility to infections (31).

There was no significant difference in the β-carotene content of the bread samples which ranged from 0.18 ± 0.00 mg/100 g to 0.10 ± 0.00 mg/100 g. It was observed from the result that the β-carotene content of the samples decreased as the amount of beetroot powder increased. This is because the carotenoids in red beetroots are in small quantities (32) and beetroot leaves are richer in carotenoids compared to tubers since carotenoids are accumulated in the chloroplasts of green plants (33). β-carotene is one of the most abundant carotenoids in food and humans. It has the highest level of pro-vitamin A activity and acts against type 2 diabetes, cardiovascular diseases, obesity, and metabolic syndrome (34).

Lycopene is a bioactive compound with high antioxidant properties and it is responsible for the red colour in foods. It promotes health and reduces the risk of cardiovascular diseases (35). The result shows that the bread samples enriched with beetroot were poor in lycopene and the lycopene content decreased from 1.52 ± 0.05 mg/100 g in sample A to 0.27 ± 0.01 mg/100 g in sample D as more beetroot powder was added. This can be because red beetroot is a poor source of lycopene when compared to other foods like tomato, watermelon, red-fleshed guava, and papaya (36).

The result of the sensory evaluation as shown in Table 5 shows that sample C having 10% beetroot powder had the most acceptable colour and aroma. This result is similar to that of Ingle *et al.* (11) and Lucky *et al.* (14) where the bread and cake samples with 10% and 15% beetroot powder respectively, were most preferred in terms of colour. However, sample A had the most liked texture, taste, and overall acceptability. This agrees with the results of similar studies recording a higher preference for biscuits and cookies having zero percent beetroot powder compared to those enriched with beetroot powder (8, 10). The suggestion of Kohajdová *et al.* (15) that the addition of higher levels of beetroot resulted in an unpleasant, earth-like aroma and taste of baked rolls, explains why the taste of the samples enriched with beetroot was undesirable. An increase in the beetroot powder content resulted in a harder texture of the bread samples. This increased hardness was attributed to the high fibre content of beetroot in studies where food products enriched with beetroot powder were hard in texture (8, 11). Furthermore, the increased hardness of samples as beetroot powder was increased may be attributed to the dilution of wheat proteins with beetroot proteins and fibre (11). It was suggested by some studies that wheat flour could be substituted by beetroot powder up to 10% to get the best sensory qualities in baked goods (37, 38).

CONCLUSION

The study assessed the nutritional and sensory quality of bread produced from wheat flour and beetroot powder. The result revealed that incorporating beetroot into bread production improved the overall nutritional qualities of the bread. The beetroot bread samples had lower carbohydrate and moisture contents and higher protein, fat, fibre total ash, and vitamin C content compared to whole wheat bread. They also contain zinc, iron β-carotene, and lycopene. However, there was no significant difference in the zinc and iron contents of the bread samples while the β-carotene and lycopene contents decreased as the amount of beetroot powder was increased. The sensory evaluation shows that sample C had the most acceptable colour and aroma while sample A was more preferred in terms of texture, taste, and overall acceptability. Bread produced from beetroot can be used by diabetics, for weight management and prevention of cardiovascular diseases due to their high fibre and low carbohydrate contents. The colourful appearance can make it attractive to children. They can also be consumed by healthy individuals because of their enhanced nutritional qualities.

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