



Effect of Orange Peel Flour on the Quality Characteristics of Bread

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Authors' contributions

Author LCO designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author MNA managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: This study was carried out to investigate the effects of orange peel flour (OPF) substitution with wheat flour in bread production (substitution levels of 3, 6 and 9%) on the proximate composition, phytochemicals content, baking and sensory characteristics.

Place and Duration of Study: Department of Food Science and Technology, Ebonyi State University, Abakaliki, Ebonyi State, Nigeria for seven months.

Methodology: Oranges were washed thoroughly and peeled. Peels were boiled in water, sundried and ground into flour. Bread was produced by replacing wheat flour with 3, 6 and 9% OPF. Bread samples were analyzed for proximate composition (fat, moisture, protein, ash, fibre and carbohydrates), phytochemicals (tannins, saponins and alkaloids), baking characteristics (oven spring, loaf volume, specific volume and weight) and sensory quality.

Results: The addition of orange peel flour led to reduction in protein (8.2-2.7%) and fat (1.7-0.8%) but increased the ash (2.3-4.3%), fibre (0.6-5.8%) and carbohydrates (59.9-62.1%) contents. Phytochemicals levels also increased with increased levels of orange peel flour in the samples. Tannins ranged from 3.6-8.0mg/g, saponins from 0.9-1.4mg/g and alkaloids from 3.6-4.8mg/g. Oven spring decreased from 2.0 to 0.2cm, loaf volume from 8.0 to 4.8cm³ and specific volume from 5.3 to 3.2cm³/g. Sensory quality decreased with increase in orange peel flour for all the attributes studied. However sensory quality of bread made with 3% OPF did not differ from that made with 100% wheat flour.

Conclusion: The use of orange peel flour in bread has the advantage of improving the

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fibre, ash and phytochemicals levels in bread. However only bread produced with 3% OPF had sensory quality comparable to that produced with 100% wheat. Orange peel flour in bread production will not only add value to food but will also reduce environmental pollution as well as reduce the cost of importation of wheat.

Keywords: Orange peel flour; fibre; bread; phytochemicals; quality.

1. INTRODUCTION

Citrus is the most abundant crop in the world [1]; with oranges, grapefruits, lemons being the most common citrus fruits. Sweet orange (*Citrus sinensis*) is the most widely grown of the citrus trees. As of 2010, Brazil was the world's largest producer of oranges, with an output of 18.1 million tons. This was followed by America and India which produced 7.5 and 6.0 million tons respectively [2]. Oranges are mainly processed to obtain juice. They are also used to produce jams and marmalade. For some time the food industry has shown a special interest in finding uses for citrus industry by-products [3]. Sweet orange oil is a by-product of the juice industry produced by pressing the peel. It is used for flavouring food and drinks and also in the perfume industry and aromatherapy for its fragrance. The edible portion of the orange is referred to as the endocarp and surrounding the endocarp, is the peel. The peel consists of the flavedo and albedo which could be considered as potential sources of fibre and phytochemicals [4]. The roles of fibre and phytochemicals in sustaining good health cannot be over-emphasized. The benefits of fibre in diets include promotion of digestive health and weight loss, control of blood sugar levels and prevention of Type 2 diabetes. Other benefits include lowering cholesterol, indirectly preventing heart disease and stroke [5]. Phytochemicals are non-nutritive plant chemicals that have either protective or disease protective properties. Dietary intake of phytochemicals may promote health benefits, protecting against chronic degenerative disorders, such as cancer, cardiovascular and neurodegenerative diseases [6].

Bread and bakery products are widely consumed throughout the world and bread has been an important food and energy source throughout human history. Wheat flour used in bread production is generally low in fibre and phytochemicals. Since orange peel has been reported to be a source of fibre and phytochemicals, its flour could help in boosting the fibre and phytochemical levels of bread. Babiker et al. [7] studied the effect of orange peel flour on the physicochemical properties of wheat bread. They however did not study its effects on the phytochemical and sensory properties of the bread. This study is therefore aimed at determining the potentials that orange peel flour substitution could have on the proximate composition, phytochemicals content, as well as the sensory quality of bread. The effects of the flour on other quality parameters of bread were also investigated.

2. MATERIALS AND METHODS

2.1 Raw Materials

Fully ripened sweet oranges (*Citrus sinensis*), wheat flour and other ingredients used for bread production were purchased from a retail outlet in Abakaliki, Ebonyi State, Nigeria.

2.2 Peel Flour Preparation

Oranges were thoroughly washed with tap water and peeled. The peels were boiled in water (1:4; peels: water) for 10mins and sundried for two days at an average temperature of 34-36°C. Afterwards, the dried peels were ground into flour and sieved to a particle size of less than 0.2mm. The flour was stored at room temperature in plastic airtight containers until needed.

2.3 Bread Making

Bread was produced by replacing wheat flour with 3, 6 and 9% orange peel flour (OPF). A sample without the addition of orange peel flour (0% OPF) was used as the control. The bread was produced using the straight dough method described by Mepba et al. [8]. The basic formula included 100g flour, 2.0g of yeast, 5.0g of sugar, 1.5g of salt, 3.0g of margarine, 75ppm ascorbic acid and 54.66ml of water. The dough was proofed for 2h under ambient conditions (32°C, 78-80% R.H). Baking was at 205°C for 30min.

2.4 Chemical Composition of Bread

Analysis of samples was carried out after 24 hours of bread production. The moisture, ash, protein, fibre and fat contents of bread samples were analyzed by AOAC [9] methods. Carbohydrate content of bread samples were calculated by difference. The energy values of the bread samples were calculated using Atwater conversion factors of 4, 4 and 9 kcal/g for carbohydrates, protein and fat respectively [4].

2.5 Determination of Phytochemicals in Bread Samples

Tannins were measured using the Folin-Denis spectrophotometric method as described by Pearson [10]. The gravimetric method as described by Harbone [11] was used to determine the alkaloid contents of the bread samples while the quantitative method described by Pearson [10] was used to determine the saponin contents of the bread samples.

2.6 Baking Characteristics of Bread

Loaf volume was measured using the method described by Hallen et al. [12] with slight modifications. The loaf was put in a metallic container with known volume (V_C). The container was topped up with rice grains, the loaf removed and the volume of the rice noted (V_R). Loaf volume (V_L) could then be calculated and recorded according to

$$V_L (\text{cm}^3) = V_C - V_R$$

After cooling for 1h, the same loaves used for measuring volume were weighed on an electronic balance. Specific volume (V_S) of bread was calculated as:

$$V_S (\text{cm}^3/\text{g}) = V_L / W$$

Where W = weight of bread.

The pH was determined by directly from the samples using a pH meter. Oven spring was determined by measuring the difference in the height of the sample before and after baking [8].

2.7 Sensory Evaluation

Sensory evaluation was carried out twenty four hours after preparation of the bread samples. The sensory panel consisted of consumers of bread who were asked to describe the degree of liking of taste, crust colour, crumb colour, crumb texture and general acceptability of the bread samples by assigning a likeness score on a 9-point scale, where 9= like extremely; 5= neither like nor dislike; 1= dislike extremely [4]. A total number of 20 semi-trained panelists evaluated each sample. Each panelist evaluated all the samples prepared for each treatment in one session. Samples which were coded with random 3-digit numbers for identification were presented to the panelists. Water was provided for the panelists to rinse their mouths between evaluations.

2.8 Statistical Analysis

SPSS 17.0 was used to conduct one-way analysis of variance (ANOVA) for determining significant differences among means. Statistically significant differences ($P<0.05$) among means were separated using the Duncan Multiple Range Test.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Bread

The proximate composition of bread samples produced is shown in Table 1. The moisture content of the bread samples ranged between 24.3 and 27.3%. Bread without OPF had the highest moisture content while bread with 9% OPF had the least value. There was no significant difference in the moisture content of bread samples with OPF. Salgado et al. [13] produced bread from wheat and cupuassu peel flour and observed that bread samples produced had moisture content ranging from 25.28 to 28.78%. These values were close to values obtained in this work. Increase in the level of OPF in the bread led to a significant ($P<0.05$) reduction in the protein and fat contents of the bread samples. This could be due to the low protein and fat contents of the orange peel. Conversely, increase in OPF resulted in increased levels of fibre and ash which were significant at ($P<0.05$). Ash content is an indication of the level of minerals present in a food material. Increased levels of minerals with increase in OPF levels could be due to high levels of minerals in orange peels. This suggests that orange peels can help in boosting the mineral content of wheat bread. Fibre has been reported to have many health benefits; it has been reported to prevent certain cancers and even lower the risk of developing hemorrhoids [14]. The increase in fibre content with increase in OPF level should therefore, attract acceptability by many consumers as most of our diets are low in fibre but high in fats and carbohydrates. It was also observed that as the fibre content of bread samples increased, there was a reduction in the moisture content. Fibre has been reported to have a high water binding capacity [15]. Therefore, increase in fibre content may have resulted in its reducing the moisture content of the bread samples. Calorie content of the bread samples ranged between 266.4 and 287.7 kcal/100g. Bread produced with 0% OPF had the highest caloric value while that produced with 9% OPF had the least caloric value. Salgado et al. [13] observed that bread produced with higher levels of cupuassu peel flour exhibited lower calorie factors when compared to those

produced with lower levels of peel flour. They suggested that the low calorie factors observed in bread with high levels of peel flour may be associated with the replacement of carbohydrates from wheat flour by the complex polysaccharide fibre in the fruits peel.

Table 1. Proximate composition of bread samples produced with different concentrations of orange peel flour

OPF (%)	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	Carbohydrates (%)	Energy (kcal/100g)
0	27.3 ^a ±1.2	8.2 ^a ±0.3	1.7 ^a ±0.2	2.3 ^a ±0.3	0.6 ^a ±0.1	59.9 ^a ±1.2	287.7
3	25.5 ^{ab} ±1.8	4.4 ^b ±0.8	1.5 ^b ±0.3	3.7 ^b ±0.0	4.7 ^b ±0.3	60.2 ^a ±0.5	271.9
6	24.5 ^b ±1.0	3.4 ^c ±0.6	1.5 ^c ±0.3	3.8 ^c ±0.0	4.9 ^b ±0.5	61.9 ^b ±0.8	274.7
9	24.3 ^b ±1.3	2.7 ^d ±0.7	0.8 ^d ±0.3	4.3 ^d ±0.4	5.8 ^c ±0.7	62.1 ^b ±0.3	266.4

Mean values in the same column with the same superscript are not significantly different, $P>0.05$

OPF =Orange peel flour

3.2 Levels of Some Phytochemicals in Bread Samples

The levels of some phytochemicals in bread produced are presented in Table 2. The presence of phytochemicals in food could provide beneficial health effects to the consumer [6]. For all the phytochemicals studied, 0% OPF had the lowest value while 9% OPF had the highest value. Increased levels of OPF led to increase in the levels of phytochemicals. This result confirms reports that orange peels contain phytochemicals [4]. With respect to the tannins, there was no significant difference between samples containing OPF whilst for alkaloids; bread sample with 3%OPF did not significantly differ from the control. Tannins and saponins have been reported to have antioxidant and anti-mutagenic properties while alkaloids have anti-inflammatory and antioxidant properties [16]. These substances when present in high concentrations could have toxic effects on the consumers but all the levels present in this study were within safe limits [17].

Table 2. Levels of some phytochemicals in bread samples with different concentrations of orange peel flour

OPF (%)	Tannins (mg/g)	Saponins (mg/g)	Alkaloids (mg/g)
0	3.6 ^a ±0.8	0.9 ^a ±0.0	3.6 ^a ±0.3
3	6.7 ^b ±1.5	1.0 ^b ±0.0	3.8 ^a ±0.3
6	7.7 ^b ±1.0	1.1 ^c ±0.0	4.2 ^b ±0.1
9	8.0 ^b ±1.3	1.4 ^d ±0.2	4.8 ^c ±0.2

Mean values in the same column with the same superscript are not significantly different, $P>0.05$

OPF =Orange peel flour

3.3 Baking Characteristics of Bread Samples

The baking characteristics of the bread samples are presented in Table 3. The weight, volume, specific volume and oven spring of the bread samples decreased with increase in OPF. The reason for this trend could be due to the reduction in the amount of gluten and a lower ability of the dough to enclose air [18]. Gluten is responsible for the elasticity of the dough by causing it to extend and trap carbon (IV) oxide generated by yeast during fermentation. When gluten coagulates under the influence of heat during baking, it serves as a framework for the loaf, which becomes relatively rigid and does not collapse [8]. Increased substitution with OPF may have reduced the gluten content and this might explain the observed decreases in some of the baking characteristics. As seen in Table 1, there was an

increase in fibre content with increase in OPF. Decrease of specific volume with increasing levels of fibre could be due to the dilution of gluten proteins [19] and the interactions among fibre components, water and gluten [20]. Kohajdova et al., [3] observed that the volume index of biscuits decreased significantly when the amount of fibre obtained from grapefruit by-products increased in the wheat dough. Mepba et al. [8] produced bread from 100% wheat which had a specific volume of 5.3cc/g. Their value was similar to what was obtained in this study for bread made with 100% wheat. However, as they substituted wheat flour with plantain flour, there was a decrease in the specific volume. Several other researchers have also observed reduction in the volume of bread when non wheat flours were incorporated to wheat flour [7,12]. Reduction in these baking characteristics with increase in OPF could lower acceptability of the bread samples.

Table 3. Baking characteristics of bread samples with different concentrations of orange peel flour

OPF (%)	Weight (g)	Volume (cm ³)	Specific volume (cm ³ /g)	pH	Oven spring (cm)
0	15.0 ^a ±1.1	80.0 ^a ±3.2.	5.3 ^a ±0.3	4.4 ^a ±0.4	2.0 ^a ±0.5
3	13.0 ^b ±0.8	68.0 ^b ±4.3	4.8 ^b ±0.2	5.1 ^b ±0.3	1.1 ^b ±0.3
6	12.0 ^c ±0.3	55.0 ^c ±7.5	4.2 ^c ±0.3	5.3 ^c ±0.0	0.2 ^c ±0.4
9	11.0 ^c ±1.0	48.0 ^c ±6.3	3.2 ^c ±0.8	5.4 ^c ±0.2	0.2 ^c ±0.3

Mean values in the same column with the same superscript are not significantly different, $P>0.05$
OPF =Orange peel flour

3.4 Sensory Characteristics of Bread Samples

For all the sensory characteristics studied (with the exception of texture), bread samples from 0% OPF and 3% OPF did not differ significantly (Table 4). Even though 3% OPF had a lower rating for texture than 0% OPF, it was still liked by the assessors. Bread made with 9% OPF received the lowest ratings for all the attributes. Most of the attributes of 9% OPF bread were disliked slightly. Generally, increase in OPF resulted in decrease in sensory scores. Increase of OPF in bread samples resulted in bread with increased bitter unpleasant taste while the crust and crumb colour of the samples got progressively darker.

Table 4. Sensory characteristics of bread samples with different concentrations of orange peel flour

OPF (%)	Taste	Crust colour	Crumb colour	Texture	Loaf Appearance	General Acceptability
0	8.2 ^a ±0.3	8.0 ^a ±0.5	7.7 ^a ±0.7	8.0 ^a ±0.9	7.7 ^a ±1.1	8.6 ^a ±0.7
3	8.0 ^a ±0.3	7.6 ^a ±0.4	7.5 ^a ±0.5	6.9 ^b ±0.1	7.0 ^a ±0.6	8.3 ^a ±0.6
6	5.1 ^b ±0.8	5.4 ^b ±0.6	5.4 ^b ±0.5	5.7 ^c ±0.8	5.2 ^b ±0.4	7.2 ^b ±0.4
9	4.4 ^b ±0.9	4.8 ^b ±0.7	5.0 ^b ±0.4	4.9 ^c ±0.4	4.4 ^c ±0.3	6.8 ^b ±0.3

Mean values in the same column with the same superscript are not significantly different, $P>0.05$
OPF =Orange peel flour

4. CONCLUSION

This study investigated the potentials of OPF in bread production. The use of OPF in bread has the advantage of improving the fibre, ash and phytochemicals levels in bread. However only bread produced with 3% OPF had acceptable sensory quality. This bread had sensory

quality comparable to bread made with 0% OPF and is therefore recommended for practical purposes. Other samples showed depressed loaf volume and oven spring. The use of OPF in bread production will not only add value to food but also reduce the cost of importation of wheat.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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