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Effect of sourdough fermentation on the physical properties and sensory characteristics of bread made from Wheat (*Triticum aestivum*), Orange-Fleshed Sweet Potato (*Ipomoea batata* L.) and Soybean (*Glycine max* L.) Composite Flour

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Abstract
Sourdough bread was prepared by fermentation of wheat flour, orange-fleshed sweet potato and soybean composite flour using strains of Lactobacillus plantarum and Saccharomyces cerevisiae. To evaluate the effect of sourdough fermentation on the physical properties and sensory characteristics of the sourdough bread, the product was analyzed for loaf weight, height, volume, texture; crack and crust colour then subjected to sensory evaluation. The results revealed that the sourdough loaf weight, height and volume were; 153.2g, 1.88cm and 218cm^3, while the control sample was 181.1g, 1.26cm and 216cm^3, respectively. There was no significant ($p>0.05$) difference in texture, crack and crust colour. Sensory characteristics showed appearance (6.75 and 6.0), taste (6.45 and 5.83), aroma (5.66 and 4.75), texture (6.44 and 5.33) and overall acceptability (6.33 and 5.25) of sourdough bread and the control sample respectively. Fermentation positively had impact on the physical properties and sensory characteristics of sourdough bread produced. Lactic acid bacteria strains have the ability to improve loaf weight, height, volume and sensory acceptability. Sourdough fermentation technology is recommended to improve dough quality without adding baker's yeast.

Keyword: *sourdough bread, physical properties, sensory characteristics, fermentation*

Introduction

Sourdough bread is a traditional food product, fermented with sourdough, and has been known since ancient times (Lau et al., 2021; Marsh et al., 2014). Sourdough is a mixture of flour and water that is fermented by naturally occurring lactic acid bacteria (LAB) and yeast (Gänzle and Michael, 2014), the yeast produces gas (carbon dioxide) which leavens the dough, and the lactic acid bacteria produce lactic acid, which contributes flavor in the form of sourness. The application of sourdough to wheat breads produced several effects, including leavening, acidification, improvement of the dough properties, flavor of the bread, texture, delayed firmness and staling, Gocmen et al. (2007).

Fermentation is the major route for volatile formation in sourdough and bread crumb. It produces mainly acids, alcohols, aldehydes, esters and ketones (Pico, Bernal, Gómez, 2015). Acidification (especially the formation of acetic acid) is the main factor that enhances pungent flavor and diminishes fresh flavor. Sourdough fermentation improved digestibility by breaking down some of the phytates and other anti-nutrients present in wheat, making the bread more easily digestible. Sourdough fermentation increases the bioavailability of some nutrients, such as iron and zinc and

produces a unique flavor and texture that many people find appealing (Song, Perez-Cueto, Bredie, 2018). Success has been reported in the use of sourdough fermentation on the improvement of the physical quality of wheat bread and some wheat-free breads including loaf volume, height etc (Edema et al., 2013). Sourdough is considered one of the most effective methods for enhancing bread volume without relying on additives (Fraberger et al., 2020)

The acidic medium conditions the dough improves flavour and gas retention resulting in good product texture, massive bread volume; During baking of the fermented sourdough, as the temperature increases, it causes the yeast to produce carbon dioxide and alcohol that cause sudden volume rise (oven spring) (Axel et al., 2017).

Temperature affects the rate of fermentation, with optimal temperatures ranging from 20°C to 25°C. Again, longer fermentation times can result in a sourer flavor and a more open crumb texture. The type and population of microorganisms present in the sourdough starter can affect the flavor, texture, and aroma of the bread. Also, Dough hydration: The level of dough hydration can affect the rate of fermentation and the final texture of the bread.

Composite flour is defined as a mixture of flour, starch, and other ingredients to replace all or part of wheat flour in bakery and pastry products (Settanni, Ventimiglia, Alfonzo, Corona, Miceli, Moschetti, 2013). Sourdough fermentation is a complex process that can have a significant impact on the physical properties and sensory characteristics of bread, hence, the aim of this study was to determine the effect of sourdough fermentation on the physical properties of bread made from wheat (*Triticum aestivum*), orange-fleshed sweet potato (*Ipomoea batata* L.) and soybean (*Glycine max* L.) composite flour.

2.0 Materials and methods

2.1 Material procurement

Wheat flour, sugar, and salt (dangote brand), soybean, margarine, eggs and orange flesh potato were purchased from the fruit garden Market Mile 1 Port Harcourt, Rivers State, Nigeria.

2.2 Methods

2.2.1 Preparation of flour samples

2.2.1.1 Soybean flour

Soybean flour was produced according to the method described by Barber, Osuji, Onuegbu & Ogueke, (2020) with some adjustments. Three hundred (300 g) grams soybeans were steeped for 24 h. The rehydrated beans were rubbed in-between the hand to remove the hull and washed with clean water. The bean seeds was drained and boiled for 30 min at 100˚C then dried in the oven at 60˚C for 8 h. It was milled into flour and packaged until required for use.

2.2.1.2 Orange flesh potato flour

The method described by Amith, Chattopadhyay & Majundar, (2012) with some modifications was used. Five hundred (500 g) grams of Orange flesh potato tubers were peeled, washed, sliced, soaked (for 24 h), oven-dried, and milled into powder using a milling machine. The milled powder was sieved using 0.25 mm mesh and packaged for further use.

2.2 Analytical Methods

2.2.1 Physical properties of sourdough bread

The bread baking performance was evaluated by measuring the loaf weight, loaf height, loaf volume, texture, crack and crust colour. These measurements were carried out after the bread baking and cooling for 1 h.

2.2.2 Determination of loaf weight: The weight of bread samples was determined after sufficient cooling (1 h) using digital balance (0.001 g accuracy) (RADWAG Wagl Elektroniczne, WTC3000, Poland) and the values recorded in duplicates according Iwe *et al*. (2017).

2.2.3 Determination of Loaf Height (mm)**:** To determine the loaf height (H), three slices of bread were taken from the middle of the loaf and placed edge to edge. Height of the three slices of bread was measured by meter scale. The slices of bread were rotated at an angle of 90° for duplicate reading, the maximum height, highest point, of each bread loaf sample was measured in centimeters to the nearest tenth and recorded for further analysis

2.2.4 Loaf volume (cm^3): First, the weight (W) of the bread loaf was quantified then the loaf volume (V1) was determined by the Rapeseed Displacement Method according to the AACC, (2010) and modified by Iwe *et al*. (2017) using Millet seeds instead of rapeseeds. The loaf was put in a baking pan of known volume (V2) and the baking pan filled to the brim with millet seeds. The edge of a meter rule was used to cut off all seeds above the pan edge such that the seeds formed a plateau with the edge of the pan. The loaf was removed and the volume of the millet seeds (VM) was measured using a measuring cylinder.
Loaf volume (VL) was then determined according to the formula:

$$VL\ (cm^3) = V1 - V2.$$

2.2.5 Texture analysis:

2.2.6 Sensory evaluation of sourdough bread

Coded samples of the bread were presented to twenty (20) panellists comprising members of staff and students from Department of Food Science Technology, Rivers State University, Port Harcourt, for sensory evaluation. They were presented with coded samples of bread and water to rinse their mouths after tasting each of the bread samples. The samples were presented in a randomized manner such that the control sample was unidentified. The organoleptic attributes to be evaluated include: colour, taste, texture, aroma, crumb, and overall acceptability using the 9-point hedonic scale as described by Obinna-Echem, Wachukwu-Chikaodi and Okwagwung (2020). The degree of likeness was expressed as: Like extremely-9, Like very much -8, Like moderately-7, Like slightly-6, Neither like nor dislike-5, Dislike slightly-4, Dislike moderately-3, Dislike very much-2, Dislike extremely-1.

2.2.6 Statistical analysis

All data were expressed as means of three independent trials with standard deviation. Minitab 18.0 version statistical software was used to assess difference between treatments and data subjected to analysis of variance (ANOVA). Means were compared and Duncan's multiple range test was used to separate means where differences exist, and 5% significance was accepted.

3.0. Results and Discussions

The effect of sourdough fermentation on the physical properties of sourdough bread made from wheat orange-fleshed sweet potato and soybean composite flour is displayed in Tables 3.

The highest bread weight (181.1 g) was recorded in the control sample (bread made using commercial yeast) while the sourdough bread had the lowest weight (153.2 g). The sourdough bread loaf weight was lower than 245.75–246.97 g reported by Gänzle, & Zheng, (2019) but higher than 123.03–141.87 g reported by Adisa *et al*. (2019). Weight improvement is not to the advantage of the baker as consumers may not be attracted much. High weight value of bread could be traced to higher bulk density of flour.

Loaf height, as an indicator of the increase in volume, was measured based on the highest point of the sourdough bread (Table 3). Loaf height varied between 6.88 and 6.26cm for sourdough and bread leaven with baker's yeast, respectively. Sourdough bread was significantly ($p < 0.05$) higher than the control due to sourdough fermentation.

The loaf volumes were determined from the sourdough bread after 1 h of baking. Sourdough bread had the highest loaf volume of 218 cm^3 while the control sample was the lowest (216 cm^3). High loaf height could be due to the higher retention of gas released during sourdough fermentation. High loaf volume in this study is a welcome development and will attract more sales with income since consumers purchase breads based on size. The loaf volume values in this study were lower than 249.1–500.61 g/cm^3 reported by Adisa *et al*. (2019) for sourdough breads from whole wheat-Bambara nut flour and whole grain millet. In terms of loaf volume sourdough bread tends to have a larger volume and lower density than traditional bread due to the increased carbon dioxide production. The variations could be traced to flour type, protein quality and the level of yeast activities. Texture, crack and crust colour properties of the bread samples showed respectively, hard, medium, dark brown for sourdough bread and the control samples. For crumb texture, sourdough fermentation produces a more open, tender, and aerated crumb texture due to the production of carbon dioxide and the breakdown of starches. Similarly, crust color and texture become darker, crisper, and more flavorful due to the Maillard reaction, a chemical reaction between amino acids and reducing sugars.

Table 3 Effects of sourdough fermentation on the physical properties of sourdough bread

Sample	Weight (g)	Height (cm)	Volume (cm^3)	Texture	Crack	Crust colour
SD	153.2 ± 0.06^b	6.88 ± 0.06^a	218 ± 0.06^a	Hard	Medium	Dark brown
CB	181.1 ± 0.06^a	6.26 ± 0.06^b	216 ± 0.06^b	Hard	Medium	Dark brown

Values are means ± standard deviation of duplicate determination. Means that do not share a letter are significantly different (P<0.05).

SD = sourdough bread

CB = bread baked using commercial yeast

Effect of sourdough fermentation on the sensory characteristics of bread from wheat orange-fleshed sweet potato and soybean composite flour on the basis of appearance, taste, texture, aroma and overall acceptability is displayed in Tables 4. Results showed significant ($p<0.05$) difference between the bread samples in all the sensory attributes. Differences were observed in the appearance, taste, aroma and overall acceptability of the bread samples. The aroma of sourdough bread is often described as more intense, fruity, and slightly sour. The bread leavened with Saccharomyces cerevisiae was sweet while sourdough bread was sour. It had been reported that

yeasts make a useful contribution to the improvement of flavour and acceptability of fermented cereal gruels, sourdough fermentation produces a more complex, tangy, and slightly sour flavor profile due to the production of lactic acid and other compounds (Fraberger, Ammer and Domig, 2020). Many of the taste panel members commented that the sourdough was creamy in terms of mouthfeel; the mouthfeel of sourdough bread is often described as more tender, creamy, and satisfying.

The effect of sourdough fermentation on the sensory characteristics of sourdough bread is presented in Table 4. Sensory scores varied from 6.75 (appearance) 6.45 (taste), 5.66 (aroma), 6.44 (texture), 6.33 (overall acceptability) for the sourdough bread and 6.0 (appearance), 5.83 (taste), 4.75 (aroma), 5.33 (texture) and 5.25 (overall acceptability). Sample likeability rating test, as reported by Rosales-Juárez *et al*., (2018), was carried out on two selected samples, where a hedonic scale (nine levels of acceptance) was used, asking to grade the samples with values from 9 for the "like extremely" level of acceptance down to 1 for the "dislike very much" level of acceptance. The evaluation was performed with a panel that consisted of 20 non-trained (adults) as the product was intended for.

Table 4 Effect of sourdough fermentation on the sensory characteristics of sourdough bread

Sample	Appearance	Taste	Aroma	Texture	Mouthfeel	Flavour	Overall acceptability
SD	6.75 ± 0.06^{a}	6.45 ± 0.04^{a}	5.66 ± 0.10^{a}	6.44 ± 1.10^{a}	Creamy	Sour	6.33 ± 0.02^{a}
BYS	6.0 ± 0.11^{b}	5.83 ± 0.00^{b}	4.75 ± 0.04^{b}	5.33 ± 0.03^{b}	Tender	Sweet	5.25 ± 0.05^{b}

Values are means ± standard deviation of duplicate determination. Means that do not share a letter are significantly different (P<0.05).

SD = sourdough bread

BYS= sample leavened with baker's yeast

4.0. Conclusion

The study showed that sourdough fermentation had significant impact on the physical properties and sensory characteristics of sourdough bread produced. Adding orange-fleshed sweet potato and soybean to wheat flour to produce sourdough bread is an effort to substitute or minimize imported wheat flour in Nigeria. Sweet potatoes and soybean price is low and easily obtained in the local market. They contain carbohydrates and calories equivalent to wheat flour.

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