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Substitution of Wheat Flour by Ginger Residue Flour in the Production of Bread

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Abstract: In developing countries, bread is a commodity inaccessible to the most vulnerable populations. This inaccessibility worsened with the war in Ukraine leading to an increase in the price of wheat on the world market. This study was carried out with the aim of valuing the residue of ginger in partial substitution of wheat flour by that of ginger in the manufacture of bread in order to reduce the cost of bread. The residues were obtained after grinding the ginger then maceration in water and at the end of filtration of the macerate. The residue obtained is dried at 60°C. for 24 hours then ground and packaged in a plastic bowl. The formulation was made by mixing 5 g of residue flour with 95 g of wheat flour. The physicochemical and functional properties of the flours were determined followed by the sensory evaluation of the breads produced. Substitution of 5% wheat flour resulted in reduced moisture (11.15%) and improved fiber content (5.15%). Regarding functional properties, the ginger residue resulted in an increase in water absorption capacity (128.21%) and swelling capacity (12.66 g/g). The sensory evaluation showed that the sweet bread produced with the ginger residue was the most appreciated. This study suggests that ginger residues could be valorized in the production of sweet bread.

Keywords: Residue, Ginger, Bread, Wheat Flour, Ginger Flour

1. Introduction

Food security remains a major problem in developing countries. There is a need to increase global food production to meet future demand from a growing population of around 9 billion in 2050 [1]. According to FAO, wheat production in the world over the period 2022-2023 will be 784 million tons [2]. This production of wheat for its transformation into bread and derivative products meets market needs. Most wheat breeding criteria are based on their ability to produce large loaves. Thus, the consumption of wheat has increased due to the increase in the world population. Added to this is the change exotic food habits adopted by most non-wheat producing countries.

In Africa, although it has never been part of the staple diet, the consumption of wheat flour has increased in recent years [3]. According to United Nations in 2014, approximately 60% of Africa's population would live in urban in 2050, which would cause to increase the demand for wheat-based foods [4]. Currently, Africa only produces about 27 million tons of the wheat, with the rest imported [5]. This dependence on imports is harmful to African economies. This situation worsened with the war in Ukraine by the rise in the price of wheat on the international market. In view of this situation, the use of alternative sources of flour with a view to a partial substitution of wheat is encouraged [6].

Bread is a widely consumed wheat flour product around. It is obtained by fermentation from wheat flour, water, yeast and salt. Studies have reported using blended flour as a way to reduce dependence on wheat for the production of baked goods [7]. These results have shown that the partial substitution of wheat flour by cassava flour in bread-making yields bread good quality [8]. Other tropical flours have also been incorporated into wheat flour for the production breads with soybeans, corn and millet [9]. However, there are no data on the use of agricultural residues in the production of bread.

Thus the objective of this study is to evaluate the organoleptic characteristics of the bread produced by incorporating residues of *Zingiber officinale* (ginger) for its valorization.

2. Material and Methods

2.1. Material

2.1.1. Material Biological

Biological material used consists of ginger, wheat flour type 55 and baker's yeast that were purchased from the Korhogo market in Northern of Ivory Coast.

2.1.2. Chemicals

All solvents (n-hexane) were purchased from Merck. Sulfuric acid, Bomothymol green, red methyl and sodium chlorure were purchased from Sigma-Aldrich. All chemicals used in the study were of analytical grade.

2.2. Methods

2.2.1. Flour Production

Ginger are sent to the laboratory where they are sorted, washed with distilled water and stripped of their skin then crushed in a blender with 500 mL distilled water. After filtration, residue is pressed, then rinsed several times with distilled water and dried in an oven (Memmert) at 60°C for 24 hours. After 24H dried residue are crushed using a micro-grinder (culatti) equipped with a mesh screen 10µm and packaged in a plastic jar.

2.2.2. Preparation of the Compound Flour

Flour production was carried out according to the method described by [9]. 5 g Ginger flour were mixed with 95 g of wheat flour type 55.

2.2.3. Physicochemical Analysis

Proximate analysis was performed using official methods [10]**.** "The moisture content was determined by the difference of weight before and after drying flour (5 g) in an oven (Memmert, Germany) at 105°C until constant weight. Ash fraction was determined by the incineration of flour (5 g) in a muffle furnace (Pyrolabo, France) at 550°C for 12 h. Proteins were determined through the Kjeldhal method and the lipid content was determined by Soxhlet extraction using hexane as solvent". Carbohydrates were calculated using the following formulas [11]**:** Carbohydrates (%) = 100 – (% moisture + % proteins + % lipids + % ash).

2.2.4. Functional Properties Analysis

Water absorption capacity (WAC) and water solubility index (WSI) were determined according to the par [12] with slight modification. One (1) g of flour is mixed with 10 mL of distilled water for 30 min. Mixture is centrifuged during 10 min at 1200 trs/min. The pellet is weighed and the supernatant is dried at 105°C. Water absorption capacity and water solubility index were determined to the following formula:

$$WAC\ (\%) = [(Pm - Sw) / Sw] \times 100$$

with Pm: pellet mass, Sw: flour weigh

$$WSI\ (\%) = [ms / Sw] \times 100$$

with ms: supernatant dried mass.

Swelling capacity (SC) was determined according to the method [13]. Four (4) g of flour is homogenized in 40 mL of distilled water. Mixture is heated at 90°C for 1h. After 1h, the tube is cooled and then centrifuged at 5000 rpm for 10 min. The pellet is weighed and then dried at 105°C and finally weighed. The following formula was used for to determine the swelling capacity:

$$SC\ (g/g) = Pm / [Sw\ (1 - Mo) \times (100 - So)]$$

with Pm: pellet mass, Sw: flour weight, Mo: moisture, So: solubility.

2.2.5. Bread Production

Pasta was produced according to the method of [1].

Table 1. *Different formulations.*

Ingredients	Bastard bread (ordinary)		Sweet bread	
	Control bread	Incorporated bread	Control bread	Incorporated bread
Wheat flour (%)	100	95	100	95
Ginger flour (%)	0	5	0	5
Water (%)	60	60	60	60
Sugar (%)	0	0	15	15
Yeast (%)	1.5	1.5	1.5	1.5
Oil (%)	0	0	2	2
Salt (%)	1.5	1.5	0	0

The stages of bread production are: kneading, pointing, dividing, relaxing, shaping, proofing, cooking and unloading.

2.2.6. Sensorial Analysis

Hedonic test using twenty (20) untrained subjects was used for sensory analysis [14]. The test focused on of appearance, color, smell and taste on a scale from 1 to 9 points which indicates the level of panelist preference. The breads are coded according to the formulation (4 breads) and submitted to each panelist randomly.

2.2.7. Statistical Analysis

The statistical analyses were performed with Graph Pad Prism software version 8.0.2 (263). The variance analysis (ANOVA) was performed to determine differences between the averages according to method of Turkey at the 5% threshold ($p<0.05$ was considered significant). The results were expressed as averages with standard error on mean (mean ± SEM).

3. Results and Discussion

3.1. Physicochemical Properties

Table 2 presents the results of the physicochemical analyses. The physicochemical parameters are significantly different ($p < 0.05$). Moisture contents of different flours are statistically different. Ginger flour (9.48±0.12%) has the lowest content followed by formulated flour (11.15±0.13) and wheat flour (11.85±0.35%. These contents are lower than those in wheat flour (10.75%), voandzou (7.07±0.35%) and flour incorporated at 5% (8.83± 0.51%) voandzou flour [15]. This difference would due to the drying time of our samples. These low levels may not influence the quality and functionality of the flours. Moreover, with contents lower than 12%, flours could limit the proliferation of microorganisms, in particular moulds, which would lead to their conservation over a long period [16]. Wheat flour (0.53± 0.03%) records the highest ash content followed by 5% incorporated flour (0.45 ± 0.02) and ginger flour (0.12 ± 0.02%). Ash content of incorporated flour is lower than that in wheat flour incorporated with 5% corn flour [17]. Ash content in formulated flour is higher than those in maize flour [18]. The low ash content in ginger flour is thought would due to the leaching of minerals into the water during the extraction of ginger juice. Proteins contents vary from 5.60 ± 0.13% to 12.53 ± 0.71%. Proteins content in ginger is higher than those in Dioscorea cayenensis flour [18]. The low proteins content of the different formulation would explained by the fact that cereals and ginger are not good sources of protein. Lipids contents oscillate between 0.05 ± 0.01 and 1.83 ± 0.27%. These levels are higher than those and in taro sosso flour (0.40%) and in artisanal infant flour (1.3%) [19, 20]. With these low lipids levels, the consumption of the flours studied could be advantageous for obese people. Carbohydrates are the main components of cereals. Total carbohydrates are highest in ginger (84.75 ± 0.18%), followed by formula (76.24 ± 0.35%) and wheat flour (73.26 ± 0.55%). Total carbohydrates of ginger are made up of 55.55% fibers and those of wheat and the formulation 2.89% and 5.15% respectively. Fibers content of our formulation is higher than that in wheat flour at 5% voandzou flour (1.12%) [15]. The high content of our formulation could be beneficial for the consumer since the fibers facilitate intestinal transit [21].

Table 2. *Physicochemical properties of different flours.*

Parameters	Wheat	Ginger flour	Incorporated ginger
Moisture (%)*	11.85± 0.35a	9.48± 0.12c	11,15± 0.13b
Ash (%)	0.53± 0.05a	0.12± 0.02c	0.45± 0.02b
Proteins (%)	12.53± 0.71a	5.60± 0.13c	10.93± 0.15b
Lipids (%)	1.83± 0.27a	0.05± 0.01c	1.23± 0.09b
Total carbohydrates (%)	73.265± 0.55c	84.75± 0.18a	76.24± 0.35b
Fibers (%)	2.89± 0.42c	65.55± 0.61a	5.15± 0.05b

Data are represented as Means ± SD (n = 3). Means in the line with no common letter differ significantly ($p<0.05$) for each flour

3.2. Functional Properties

Functional properties of the different flours are presented in Table 3. Wheat flour with the highest solubility index (11.13%) followed by formulated flour (8.56%) and finally ginger flour (3.93%). These solubility indices are lower than those in flours formulated (≥ 28%) with wheat and voandzou [15]. The low solubility index of ginger is due to the leaching of certain substances such as starch and soluble sugars during the extraction of the juice as well as to its high fiber content. Solubility of a product depends on the level of amylose in the starch and its origin [22]. Water absorption capacity is an essential indicator that allows to know if flours can be used food formulations water using [23]. Ginger flour (330.33%) records the highest water absorption capacity followed by formulated flour (128.21%) and wheat flour (112.18%). These values are higher than those in the flour of three cassava varieties (103.81 ± 1.13 to 116.42 ± 5.18%) Madagascar [24]. This high water absorption capacity in ginger and formulated flours would be due to their high fiber content, the water retention of which is proportional to the fiber content [25]. Ginger flour with a very high water absorption capacity could be an important ingredient in the manufacture of bakery products [26]. It will allow the addition of more water to the dough facilitating its manageability while preserving the freshness in the bread. Swelling capacity varies from 12.15 to 15.83 g/g. Ginger flour has the greatest swelling capacity unlike wheat flour and formulated flour which have statistically identical swelling capacities. Swelling capacity obtained in our different flours coincides with those in sorghum (12 to 15 g/g) and millet (11 to 15 g/g) flours [27]. High capacity in ginger flour would be explained by the water retention capacity of the fibers unlike starch which gelatinizes and leads to its solubilization.

Table 3. *Functional properties of different flours.*

Parameters	Wheat	Ginger flour	Incorporated ginger
Water solubility index (%)*	11.13± 0.65a	3.93± 0.30c	8.56± 0.15b
Water absorption capacity (%)	112.18± 0.05c	330.23± 0.28a	128.21± 0.33b
Swelling capacity (g/g)	12.15± 0.23b	15,83± 0.15a	12.66± 0.45b

Data are represented as Means ± SD (n = 3). Means in the line with no common letter differ significantly ($p<0.05$) for each flour

3.3. Sensory Characteristics

Results of the sensory analysis are presented in figure 1. Concerning the bastard bread, there is a significant difference between control bread and bread made from the formulated flour. Control bread is more appreciated with an acceptability score of 5.154 against 3.17 for the formulated bread. Tasters did not appreciate the color (4.04), the smell (4.25) and the taste (2.28) of the formulated bread (2.28) compared to the control bread. These results are similar to those in bread produced with wheat flour and fermented cassava flour [28]. Depreciation of formulated bread could be attributed to the pungent smell and taste of ginger. For sweet bread, the scores are statistically identical. The color, appearance and smell of bread produced with formulated flour are more popular than that of sweet wheat-based bread. Contrary to these criteria, the taste of sweet bread made from wheat is more appreciated. The appreciation of sweet breads could be due to the sugar and oil added during the production of the pasta.

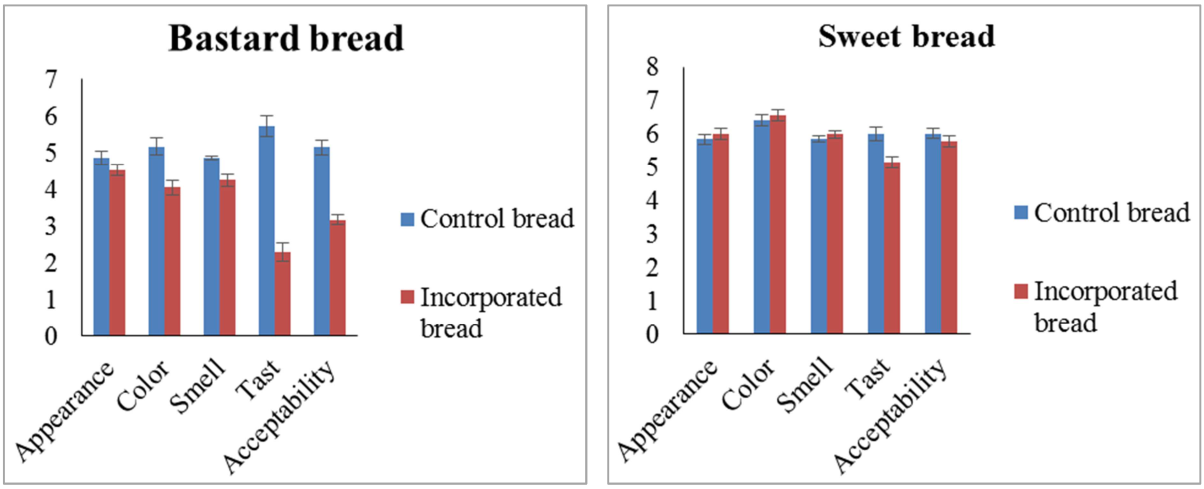

Figure 1. *Sensory characteristics of the breads produced.*

Bastard bread control Bastard bread formuled Sweet bread control Sweet bread formuled

Figure 2. *Different formuled breads.*

4. Conclusion

Agricultural residues are generally underutilized in developing countries. In order to valorize them, the impact of the incorporation of ginger residue in wheat flour on the physicochemical, functional and sensory properties of the bread produced were evaluated. After evaluation, the results revealed that the incorporation reduced the moisture content and increased the fiber content, the water absorption capacity and the swelling capacity of the flour. This reduction in humidity could be advantageous for the preservation of the flour. As for the increase in fibers, water absorption capacity and swelling capacity, it would be beneficial to the baker and the consumer. The sweet bread produced is most appreciated. It would be desirable to compare ginger residue with other agricultural residue such as cocoa placenta and to assess their digestibility in order to contribute effectively to the food security of populations.

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