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Screening and Partial Substitution of Indigenous Wheat Cultivars with Millet and Cassava Flours: Impact on Bread Volume and Acceptability

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Abstract

Locally, bread was made using native Nigerian wheat flour, with a 10% equal substitution of millet and cassava flour. After the physicochemical characteristics of the resultant flour samples were examined and contrasted with the control sample, the volume of the resulting bread was calculated. Every result was contrasted with that of a Northern Nigerian flour mills plc. Kano (control sample). When comparing Atilla gan atilla to other local wheat cultivars, the results showed no significant difference ($p \geq 0.05$) in bread volume, protein content, or total energy. Because of the conditioning process, the wheat flour had a higher moisture content than the millet grain flour. The wheat samples had the highest protein content of all the millet samples used in this analysis. Due to the rise in wheat imports, the study recommended the need to use locally grown wheat flour to produce bread with even substitution with millet and cassava rather than relying solely on the imported ones, which may lower expenses and boost the Agricultural Transformation Agenda.

Keywords: *Bread, Substitution, Nigerian indigenous grains, Wheat flour, Millet flour, Baking test*

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Background to the Study

Bread is a baked good made from starchy flour and cereal that has been moistened, kneaded, and baked (IFIS, 2009). The majority of Nigerians primarily consume flour products for breakfast, lunch, and occasionally dinner (Sanful and Darko 2010). These products are composed of four basic ingredients: flour, water, yeast, and salt (Ihekoronye, 1985). Nigerian bread consumption and prices are stable and rising, with foreign wheat serving as the primary ingredient (Sanful and Darko 2010).

Numerous studies have been carried out to encourage the use of composite flours, which reduce the amount of imported wheat and increase demand for locally grown crops by substituting some locally grown bread for imported wheat flour (Sanful and Darko 2010). Thanks to developments in food science and technology, baked goods can now be produced by partially substituting nonwheat flour from cereals, legumes, and roots or tubers for wheat flour (Arowolo *et al.,* (2011). Gero/maiwa/dauro is the Hausa term for pearl millet (Ajeigbe *et al.,* in 2020). According to Izge and Song (2013), it is regarded as a staple food for millions of people in arid and semiarid parts of the world, particularly northern Nigeria. The nation's food security is positively impacted by its drought-resistant crop (Saleh *et al.,* (2013). According to Izge and Song (2013), pearl millet is used as a staple grain in northern Nigeria in millions of tons.

Pearl millet grains are generally free of any significant antinutritional factors that lower the bioavailability of nutrients, according to research (Izge and Song 2013). Technologies for processing millet encourage its use as food for the world's large and expanding population (Saleh, Zhang *et al.,* (2013). In addition to helping to reduce antinutritional factors like phenols, phytic acids, and tannins, another study verified that processing enhances the grains' dietetic and sensory qualities (Ramashia *et al.,* 2019).

Nutritionists, food scientists, and technologists are now greatly interested in the possible health advantages of millet grain (Saleh *et al.,* 2013). Millet grains are characterized by high carbohydrates concentrations, dietary fiber, and essential amino acids, phytochemicals and essential minerals. Additionally, it can lower the nutritional risk of gastrointestinal tract disorders, high blood pressure, and diabetes mellitus. The nutritional qualities and utility of millet flours have not been thoroughly investigated (Ramashia *et al.,* 2019). A herbaceous perennial crop belonging to the Euphorbiaceae family, cassava (*Manihot esculentacrantz*) is widely consumed in Nigeria as the main staple diet. For families with low and moderate incomes, it has been regarded as a significant nutritional source of dietary energy (Nwosu et al., 2014. The bakery, pharmaceutical, food, and clothing industries all use cassava tubers as raw materials. Since cassava is the primary plant part used in developing nations, the nutritional value of cassava roots is also significant. Hasmadie *et al.,* in 2020). According to Nwosu *et al.,* 2014, the Igbo, Yoruba, and Hausa tribes, cassava is commonly referred to as "akpu," "ege," and "rogo.".

Materials and Methods

Materials

Lake Chad Research Institute, Maiduguri, supplied three Nigerian indigenous millet grains and three local (indigenous) wheat varieties (Seri-M82, Cettia, and Atilla gan Atilla) for this study. Hard winter wheat flour (control) and a variety of cassava flours were supplied by Northern Nigeria Flour Mills, plc. Kano. The reagents and tools for production and analysis were supplied by the labs of these participating institutions.

Methods

The Department of Food Science and Technology, Kano University of Science and Technology Wudil, and Northern Nigeria Flour Mills, plc were the three locations where the study was carried out due to the circumstances. Kano.

Sample Preparation

Samples of local millet and wheat were manually cleaned using a tray. All undesired materials, including stones, metal objects, light debris, and animal parts, were eliminated. To make bran removal easier with a mortar and pestle, each variety was conditioned to a moisture content of roughly 14%. After the wheat and millet samples were cleaned, sorted, tempered, and dehulled, they were ground using hammer milling machines (HM0274, Japan Model) and then run through a sieve with an aperture of DIN 4188 (0.12 mm). In Kano, Nigeria, the northern Nigerian flour mills plc. provided the processed cassava flour.

Formulation of Blends

Three out of the eight bread samples were made using all three of the indigenous wheat flours from Nigeria. Atilla Gan Atilla, the sample with the highest percentage of gluten, crude protein, and bread volume, was selected for further substitution with super sosat, the millet flour variety with the best percentage of crude protein among the three. Using 90 percent, 80 percent, and 70 percent Atilla Gan Atilla flour (the best-selected local wheat flour) in place of 10 percent, 20. In another version, a portion of the chosen local wheat flour was replaced with 10% cassava flour. Last but not least, the final sample was used as a standard control, producing bread using imported hard winter wheat flour from Northern Nigeria Flour Mills Kano.

Table 1: Formulations of flour blends for screening and partially substituting native wheat cultivars with cassava and pearl millet to increase bread's volume and acceptability.

	Formulations							
Ingredients	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**
hard winter wheat	100	0	0	0	0	0	0	0
Seri-M82	0	100	0	0	0	0	0	0
Cettia	0	0	100	0	0	0	0	0
Atillagan Atilla	0	0	0	100	90	80	70	90
Sosat	0	0	0	0	0	0	0	0
Super sosat	0	0	0	0	10	20	30	0
LCIC 9702	0	0	0	0	0	0	0	0
Cassava	0	0	0	0	0	0	0	10
Total	100	100	100	100	100	100	100	100

Bread-Making Process

Bread is made with the following percentage of ingredients: flour, yeast, fat, salt, sugar, and water. Optimal sorption was achieved using 500 g of flour, 2 percent flour basis mixture of compressed yeast, 1 percent flour basis mixture of sodium salt, 1 percent flour basis mixture of sugar, 3 percent flour basis mixture of fat, and 500 Brabender units of distilled water. The ingredients were mixed for 4 min, allowed to rest for 10 min, divided (100 g), kneaded and then allowed to rest (15 min). We followed the procedure outlined by Iglesias-Puig and Haros (2013) when making the bread.

Chemical Analyses of the Samples

The percentage of dry and wet gluten, the baking test, and the proximate composition (moisture, crude protein, fat, ash, fiber, and carbohydrate contents) were all ascertained (using the AOAC standard procedures).

Determination of Proximate Composition and Energy Value

The proximate compositions (moisture content, crude fiber, crude fat, total ash, and crude protein contents) of both grains (wheat and millet) and flour were determined via standard methods as described previously (A.O.A.C. 2012). carbohydrate content was determined by following difference: Carbohydrate (%) = 100 – (% protein + % fat + % fiber + %ash + % moisture)

Estimation of Energy Value

The energy value (kca/100 g) was calculated via the Atwater factor method described by (Obiegbuna, 2005). The fat, protein, and carbohydrate contents were multiplied by their physiological fuel values of 9.0, and 4.0, respectively, and the sum of the products was taken.

$$\text{Energy value} = (4 \times P) + (9 \times F) + (4 \times C)$$

Where;
P = protein (%)
F = Fat content (%)
C = Carbohydrate content (%)

Wet Gluten

The percentage of wet gluten was calculated using the procedures outlined by ICC (1960). After being weighed, a total of 10 g of the flour sample was put into a metal vessel with enamel. Five milliliters of sodium chloride solution were added to the vessel's weighed flour, stirring constantly with a spatula, until a dough formed. The dough was then shaped, tied to cheesecloth, and washed with 250 milliliters of 2% salt solution.

The dough was removed from the cloth, rinsed with tap water to remove any leftover starch, and then weighed (gelatinized gluten).

Calculation:

Weights 10× were used to obtain the percentage of wet gluten.

Dry Gluten

Wet gluten percentage was calculated using the procedures outlined by (ICC, 1960). Wet gluten was baked for an hour at 180 degrees Celsius. After dry bulb gluten developed, it was taken out and dried for five minutes in a desiccator before being weighed.

Calculation:

Weights obtained × 10 = percentage dry gluten

Sensory Assessment of Bread

The different bread samples were appropriately labeled and made available to the panelists. They were given bottled water to rinse their mouths after tasting each sample to prevent interfering with the next one, and they evaluated the samples based on the grading parameter on the questionnaire that was given to each panelist. The method outlined by Iwe (2002) was used to perform the sensory evaluation of the bread. Twenty panelists graded the various samples using a nine-point hedonic scale based on the following criteria: taste, texture, appearance, aroma, and general acceptability.

Statistical Analysis

The new Duncan multiple ranged test (NDMRT) was used to separate the means after all analyses were performed in triplicate and subjected to analysis of variance (ANOVA). Every sample's mean and standard deviation were determined and contrasted. Analysis of the results was done using SPSS for Windows version 21.0.

Results and Discussion

Proximate Composition and Energy Value of Millet and Wheat Grains

Tables 2 and 3 show the energy value and approximate composition of local (Nigerian indigenous) millet and wheat grain samples. There was no significant difference ($p<0.05$) in the moisture content of the millet grain samples, which ranged from 8.35 to 9.45 percent. The local samples (Nigerian indigenous wheat grains) had a moisture content ranging from 11.65-14.4 percent, while the control samples had a significantly lower moisture content ($p<0.05$). The quantity of water molecules included in a food product is referred to as its moisture content. Samples with a high moisture content are more likely to spoil and have a shorter shelf life (FAO, 2003). These grains' shelf stability decreases with increasing moisture content. Therefore, dried goods with a low moisture content have a longer shelf life. Additionally, it significantly affects the taste, texture, appearance, weight, shape, and shape of products (Moore, 2020).

There was no discernible difference in the fat content between the samples of sosat and super sosat millet grain, which ranged from 4.60 to 5. 20 percent. With only 1.75 percent fat, LCIC 9702 had a much lower fat content. All of the wheat grain samples had fat contents that were not significantly different from one another, with the range of 1.74 to 1.89 percent and the control sample's fat content being 2. 25 percent. Super Sosat had a significantly higher ($p< 0.05$) protein content (9.35 percent) than both Sosat and LCIC9702. Because of the comparatively high percentage protein content of the Super Sosat, millet grain samples were chosen for substitution in the bread production process in this study. The protein content of the Sosat and LCIC 9702 samples was 8.35, 7. 70 percent, respectively.

There was no significant difference ($p<0.05$) in the percentage protein content of the wheat grains (Cettia, Seri M82, and Atilla Gan Atila) between the hard winter wheat grain from Northern Nigeria Flour Mills, plc and the local Nigerian indigenous wheat grain, Atillagan Atilla. Kano. The wheat grain chosen for further substitution is Atillaganatilla due to its comparatively high protein content.

Table 2: Proximate composition and energy value of millet grains

Sample	Moisture (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	CHO (%)	E V (Kcal/100g)
SST	9.45 ± 0.007^{a}	$8.35.\pm0.07^{b}$	5.20 ± 0.28^{a}	3.05 ± 0.07^{ab}	2.00 ± 0.00^{a}	71.96 ± 0.35^{c}	367.84
SSST	8.35 ± 0.07^{b}	9.35 ± 0.07^{a}	4.60 ± 0.07^{a}	3.30 ± 0.14^{a}	1.53 ± 0.00^{b}	72.82 ± 0.07^{b}	369.63
LCIC	9.15 ± 0.21^{a}	7.70 ± 0.21^{c}	1.75 ± 0.21^{b}	2.90 ± 0.14^{b}	1.87 ± 0.16^{a}	76.68 ± 0.08^{a}	353.09

The values are the means ± standard deviations of three determinations. Values with different superscripts in a column are significantly different at p<0.05. SST= Sosat, SSST= Super sosat and LCIC= LCIC 9702 CHO = carbohydrate

Table 3: Proximate composition and energy value of wheat grains

Sample	Moisture (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	CHO (%)	E V(Kcal/100g)
AGATL	14.4±0.14[a]	11.85.±0.07[a]	1.85±0.07[a]	3.05±0.07[a]	1.58±0.92[a]	67.28±0.31[d]	333.15
SM82	11.65±0.07[b]	8.70±0.42[b]	1.74±0.02[a]	3.05±0.07[a]	0.85±0.15[b]	74.80±0.08[b]	348.10
CTA	11.65±0.07[b]	6.95±0.07[c]	1.89±0.14[a]	2.95±0.07[a]	0.35±0.05[b]	75.73±0.04[a]	347.71
CTRL	10.25±0.35[c]	12.25±0.35[a]	2.25±0.35[a]	1.95±0.07[b]	1.40±0.14[a]	71.90±0.28[c]	356.85

The values are the means ± standard deviations of three determinations. Values with different superscripts in a column are significantly different at p<0.05. AGATL = AtillaGanAtilla, SM82 = Seri M82, CTA = CETTIA and CTRL = Control, CHO = carbohydrate.

Proximate Composition and Energy Value of Wheat Flour

Table 3 displays the wheat flour's proximate composition. Atilla Gan Atilla Seri M82 and Cettia, local (Nigerian indigenous wheat flour), had moisture contents ranging from 11 to 14. 90%. The atilla gan atilla samples had a significantly ($p<0.05$) higher moisture content than the other samples, including the control. This could be due to the drying technique used (Ijahet al. in 2014). The samples' high moisture content suggests that they are comparatively susceptible to spoiling, which results in a short shelf life (FAO, 2003). A low moisture content guarantees greater shelf stability in any product, as the higher the moisture content, the lower the shelf stability of the products (Moore, 2020). With a moisture content of 11.04%, the Seri M82 sample had the lowest moisture content of any flour made from indigenous Nigerian wheat.

All local (Nigerian indigenous wheat) flour samples had fat contents between 1.10 percent to 1.50 percent, while the control sample had a fat content of 0.90 percent. Since the germ contains oil, minerals, and vitamins, its removal during processing is the reason why the wheat grains have a higher fat content than the flour samples. This is consistent with the findings of Ihekoronye and Ngoddy (1985), who claimed that because the germ is found at the bottom of the grain kernel and contains oil, it is removed along with the bran. Liu and colleagues (2017), concluded that the final flour's nutrient content decreases with the amount of highly processed wheat grains.

Each of the local (Nigerian indigenous wheat) flour samples had a protein content between 6.30 to 9.86 %, with atilla gan atilla having the highest protein content at 9.85 percent and cettia having the lowest at 6. 30 percent. The control sample had a protein content of 10.90 percent, which was significantly high ($p<0.05$). When given to children, a product's high protein content is a key indicator for encouraging the growth, development, and repair of worn-out tissues. Arnarson (2017) asserts that protein is a vital nutrient for growth and one of the main constituents of bodily tissues. In comparison to all local (Nigerian indigenous wheat) flour, the flour's crude fiber content ranged from 0.63 to 0.78, and it was not significantly different ($p<0.05$); the control flour had the lowest crude fiber content, at 0.55 percent. The high protein content of the flour may be the cause of the low dietary fiber content. One risk factor for chronic childhood constipation is a diet low in fiber (Soile 2011).

The type of milling machine used and the degree of flour extraction are the reasons why local (Nigerian indigenous wheat) flour has a higher crude fiber content than the control flour. Numerous studies have demonstrated the important role that dietary fiber plays in human health. The avoidance of a number of illnesses, including diabetes, cancer, diverticulosis, constipation, irritable colon diseases, and cardiovascular diseases (Slavin, 2005). The flour had the lowest ash content (0.69 percent, $p<0.05$), and the range was 0.87 to 1.00 percent. When a sample of flour is burned to ash, the mineral content of the flour increases as the extraction rate increases (Scade, 1975). Ash is what's left over after burning that is inorganic (mineral) (Harris, 2017).

Table 4: Proximate composition and energy value of wheat flour

Sample	Moisture (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	CHO (%)	E V (Kcal/100g)
AGATL	14.90 ± 0.14^{a}	$9.85.\pm0.07^{b}$	1.10 ± 0.14^{bc}	0.75 ± 0.07^{a}	0.85 ± 0.01^{b}	72.56 ± 0.14^{c}	339.50
SM82	11.04 ± 0.14^{d}	8.60 ± 0.14^{c}	1.30 ± 0.0^{ab}	0.63 ± 0.04^{ab}	1.00 ± 0.14^{a}	77.08 ± 0.05^{b}	354.40
CTA	12.15 ± 0.21^{c}	6.30 ± 0.28^{d}	1.55 ± 0.07^{a}	0.78 ± 0.04^{a}	0.87 ± 0.14^{b}	78.36 ± 0.40^{a}	352.57
CTRL	13.75 ± 0.07^{b}	10.90 ± 0.28^{a}	0.90 ± 0.14^{c}	0.55 ± 0.07^{b}	0.69 ± 0.03^{c}	73.21 ± 0.40^{c}	346.54

The values are the means ± standard deviations of three determinations. Values with different superscripts in a column are significantly different at p<0.05. AGATL = AtillaGanAtilla, SM82 = Seri M82, CTA = CETTIA and CTRL = Control

Fig. 1: Percentage Bread volume of Locally Grown Wheat

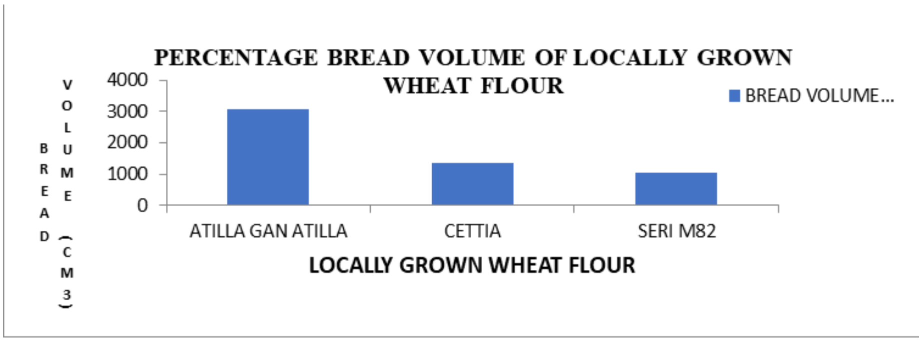

Fig. 2 a: 100% Atilla Gan Atilla Bread

Fig. 2 b: 100% Foreign wheat flour bread from Northern Nigeria Flour Mills Plc, Kano

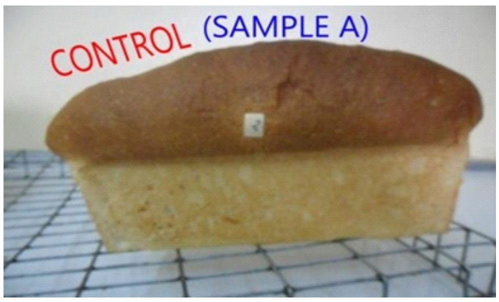

Fig. 3 a: 90% atilla gan atilla flour and 10% flour.

Fig. 3 b: 90% atilla gan atilla with 10% millet cassava Flour bread

(a-b) Baking Test

Fig. 1. In comparison to the Cettia and Seri M82 flour samples, the percentage bread volume of the local (Nigerian indigenous wheat) flour sample, atilla gan atilla, was significantly ($p<0.05$) higher. Since atilla gan atilla flour produces a comparatively high specific volume of bread, it is chosen as a millet and cassava substitute.

Fig 2 (a-b) displays a picture of bread made using hard winter wheat flour (control) and 100% local flour (Nigerian indigenous wheat), "Atilla gan atilla." The results showed no significant difference ($p \geq 0.05$) between the two samples. Fig 3 (a-b), demonstrates images of breads made with 10% millet flour and 10% cassava flour. The bread volume did not differ significantly between the two samples ($p \geq 0.05$). Numerous studies have verified that substituting a portion of wheat flour with non-wheat flour can produce bread that is acceptable. Since the leaf volume of bread offers a numerical assessment of baking performance, it is a crucial indicator of bread properties (Krishnan et al. (1987)). When 10% millet and cassava were added to the bread samples, there was a slight drop in the loaf volume.

The gluten dilution effect was blamed for the bread's volume decrease (Krishnan et al. 1987), which was linked to the dough's low protein network (Rosellet al. (2001). This led to weak interactions between starch and gluten (Oates, 2001). The increased amount of amylopectin in the flour reduced the bread's loaf volume by increasing the loaf's water retention and decreasing its gas retention during baking (Lee et al. 2001).

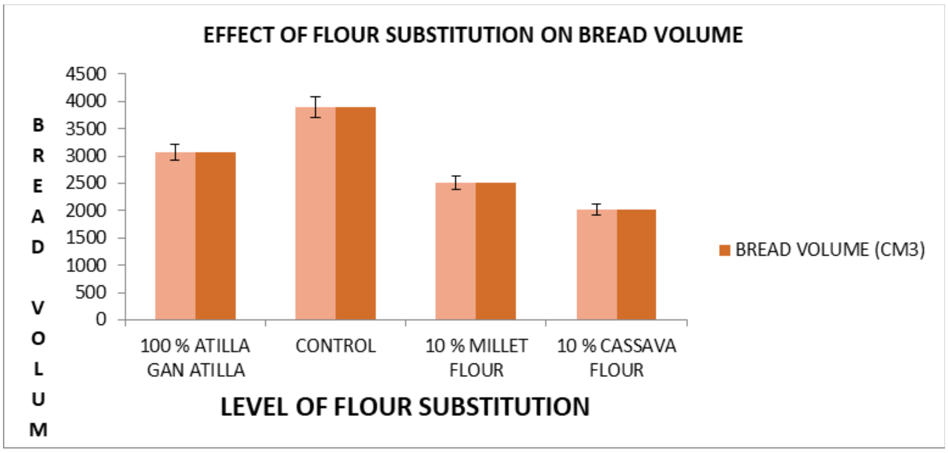

Fig. 4: Effect of flour substitution on bread volume

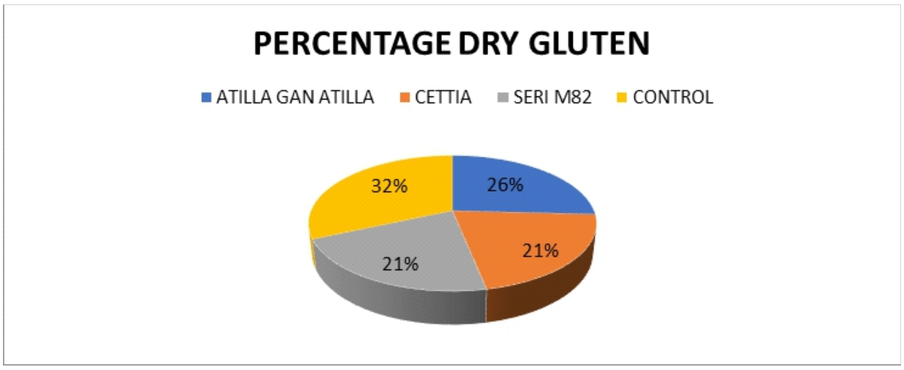

Fig. 5: Percentage of dry gluten

According to Shewry (2019), gluten is characterized as the largely protein-based mass that remains after the starch and other soluble substances of the dough are washed in a high-water or diluted salt solution. In the local (Nigerian indigenous wheat) flour samples, the percentage of dry gluten varied from 21 to 26 percent. The highest gluten content was found in the atilla gan atilla flour, which had a 26 percent dry gluten content. The atilla gan atilla flour and the control flour differed significantly ($p \geq 0.05$). The secret to wheat flour's special capacity to be used in the creation of leavened bread is gluten, the dough-forming protein (Day et al. (2006).

Numerous baked goods' appearance and crumb structure are influenced by gluten, which has been demonstrated to be the structure-forming protein in flour and gives dough its elastic properties (Gallagher et al. (2004). According to research, gluten is the protein in flour that gives it its structure. It also gives dough its elastic properties, which help to give many baked goods their appearance and crumb structure (Gallagher et al. 2004, 2004).

Table 4: Sensory Profile of Bread

SAMPLE	AROMA	COLOUR	MOUTHFEEL	TEXTURE	O/ ACCEPT.
AA	7.42 ±1.31^{b}	7.43 ± 5.65^{a}	7.22 ± 1.31^{a}	7.05 ± 1.34^{a}	7.44 ±1.28^{a}
AB	7.23 ±1.12^{b}	6.27 ± 1.56^{b}	7.25 ± 18^{a}	6.88 ± 1.25^{a}	7.01 ± 1.42^{ab}
AC	6.90 ± 44^{a}	6.01 ± 1.21^{bc}	6.14 ±1.60^{ab}	6.62 ± 1.13^{a}	6.30 ± 1.22^{c}
AC	7.00 ± 44^{a}	6.30 ± 1.21^{bc}	6.52 ±1.60^{ab}	6.90 ± 1.13^{a}	6.50 ± 1.22^{c}

Keys: AA = 100% wheat flour (control), AB = 100 atilla gan atilla, AC = 10% millet flour, and AC = 20% millet flour. Means with the same letter along the column are not significantly different ($p \leq 0.05$). the values are the means ± standard deviations O ACCEPT = Overall acceptability.

Table 4 displays the findings of the bread's sensory analysis. In terms of mouthfeel and texture, there was no discernible difference between the bread samples made with 100% wheat flour and those made with 10% or 20% millet flour ($p<0.05$). According to these results, bread is not significantly impacted by the degree of substitution in terms of raising dough and yeast activity. This result supports Corriher's (2001) assertion that the porosity and texture of baked dough products are caused by an increase in the amount of carbon dioxide that yeasts produce during fermentation. The breads made with 100 percent wheat flour and those made with 10 percent millet flour did not significantly differ in aroma or overall acceptability ($p<0.05$). The overall acceptability and scent ($p<0.05$). There was a significant difference in color between the bread made with 20 percent millet flour and the other two samples ($p<0.05$), but there was a significant difference between the bread made with 100 percent wheat flour and the other two samples ($p<0.05$). Customers generally accept all of the bread samples produced in terms of their organoleptic qualities. The findings showed that the panelists approved of the bread samples. This outcome is consistent with Cheng-Changet al.'s report. (2010), who found that the more value, the more acceptable it is to consumers.

Conclusion Recommendations

1. By using locally available wheat grains and other non-gluten flours, it is possible to create a bread that is acceptable and has high stability, high volume, nutritional status, a reasonably good loaf, and good sensory qualities. Other locally available non-gluten flours can even be substituted for local flour such as millet and cassava flour, which could result in improved food security, lower import costs, and the creation of jobs and wealth.
2. It is advised to use local (Nigerian indigenous wheat) flour, even if it can be substituted with other local (Nigerian indigenous gluten-free) flours made from different grains. The baking potential of other local (Nigerian indigenous wheat) flour varieties should also be investigated further, and it is advised that the finished product be analyzed.

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