ARID ZONE JOURNAL OF ENGINEERING, TECHNOLOGY & ENVIRONMENT
AZOJETE December 2022. Vol. 18(4):555-574
Published by the Faculty of Engineering, University of Maiduguri, Maiduguri, Nigeria.
Print ISSN: 1596-2644, Electronic ISSN: 2545-5818
www.azojete.com.ng

ORIGINAL RESEARCH ARTICLE

EFFECTS OF DIFFERENTLY TREATED CASSAVA FLOURS BLENDED WITH BAMBARA GROUNDNUT FLOUR ON THE BREAD MAKING POTENTIAL OF TWO NIGERIAN WHEAT CULTIVARS

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ARTICLE INFORMATION

Submitted 12 August, 2022
Revised 7 November, 2022
Accepted 8 November, 2022

Keywords:
Cassava flour
Fermentation
Dry heat treatment
Nigerian wheat cultivars
Wheat-cassava bread
Minerals

ABSTRACT

Studies involving the use of composite flour for baked goods are unending for reasons such as high quest for functional foods, unsustainable wheat import and nutritional enhancement of baked goods. In this study, cassava flour (CF) was differently treated: roasted (Cr), fermented (Cf), oven dried (Co) and sundried (Cs) before separately blended with flours from de-braned, hammer milled Nigerian wheat varieties, Norman (Wn) and Atilla (Wa) in the ratio of 75:25. The blends (8) were used to bake breads. Refined commercial wheat flour bread was the control. The breads and the flour blends were evaluated for physical, chemical and sensory qualities using standard procedures. Results revealed that the blends had higher ash (0.57-1.31%) and carbohydrate (76.69-81.03%), lower moisture (8.27-10.30%), protein (6.91-10.10%) and crude fat (1.28-2.45%) and desirable higher water and oil absorption capacities (0.85-1.30mg/g) and (1.16-1.40g/g) respectively. There were improvements in the swelling power (6.91-10.10g/g) and solubility (4.00-7.00%) due to CF addition. The ash, protein, and fibre of the treated breads were higher, while the carbohydrate and fat were lower than in the wheat bread. Specific loaf volume (SLV) of wheat bread (2.58ml/g) and bread with oven dried CF (2.61ml/g) were higher; others had lower SLV not significantly different from each other ($p>0.05$). There were significant increase($p<0.5$) in the mineral contents of the composite bread, more in the bread with sun and oven dried CF. The least amounts were recorded in the breads containing fermented CF for obvious reasons. As for wheat flour and the flour blends, they varied respectively: K 84.04-140.56, Ca 20.29-38.79, Mg 17 51-32.32, Fe 2.26-4.91 and Zn 1.40-2.59 (mg/100g) greater in the blends. As for the breads, significant variations were K 157.36-296.29, Ca 22.61-60.94, Mg 32.78-70.54, Fe 2.98-7.47, and Zn 1.56-7.47 (mg/100g) lower in wheat bread and bread containing fermented CF. Wheat bread had superior sensory attributes followed by bread with oven-dried CF but the bread with fermented CF had the poorest sensory ranking. The composite bread had better nutritive value and poorer sensory properties, demanding the use of flavour enhancing agents in order to mask the unpleasant fermented taste and aroma. Addition of dry heat treated CF to wheat flour (25:75) produced bread with overall quality comparable to wheat bread.

1.0 Introduction

Bread is a spongy, yeasted baked dough of worldwide acceptance and its consumption although is reported to be on the decline in developed economies (Dewettinck et al., 2008), who incidentally are situated in the wheat belt of the world. Rising urbanization, income enhancement and adoption of western styled diet, bread like many others foods has become an important staple, a food security item in the lives of urban dwellers in developing countries, supplying vital nourishment through provision of dietary energy, protein, minerals, vitamins and non-nutrients bioactive compounds (Dewttinck et al., 2008). The unsustainability of the production of affordable nourishing bread from costly imported wheat motivated FAO (1970) to initiate research on composite flour technology, a concept that has taken root and expanded to include baked and unbaked foods. The technological challenge has always been how to overcome the effects of gluten dilution on addition of non-wheat to wheat flour at higher level of replacement which in turn lower bread volume and alter bread texture. Wheat grain contains 8-15% protein, 75-80% of the total is endosperm protein. There are two types of this protein: gliadins and glutenin (Shewry, 2002), these two during dough formation constitute the gluten, a visco-elastic material with both nutritional and functional properties, and responsible for retaining leavening gases during fermentation and baking, and also provides structural frame to baked goods.

Cassava flour on the other hand contains approximately 80-90% starch, <5% protein, <1.5% fat among other constituents (Montagnac et al., 2009; Oladunmoye et al., 2010). Availability of high quality cassava flours from improved cassava varieties in Nigeria has made the formulation of wheat-cassava composite flours a commercial reality which continued to attract further investigations (Eleazu et al., 2014; Oladunmoye et al., 2014; Aondoaver et al.,2021). However, the problem of bread volume depression remained the subject of many studies with varying outcomes. The study is currently being refocused from the evaluation of gluten quality and quantity to modifying the properties of non-wheat starch to accommodate greater than 10% wheat flour replacement. It was reported that higher than 10% substitution was said to have impaired bread volume and texture (Eriksson et al., 2014). Recent studies by Olurin et al. (2021) demonstrated that among processing variables, cassava level significantly impact wheat-cassava loaf specific volume. It was also observed that 10% addition was found to be the optimum (Eriksson et al., 2014). Nindjin et al. (2011) concluded that cassava starch had better bread making power than cassava flour because of lower fibre content, the same authors reported that up to 30% starch inclusion yielded bread not different from the wheat bread. Additionally, Squenza et al. (2021) concurred that cassava starch is better than cassava flour, that 20% cassava flour reduced bread volume. Starch can be modified through physical, chemical, and biological processes to suit end-use requirements. Eduardo et al. (2013) reported that bread with roasted CF had significant higher volume unaffected by pectin and cassava level unlike bread with fermented or sun dried CF. Iwe et al., (2015), Miyazaki et al., (2006) and Dudu et al., (2020), applied modified cassava starch as partial replacement of wheat flour and reported better bread quality which was not different from wheat bread. Heat treatment alters starch microstructure. Furthermore, Senanayake et al., (2013) reported moist heat treatment of sweet potato starch increases its gelatinization temperature, enzymic susceptibility, swelling volume, and changes its X-ray diffraction pattern, in addition to enhancement of solubility index and swelling power. Enzymes such as amylases, proteases, xylanases etc. are used as bread improvers for better bread making performance through enhanced aeration. Among oxidants, ascorbic acid tops the list as bread improver, a powerful reducing agent that reinforces disulphide bonds of gluten network of weak flour for greater bread volume. Therefore, Idowu et al. (2017) applied specific improvers to enhance air incorporation in wheat-cassava bread, and observed 10% cassava bread had the best SLV and noted that soy flour addition had bread volume depressing effect. Pasqualone et al. (2010) on the other hand, utilized aerating property of egg white to produce acceptable wheat-cassava bread. Aristizabel Galvis et al. (2017) observed that more than 20% cassava flour inclusion requires addition of additives to the formulation for greater bread quality. But contrarily, Lagnika et al. (2019) reported 20% cassava flour was the best level and noted that water and oil absorption capacities increased while swelling power decreased on partial replacement of wheat flour with cassava flour. Erikkson et al. (2014) reported 13.4g/g swelling power for wheat flour against 8.75g/g for CF indicating greater associate force within CF starch granules than in WF. However, Agbara et al. (2020) reported that water absorption capacities of different brands of wheat flours sold in Nigerian markets were enhanced on blending with either CF or sweet potato flour and concluded that greater flour water absorption was responsible for reduced bread volume and heavier weight in composite breads. Dry heat application causes starch dextrinization, which leads to increased solubility and decreased swelling power, and in some cases residual water availability leads to initial gelatinization prior to dextrinization. Heat application leads to amylose chains interaction or their binding to lipids, a process that alters starch functionality (Hover, 1994). Fermentation on the other hand changes starch microstructure, causes perforation of granules due to the action of microorganisms and their enzymes (Oyeyinka and Kayitesi, 2020) leading to the production of lactic acids and other flavour enhancing substances (Demiate et al., 2000). Numfor et al. (1995) observed that average starch granule diameter, solubility and swelling power were depressed after fermentation. In the present study differently treated cassava flours were blended with debranned, undegermed flours from two Nigerian grown wheat cultivars (Norman and Atilla), the effects of the treatments on the quality of wheat-cassava bread were evaluated with reference to bread produced from commercial wheat flour.

2. MATERIALS AND METHODS

2.1 Material Procurement and preparation

2.1.1 Collection of raw materials

Nigerian wheat cultivars (Norman and Attila) were obtained from the Lake Chad Research Institute (LCRI). Cassava roots and commercial wheat flour (Premium wheat flour, IRS Flour Mills, Lagos Nigeria) and other baking ingredients were sourced from Gamboru market, Maiduguri, Borno State Nigeria.

2.1.2 Preparation of wheat flour

The wheat cultivars, Norman and Atilla were sorted, tempered, debranned, sun-dried and milled into flour. The flours were sieved through 0.250mm and stored in an airtight plastic jars to prevent moisture re-absorption (Figure1)

Wheat
↓
Sorting
↓
Debranning
↓
Sun-drying
↓
Milling
↓
Sieving
↓
Wheat flour

Figure 1: Flow chart for wheat flour production

2.1.3 Preparation of cassava flour (fermented)

The cassava roots were sorted washed, peeled, sliced, rinsed and soaked in water for 72 h for fermentation to take place. The water was changed every 24 h. The fermented cassava slices were further sun-dried for 3 days and milled into flour. The flour obtained was sieved (0.250 mm) and stored in an airtight plastic jar and left at room temperature.

2.1.4 Preparation of cassava flour (Roasted)

The cassava roots were sorted, washed, peeled, sliced, rinsed, air dried and toasted at high temperature (150-180°C) in a pan using gas cooker for 15-20 min in order to gelatinize starch. The roasted cassava slices were further sun-dried for 48 h and milled into flour. The flour obtained was sieved with 0.250mm mesh and stored in an airtight plastic ja

2.1.5 Preparation of cassava flour (oven-dried)

Fresh cassava roots were sorted, washed, peeled, sliced, rinsed, and oven dried at 80°C for 10 h. The oven-dried cassava slices were further air-dried for 3 days and then milled. The flour obtained was sieved through 0.250mm sieve and stored in an airtight plastic jars.

2.1.6 Preparation of cassava flour (sun-dried)

Fresh cassava roots were sorted, washed, peeled, sliced, rinsed and sun-dried for 72 h. The sun-dried cassava slices were milled into flour and sieved. The flour obtained was stored in an airtight container and left at room temperature. The flowchart are combined and shown in Figure 2

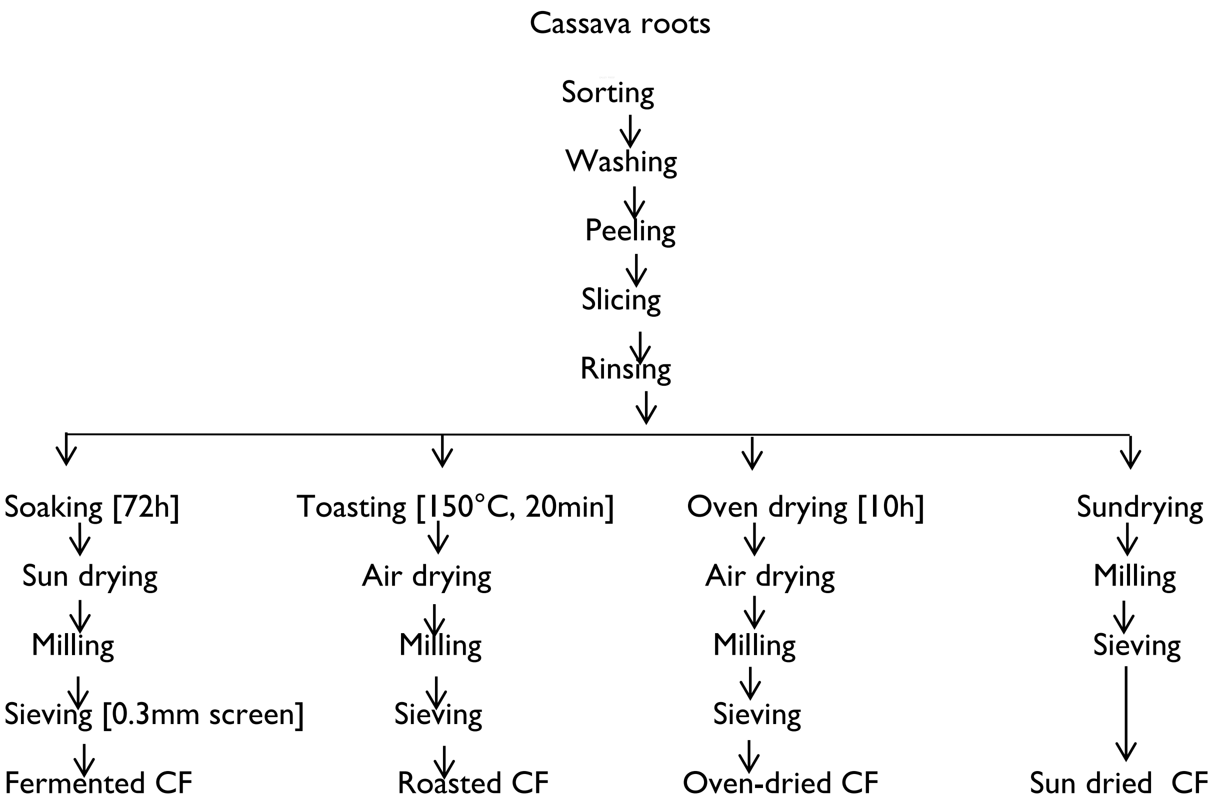

Figure 2: Process flow chart for production of differently treated cassava flours (CF)

2.2 Blend Formulation

Flour blends were produced in the following ratio; 75% wheat flour and 25% cassava flour. The formulations were: i) W_nC_f (Norman-fermented cassava flour, CF) ii) WnCr (Norman-roasted CF) iii) W_nC_o (Norman-oven dried CF) iv) W_nC_s (Norman-sun dried CF) v) W_aC_f (Atilla-fermented cassava CF) vi) W_aC_r (Atilla-roasted CF) vii) WaCo (Atilla-oven dried CF) viii) W_aC_s (Atilla-sun dried CF) ix) W100% (commercial wheat flour). C_f, C_r, C_o, C_s: fermented, toasted, oven-dried, sun-dried cassava flours. Each blend was thoroughly mixed in a kitchen mixer and packaged for analysis and bread making.

2.3.1 Determination of Functional Properties of Blends and Wheat flour

Bulk density, water and oil absorption capacities, swelling power and solubility were determined as shown below.

2.3.2 Bulk density (BD)

The sample was filled into a 50ml cylinder up to 10ml mark; the cylinder was tapped gently on a laboratory bench to fill the air spaces within the flour in the cylinder (Murphy et al., 2005). BD is equivalent to flour weight divided by flour volume

2.3.3 Water absorption capacity (WAC) and oil absorption capacity (OAC)

WAC and OAC were determined by modified method of Niba et al. (2001). One gram (1g) weight was suspended into 5ml of distilled water for WAC and another one gram (1g) suspended into 5ml of peanut oil in a centrifugal tube. The slurry was shaken on a flat form tube rocker for 20 min at room temperature and centrifuged at 3000 rpm for 15 min. The supernatant was decanted and the tube inverted over tissue paper to allow the adhering drop of water or oil escape and later the tube was reweighed.

WAC/OAC = (Wt. of sediment-Wt of sample)÷(sample Wt)…….. (1)

2.3.4 Swelling power and solubility

The swelling powers of flours were determined based on a modified method of Leach et al. (1959) with modification: 0.5g of sample was placed into a pre-weighed centrifuge tube. 10ml of distilled water was then added and stirred. The mixture was placed on a water bath thermostatically controlled at 80°C with continuous stirring for 30 min. It was cooled to room temperature and centrifuged at 1500rpm for 15 min. The supernatant was poured into a pre-weighed crucible and then placed in an oven to evaporate. The solid residue left behind in the crucible expressed as a percentage of the weight of sample was % solubility. The weight of the sediment in the tube expressed as a percentage of sample weight was the swelling power.

2.4.1 Bread Recipe for Bread Production

The recipe used for bread production is as shown below on 100% flour basis. Flour =100g, sugar = 7g, salt =1g, yeast =1.4g, fat = 7g, warm water = 60-70ml.

2.4.2 Bread Making Procedure

The AACC (2000) straight dough method (10-10B) was slightly modified to prepare the various breads. Dry ingredients were initially mixed in a mixer (MC-B100 Crown Star, China), later sugar (small portion) and yeast earlier dissolved in warm water were added and mixed and finally the shortening was robbed in and kneaded into smooth elastic-like dough, covered and allowed to ferment 90 min. After the first fermentation the dough was cut into roughly equal sizes and weighed, shaped and placed into greased bread pans and proofed for another 60 min in a fermentation cabinet. (80-85% R.H, 30±2°C). The proofed dough pieces were baked at 180-200°C for 30 min in a gas oven. After baking, the loaves of bread were allowed to cool to ambient temperature.

2.4.3 Determination of Physical Properties of Bread

2.4.4 Bread weight

The weight of cooled bread was determined by weighing each loaf of bread on an electronic weighing balance to the nearest tenth of a gram.

2.4.5 Bread volume

The volume of bread was determined by modification of rapeseed displacement method. (millet seed displacement method) (AACC, 2000). A loaf of bread was placed in containers of known volume, unoccupied spaces filled with filled with millet seeds to the brim. Subtracting the volume occupied by the millet seeds from the total volume of the container was regarded as volume occupied by a loaf of bread.

2.4.6 Specific loaf volume

The specific loaf volume (SLV) was obtained by dividing loaf volume by loaf weight (AACC, 2000).

2.5 Determination of Proximate Composition of the flours and the bread

Moisture, crude protein, crude fat, crude fibre, total ash, was determined using the established procedures of AOAC (2005). Carbohydrate contents were obtained by 'difference'.

2.5.1 Determination of moisture content

The moisture content was determined by drying 2 g of the sample in at 150°C for 1 h. Weight loss expressed as the percentage of the initial weight was regarded as % moisture content.

2.5.2 Ash content

Ash content was determined by incinerating 5g of each sample in a muffle furnace at 550°C for 5 h, the grey ash were cooled in a desiccator to avoid absorption of moisture and weighed after to obtain ash content.

2.5.3 Crude fiber

About 5g (W_o) of sample was weighed into a 500ml Erlenmeyer flask and 100ml of TCA digestion reagent was added. The samples were then boiled for 40 min counting from the start of the boiling. The flasks were removed from the heaters, cooled (30 min) then filtered through a Whatman No. 4. The residues were washed with hot water stirred once with a spatula and transferred to a porcelain dish. The samples were dried overnight at 105°C. After drying, samples were cooled in desiccators and each weighed as W_1. The samples were burnt in a muffle furnace at 500 °C for 6 h, allowed to cool and re-weighed as W_2.

% Crude fiber = $W_1 - W_2 \div (W_o) \times 100$……..Equation (2) where $W_o \rightarrow$ Dry weight of food sample, $W_1 \rightarrow$ Weight of crucible + fiber + ash, $W_2 \rightarrow$ Weight of crucible + ash (2)

2.5.4 Fat content

The soxhlet extraction method was used for the determination of the fat content of the samples. About 5g of each sample was weighed and the weight of the flat bottom flask taken with the extractors mounted on them. The thimbles were held half way into the extractors with the weighed samples. Extractions were carried out using petroleum ether (boiling point 40-60°C). The thimbles were plugged with cotton wool. At the completion of extraction, the solvents were removed by evaporation on water bath and the remaining part in each flask was dried at 80^0C for 30min in the oven to dry the fat. The flasks were cooled in a desiccator, and reweighed to obtain the wright of fat expressed in percentage.

2.5.5 Protein content

The micro Kjeldhal method was used to determine crude protein content of the samples. About 0.2g of each sample was placed into digestion flask, 10g of catalyst (copper sulfate and sodium sulfate, 5:1) and 25ml concentrated sulfuric acid were added to each digestion flask The flasks were placed into the digestion block in the fume cupboard and heated until frothing ceased giving clear and light blue green coloration. The mixtures were then allowed to cool and diluted with distilled water (total, 250ml). Distillation apparatus were connected and 10ml of the samples poured into separate receivers of distillation apparatus. Also 10ml of 40% sodium hydroxide (NaOH) was added. The released ammonia was absorbed by boric acid which was then titrated with 0.02m of hydrochloric acid until green color change to purple. Percentage of nitrogen in the sample was calculated using the formula below

$$\% \text{ Nitrogen} = (T-B) \times \text{normality of acid} \times 14.008 \div (\text{Weight of sample} \times 1000) \times 100 \quad (3)$$

Where B= blank titer value, T = Actual titer value, % protein = %N x 6.25

2.6 Determination of mineral composition of the blends and bread

The minerals (potassium, calcium, magnesium, zinc, and iron) were determined according to the established procedures of AOAC (2005) using the ashes obtained during the ash determination process.

2.7 Evaluation of Sensory Properties of Bread

Twenty (20) panelists s consisting of 9 males and 11 females evaluated the breads based on shape, crust color, aroma, crump sponginess, mouth feel, taste, and acceptability on a 9-point Hedonic scale where 9 is like extremely, 5 neither like nor dislike and 1 equivalent to dislike extremely. (Ihekoronye and Ngoddy, 1985). Coded samples were randomly presented to the panelists during a two sessions of 10 judges each. Warm water was provided for mouth gargling.

2.8 Statistical Analysis

Data (functional, chemical, sensory properties) were subjected to analysis of variance. Means were separated using Duncan's Multiple Range test and significance set at 5% probability ($p<0.05$)

3. Results and Discussion

3.1 Functional properties of wheat and differently processed cassava composite flours

Table 1 reveals the bulk density of the flours ranged between 0.62g/ml (W_aC_f) and W_nC_f and 0.68g/ml for W100, W_nC_o, and W_aC_r indicating fermented cassava flour had lower density or higher porosity due to presence of coarser flour particles. Lower density may correlates positively with lower calorific value, usually finer starchy stuff presents higher density. The blends containing oven or roasted cassava flour (CF) had relatively higher bulk density (0.65-0.68) indicating higher dry matter or greater nutritive value or presence of finer flour particles. Bulk density has greater influence on dispersibility, wettability and other hydration properties of blends as in wet processing apart from its influence on handling and storage. Bulk density is generally influenced by flour density and its granulation characteristics which determines the packaging requirements and material handling (Adebowale et al., 2012). The water absorption capacities (0.85-1.30g/g), oil absorption capacities (1.16-1.40ml/g), swelling capacities (6.71-10.10g/g), and water solubilities (4.00-7.00%) with the following grand mean 1.10g/g, 1.27g/g, 7.61g/g, and 4.58%. These values are not far from the values reported by Aondoaver et al., (2021) for wheat-cassava (90:10) flour. Agbara et al. (2020) reported water absorption capacities of 1.31-2.00ml/g for different brands of wheat flours sold in Nigerian markets and their blends with either 20% cassava or 20% sweet potato flour. Lagnika et al., (2019) had earlier observed an increase in WAC & OAC and decrease in swelling power on replacing 20% wheat flour with CF. The blends had greater water absorption than the wheat flour and among the blends, more in those containing oven and sun-dried CF. Flour water absorption capacity is determined by the presence of hydrophilic groups of proteins and carbohydrates that are able to form hydrogen bonds with water molecules (Singh, 2001). WAC gives general idea of flour suitability in aqueous food formulations, dough handling and machinability as commercial bulk fermentation (Okerie, et al., 1988). The blends had higher oil absorption capacity (OAC) than the control, a desirable quality for better bread texture and flavour. Again blends containing Atilla flour blended with either roasted or oven dried cassava flour had greater OAC. Swelling capacity is under the influence of many factors such as temperature, starch granule type, ratio of amylose to amylopectin. The blends had greater swelling powers (SP) (6.71-10.10) than the wheat flour (6.71g/g), the variation between them was not wide as indicated by the coefficient of variation of 0.533%, however blends with fermented cassava flour had the highest SP (WaCf 10.1g/g and WaCf 7.98g/g). The control had higher fat contents than others, and might be responsible for reduced swelling. Water solubility of the blends (4.00-7.00%) was low and the control had the least, with minimal variations between the observed values. Polymers such as starch and protein form a colloidal solution with water. However, flours naturally contain free sugars, amino acids and shorter chain polypeptides and amylose leached out during heating. Starch dextrinization as a result of dry heat application might lead to increased flour water solubility, therefore, blends containing dry heat treated CF blended with Norman had slightly greater solubility. The solubility of flour is influenced by such factors such as flour composition, particle size, temperature, pH, and processing and storage conditions (Mirhosseini and Amid, 2013). Swelling capacity is said to be a combined effect of protein and starch content in flour (Woolfe, 1992). Swelling capacity is also related to ratio of amylose to amylopectin of the starch (Adebowale et al., 2005). Lower amylose content is equivalent to higher flour swelling power. Oladunmoye et al. (2014) reported greater amylose in wheat starch (28.19%) than in cassava starch (19.49%), against 25.53% reported by Ojo et al. (2017) for cassava starch. The bottom line is higher bulk density, water and oil absorption capacities, swelling power, and solubility are desirable properties for flours used for baked goods especially bread making.

Table 1: Functional Properties of Flour Blends Produced From Nigerian Wheat (Norman and Atilla) with Differently Treated Cassava and Control

Sample	BD (g/ml)	WAC(g/g)	OAC(g/g)	SP(g/g)	SLB (%)
W	0.68 ± 0.00^{a}	0.85 ± 0.05^{d}	1.11 ± 0.03^{c}	6.71 ± 0.01^{d}	4.00 ± 0.00^{d}
WnCo	0.68 ± 0.0058^{a}	1.12 ± 0.01^{c}	1.13 ± 0.10^{c}	7.16 ± 0.03^{c}	6.00 ± 0.20^{b}
WaCo	0.67 ± 0.0115^{a}	1.30 ± 0.10^{a}	1.34 ± 0.10^{a}	7.33 ± 0.03^{ab}	5.00 ± 1.00^{c}
WnCr	0.65 ± 0.0100^{b}	1.21 ± 0.10^{ab}	1.11 ± 0.10^{c}	7.12 ± 0.01^{c}	7.00 ± 0.50^{a}
WaCr	0.68 ± 0.0058^{a}	1.29 ± 0.10^{a}	1.35 ± 0.10^{a}	7.20 ± 0.1^{ab}	5.00 ± 0.00^{d}
WnCs	0.65 ± 0.0115^{b}	1.11 ± 0.00^{cd}	1.22 ± 0.10^{b}	7.31 ± 0.01^{ab}	4.00 ± 0.30^{d}
WaCs	0.63 ± 0.0115^{c}	1.07 ± 0.20^{cd}	1.26 ± 0.10^{b}	7.51 ± 0.01^{b}	5.00 ± 1.00^{c}
WnCf	0.63 ± 0.0100^{c}	1.12 ± 0.02^{c}	1.24 ± 0.10^{b}	10.1 ± 0.05^{e}	6.00 ± 0.00^{e}
WaCf	0.62 ± 0.0058^{c}	0.97 ± 0.10^{d}	1.24 ± 0.10^{b}	7.98 ± 0.01^{a}	5.00 ± 1.00^{c}
CV%	1.34	4.58	4.17	0.533	13.45

Data are Means ± SEM. (n=3) Means with the same superscript in a column are not significantly different (p>0.05). W: 100% commercial wheat flour, W_n: Norman, W_a: Atilla, C_o, C_r, C_s, C_f are oven-dried, toasted, sun-dried, fermented cassava flours respectively blended with Wn &W_a 75:25. BD:bulk density, WAC & OAC: water & oil absorption capacity, SP:Swelling power, SLB: Solubility.

3.2 Proximate composition of the composite flours produced from differently treated cassava flours blended with Atilla and Norman (wheat cultivars) flours

Table 2 shows that the wheat (W) flour had higher moisture, protein, crude lipid and lower ash and carbohydrate. Moisture, ash, protein, crude lipid, and carbohydrate contents of the flour blends varied significantly (p<0.05) from 8.27%-10.30%, 0.57-1.31%, 7.49-9.20%, 1.28-1.24% and 76.69-81.03% respectively. Among the blends those containing sun-dried CF had slightly higher moisture while those with toasted and oven dried CFs had the least. Effective flour storage demands moisture contents less than 14% (Ahmed, 2015). Additionally, effective packaging and low temperature storage. The ash contents of wheat-fermented CF blends were lower than in other blends but greater than the ash content of the commercial wheat flour (0.67%) and greater ash were located in wheat-sundried CF blends (W_nC_s 1.15% and W_aCs 1.13%. Leaching that occurred during fermentation/soaking was responsible for the lower ash contents of blends containing fermented CF. Ash represents the inorganic material component and the extent of its presence is determined by flour extraction rate. Protein content of the control (W) was higher (9.20%) and decreased in the blends, and among the blends it was higher in wheat-sundried CF and lower in blends containing roasted and fermented CFs (WaCfn7.49%, W_nC_f 7.75, W_aC_o 7.63% and W_nC_r 7.51%). Agume et al. (2017) similarly reported that soaking and roasting of soybeans decreased total protein of soy flour by 23%. Crude lipids were lower in the blends (1.28 and 1.76%), highest in the control(W) (2.45%). Lower fat and protein CF dilutes the level of the same in wheat flour whenever blended together. Cassava flour contains less than 1-3% protein and less than 1.5% fat (Montagnac et al., 2009). CF addition to wheat flour for bread making is primarily to obtain affordable bread with good physical and sensory characteristics, not necessarily for nutrient value enhancement, however there were enhancement of the ash and possibly the dietary fibre contents of the blends although it was not measured. CF has a dietary fibre content of 4% against 1.5% in the fresh tuber (Montagnac et al., 2009). Ibidapo et al. (2019) did not observe any meaningful differences in the proximate compositions of the flours of four Nigerian grown wheat cultivars, the following range of values were obtained: protein 15-16%, fat 0.88-1.3%, fibre<3.5%, ash<1.0% and carbohydrate 69-73%.

Table 2: Proximate Composition (%) of Norman and Atilla wheat cultivars blended with differently treated cassava flours (75:25)

Sample	Moisture	Total ash	Crude protein	Crude lipid	CHO
W	10.30±0.05[a]	0.65±0.06[d]	9.20±0.04[a]	2.45±0.00[a]	76.69±0.09[d]
WnCo	8.78±0.09[c]	1.31±0.03[a]	8.43±0.06[b]	1.64±0.02[c]	78.63±0.16[c]
WaCo	8.27±0.03[d]	0.96±0.03[c]	7.63±0.11[c]	1.51±0.12[d]	80.68±0.28[ab]
WnCr	8.30±0.02[d]	0.98±0.00[c]	7.51±0.03[c]	1.28±0.06[e]	80.95±0.06[a]
WaCr	8.28±0.02[d]	1.00±0.01[c]	7.69±0.03[c]	1.63±0.01[c]	80.51±0.08[ab]
WnCs	9.91±0.02[b]	1.15±0.02[b]	9.06±0.04[a]	1.65±0.01[c]	77.05±0.09[d]
WaCs	9.50±0.00[b]	1.13±0.03[b]	8.63±0.17[b]	1.49±0.29[d]	78.14±0.43[c]
WnCf	8.76±0.01[c]	0.69±0.01[d]	7.75±0.01[c]	1.76±0.01[b]	80.37±0.03[b]
WaCf	8.97±0.02[c]	0.57±0.01[e]	7.49±0.02[d]	1.37±0.02[e]	81.03±0.06[a]
CV%	0.4087	2.83	0.9146	6.49	0.2387

Data are Means ± SEM.(n=3) Means with the same superscript in a column are not significantly different (p>0.05).W: commercial wheat flour, Wn: Norman, Wa: Atilla, Co, Cr, Cs, Cf are oven-dried, toasted, sun-dried, fermented cassava flours respectively blended with Wn &Wa 75:25

3.3 Proximate compositions (%) of bread produced from Nigerian wheat cultivars (Norman and Atilla) blended with differently treated cassava flours (75:25)

Significant variations (P<0.05) were observed in the proximate composition of the breads (**Table 3).** Bread moisture reflects baking time and temperature, nature of ingredients used in formulation and also proofing time. Bread moisture varied from 21.14% (WaCf) to 30.18% (WnCo). Formulations containing oven-dried and roasted CF had higher moisture especially those blended with Norman wheat flour. Bread moisture has implications on its tenderness, storage stability and stalling tendency. High moisture content has been associated with short shelf life of composite bread as it encourages microbial proliferation that leads to bread quality deterioration (Eleazu et al., 2014) but reduces rate of stalling and greater tenderness on the other hand. Wheat bread had lower moisture as similarly reported by Ndungu et al. (2015) and Pasqualone et al.(2010). Crude lipid content of the breads were enhanced in some, but in others fat contents of the composite breads were lower than recorded for the wheat bread, the values varied from 7.19% (WaCr) to 10.86% (WaCf), least in the bread containing roasted or oven dried cassava. But an increase in oil has been reported in the flours of some seeds after roasting (Agume et al.,2017). The difference in the fat contents of the breads must have originated either from the wheat cultivars since cassava is a poor source of fat and moreover equal amounts of fat were used in the formulations. With reference to **Table 2,** Atilla tends to contain slightly higher fat than Norman, the two wheat cultivars were equally treated during milling. The dietary fiber contents of the breads (0.57-1.21%) were in majority of the cases higher in the treated breads and which originated from the added cassava flours, breads with fermented cassava and wheat bread had the least level of fibre. Norman wheat flour proved to be fibre richer than Atilla flour or it could be the effect of dry heat treatment the cassava roots received. Both soluble and insoluble fiber are now recognized to be beneficial to humans, breads like most processed foods from refined cereal or root tuber flours are not good sources of dietary fibre needed for the well-being of modern man that cherish convenient foods and ready-to-cook refined cereals. The higher carbohydrate content of the wheat bread (49%) indicates higher dietary energy, the amount was not significantly different(p>0.05) from the amounts recorded for bread with fermented CF (47.70-47.94%) and the lower amounts were recorded in the breads that contained roasted, oven dried or sundried CF. Eleazu et al. (2014) reported carbohydrate content of 42.91-47.09% for cassava breads. Addition of differently treated CFs to wheat flour enhanced the ash contents, greater than 1.12% observed in the control, and ranged from 1.18% to 1.81% in the composite flour breads. Breads with fermented CF had lower ash contents as observed in W_nC_o (1.18%). Blending increased the ash contents of the resulting blends but more in breads due to added yeast, salt and water used in formulations. Ash indicates the inorganic component of biological material, flour extraction rate determines its colour and ash content. Although higher ash content is beneficial to human nutrition, however sensory attributes of the breads could be impaired if overly high amounts of ash is present, and perhaps accompanied by higher presence of antinutrients. The protein content of the breads varied from the lowest recorded for Atilla-fermented CF bread (10.78%) to 15-41% (Norman-oven dried CF) bread. Breads with oven or roasted CF had higher protein, perhaps due to higher dry matter content of dry heat treated CF. Flours from Nigerian wheat cultivars used in the study had higher level of protein and fat than the commercial wheat flour used as the control. Ibidapo et al. (2018) had earlier made similar observation and observed insignificant difference in the nutritional value of four Nigerian grown wheat cultivars. Higher amounts of fat was recorded in breads containing fermented and sundried CF, and in wheat bread. Atilla breads had higher amounts of fat than Norman. The Bottom line is bread containing heat treated CF have greater, ash, protein, moisture, and lower fat, fibre and carbohydrate.

Table 3: Proximate compositions (%) of bread produced from Nigerian wheat cultivars (Norman and Atilla) blended with differently treated cassava flours (75:25)

Sample	Moisture	Total ash	Crude protein	Crude lipid	Crude fiber	CHO
W	22.46 ± 0.18^{d}	1.12 ± 0.08^{d}	11.45 ± 0.09^{d}	10.10 ± 0.13^{b}	0.67 ± 0.01^{c}	49.00 ± 0.43^{a}
WnCo	30.81 ± 0.61^{a}	1.18 ± 0.01^{d}	15.41 ± 0.30^{a}	8.25 ± 0.06^{d}	1.21 ± 0.07^{a}	44.73 ± 0.66^{b}
WaCo	29.47 ± 0.14^{b}	1.49 ± 0.02^{b}	14.73 ± 0.07^{b}	9.29 ± 0.06^{c}	0.95 ± 0.03^{b}	42.39 ± 0.26^{d}
WnCr	30.49 ± 0.47^{a}	1.81 ± 0.01^{a}	15.24 ± 0.24^{a}	7.19 ± 0.10^{cd}	0.97 ± 0.01^{b}	45.50 ± 0.70^{b}
WaCr	30.38 ± 0.22^{a}	1.76 ± 0.03^{a}	15.19 ± 0.11^{a}	7.73 ± 0.05^{d}	0.88 ± 0.03^{b}	44.71 ± 0.32^{b}
WnCs	27.22 ± 0.26^{c}	1.73 ± 0.02a	13.89 ± 0.14^{c}	9.36 ± 0.05^{c}	1.18 ± 003^{a}	43.32 ± 0.22^{c}
WaCs	23.70 ± 0.02^{d}	1.56 ± 0.03^{b}	12.09 ± 0.01^{d}	10.62 ± 0.12^{a}	1.11 ± 0.02^{ab}	44.39 ± 0.39^{b}
WnCf	28.23 ± 0.10^{b}	1.26 ± 0.04^{c}	14.40 ± 0.05^{b}	8.06 ± 0.13^{d}	0.67 ± 0.01^{c}	47.78 ± 0.45^{a}
WaCf	21.14 ± 0.16^{d}	1.45 ± 0.02^{b}	10.78 ± 0.08^{cd}	10.86 ± 0.06^{a}	0.57 ± 0.02^{d}	47.94 ± 0.36^{a}
CV%	1.10	2.34	1.09	0.9905	3.17	0.9820

Data are Means ± SEM.(n=3) Means with the same superscript in a column are not significantly different (p>0.05).W: commercial wheat flour, Wn: Norman, Wa: Atilla, Co, Cr, Cs, Cf are oven-dried, toasted, sun-dried, fermented cassava flours respectively blended with Wn &Wa 75:25

3.4 Physical Properties of Bread Produced from the Blends of Nigerian Wheat cultivars (Norman and Atila) and Differently Treated Cassava flours

As shown in **Table 4,** bread weight (429-456g), volumes (1010-1170ml) and specific volumes (2.25-2.68) were comparable indicating little variation between the values obtained. Wheat bread had the least weight and therefore responsible for the highest specific volume but bread containing oven dried Cf blended with Norman (WnCo) had the highest bread volume (1170ml) significantly not different from the volume of wheat bread (1150ml). Others had absolute bread volumes less than these two (WnCo and W100%). Breads containing Norman had greater volumes than those containing Atilla, perhaps Norman is a stronger wheat and able to do well with dry heat treated CF. Agbara et al. (2020) reported 2.16-2.48 ml/g SLV for 20% cassava or 20% sweet potato bread and SLV of 2.55-3.28ml/g for bread made from different wheat flour brands sold in Nigerian markets which are similar to SLV obtained in the present study. Expectedly, higher SLV was recorded for wheat bread as equally reported by Padqualone et al.,2010; Menon et al.,2015; Agbara et al.,2020). Higher water absorption capacity of the blends (Agbara et al., 2020) or higher particle size of CF (Lagnika et al.,2019) and fibre content of CF (Agbara et al.,2020) than obtain in wheat flour might be responsible for the bread volume depression and not necessarily gluten dilution, and this calls for use of CF of finer granulation therefore lower fibre content for CF inclusion greater than 10%. Erikkson et al. (2014) observed that CF from three varieties of cassava had greater swelling power, solubility and water binding capacity than wheat flour. But Lagnika et al. (2019) reported greater water absorption for wheat flour than CF; varietal differences and location might be responsible for this disparity. Bread volumes and specific volumes for bread with sundried and fermented CF performed poorly despite the fact that they had lower water absorption. Chisenga et al. (2020) reported a lower specific loaf volume (SLV) of 1.5-2.5 g/ml for wheat-cassava bread against higher SLV reported by Erikkson et al.(2014). Aristizabal et al. (2017) recommended addition of improvers if the added CF is greater than 20%. Idowu et al. (2015) reported greater SLV (3.14-3.57ml/g) for 10% cassava bread treated with improvers. Fermented cassava flour had comparable bread volume depressing effect like theheat treated CF; dextrinization of cassava starch molecule occurred as a result of dry heat application and caused reduction of its swelling power but increased its water absorption due to higher dry matter content. However, bread volume enhancing effect of dry heat treated CF was not significantly different from that of wheat flour or the effect could have originated from greater bread making power of Norman than Atilla as observed in this study. **Table 4**

Table 4: Physical properties of bread produced from the blends of Nigerian wheat cultivars (Norman and Atila) and differently treated Cassava flours

Sample	Specific loaf volume (ml/g)	Loaf volume (ml)	Bread weight (g)
W (100%)	2.68±0.10^{a}	1150±9.21^{a}	429±2.08^{c}
WnCo	2.61±0.11^{a}	1170±9.20^{a}	448±3.10^{b}
WACo	2.29±.009^{a}	1030±9.10^{c}	450±5.13^{a}
WnCr	2.39±0.08^{b}	1090±5.30^{b}	456±5.25^{a}
WaCr	2.25±0.03^{b}	1010±7.41^{c}	449±5.10^{a}
WnCs	2.31±0.03^{b}	1035±7.50^{c}	448±2.11^{b}
WaCs	2.37±0.07^{b}	1060±5.81^{b}	447±3.00^{b}
WnCf	2.37±0.08^{b}	1060±5.07^{b}	447±3.02^{b}
WaCf	2.25±0.02^{b}	1010±4.98^{c}	451±5.12^{a}
CV%	0.06	7.06	3.76

Data are Means ± SEM.(n=3) Means with the same superscript in a column are not significantly different (p>0.05).W: commercial wheat flour, Wn: Norman, Wa: Atilla, Co, Cr, Cs, Cf are oven-dried, toasted, sun-dried, fermented cassava flours respectively blended with Wn & Wa 75:25.

3.5 Mineral compositions (mg/100g) of flour blends produced from Nigerian wheat (Norman and Atilla) cultivars blended with differently treated cassava flours (75:25)

The mineral contents of the commercial wheat flour (W) and the wheat-cassava flour blends are presented in **Table 5.** Atilla-fermented cassava flour had the least concentration of the investigated elements (K, Ca, Mg, Fe and Zn) as a result of leaching and the mineral content of the refined wheat flour and those of Norman-fermented cassava flour were not significantly different (p>0.05). Norman-oven dried CF (WnCo) had the greatest concentration of these elements and the next were blends containing sun-dried CF. Norman appeared to have greater mineral content than Atilla as revealed by higher mineral content of Norman containing blends. Since dry heat exposure increases the dry matter content of a product, therefore all the samples containing dry heat treated CF had higher mineral content than blends containing fermented CF. Refined wheat flour unless fortified after milling, gets depleted of essential macro- and micro- nutrients including non-nutrient bioactive compounds due repetitive grinding and sifting. According to Lopez et al. (2003), 80% of the total amount of minerals is concentrated in the aleurone layer of wheat pericarp (bran), which is removed during milling while only 20% minerals are present in endosperm. Hussein et al. (2013) similarly reported lower levels of elements in wheat flour milled in a Quadrumat junior mill than in barley and corn flours ground whole. The order of dominance of the elements in the various blends was K>Ca>Mg>Fe>Zn and the range recorded for each investigated element in the blends were: K 84.96-140.56 > Ca 17.62-38.79 > Mg 14.69-32.32 > Fe 2.23-4.91 > Zn 1.17-2.5mg/100g. The values recorded for refined wheat flour in this study were within the wide ranges reported by Araujo et al. (2015) for mineral content of commercial wheat flours sold in Brazilian cities. But Emmanuel-Ikpeme et al. (2012) and Hussein et al.(2013) reported slightly higher mineral contents in the respective wheat flours that served as control in their various, however values reported by Oluwalana et al. (2012) for both the wheat flour and wheat-sweet potato bread were lower than the concentrations of the same elements obtained in this study.

Table 5: Mineral compositions (mg/100g) of flour blends produced from Nigerian wheat (Norman and Atilla) cultivars blended with differently treated cassava flours (75:25)

Sample	K	Ca	Mg	Fe	Zn
W (100%)	84.04±2.05^{d}	20.29±0.21^{d}	17.51±0.43^{d}	2.66±0.65^{d}	1.40±0.03^{c}
WnCo	140.56±3.43^{a}	38.79±0.39^{a}	32.32±0.33^{a}	4.91±0.50^{a}	2.59±0.03^{a}
WaCo	100.77±0.50^{cd}	29.36±0.72^{c}	24.47±0.60^{c}	3.72±0.91^{c}	1.89±0.02^{b}
WnCr	105.89±2.58c	30.25±0.74^{c}	25.21±0.62^{c}	3.83±0.93^{c}	1.68±0.58^{b}
WaCr	107.47±2.62^{c}	29.66±0.30^{c}	25.59±0.62^{c}	3.75±0.38^{c}	1.98±0.02^{b}
WnCs	119.22±1.20^{b}	35.27±0.86^{b}	28.39±0.29^{b}	4.31±0.44^{b}	2.27±0.02^{a}
WaCs	121.36±2.96^{b}	34.67±0.85^{b}	28.89±0.70^{b}	4.39±1.07^{b}	2.23±0.02^{a}
WnCf	84.96±2.07^{d}	20.51±0.21^{d}	17.70±0.43^{d}	2.69±0.66^{d}	1.42±0.03^{c}
WaCf	68.08±0.69^{d}	17.62±0.43^{e}	14.69±0.36^{e}	2.23±0.54^{e}	1.17±0.03^{d}
CV%	2.15	2.03	2.12	1.97	10.54

Data are Means ± SEM.(n=3) Means with the same superscript in a column are not significantly different (p>0.05). W: commercial wheat flour, Wn: Norman, Wa: Atilla, Co, Cr, Cs, Cf are oven-dried, toasted, sun-dried, fermented cassava flours respectively blended with Wn &Wa 75:25

3.6 Mineral contents of breads produced form the blends of Nigerian wheat cultivars with differently treated cassava flours (75:25)

Significant enhancements of the mineral contents of the composite breads were the outcome of blending wheat flour with differently processed CF **(Table 6).** Wheat bread and breads containing fermented CF had the least concentration of K, Ca, Mg, Zn and Fe and in most cases were not significantly different (P>0.05) from the concentration of the same element in the refined wheat flour used as the control, and higher levels of concentration of these minerals were observed in breads containing roasted and sundried CF. Leaching during soaking/fermentation was responsible for the lower contents of minerals in bread containing fermented CF. Sun drying had little negative impact on the mineral contents of the cassava flour than roasting, oven drying and fermentation therefore breads containing sundried CF contained the highest levels o investigated elements closely followed by bread containing roasted and oven dried CF perhaps due to higher dry matter than fermented CF.

The order of dominance followed the same trend noticed earlier in the composite flours (**Table 6).** Higher nutritive value is one of the outcomes of the application of composite flour in bread making. Separate or combined inclusion of quinoa, chickpea or spirulina flour is responsible enhanced mineral content of shammy bread reported by El-Said et al. (2021), in another study, Okereke et al. (2021) enhanced the mineral content of wheat-root tuber native or modified starches with the addition of Moringa oleifera seed flour. Observed increased in the minerals in the present work must have originated from the flours of two wheat cultivars that were not commercially milled therefore retained higher level of nutrients, and the additional effect of added cassava flours. Oluwalana et al (2012) similarly observed greater enhancement in the mineral content of wheat-sweet potato bread than in the wheat bread. Winiarskar-Meczan and Kviecien (2011) reported the following mean levels of minerals contained in various bread types consumed in Lublin, Portland: 12.22, 56.2, 362.5, 110.4, 308.4, 2.7, 1.9, 0.4, 2.1 (mg/100g) for Ca, Mg, Na, K, P, Fe, Zn, Cu, Mn respectively, these values are lower than the levels of minerals obtained in this study, perhaps due to lower dry matter (56.94-62.20%) of the reported breads in question. Processing conditions, prevailing soil characteristics, location and cultivar of crop are among the factors influencing mineral content of food products.

Table 6: Mineral compositions (mg/100g) of composite bread produced from the blend of Nigerian wheat Norman and Atilla blened with differently treated cassava

Sample	K	Ca	Mg	Zn	Fe
W	157.36±8.71[c]	22.61± 1.61[f]	32.78± 1.82[e]	1.56± 0.13[c]	2.98± 2.47[f]
WnCo	271.10±7.31[b]	45.43± 0.28[d]	62.34± 0.47[c]	3.02± 0.01[b]	5.78± 0.36[c]
WaCo	225.59±2.64	43.50± 1.50[d]	54.78± 1.70[d]	2.80± 0.01[b]	5.53± 1.90[d]
WnCr	271.26±5.55[b]	54.59 ±1.02[b]	64.58± 1.32[bc]	3.64± 0.06[a]	6.93± 1.30[b]
WaCr	269.55±3.90[b]	51.94± 1.26[c]	64.17± 0.92[bc]	3.46± 0.08[a]	6.59± 1.60[bc]
WnCs	296.29±2.94[a]	60.94± 1.73[a]	70.54± 0.70[a]	3.92± 0.04[a]	7.47± 0.82[a]
WaCs	280.52±3.20[a]	53.89± 0.27[b]	66.79± 0.76[b]	3.47± 0.10[a]	6.84 ±0.35[b]
WnCf	170.99± 7.56[b]	25.73± 0.56[e]	35.62± 1.57[e]	1.77± 0.10[c]	3.39 ±1.90[e]
WaCf	149.92± 2.87[c]	25.45± 0.26[e]	32.33± 1.82[e]	1.69 ±0.02[c]	3.23± 0.34[e]
CV%	4.96	0.94	1.23	0.06	1.22

Data are Means ± SEM. (n=3) Means with the same superscript in a column are not significantly different (p>0.05). W: commercial wheat flour, Wn: Norman, Wa: Atilla, Co, Cr, Cs, Cf are oven-dried, toasted, sun-dried, fermented cassava flours respectively blended with Wn &Wa 75:25

3.7 Sensory Characteristics of Bread Produced from the blends of Nigerian Wheat cultivars (Norman and Atilla) and Differently Treated Cassava flours (Table 7)

3.7.1 Shape

Denatured protein along with gelatinized starch granules is responsible for the structural framework of bread and other baked goods. Addition of differently processed cassava flour (CF) at 25% level was sufficiently enough to dilute the gluten level, therefore the control had the best shape (8.07) on a 9-point hedonic scale, followed by the bread containing oven dried (WnCo 7.53 and WaCo 7.33.) and sun dried cassava.

Bread containing roasted CF had the poorest shapes WaCr 6.20 and WaCr 6.40 indicating the adverse effects of incorporating fully pre-gelatinized starch on bread shape.

3.7.2 Crust Colour

Crust defines the extent of browning, which is determined by temperature and time of baking and availability of sugar substrates for browning reactions. Generally, crust colour of the various bread was generally low, the oven dried (7.67) and sundried (7.15) had better crust colour scores that were not significantly different from wheat bread. Bread with fermented CF had the poorest crust colour because not sufficiently browned because of reduced sugar availability for browning.

3.7.3 Aroma

Generally, aroma of the various bread were equally high but the fermented cassava aroma caused lower aroma scores for bread with fermented CF (WnCf 7.07 and 6.93 WaCf), wheat bread, oven dried, roasted and sundried breads had greater aroma scores. Unpleasant aroma and colour can develop during fermentation or during sun drying of CF no matter the length of time involved, which in turn might affect the bread aroma or colour negatively. On the other hand roasting introduces pleasant aroma to foods but uncontrolled roasting process impairs both aroma and appearance of roasted foods. Bread containing Atilla appeared to have higher aroma scores. Aroma scores of the 100% wheat was not significantly different from aroma of breads containing roasted CF

3.7.4 Mouth feel

This occurs as a result of the impression conveyed to the tactile receptors in bucal activity concerning the smoothness, coarseness, oiliness, dryness etc. of the food. Mouth feel scores varied from 8.53 for the wheat bread and decreased progressively in the composite breads to 6.40 (WnCf), meaning the wheat bread had better smooth passage in the mouth than the treated breads. Others with high mouth feel scores were: WnCo 7.40, WnCs 7.40, WaCf 7.27 and WaCo 7.00. Difference in flour granulation decides both texture and mouth feel of the breads among others parameters.

3.7.5 Taste

Taste score of 100% wheat (8.40) was significantly higher than those of composite bread just like any other bread attribute under investigation here. Bread taste is determined by presence of simple sugars, bread pH or acidity as well as salt and other bread ingredients in the formulation. Bread with fermented Cf with reduced pH had the poorest taste (WnCf 7.00 and WaCf 6.20) followed by sun-dried CF (WnCs 7.07 and WaCs 6.93), the taste was influenced by fermented odour. In fact addition of differently CF altered the taste profile of the wheat breads, CF itself has bland taste and excellent white colour, and the treatments were responsible for the lower taste scores of composite breads.

3.7.6 Overall acceptability

The overall acceptability was significantly greater in the wheat bread followed by bread containing oven dried CF and other breads containing Atilla, least acceptability scores were recorded for bread with fermented CF. Human taste buds usually resists the introduction of novel or modified foods and this resistance usually gives way with time due to sensitization both physical and physiological.

Table 7: Sensory Characteristics of Bread Produced From The blends of Nigerian Wheat cultivar (Norman and Atila) and Differently Treated Cassava flours

Sample	Shape	Crust Color	Aroma	Crumb Structure	Mouthfeel	Taste	Overall Acceptability
W	8.07±3.09^{a}	7.60±2.92^{a}	7.73±2.68^{a}	8.33±2.35^{a}	8.53±2.41^{a}	8.40±2.59^{a}	8.80±1.80^{a}
WnCo	7.53±2.81^{a}	7.67±2.35^{a}	6.53±3.03^{d}	7.93±2.39^{a}	7.40±2.55^{b}	7.47±2.60^{b}	7.40±2.15^{b}
WaCo	7.33±2.88^{b}	6.73±2.75^{b}	7.13±2.08^{c}	6.67±3.02^{c}	7.00±2.65^{c}	7.00±2.89^{c}	7.80±2.82^{b}
WnCr	6.20±2.86^{d}	6.33±2.72	7.27±2.76^{c}	6.93±3.62^{c}	6.60±3.44^{d}	6.73±2.67^{d}	6..73±2.67^{d}
WaCr	6.40±2.59^{d}	7.00±2.36^{ab}	7.60±2.76^{a}	6.80±3.14^{c}	6.87±3.20^{c}	7.20±3.54^{b}	7.20±3.34^{c}
WnCs	7.27±3.09^{b}	6.80±2.78^{b}	7.33±2.45^{b}	7.13±2.92^{b}	6.93±3.09^{c}	7.07±2.53^{c}	7.07±2.53^{c}
WaCs	6.60±2.80^{d}	7.15±3.10^{a}	7.47±2.25^{b}	7.00±2.69^{b}	7.40±3.80^{b}	6.93±.2.53^{d}	6.93±2.53^{c}
WnCf	6.27±2.83^{d}	6.07±3.15^{d}	7.07±3.12^{c}	6.60±2.84	6.40±3.16	7.00±2.85^{c}	6.20±3.01^{e}
WaCf	7.07±2.91^{c}	6.55±3.10^{c}	6.93±2.79^{d}	7.20±2.52^{b}	7.27±2.88^{b}	6.20±3.01^{e}	6.60±2.80^{d}
CV%	3.14%	3.10%	2.78%	2.82%	3.13%	2.94%	2.73%

Data are Means ± SEM.(n=3) Means with the same superscript in a column are not significantly different (p>0.05). W: commercial wheat flour, Wn: Norman, Wa: Atilla, Co, Cr, Cs, Cf are oven-dried, toasted, sun-dried, fermented cassava flours respectively blended with Wn &Wa 75:25.

4. Conclusion

Norman performed better than Atilla with dry heated cassava flour in terms of bread volume and flavour. However, depressed bread volume in the treated breads was observed and this is a recurring and yet to overcome challenge in the application of composite flour for bread making. But the truth is oven dried, roasted and sun-dried cassava flours blended with any of these wheat varieties produced acceptable bread with higher nutritive value and comparable bread volume with respect to wheat bread. However, bread containing fermented CF required additional flavour enhancing agents to mask unpleasant fermented odor and taste. Moreover, fermented cassava flour had poorer functional properties inimical to bread dough formation, and mineral leaching during soaking further depleted mineral contents of the blends and breads containing fermented cassava flour (CF). The bottom line: pretreatment of cassava flour or its starch provides better functionality and satisfaction of end use requirements, and dry heat pretreated CF provides better performance in bread making.

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