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Quality evaluation of wheat-cassava bread as affected by fruit juice inclusion in dough formation

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Abstract
In this present study, breads (B) were produced from Wheat (W)flour and wheat-cassava(WC) flour, the liquids used in dough formation were fruit juices from Orange (O), Watermelon (WM), Pineapple (P) and mixed fruit(MF).Ten experimental runs listed here were generated including two controls treated with water only: WB, WCB, WB+O, WB+P, WB+WM, WB+MF,WCB+O, WCB+P, WB+WM, and WCB+MF. The physicochemical properties of the flours, the fruit juices and the breads were evaluated. The pH, titratable acidity (%), total soluble solids, moisture contents of the fruit juices varied significantly from 3.65-5.15%, 0.19-1.03%, 9.32-12.20%, 89.62-96.51% respectively. Cassava flour had higher coarse granulation which affected negatively the finer textured wheat flour. Wheat flour had higher protein content (10.71%) and the cassava flour higher amounts of dietary fibre (2.87%) and ash (2.57%). The moisture, ash, fat, crude fibre and carbohydrate (by difference) contents of the various bread were 26.70-29.33%, 1.23-1.60%, 6.29-8.89%, 2,61-2.74% and 58.00-59.71% respectively. The specific loaf volumes were all high more in the control (4.97ml/g) than in the treated (4.06-4.47ml/g) The order of dominance of mineral elements in the breads was K>P>Mg>Na>Ca>Fe>Zn, higher in fruit juice treated breads and the amounts doubled or tripled in those breads containing mixed fruit juice. The crust color, crumb grain, taste, aroma, and overall acceptability scores of the breads were very high above 7on a 9-point hedonic scale and mix-fruit juice breads received the least scores. This study has demonstrated convincingly that the nutrient profile, volume and sensory attributes of bread can be enhanced by using fruit juice in dough formation.

Keywords: wheat-cassava bread, fruit juice, cassava flour, dough acidification, mineral elements

1. Introduction

Bread is a fermented spongy confection, a product of baked dough consisting of four basic ingredients: flour, water, yeast, and salt, however modern bread contains additional ingredients for enhanced nutritional and sensory quality. The frequency and quantity of bread consumption has made it the most popular food source that provides substantial amounts of macro- and micro-nutrients to the teeming consumers (Pomeranz, 1987) [31], especially the low-income earners in developing countries of the world. The consumption of bread in Nigeria cuts across all socio-economic strata especially the urban dwellers and traceable to its convenience, ready-to-eat food item with high digestibility, providing easily sufficient cheap dietary energy. The uniqueness of wheat grain as a cereal of choice for baked goods is due to the presence of two endosperm proteins (gliadins and glutenins) accounting for 78-85% of total wheat proteins (MacRitchie, 1994) [25], these two insoluble proteins collectively called gluten are responsible for viscoelastic nature of wheat dough (Shewry, 2009); providing structural framework and the ability to retain expanding leavening gas during baking. Wheat crop does not thrive in humid tropics therefore expanding demand for wheat-based products such as bread, biscuits, pastas, noodles etc is met through massive importation of wheat. Nigeria is the second largest consumer of wheat in sub-Saharan Africa behind South Africa, demand is in excess of 4.63 million tons amounting to 1.5billion in 2016/2017 (PROSHARE Ecosystem, 2017) [32], a big drain on foreign exchange reserve. The need to curtail this drain and provide cheap nutritious baked goods is the reasons behind composite flour technology, a blend of wheat and non-wheat flours aimed to cut cost and at the same time improve on the functional, nutritional and sensory quality of baked goods which is not possible with single cereal grain flour. Nigeria is the largest producer of cassava (Manihot esculenta, Crantz) 59 million tons approximately 20% of global total (IITA, 2017) of which 70% is consumed directly as gari, fufu, elebo, akpu etc. The cassava crop is a woody perennial herb which originated from the Pre-Columbian tropical forests of South America, now cultivated extensively in humid and sub-humid regions of the world. Wheat-cassava bread although not new in Nigeria yet commercial scale production has not been realized despite Nigerian government policy of mandatory inclusion of 10% cassava in wheat flour (Agunbiade *et al*., 2017) [2] and the compliance was short-lived and was not enforced. Literature is replete with work on wheat-cassava bread including currently those of Eduardo *et al*. (2013) [14]; Nwosu *et al*. (2014) [27], Ericksson *et al*. (2014); Ndung'u *et al*. (2015); Olubunmi *et al*; (2017) [30]; Iwe *et al*. (2017) [21]; Agunbiade *et al*. (2017) [2] among many others.

The role of water in dough formation apart from being a solubilizing agent for mixing of flour and added ingredients, also needed for yeast activity, starch gelatinization, protein denaturation and the steam generated during baking acts as additional leavening agent. Most succulent fruits contain mainly water, about 92.5-96.8% in orange, pineapple and water melon (Bhardwaj *et al*., 2014) [9], containing easily absorbable mineral elements mainly potassium, calcium and magnesium among others (Sairi *et al*., 2004) [33], this three cooperatively regulate blood pressure and ensure heart health. Orange, pineapple and water melon juices respectively contain 125mg, 65mg and 100mg of potassium in 100ml (Gopalan, 2010) [17]. Simple sugars (sucrose, glucose and fructose) present in these fruits are known sweetening agents and readily fermentable substrates for yeast activity. Organic acids (citric, malic ascorbic acid etc) in fruits are flavourants which enhance dough acidification and in turn enhance fermentation; the desirable dough rheology include reduced mixing time and dough extensibility as a result of enhanced proteolytic and amylolytic reactions (Komlenic *et al*., 2012) [23] as well as reduction of bread stalling and spoilage. Su *et al*. (2019) reported higher loaf volume as a result dough acidification with organic acids. Ascorbic acid, a flour improver is available in many fruits; it is reported that 100ml of orange, pineapple and watermelon juices contain 64mg, 32.3mg, and 11mg ascorbic acid respectively (Gopalan *et al*., 2010; Bhardwaj *et al*., 2014) [17, 9]. Baratto *et al*. (2016) [11] describes ascorbic acid function in bread dough as reinforcing the gluten network through formation of disulphide bonds which ensure better gas retention, higher loaf volume and fine crumb structure. Enzymes such as proteases (bromelin in pineapple), amylases are available in some fruit juices in different concentrations and these are commercially known flour improvers. Phenolic acids and flavanones such as hesperdin, narirutin etc are present in fruit juices, these according to Franke *et al*. (2005) [16] possess antioxidant activity which ameliorate oxidative stress (Wall, 2006). Food habits and choices evolve, this evolution has been enhanced by globalization and urbanized life styles, crave for functional foods, which provide additional health benefits beyond basic nutrition. Therefore, the thrust of the present study was to produce wheat and wheat-cassava bread using fruit juices from orange, pineapple and watermelon as the only liquid in dough formation and thereafter evaluate the physicochemical and sensory properties of the breads.

2. Materials and Methods

2.1 Collection of raw materials

Fresh sweet cassava roots, watermelon, sweet oranges (Damboa variety), pineapple were purchased at the Gamboru vegetable market, Maiduguri, Northeastern Nigeria. Other ingredients/materials such as All-purpose wheat flour (Crown Flour mills, Lagos Nigeria) white granulated sugar, dried baker's yeast, table salt, baking fat were sourced from local shops. The materials were conveyed to the Food Process Laboratory of the Department of Food Science and Technology, University of Maiduguri.

2.2 Preparation of the raw Materials

2.2.1 Cassava flour production

Washed cassava roots were peeled, cut into small bits and grated in a prewashed local grinding machine, the mash was placed in a cotton bag and repeatedly pressed to reduce the moisture content, and later dried in a cabinet drier at 65°C until sufficiently dried (16 h) The dried material was milled in a laboratory hammer mill and manually sieved on a 300µm sieve.

2.2.3 Extraction of fruit juices

The rind of washed oranges were manually removed, the seeds remove from the segments, the remaining pulp was blended in Master Chef mixer (MC-B180 Crown Star, China) medium speed 3 min. Water melons were cut into four segments, the reddish pulp was sliced off and de-seeded pulp was blended; pineapples were peeled and cut into smaller pieces, the eyes were removed and the pulp was blended. The juice from the blended oranges, watermelons and pineapples pulps were separately extracted using a double folded cheese cloth, 150ml of distilled water was added to the residue left behind to assist thorough extraction of fruit juice. Mixed fruit juice was obtained by mixing orange pineapple and watermelons juices in equal proportion

2.2.4 Wheat bread and Wheat-cassava bread formulations

A composite flour containing70% wheat flour (W) and 30% cassava flour(C) was thoroughly blended in a kitchen mixer. The wheat bread (WB) and Wheat-cassava bread (WCB) with water served as the control. Orange (O), Pineapple (P) and Watermelon (WM) and mixed fruit (MF) juices were each used to produce bread form wheat flour code-named as follows: WB+O, WB+P, WB+WM, and WB+MF. The same fruit juices were each served as the only liquid used to form wheat-cassava dough and the bread there from were code-named: WCB+O, WCB+P, WCB+WM, and WCB+MF.

2.2.5 Bread Production

Straight dough method as described by AACC (2000) [4] was adopted for bread production. The recipe used is as presented in Table 1. Dry ingredients including the shortening were placed into the mixer and mixed for 2 min, medium speed, later water or fruit juices was added and mixed for 5 min, the resulting dough was placed in a stainless steel bowl covered with a cheese cloth and placed in a fermentation chamber(RH 85%, 37±2°C) for the first proof of 60min.The proofed dough was degassed manually using a rolling pin on a greased board, dough pieces (250g) wee manually rounded and placed in a greased aluminum pans and given a second proof of 60min and baked at 200°C 30min.Cooled loaves of bread were packaged in low density polyethylene bags prior to sensory and physicochemical evaluations.

2.3.0 Physicochemical analysis of the flours, blends, fruit juices and breads

Table 1: Bread Formulations

Ingredient	WB	WCB	Fruit juice-WB	Fruit juice WCB
Wheat flour (g)	1000	700	1000	700
Cassava Flour (g)	-----	300	-------	300
Granulated sugar (g)	50	50	30	30
Shortening (G)	20	20	20	20
Edible salt (g)	15	15	15	15
Dried Yeast (g)	15	15	15	15
Water (ml)	600-650	600-650	-------	------
Fruit juice (ml)	-------	-------	600-650	600-650

2.3.1 Particle size distribution of the flour and their blends

Nine test sieves (Endecotts) (1mm-0.63mm) mounted on a sieve shaker (EFL-300 Endecotts, UK) agitated for 10mins at the amplitude of 80 for 10mins was used to determine percentage retentions on each sieve, a measure of particle size distribution.

2.3.2 Physicochemical properties of the fruit juices

The pH of the fruit juices were measured using a digital P^H meter (PH-125, Search Tech Instruments, China), previously calibrated with acetate buffer pH 4.0. Total soluble solids in each fruit juice were determined using a hand held Refractometer (Master-53α, Atago Japan), readings were expressed in degree Brix. Acidity of the fruit juice was determined using 10ml of the juice diluted to 20ml with distilled water and titrated with 0.1M of NaOH using 1% Phenolphthalein as indicator. Titratable acidity (%) as citric acid was calculated from the formular: (Molarity of the alkaline × titre value × milliequivalent of citric acid ie 0.064 × 100) divided by volume of the juice used (AACC, 2000) [4]. Moisture content was determined by oven drying five grams (5gram) of each juice placed on pre-weighed aluminum evaporating dishes, oven-dried at 105°C for 3 h, weight difference after cooling in a dessicator expressed as a percentage of sample weight was regarded as water content (AACC, 2000) [4].

2.3.2 Water Absorption Capacity (WAC) of the flours / blends

The WAC of the flours or their blends were determined according to the method described by Beuchat (1977) [8], involving 1g of the sample mixed with 10ml distilled water in a centrifuge tube, centrifuging at 3000rpm for 30mins after first allowing to stand for 30min. The volume of the supernatant per unit weight of the sample (ml/g) was reported as the WAC.

2.3.3 Proximate composition of the flour their blend and their breads

The proximate compositions of the samples were determined according to the established procedures of AACC (2000) [4]. The moisture (air –oven drying, 105°C 1hr); Protein (N×6.25) (micro-kjeldahl method); Fat (Soxhlet extraction using petroleum ether); Ash (ashing at 550°C 6 h in a muffled furnace); crude fibre (alternate digestion of the defatted sample with dilute alkali (NaOH) and dilute acid (H_2SO_4) and incineration in a muffle furnace). The carbohydrate contents were calculated by 'difference'.

2.3.4 Mineral contents of the breads

The mineral contents of the samples were determined according to AOAC (2005) [5] procedure. Samples were dry-ashed, the ash was dissolved with 20ml of dilute hydrochloric acid, filtered using Whatman No. 4, the filtrate was made up to 100ml using deionized water in a graduated cylinder. Zinc, Calcium, Magnesium and Iron were determined in 10ml aliquots of the filtrates using atomic absorption spectrophotometer (Perkin-Elmer 410021, USA) and Phosphorous was assayed calorimetrically using vanado molybdate method of AOAC (2005) [5]. Potassium contents were determined using a flame photometer (Jenway PFP7, UK). Concentration of elements were expressed in mg/100mg which were extrapolated from standard curves prepared using the respective standard solutions.

2.3.5 Physical properties of the breads

Cooled loaves of bread were weighed; their volumes obtained using millet-seed (instead of rapeseed) displacement method and the specific loaf volumes (ml/g) calculated (AACC, 2000) [4].

2.3.6 Sensory assessment of the breads

Ten member semi-trained panel made up of seven men and seven women, of the Department of Food Science Technology, University of Maiduguri assessed the appearance/colour, shape, texture, taste, crumb structure of the breads on a 9-point hedonic scale where 1 represents extremely disliked, 5= neither liked nor disliked and 9 = extremely liked. Bread slices were presented to the panelists on coded disposable plates.

2.3.7 Statistical Analysis

Procedures were replicated and data generated were subjected to one-way analysis of variance, means were separated using Duncan's multiple range test and significance was accepted at p-value of 5%(p<0.05). SPSS version 16 was used to carry out the statistical analysis.

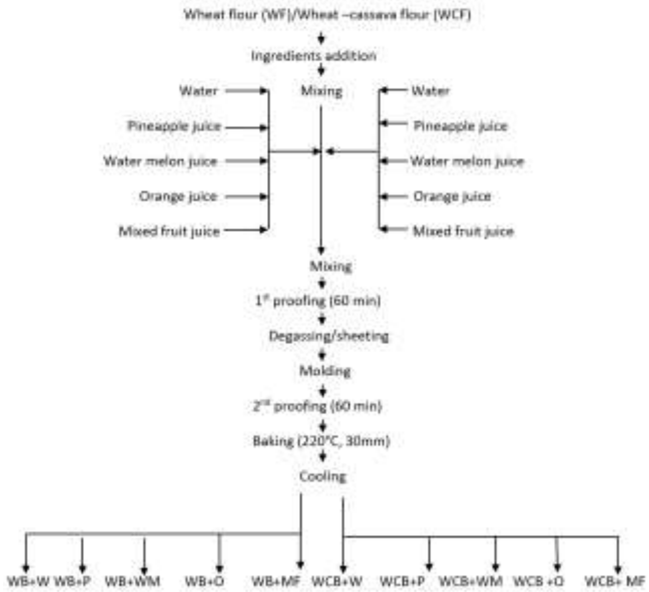

Fig 1: Flow chart indicating production process of fruit juice wheat and wheat-cassava bread

2.4.0 Results and Discussion

2.4.1. Granulation profile and water absorption capacities of the flours

Coarser flour particles were higher in cassava-flour (CF) as indicated by retention of 31.73% on the 700-1000µm sieves and its blend with finer wheat flour caused an increase in the percentage of coarse particles in wheat flour from 5.35% to 27.19% (WCF). Wheat flour (WF) had the highest proportion of fine particles. Wheat, wheat-cassava and cassava flours had equivalent proportion of the medium grained fractions (300-500um) as indicated by similar percentage retentions (Table1). Cassava flour required for bread or any other baked goods therefore requires special milling in order to achieve similar granulation as wheat flour so as to avoid poor hydration and mixing during dough formation. Sakhre *et al*. (2014) reported finer flour produced better bread because of higher content of damaged starch and higher quantity and quality of protein than coarser fraction; coarse particles according to Crabtree and James (1982) reported by Oludunmoye *et al*. (2010) puncture gas cells therefore detrimental to bread volume and texture. Water absorption capacity (WAC) of WF (2.55ml/g) was significantly higher than WCF (2.35ml/g) and 1.17ml/g of

CF. WAC is indicative of amount of water required for optimum dough consistency. Doxastakis *et al*. (2002) [13] reported that higher WAC is a property of composite flours/starch with higher protein content therefore availability of hydrophilic groups could be responsible for higher water absorptions of WF and WCF (Shrestha and Srivastava, 2017) [36]. Although higher WAC means higher bread yield however excess water absorption by a flour or blend is detrimental not only to bread specific volume but also to its storage stability. Adeleke and Odedeji (2010) [1] reported a decrease in WAC of wheat flour on blending with sweet potato from 2.45 to 1.18ml/g for wheat- sweet potato flour.

Table 1: Granulation characteristics (% retention) and water absorption capacities of the flours/ blend.

Flour/blend	Coarse sieves (700-1000µm)	Medium sieves (500-300µm)	Fine sieves (250-63µm)	WAC (ml/g)
WF	5.35	33.98	60.94	2.55
CF	31.73	34.54	26.02	1.17
WCF	27.19	30.40	29.43	2.35

WF= Wheat flour, CF= Cassava flour, WCF= Wheat-cassava flour.

Proximate composition of the flours and blend

The moisture levels (9.59-10.48%) of the flour/blend were low enough to ensure storage stability provided adequate measure is taken to protect them from the environmental influence.(Table 2) Wheat flour (WF) had significant higher protein, fat, than cassava flour (CF) while the latter had greater amounts of ash (2.57%), crude fibre (2.87%) and carbohydrate (80.76%). Replacement of wheat flour with 30%, starchy stuff decreased the quantity of gluten which constitutes about 50-80% of wheat storage proteins and is responsible for visco-elasticity of wheat flour dough, essential for gas retention in leavened baked goods (Singh and MacRitche, 2001) [37]. Repeated grinding and sieving in order to recover the wheat endosperm with the exclusion of wheat germ and outer coverings will definitely lead to lower levels of ash, fibre, and fat in wheat flour than in whole wheat flour except fortified.

Table 2: Proximate composition (%) of wheat flour and wheat-cassava flour used bread production

Flour/blend	Moisture	Ash	Protein	Fat	Crude fibre	Carbohydrate
WF (100:00)	9.81^{a}	1.94^{b}	10.71^{a}	2.25^{a}	0.62^{c}	74.67^{b}
CF (100:00)	10.09^{a}	2.57^{a}	2.52^{c}	1.47^{bc}	2.87^{a}	80.50^{a}
WCF (70:30)	10.19^{a}	2.14^{ab}	6.18^{b}	1.97^{b}	1.87^{b}	83.25^{a}

W=wheat, C=cassava, F=flour.

Proximate composition of the various fruit juice bread and the control.

Protein contents of wheat bread(WB) treated and the control(8.85-8.99%) were significantly not different from each other but significantly higher than those of wheat-cassava bread (WCB) (6.67-7.14%) and ranged from 8.99% (WB+MF) to 6.25% (WCB+MF).Fruit juice or cassava are not good sources of protein or fat and most bread flours are strong with at least 11% protein. Soybean addition was responsible for higher bread protein reported by Nwosu *et al*. (2014) [27] for wheat-cassava bread. Addition of cassava to wheat flour decreased the gluten content of the blend. The highest value of fat (1.89%) was in WB+W (control) and reduced progressively in all fruit juice treated breads more in fruit juice treated WC breads (1.05-1.75%) and the least value (1.05%) was in WCB+MF. Crude fiber contents were higher but not significantly different in wheat-cassava bread (2.41(WCB+WM)-2.74% (WCB+MF) than in wheat bread (2.01(WB+O)-2.25% (WB+WM) and ash content of wheat bread (1.23%) was the least, higher levels were found in treated wheat-cassava bread (1.45-1.60%) Cassava is a good source of ash, dietary fibre and carbohydrate which however depends on the age of the roots, soil composition, geographic location, variety and cultural practices; as for wheat flour, its ash content depends on extraction rate and further fortification. Ash contents of the wheat bread treated with fruit juice were slightly enhanced and greater than the control indicating positive influence of fruit juice inclusion, this enhancement is even higher in wheat-cassava bread. Similarly, Dhaka and Sangeeth (2017) [12] reported increase in ash and fibre contents with increased substitution of wheat flour with sweet potato. The carbohydrate contents obtained by difference were not significantly different although numerically WC breads seemed to contain higher level of carbohydrate than wheat breads and the values ranged from 58.00 (WB+W) to 59.52% (WCB+P). There were no clear-cut differences between the moisture contents (26.70WB+P-29.33%WCB+MF) of all the bread, although slightly higher in wheat-cassava bread. Odunlade *et al*. (2017) [28] reported bread moisture of 21.9% to 26.9% (Wheat bread). Many factors determine moisture contents of bread including baking temperature and time, fermentation time and water absorption capacity of the ingredients, moisture level influence bread stalling and storage potential. Similar observations were reported by Igbabul *et al*. (2014) [18], Iombor *et al*. 2016 and Iwe *et al*. (2016) [19, 21].

Table 3: Proximate composition (%) of wheat and wheat-cassava bread treated with different fruit juices.

Bread type	Moisture	Ash	Protein	Fat	Crude fiber	Carbohydrate
WB+W	27.00^{b}	1.23^{c}	8.85^{a}	1.89^{a}	2.21^{c}	58.00^{a}
WB+WM	26.99^{b}	1.38^{b}	8.99^{a}	1.75^{ab}	2.25^{c}	58.64^{a}
WB+P	26.70^{b}	1.39^{b}	8.90^{a}	1.70^{ab}	2.03^{d}	59.28^{a}
WB+O	26.93^{b}	1.37^{b}	8.89^{a}	1.71^{ab}	2.01^{d}	59.09^{a}
WB+MF	27.80^{ab}	1.48^{ab}	8.87^{a}	1.73^{ab}	2.12^{cd}	58.00^{a}
WCB+W	28.23^{a}	1.45^{ab}	7.10^{b}	1.08^{b}	2.43^{b}	59.71^{a}
WCB+WM	28.90^{a}	1.47^{ab}	7.11^{b}	1.13^{b}	2.41^{b}	58.98^{a}
WCB+P	28.30^{a}	1.49^{ab}	7.14^{b}	1.10^{b}	2.45^{b}	59.52^{a}
WCB+O	28.82^{a}	1.51^{ab}	7.13^{b}	1.12^{b}	2.37^{b}	59.05^{a}
WCB+MF	29.3	1.60^{a}	6.25^{c}	1.05^{b}	2.74^{a}	59.03^{a}

WB= Wheat bread, WCB=Wheat-cassava bread (70:30), W= water, WM= water melon juice,
P= pineapple juice, O= orange juice, MF= mix fruit juice.

Physicochemical properties of the fruit juices

Orange and pineapple juices were more acidic than water melon and mixed fruit juices because of lower P^{H} and higher % acidity (as citric acid). The P^{H} and titratable acidity (TTA) ranged from 3.69%-4.85% and 0.19%-1.03% respectively. Similar findings were reported by Ali *et al*. (2016) for pineapple juice; Yau *et al*. (2010) [40] water melon juice and Kale *et al*. (2011) [22] for orange juice. The state of ripeness of the fruit and fruit variety influence the pH, TTA and soluble solids among other factors. The total soluble solids as expressed in degree Brix varied from 9.32 in orange to 12.20 in pineapple juice. Water melon juice contained more water (94:51) than others. Although lower pH reduces mixing time however the stability and extensibility of the dough is reduced.

Table 4: Some of the physicochemical properties of the fruit juices

Juice	P^H	TTA (%)	Brix	Moisture	Colour
Watermelon	5.15[a]	0.19[d]	9.32[c]	96.51[a]	Pink
Orange	3.69[b]	1.03a	10.95[b]	89.62[b]	Yellow
Pineapple	3.84[b]	0.88[b]	12.20[a]	90.44[b]	Yellow
Mixed fruit juices	4.68[a]	0.61[c]	10.86[b]	98.22[c]	Yellowish Pink
Water	7.21	NA	NA	NA	Normal

Values are mean of triplicate determinations. Means in the column bearing different superscripts are significantly different (P<0.05); NA=not available

Mineral profile of the breads

The increasing order of the mineral elements in the various breads was K>P>Na>Mg>Ca>Fe>Zn. Bread that contained water had lower levels of the mineral elements. It is generally observed that mixed fruit juice breads had greater amounts of minerals than others. Bhardwaj *et al.* (2014) [9] reported that notable minerals in fruit juices are K, Ca, Mg; also, Sairi *et al*. (2004) [33] pointed out Mg, P and K as dominant elements. Added common salt enhanced the sodium contents of the breads which varied from 100.10-300.20mg/100g indicating that addition of external source of Na in form of common salt was unnecessary. Potassium contents increased significantly from 200.05mg/100g in the WB+W to 601.11mg/100g (WCB+MF), Na and K cooperatively regulate heart function, electrolyte balance and nerve transmission in humans.

Equally the controls had the least amounts of calcium (36.10mg/100g, WB+W) and 56.10mg/100g (WCB+W), higher among the treated, the least value(93.33mg/100g) was observed in WCB+WM. As for phosphorous contents of the breads the same trend was observed, the least levels in WB+W (150.30mg/100g) and WCB+W (140.69mg/100g), the mixed fruit juiced breads the highest respectively 401.21mg/100g and 390.40mg/100g for WB+MF and WCB+MF. Calcium and Phosphorous are needed not only for mineralization of tissues, also the ratio of Ca to P of 1 or greater and Na-to K of 1 or lesser are required in humans for normal blood pressure and lipid metabolism (So Young Bu, 2015). Magnesium (Mg) contents was also enhanced (17.30-305.66mg/100g), it is also an important element for heart health. Iron (5.25-17.08mg/100g) and Zinc (2.51-5.05mg/100g), two microelements that are of worldwide deficiency increased in the treated breads, fruit juices are not known as rich source of these elements and must have originated from either wheat or cassava flour. Fe and Zn are readily absorbed in the presence of ascorbic acid, a powerful reducing agent but the baking process must have destroyed available ascorbic acid. Improvement in nutrient density of composite flour bread including the mineral profile as observed in this study was in line with those reported by Bolarinwa *et al.* (2017) [10] for Moringa seed flour treated bread, Nduugu *et al.* (2015) [26] for oyster mushroom bread, Iombor *et al*. (2016) [19] for Sesame seed bread.

Table 5: Mineral composition of the fruit juice treated wheat and wheat-cassava bread samples

Bread	Na	K	Ca	Mg	P	Fe	Zn
WB+W	100.20[d]	200.05[c]	36.10[e]	17.30[d]	150.30[d]	5.25+0.51	2.51+0.05
WB+WM	175.30[c]	320.10[bc]	105.20[c]	200.40[bc]	220.50[c]	7.14+0.22	1.42+0.03
WB+P	180.25[c]	405.10[b]	126.00[cd]	290.50[bc]	308.20[b]	11.21+0.09	2.80+0.09
WB+O	190.55[c]	208.50[c]	240.50[b]	195.00[c]	300.20[b]	15.67+0.12	5.05+0.05
WB+MF	250.00[b]	580.23[a]	380.29[a]	290.30[a]	401.21[a]	17.08+0.31	4.14+0.02
WCB+W	165.67[c]	210.30[c]	56.10[e]	223.30[c]	140.69[d]	7.11+0.21	2.30+0.02
WCB+WM	184.75[c]	301.21[bc]	93.33[d]	235.40[bc]	174.30[cd]	8.11+0.81	2.96+0.07
WCB+P	189.30[c]	296.33[bc]	103.00[c]	245.09[bc]	201.21[c]	9.64+0.41	3.13+0.06
WCB+O	192.20[c]	301.24[bc]	208.20[b]	288.80[bc]	210.40[c]	10.43+0.50	2.55+0.05
WCB+MF	302.10[a]	601.11[a]	330.20[a]	305.66[a]	390.40[a]	11.78+0.29	3.96+0.02

WB= Wheat bread, WCB=Wheat-cassava bread (70:30), W= water, WM= water melon juice= pineapple juice, O= orange juice, MF= mix fruit

Physical properties of wheat or wheat-cassava bread with or without fruit juices.

Wheat bread (control) had the highest volume (838ml) and specific loaf volume (SLV, 4.97) significantly higher (P<0.05) than the treated breads, however among the treated, there were significant differences in the SLV which ranged from 4.06ml/g (WB+O) to 4.47ml/g (WB+WM). The SLVs reported by Igbabul *et al*. (2016) [18] for wheat – maize sweet-potato bread; Eriksson *et al*. (2014) [15] for wheat- cassava bread; Iombar *et al*. (2016) for sesame treated bread; Nduugu for Mushroom bread; Fazilah *et al.* (2014) [7] for tempoyak bread were all less than SLV obtained in this study(4.06-4.97). Bead weights were not significantly different, treated or not treated and ranged from 168.5g (control) to 180.5g (WB+MF). The higher bread volumes and SLV recorded in this study can only be linked to presence of organic acids, ascorbic acid and availability of fermentable substrates present in added fruit juice.

Table 6: Weight, volume, and specific volume of the wheat and wheat- cassava bread samples treated with fruit juices.

Bread Type	Weight(g)	Volume (ml)	SLV (ml/g)
WB+W	168.5[b]	838[a]	4.97[a]
WB+WM	175.5[ab]	767[ab]	4.47[ab]
WB+P	174.5[ab]	752[ab]	4.32[b]
WB+O	175.0ab	710[b]	4.06[c]
WB+MF	180.5[a]	760[ab]	4.21[b]
WCB+W	173.5[ab]	755[ab]	4.45[ab]
WCB+WM	174.5[ab]	765[ab]	4.38b
WCB+P	175.0[ab]	780[ab]	4.45[ab]
WCB+O	174.5[ab]	714[b]	4.09[c]
WCB+MF	177.5[a]	770[ab]	4.33[b]

WB= Wheat bread, WCB=Wheat-cassava bread (70:30), W= water, WM= water melon juice,
P= pineapple juice, O= orange juice, MF= mix fruit juice.

Sensory attributes of wheat or wheat-cassava bread treated with or without fruit juice

No significant variation was observed in the crust colour of all the bread types; however, the wheat bread was more evenly browned than the fruit juice treated therefore was rated the best (8.7) on a 9-point hedonic scale. The taste scores of WB+W (7.9), WB+WM (7.6), WB+O (7.7) and WCB+O were better and not significantly different (P>0.05), while pineapple and mix fruit treated bread either WB or WCB received the least taste scores but not rejected. The texture (softness) of WB+W was significantly higher (8.0) than others however none scored less than seven except WB+P, WCB+P and WCB+MF. Crumb grain (evenness of the air cells) of WB+W had the best score (8.5), however fruit juice treated WB or WCB were well appreciated generally. Crumb grain scores varied from 7.0 to 8.5 (WB+W). No significant difference was observed among the aroma scores (6.9 – 7.5) of all the bread. It was observed that watermelon and orange juice treated WB or WCB had greater overall acceptability scores. Despite the natural reluctance to accept what is new or modified, the fruit juice treated breads were very much appreciated by the test panelists. Acid produced during fermentation favourably modify bread flavour and texture, apart from stalling and spoilage retardation.

Table 7: Sensory attributes of the wheat and wheat-cassava bread treated with or without fruit juice

Bread	Crust colour	Taste	Crumb texture	Crumb grain	Aroma	Overall acceptability
WB+M	8.1^{ab}	7.9^{a}	8.2^{a}	8.5a	6.9^{a}	8.3^{a}
WB+WM	8.9^{a}	7.6^{a}	7.9^{a}	8.0ab	6.9^{a}	7.7^{ab}
WB+P	8.0^{ab}	6.3^{b}	6.8^{c}	7.8ab	7.0^{a}	7.1^{bc}
WB+O	7.1^{b}	7.1^{ab}	7.6^{ab}	7.4b	7.4^{a}	7.9^{ab}
WB+MF	7.8^{ab}	7.4^{ab}	7.4^{ab}	7.6b	7.2^{a}	7.5^{b}
WCB+M	7.5^{b}	7.1^{ab}	7.3^{ab}	7.1bc	6.9^{a}	6.5^{c}
WCB+WM	7.3^{b}	7.2^{ab}	7.4^{ab}	7.4b	7.5^{a}	7.5^{b}
WCB+P	7.1^{b}	6.4^{b}	6.2^{d}	7.2bc	7.1^{a}	6.0^{cd}
WCB+O	8.0^{ab}	7.5^{a}	7.3^{ab}	7.4^{b}	7.2^{a}	7.8^{ab}
WCB+MF	7.3^{b}	6.5^{b}	7.0^{c}	7.0^{bc}	7.0^{a}	7.2^{bc}

WB= Wheat bread, WCB=Wheat-cassava bread (70:30), W= water, WM= water melon juice,
P= pineapple juice, O= orange juice, MF= mix fruit juice.

Conclusion

Blending of wheat with cassava flour reduced its finer granulation and protein content of wheat flour; treatment of the dough with fruit juice acidified the dough and enhanced yeast activity and bread volumes although bromelin content of pineapple juice was detrimental to dough stability until diluted with water. Loaf specific volumes of the breads were enhanced as well as the proximate and mineral composition of the breads partly due to cassava flour and fruit juice inclusion. The dominant minerals were Potassium, Phosphorous and Magnesium. Addition of common salt as dough ingredient was found unnecessary. Mix-fruit juice bread had the best mineral profile but lowly rated sensory attributes. The study has innovated means of positively modifying and enriching both the nutrient profile and specific volumes of bread naturally, locating further use of fruit juice and cassava flour.

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