Evaluation of the Physicofunctional, Proximate Composition, and Sensory Properties of Bread Produced from Blends of Wheat, Tuber Crop and Melon Seed Flours

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***Abstract*: The study focused on production of breads from blends of wheat and tuber flours fortified with melon seed meal (MSM). Fresh roots of Cassava (C), Sweet (S) Potato, Irish (I) Potatoes were peeled, ground, dewatered, dried and milled to obtain the respective flours. Dehulled, cleaned melon seeds were air-dried, ground and one part defatted with aqueous ethanol to obtain defatted (D) melon seed meal and the remaining full (F) fat melon seed meal (MSM). Tuber flours (25%) were individually blended with wheat (W) flour (65%) and fortified with either 10% full fat(F) or defatted(D) MSM. The nine code-named samples were: WCF (65:25:10), WCD (65:25:10), WIF (65:25:10), WID (65:25:10), WSF (65:5:10), WSD (65:25:10), W (100:0:0), WF (90:10) and WD (90:10). Blends were used to produce bread; both the breads and blends were evaluated for proximate composition, physical and sensory properties. Sieve analysis revealed that cassava flour had the highest retention on >0.71>1mm sieves, wheat flour on >0.30> 0.50mm sieves and Irish potato on <0.25mm. Water absorption capacities (224-256%) of the blends were high and significantly different (p<0.05). The moisture, ash, protein, fat, crude fibre and carbohydrate contents of the blends varied significantly (p<0.05) from 6.31-8.91%, 1.51-2.00%, 6.86-12.09%, 1.91-12.58%, 2.65-6.78% and 65.73-74.92%. The composite flour breads had greater fibre (1.88-2.43%), moisture (25.39-30.63%), ash (1.61-1.85%), protein (12.72-17.77%), fat (5.22-8.31%) than the wheat bread. Bread treated with defatted MSM had smaller volume and specific volume and wheat bread the highest. Overall acceptability of all the breads was high but wheat bread and wheat bread fortified with 10% MSM had the best ratings and Irish potato bread the least. The study concluded that acceptable bread with enhanced nutrient profile and sensory properties are achievable with blends of 25% cassava or sweet potato flour and 65% wheat flour fortified with 10% melon seed meal although bread specific volumes were negatively affected volume.**

***Key words*: Wheat, Tuber crops, Melon seed, Composite flour, Bread**

I. INTRODUCTION

Bread, a spongy convenient food with its root in antiquity, is now accepted and enjoyed by all population subgroups, young or old, rich or poor, rural or urban in all climes and cultures, has now become the commonest item on a breakfast table in developing countries. Aljobar [1] reported that bread is the commonest breakfast meal for Riyadh (Saudi Arabia) residents, that its consumption decreased with increase in income level. Bread in its simplest form is made from four basic ingredients: flour, water, yeast and salt [2], optional ingredients include flours from non-wheat crops including those of tubers and grain legumes; also fat, sugar, malt flour, emulsifiers, enzymes, preservatives, milk, fruits etc.[3] Optional ingredients are used to improve the loaf physical and sensory attributes such as volume, softness, grain uniformity, texture, colour, flavour, and most importantly the nutritive value[2]. The unit operations involve in bread making include mixing, kneading, rolling, proofing/ fermenting and baking[4,5]. Qayyumet al.[6] defined composite flour as a mixture starch-enriched tuber or cereal and protein-enriched legume flour with or without wheat flour. Oil seed meal, a usual by-product of vegetable oil processing is a rich source of protein, minerals and dietary fibre.Srikantha and Erdman[7] reported that fortifying wheat bread with oilseed or legume flour could minimize the necessities for large-scale importation of wheat by non- wheat producing or deficit countries as well as the enhancement of the nutritive composition of bread possible only through multigrain flour formulation. This becomes necessary because bread is the commonest consumed food item, therefore can be used as a vehicle for provision of food enriched with calorie, minerals, protein, B-vitamins, dietary fibre and non-nutrient phytochemicals to the populace. Unlike developed world, bread consumption is increasing in developing countries like Nigeria with high youthful population and rural urban migration. Economic, social or health reason are considerations that underlie the growing interest in application of composite flour technology for bread or other bakery products production [8], it is considered advantageous in tropical countries as it reduces the importation of wheat and encourages the use of abundant, cheap, non-wheat crops [9,10,11].

The uniqueness of wheat for baked goods production is due the elastic property of its gluten that holds leavening gases during fermentation and baking [12] of such products as bread, biscuits, cookies, doughnuts and cakes, of which bread is the most popular[5].

Roots and tubers refer to plants that store edible materials in subterranean roots, corm or tuber or rhizome, these crops play a very important role in food security, as they are tolerant to environmental stress and produce reasonable yields under marginal soil conditions. These crops are the basic diets to millions of people in vast areas of tropics and subtropics where most of the world undernourished people live [13].

Sweet potato is an excellent source of energy (438kj/100g edible portion) and can produce more edible energy per hectare per day than cereals such as wheat and rice. [14] and has other advantages such as versatility, high yield, hardness and wide ecological acceptability [15]. Its protein content is higher than found in other tubers, and despite its high carbohydrate content, sweet potato has a low glycemic index due to low digestibility of the starch, making it a suitable diet for diabetic or overweight people [16,17]. Yulian et al. [18] reported that sweet potato flour contains: 6.76% moisture, 5.95% protein, 1.7% lipid, 6.75% fibre, 2.83% ash and 68.73% starch. In addition some varieties of sweet potatoes contain coloured pigments, such as β-carotene, anthocyanin and phenolic compounds, these are known antioxidants.Yulian et al.[18] successfully incorporated 40% fermented sweet potato flour for production of pan bread.

Cassava (*Manihot esculenta Crantz*) is a hardy crop that can grow in many hot and dry regions of the globe, Africa accounts for 55% of the world production, a total of 242 metric tons in 2012 [19]. Cassava root is the fourth supplier of dietary energy in the tropics after wheat, maize and rice, and the 9th worldwide [19]. Its cultivation and processing ensure household food security, income and employment opportunities for more than 500 million people in Africa, Asia and the Americas. The crop is tolerant of low soil fertility, drought and most pest and diseases with no critical date of harvest. It is an important food security crop for farmers living in fragile environments and unstable ecosystems.

Irish Potato (*Solanium tuberosum*) is a perennial plant of the solanaceae or nightshade family and is commonly grown for its starchy tuber. Nigeria is the largest producer of Irish potato in sub-Saharan Africa, the 7th in Africa with an output of 1,284,370 metric tons and per hectare yield of 3,720.1kg/ha [20, 21]. The high perishability of these tubers calls for techniques of preserving them to avoid the usual post-harvest losses, seasonal glut and scarcity, distribution problems that reduce farmer's morale and impinge negatively on productivity. Therefore, transformation of roots into flours will create avenue for production of value-added food products either alone or blending with other flours.

Melon or *Egusi* (Citrullus colocynthis L.) belongs to the *cucurbitaceae* family, a non-climbing or crawling annual with shallow fibrous root system mostly grown as a subsidiary crop interplant with either maize or yam in savannah belt and high altitude areas of Central Nigeria and irrigated farming areas of northern Nigeria. Melon is an important cash crop cultivated for their edible seeds embedded within inedible bitter pulp. Melon seed paste is a major soup thickener in Nigeria, and for the preparation of *ogiri*, a soup condiment with characteristic ammoniacal aroma. Melon seeds are regarded as power house of various nutrients: protein, (28%), oil 52%(15.9% oleic acid and 62.8% linoleic acid), fibre (2.7%), ash (3.6%), carbohydrate(8.2%) vitamins(B1, B2) and minerals(K, P, S, Ca, Mg, Mn, Fe, Zn) [22, 23]. Its defatted seed meal contains up to 60% protein and a good source of arginine, methionine and tryptophan [24]. Many oil seeds plant proteins usually in the form of their flours or protein isolates are being investigated for fabrication of novel food products or enhancement of existing ones, such foods have the advantage of low cost, nutritive, attractive and acceptable to consumers just like conventional foods from meat and fish. Umoh and Oke [25] reported enhanced biological value, net-protein utilization and protein efficiency ratio for melon seed based food products which are comparable or higher than others produced from other oil seeds. Therefore, the present study sought to evaluate the physicochemical and sensory properties of composite breads produced from blends of wheat and tuber flours fortified with either full fat or defatted melon seed meal.

II. MATERIALS AND METHODS

2.1 Materials

The raw materials used for this study were purchased at Maiduguri Monday market, Borno State, which included: wheat flour (Golden penny, Nigeria Flour Mills, Lagos), fresh cassava roots, Irish potatoes, sweet potatoes (yellow-fleshed), melon seeds (shelled), baking fat, granulated sugar, table salt, dried bakers' yeast. The processing of the raw materials and baking of the breads were carried out at Food Processing Laboratory of the Department of Food Science and Technology, University of Maiduguri, Borno State, Nigeria. All the chemicals and reagents used for the analysis were of analytical grade and some were available in the Department's chemical store.

2.2 Raw Materials Processing

2.2.1 Preparation of tuber/root flour

The raw materials (fresh cassava, Irish and sweet potato roots) were washed, peeled manually with stainless knife, rewashed, sliced (< 3mm), dried for 2-3 days in a dome dryer, ground using attrition mill and packaged for use. Prior to drying, Irish and sweet potato slices were blanched separately by immersing into warm water (1:3 weight/vol.) containing 1.0% citric acid and 0.5% sodium metabisulphite.

2.2.2 Full fat melon seed meal

Dehulled melon seeds were sorted to remove unsound seeds, extraneous materials and finally winnowed, washed, dried and ground into a fine meal.

2.2.3 Defatted melon seed meal

A portion of melon seed meal was mixed with 80% aqueous ethanol (1:3) and stirred for 5 min in a stainless bowl. The supernatant which carries the oil was then decanted. The residue was wrapped in a cheese cloth and squeezed to remove residual solvent after which the defatted residue was oven-dried for 5 h 70ºC and thereafter ground and sieved (300µm).

2.3 Formulation of the composite blends

The six (6) flour blends were produced using a constant ratio of 65:25:10 representing wheat flour: tuber flour: melon seed meal (Full fat (F) or defatted (D). Wheat flour served as the control.

Table 1 Recipe for composite bread production

Blend/ingredient	W	S	C	I	D	F	Fat (g)	Sugar (g)	Salt (g)	Yeast (g)	Water (ml)
W	1000	-	-	-	-	-	40	50	15	20	550-600
WSD	650	250	-	-	100	-	40	50	15	20	550-600
WSF	650	250	-	-	-	100	40	50	15	20	550-600
WCD	650	-	250	-	100	-	40	50	15	20	550-600
WCF	650	-	250	-	-	100	40	50	15	20	550-600
WID	650	-	-	250	100	-	40	50	15	20	550-600
WIF	650	-	-	250	-	100	40	50	15	20	550-600

W= wheat Flour, S= sweet potato flour, I= Irish potato, F= full fat melon seed meal, D=Defatted melon seed meal

2.4. Bread Production using the flour blends

The composite flour breads were produced using the straight dough method of AACC [24] with the recipe as shown in **Table** 1. The flour and other ingredients were mixed in a mixer (Master Chef MC-B180, China) for 3 minutes medium speed. The dough was covered with kitchen cloth and placed in the fermentation chamber for 90 min at the temperature of 37±2ºC, relative humidity 85%, thereafter it was degassed. The baking pans were greased with fat, the dough pieces (250g) were manually molded and placed into the pans and proofed for 60 min and later placed in the pre-heated oven, baked at 200ºC for 30minutes. The loaves of bread were allowed to cool (3-4 h), left in Zip lock bags; thereafter the physical, chemical and sensory properties of the cooled bread were evaluated.

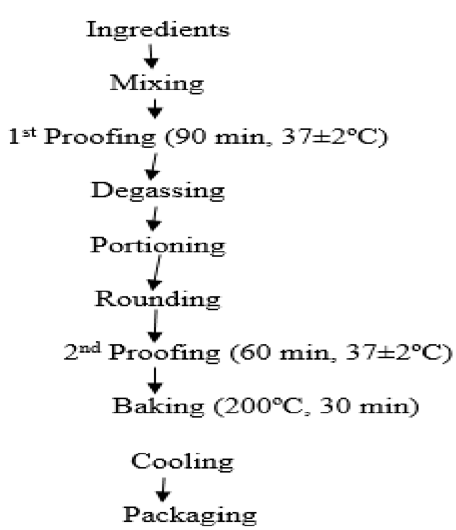

Figure 1: Flow chart for the production of bread.

2.5.0 Physicochemical Analysis of Flour Blends and Breads

2.5.1. Particle size distribution of the flour blends

The granularity of the flours were evaluated according to the AACC method 66-20.01,[27] involving a set of nine test sieves of different mesh sizes stacked together in order and mounted on a Retsch sieve shaker(AS Basic 200, Retsch GmbH). Each flour (100g) was placed on the top sieve and the machine operated for 5 min., retentions on the sieves were expressed as % of the original sample weight.

2.5.2 Water absorption capacity of the blends

The method of Solunkhe [28] was applied for the determination of water absorption capacities of the flour blends, the outcomes were expressed as gram water per gram samp**le.**

2.5.3 Proximate composition of the blends and breads.

The flour blends and composite breads were analyzed for the proximate composition (moisture, protein, ash, crude fiber, carbohydrate, and calorific value) using the procedures of AACC (26). Moisture contents were determined by drying the samples at 150ºC for 1 ½ h in an air oven. Protein contents (% N ×6.25) were determined according to the Kjeldahl method. Crude fat were determined using solvent extraction in a Soxhlet apparatus with petroleum ether (boiling point, 40-60ºC). The ash contents were determined by drying ashing in a muffle furnace at 550ºC for 5 h. Dietary fibre was determined by alternate digestion of 5g defatted sample with dilute Sulphuric acid (1.25%) and dilute Sodium hydroxide (1.25%) solution, washing, drying and finally ashed in a muffle furnace at 550ºC for 5 h. Carbohydrate contents were calculated by "difference". Calorific values (E (kcal) were obtained by multiplying the values of carbohydrate, protein and fat with Atwater conversion factors followed by summation: E = [4x(protein) + 4x(CHO) + 9x(fat)].

2.5.4 *Physical properties of the bread*

The weights of cooled loaves were measured using a laboratory weighing scale and the readings were recorded in gram. The loaf volumes were measured using millet seed displacement method, a modification of the method described by [29], and the specific volumes calculated as loaf volume divided by loaf weight (cm^3/g).

2.5.5. *Sensory evaluation of loaves of bread*

The sensory properties of the bread were evaluated on a 9-point hedonic scale as described by Larmond [30] where 9 represents liked extremely, 1 represents disliked extremely, and 5 neither liked nor disliked. Twenty (20) semi-trained judges comprising of staff and students of the Department of Food Science and Technology, University of Maiduguri, evaluated and scored the following bread attributes (crumb texture, crust colour, taste, aroma) and overall acceptance. Panelists were provided with coded samples of the breads and warn water for mouth gargling after each session.

2.6 Statistical Analysis

Determinations were conducted in duplicates and data generated were subjected to one-way analysis of variance (ANOVA). Means were separated using Duncan multiple range test and a p-value of less than 0.05 accepted as significant ($p<0.05$). Results were presented as mean ± standard error of the mean

III. RESULTS AND DISCUSSION

3.1 Classification of particle size of the flour blends

Classes of particle size in the various flours are presented in **Table 2a** and particle size distribution of the individual flours in **Table 2b**. Wheat flour had the highest retention (60.34%) or least thorough (39.66%) on 0.3-0.5mm sieves indicating medium granulation as classified here, next was sweet potato flour, 50.31% retention. Cassava and Irish potato flours had more or less equivalent medium granulation on 0.3-0.5mm sieves. Cassava flour had the coarsest granulation with the highest retention of 42.04% or 57.96% thorough on >0.71mm<1mm sieves and Irish potato flour the least, 5.42% retention or 94.58% thorough, sweet potato 11.38% retention or 88.62% thorough on >0.71<1mm sieves. On >0.063mm<0.3mm sieves cassava flour and wheat flour had the least retention 19.35 or 80.65% thorough, the finest, the next was cassava, a retention of 21.67% or 78.33% thorough meaning cassava flour was finer than sweet and Irish potatoes flours, it had the highest amount of coarse particles on higher sieves, quite an irony; sweet potato 30.67% retention or 69.33% thorough and Irish potato with the highest retention, 60.21% or 39.79% thorough on >0.063<0.3mm sieves indicating it had the coarsest granulation in relation to these sieves. 0n a <0.112mm sieve[30] reported 25% and 36% retentions for wheat and cassava flours respectively contrary to smaller retentions or finer flour particles obtained for a similar sieve size in this study. Hugo et al.[9] reported 95% and 98% for sorghum and wheat flours respectively passed through <0.212mm sieve. According to Codex A [32], granularity of wheat flour is such that at least 98% of the flour should pass through a 0.212mm sieve (US Standard Mesh No. 70). None of the flours used for blend formulation satisfied this standard, this is because hammer mill used for size reduction would not be able to produce finer flour than roller mills used for commercial wheat milling. However, flour granularity depends on many factors including processing conditions and methods. Flour/blends with finer texture are easily hydrated than coarse-textured flours which impact on dough higher mixing time, higher water absorption and undesirable mouth feel or textural quality of the end products. Sakhare et al.[33] reported finer fractions had lower ash, higher dry gluten, higher damaged starch and higher SDS value than coarse fraction. Bourre et al.[34] noted finer flour has greater starch damage, lower water absorption capacity and higher peak and final viscosities; that flour particle size affect flour and bread making properties. Overly coarse flour particles puncture gas cells and are detrimental to proper mixing and hydration of the dough and affecting the textural properties of the bread. Cassava or other roots/tubers require special milling to obtain finer flour that accord with the granularity of wheat flour for homogenous blend formulation. Menon et al.[35] reported that particle size of wheat flour influences its proximate composition and phytochemical contents such as the phenolics

Table 2a: Classification of particle sizes available within each flour as indicated by %retentions on sieves

Flour	>0.71<1mm (coarse)	%Retentions >0.30<0.5mm (medium)	>0.063<0.3mm (fine)
Wheat	19.65	50.34	19.35
Sweet potato	11.38	50.31	37.84
Irish Potato	5.45	34.38	60.21
Cassava	42.04	35.10	21.67

As for the particle size distribution of the various flours, it was observed that particle size ranging from 1mm to 0.063mm was represented in the flours as shown in **Table 2b**. Flours with highest number particles of the size, 0.3mm were in the decreasing order of %retention: wheat 38.16%, sweet potato 31.84%, Irish potato 21.76% and cassava 13.28%. Again, cassava flour particles were well represented in the higher sizes more than others: >1.0mm (28.16%), 0.71mm (11.72%), and 0.425mm (13.78%). Lagnika et al [31]similarly observed that cassava flour contains particles with bigger size than wheat flour. Only Irish potato flour had the highest retentions at the lower sieves, 0.15mm (19.57%) and 0.063mm (19.80%) indicating Irish potato flour had the fewest number of fine particles of the sizes, 0.15mm and 0.063mm than other flours, this was collaborated by the amount of flour that accumulated in the pan after sieving. As observed here, cassava flour can easily blend with wheat flour, better than others because of similar granularity.

Table 2b: Particle size distribution of the various unsieved flours used for blend formulations as indicated by retentions (%) on various sieves

Sieve size (mm)	Wheat	Cassava	Sweet Potato	Irish Potato
1.00	6.80	28.16	1.98	1.00
0.85	2.55	2.16	2.44	0.88
0.71	10.3	11.72	6.96	3.54
0.50	12.2	9.10	10.32	7.68
0.425	9.98	13.72	8.14	4.94
0.30	38.16	13.28	31.84	21.76
0.25	2.88	10.60	1.54	7.68
0.15	9.80	3.64	9.78	19.51
0.063	3.47	4.77	15.92	19.80
Pan	3.25	2.66	10.6	13.22
Total	99.56	98.81	99.52	99.8

3.2 Proximate Composition and water absorption capacities of the blends and wheat flour

Moisture contents of the wheat flour and the flour blends were generally low, a range of 6.31% (WCF) – 8.91% (W100) although moisture of wheat flour was significantly higher ($p<0.05$) but the observed variations in the moisture contents of the blends were significantly not different ($p>0.05$), **Table 3**. The dry and high temperature of the semi-arid environment of Maiduguri, northeastern Nigeria at this time of the year (April-June) was responsible for the lower moisture contents recorded, consequently water absorption capacities (WAC) of the flour blends were generally high, 286% (WSF), 285% (WCF), 273% (WIF) and 224% (WF), surprisingly higher in the blends with full fat melon seed meal (MSM), a desirable property for higher bread yield and tenderness [36]. Agbara et al. [37] reported 1.31-2.00 ml/g for water absorption capacities for different brands of wheat flours sold in Nigerian markets, which increased on blending with either cassava or sweet potato flour. Blends are known to possess higher water absorption capacity (WAC) than single grain flour [38,39]. Nwosu et al.[40] reported 2.07ml/g, 0.99ml/g and 3.61ml/g WAC for wheat, cassava and malted soybean flours respectively. Flour water absorption is a function of flour particle size, hydrophilic constituents and damaged starch content. The inorganic matter contents of blends as represented by their ash varied from 1.51% (WCD) to 2.80% (WCF) higher in the blends with full fat MSM except in wheat flour-sweet potato-defatted MSM(2.00%). Greater enhancement of the ash contents of blends with full fat MSM was noted as revealed by ash content of the wheat flour, 1.78%. Ash content of flour is a measure of the extent of refining and is reflected in the color of the flour as well as the end products. Defatting MSM with aqueous alcohol impacted negatively on the ash and protein contents of the blends containing defatted MSM. Wheat flour (W100%) had the highest protein content (12.09%), those of the blends ranged from 6.76% (WID) to 8.48% (WSF). At the level of 10% MSM addition to the blends, protein levels increased slightly but there were no clear cut differences in the protein levels of the blends, however blends with full fat MSM had slightly greater protein contents. Most flours made form root or stem tubers contain less than 5% protein Debbie, therefore when such is added to higher protein bread flour, a dilution effect on the protein content of the resulting blend or bread is commonly observed; such dilution has negative impact on bread volume and texture [47,48]. It is known that viscoelastic network formed by wheat gluten is responsible for retention of leavening gases during fermentation and baking [37], a reduction has negative mpact on bread quality [47]. Agbara et al.[37] reported higher protein, crude fibre, fat and ash contents in wheat flour than in cassava flour; this implies that the nutrient density of such blends formed from wheat and tuber flours are lower and decreases with increased replacement of wheat flour with tuber flour[41,42,31], therefore the need for fortification of such blends with rich protein sources like oil seed meals.

Blends that contained full fat MSM had significant higher fat content (5.42-12.58%) expectedly, because melon seed is a rich source of vegetable of oil [43] and whenever used to fortify low fat wheat (1.91%) or tuber flours (<1,5%), probably translates to higher calorific value, higher flavour retention and better texture of end products produced from such blends due to fat content enhancement. Contrary to Lagnika et al.[31] observation, wheat flour had the least amount of dietary fibre (2.65%), which increased with addition of tuber flour and MSM, highest amount (6.78%) was found in WSD, overall it ranged from 3.61-6.78%, Irish potato flour treated blends had the least level of dietary fibre. Carbohydrate contents of the blends as calculated by 'difference' depended on the level of other nutrients, in this case blends with higher levels of fat and protein had lower levels of carbohydrate, and mostly full fat treated blends (**Table 2**.)

Table 3 Proximate compositions (%) and Water Absorption Capacities of different flour blends.

Formulation	Moisture	Ash	Protein	Fat	CHO	Fibre	WAC (%)
W (100:0:0)	8.91±0.10^{a}	1.78±0.30bc	12.09±0.27^{a}	1.91±0.04^{f}	72.56±00^{ab}	2.65±0.10^{d}	224±1.90^{a}
WCF(65:25:10)	6.31±0.04^{bc}	2.80±0.21a	7.95±0.07^{b}	12.05±0.19^{ab}	65.75±00^{b}	5.16±0.11^{bc}	285±3.22^{a}
WCD(65:25:10)	6.75±0.07^{b}	1.51±0.04cd	6.86±0.04^{d}	5.42±0.36^{e}	73.92±00^{ab}	5.54±0.07^{b}	246±2.73^{b}
WIF(65:25:10)	7.09±0.08^{ab}	1.97±0.18b	7.23±0.04^{cd}	12.58±0.36^{a}	67.52±00^{b}	3.61±0.18^{cd}	273±2.98^{ab}
WID(65:25:10)	6.84±0.04^{b}	1.62±0.05c	6.76±0.06^{d}	6.02±0.08^{d}	74.92±00^{a}	3.84±0.10^{c}	245±2.50^{b}
WSF(65:25:10)	6.98±0.09^{b}	1.65±0.12bc	8.48±0.15^{b}	8.07±0.13^{b}	68.23±00^{b}	6.39±0.34^{ab}	286±1.41^{a}
WSD(65:25:10)	6.76±0.06^{b}	2.00±0.08b	8.41±0.09^{b}	7.54±0.49^{c}	68.51±00^{b}	6.78±0.19^{a}	233±1.34^{bc}

Values are mean¥standard error of the mean. Means in a column with differing superscripts are significantly different($p<0.05$)
W=wheat, I=Irish potato, S=sweet potato, C=cassava, F=fullfat MSM, D=defatted MSM

3.3 Proximate composition of various breads

Proximate compositions of the bread are presented in **Table 4**. Moisture contents of the bread varied significantly from 22.34% (wheat bread) to 30.63% in WD or 30.33% WID. Bread produced from blends had greater moisture contents especially those treated with defatted MSM. This can linked to higher water absorption capacity of the blends. Nwosu et al.[40] reported moisture content of 29.53-31.02% for wheat-cassava bread with added soybean flour. Nature of bread formulation and baking time among other factors influence bread moisture content. Although high bread moisture enhances bread tenderness and may delay stalling, however it decreases storage stability through faster activation of deteriorative physicochemical changes. Ash contents (1.48-1.85%) of the breads decreased compared with the levels observed in the blends, the same trends was also observed for fat (3.81-8.31%) and fibre contents (1.96-2.43%), perhaps as a result of higher moisture contents of breads relative to blends, however protein contents of the breads from the blends were higher, the control (W100:0) the least, 11. 29%, slightly lower than 12.09% observed in wheat flour. Wheat breads treated with either full fat (WF) or defatted (WD) MSM had the highest protein 17.20% and 17.77%, further indicating dilution effect of tuber flour on wheat flour protein. Among the composite breads protein content ranged from 12.72% (WID) to 16.18% (WIF) different from 11.02%-14.36% protein reported by [40] for wheat-cassava bread with soybean improver. There were moderate decrease in the fat contents of the MSM treated breads compared with those of the blends, except the control bread (W100:0) which had 3.81% fat against 1.91% in wheat flour. Expectedly, composite breads treated with full fat MSM had higher fat contents (5.32-6.92%) which were not significantly different ($p>0.05$) among, highest amounts were observed in bread devoid of root flour but treated with MSM (8.10%, WD and 8.32%, WF), usually root/stem tuber flour contains very low amounts of protein and fat and high level of carbohydrate including dietary fibre on dry basis.Oluwole et al.[44] similarly reported higher levels fat and protein in wheat-cassava treated with full fat soybean. The dietary fibre contents (1.63-2.43%) decreased appreciably in the bread from the higher values recorded in the blends, however there were no significant difference ($p>0.05$) in the crude fibre contents(1.8% bread WCD-2.02%WCF) of composite flour breads whether treated with full fat or defatted MSM but in most cases slightly greater than the dietary fibre content of the wheat bread(1.96%). The observed decrease in the carbohydrate contents of the breads (47.18% (WSF) -58.83% (wheat) as calculated by 'difference' indicated increased levels of other nutrients especially fat and protein.

Table 4 Proximate compositions (%) of the various flours produced from composite flour containing constant ratio of wheat and root tubers.

Formulations	Moisture	Ash	Protein	Fat	CHO	Fibre
W (100:0)	22.47±1.94^{f}	1.64±0.17^{b}	11.29±0.66^{a}	3.81±0.40^{d}	58.83±00^{a}	1.96±0.06^{b}
WF (90:10)	26.93±2.21^{d}	1.75±0.11^{ab}	17.20±0.04^{ab}	8.10±0.15^{a}	43.45±00^{c}	2.36± 0.23^{a}
WD (90:10)	30.63±0.42^{a}	1.85±0.03^{a}	17.77±0.06^{a}	8.31±0.15^{a}	40.80±00^{d}	2.43±0.02^{a}
WCF(65:25:10)	25.39±0.91^{de}	1.61±0.08^{b}	14.87±0.19^{c}	6.92±0.12^{c}	49.07±00^{ab}	2.14±0.05^{ab}
WCD(65:25:10)	28.15±0.28^{bc}	1.76±0.02^{ab}	14.22±0.43^{d}	5.22±0.08^{bc}	48.77±00^{ab}	1.88±0.04^{b}
WIF(65:25:10)	26.58±0.22^{d}	1.73±0.07^{ab}	16.18±0.16^{b}	6.20±0.10^{bc}	47.19±00^{b}	2.12±0.8^{ab}
WID(65:25:10)	30.33±0.47^{ab}	1.77±0.06^{ab}	12.72±0.50^{d}	5.32±0.04^{c}	47.82±00^{b}	2.04±0.04^{ab}
WSF(65:25:10)	28.48±0.16^{b}	1.48±0.04^{c}	14.50±0.12$_{cd}$	6.34±0.11^{bc}	47.18±00^{b}	2.02±0.06^{ab}
WSD(65:25:10)	27.47±0.27^{c}	1.83±0.04^{a}	14.15±0.17^{d}	5.67±0.23^{c}	48.80±00^{ab}	2.08±0.07^{ab}

Values are mean¥standard error of the mean. Means in a column with differing superscripts are significantly different($p<0.05$)
W=wheat, I=Irish potato, S=sweet potato, C=cassava, F=fullfat MSM, D=defatted MSM

3.4 Physical Properties of composite bread and the wheat bread.

Significant higher weight (458.11g) were observed in the wheat bread (W 100:0) than in all the treated bread samples, next in line was bread made from 90% wheat flour supplemented with either full fat or defatted MSM , thereafter there was a sharp decline in the weight, volume and loaf specific volume of the composite breads, **Table 5** The weight, volume and loaf specific volume of bread produced from wheat-tuber-MSM (65:25:10) blends varied 307-423.11g, 626.85ml-1161.05ml and 2.04ml/g – 2.74ml/g respectively. The decline was noticeably higher in the bread treated with defatted MSM and containing Irish or Sweet Potato.Oluwole et al.[45] reported specific volume of 2.09-3.43ml/g for wheat-cassava-soy flour breads; Ericsson et al.[46] reported 2.41-3.43 specific volume for wheat-cassava breads; Agbara et al.[37] reported 2.16-2.48 ml/g for breads with 20% sweet potato or cassava and 2.55-3.28 for breads made with wheat flour sold in Nigerian markets. The dilution of wheat gluten with addition of flour from tubers is responsible for the decline in volume and specific volume of breads produced from blends but not due to 10% addition of MSM since WF (90:10) and WD (90:10) breads had higher specific volumes, greater than bread containing either cassava or Irish or Sweet Potatoes. Ninjin et al.[46] noted that composite wheat breads generally display reduction of loaf volume and impairment of sensory quality. Nwosu et al.[40] observed similar decrease, wheat bread had the highest specific volume (3.93ml/g) which decreased to 2.35ml/g in 50:50 wheat-cassava bread with soybean improver. Studies have shown time and time again that when legume flours are blended with wheat flour, it results to changes in dough viscoelasticity and mixing properties. Mohammed et al.[47], Xing et al.[48] observed that reported addition of chickpea flour to wheat flour led to increased water absorption and dough development time of the dough, decreased extensibility and resistance to dough deformation apart from reduction of bread quality in terms of volume, internal structure and texture. Naveed Amand et al.[49] equally reported the same effects on fortification of wheat flour with Lathrus sativus flour, there were increased water absorption, arrival time, development time and decreased dough stability, consistency and tolerance index. Dough stability is generally thought to be dependent on quantity and quality of gluten but dilution of gluten with the addition of non-wheat flours such as low protein tuber crop flours and the subsequent negative interaction among fibre components, water and gluten definitely will result to stiffer bread with smaller volume [48]

Table 5 Physical properties of the various breads produced from composite flours containing ratio of wheat and root tubers.

Formulations	Weight (g)	Volume (g)	Specific volume(ml/g)
W(100%)	458.11±2.84^{a}	2431.98±5.66^{a}	5.31±0.30^{a}
WM (90:10)	439.63±5.12^{ab}	1767±4.19^{b}	4.02±0.45^{b}
WD (90:10)	309.44±4.41^{c}	980.12±3.43^{d}	3.17±0.59^{c}
WCF (65:25:10)	423.5±5.12^{ab}	1161.05±4.19^{c}	2.74±0.19^{d}
WCD (65:25:10)	333.25±8.02^{b}	998.27±2.12^{d}	2.05±0.14^{e}
WIF (65:25:10)	342.26±6.38^{b}	990.33±3.30^{d}	2.89±0.27^{d}
WID (65:25:10)	312.45±2.79^{bc}	953.43±4.28^{de}	3.05±0.10^{c}
WSF (65:25:10)	423.11±5.54^{ab}	926.61±1.81^{e}	2.19±0.23^{e}
WSD (65:2510)	307.28±3.67^{c}	626.85±3.35^{f}	2.04±0.16^{ef}

Values are mean ¥ standard error of the mean. Means in a column with differing superscripts are significantly different(p<0.05)

W=wheat, I=Irish potato, S=sweet potato, C=cassava, F=fullfat MSM, D=defatted MSM

3.5 Sensory properties of the composite flour breads and the control.

Wheat bread (W100:0) and full fat and defatted MSM treated breads (WF (90:10) and WD (90:10) had the best sensory attributes that were not significantly different (p>0.05), **Table 6**. Although, bread containing Irish potato flour had poorer crust, aroma, crumb texture yet their overall acceptability scores were not significantly different from other breads. No clear cut differences were observed in the sensory attributes of full fat or defatted MSM treated bread. Bread containing cassava or sweet potato scored equally for the attributes evaluated, the observed values were not significantly different. Wheat gluten does not confer on wheat bread any advantage other than volume enhancement and sponginess although it has unique taste stamped on the taste buds of mankind for centuries,; therefore the taste and colour of composite flour breads depend on bread formulation and baking conditions [47].

Table 6 Sensory attributes of the various bread produced from composite flours: wheat/root/stem tuber:MSM(65:25:10)

Formulation	Crust colour	Aroma	Taste	Crumb texture	Overall Acceptability
W(100%)	7.81^{a}	7.69^{a}	7.39^{a}	7.17^{a}	7.60^{a}
WF (90:10)	7.53^{a}	7.36^{a}	7.16^{a}	6.96^{ab}	7.46^{a}
WD (90:10)	7.51^{a}	7.49^{a}	7.23^{a}	6.49^{ab}	7.22^{a}
WCF(65:25:10)	7.26^{ab}	6.69^{bc}	7.00^{ab}	6.73^{ab}	7.53^{a}
WCD(65:25:10)	7.19^{ab}	7.00^{b}	7.20^{a}	7.00^{ab}	7.23^{a}
WIF(65:25:10)	5.73^{c}	5.41^{c}	7.00^{ab}	6.13^{b}	7.26^{a}
WID(65:25:10)	5.93^{c}	5.65^{c}	6.84^{b}	6.13^{b}	7.13^{a}
WSF(65:25:10)	6.40^{b}	6.47^{bc}	6.41^{b}	6.46^{ab}	7.46^{a}
WSD(65:25:10)	6.36^{b}	6.65^{bc}	6.95^{ab}	7.00^{a}	7.33^{a}

Values are mean¥standard error of the mean. Means in a column with differing superscripts are significantly different(p<0.05)

W=wheat, I=Irish potato, S=sweet potato, C=cassava, F=fullfat MSM, D=defatted MSM

IV. SUMMARY AND CONCLUSION

Retentions on sieves had shown that cassava flour had the coarsest and finest granulation both ends, Irish Potato the coarsest on lower sieves, then Sweet Potato and wheat flour in between. Water absorption capacities were higher in blends than the wheat flour. Melon seed meal had greater impact on the enhancement of the fat and fibre content of the blends, its impact on the protein was masked by the presence of tuber flour. A different scenario was observed with regard to composite flour breads: they had higher moisture and protein but lower fat, fibre and carbohydrate, multi-flour formulations had increased moisture content of the breads, already concurred by their water absorption capacity values of the blends. Wheat bread fortified with melon seed meal full fat or defatted had greater fat contents than the untreated control or wheat-tuber-MSM breads, understandably, the least fat contents were recorded in breads with defatted MSM. Wheat bread had the highest loaf volume and loaf specific volume, next were the wheat breads fortified with 10% MSM (full fat or defatted) and thereafter the scores decreased further especially in those containing defatted MSM. The sensory attributes of wheat bread was rated the best not distinguishable from those bread devoid of root/stem tuber flour but contained MSM. Among wheat-tuber-MSM breads, those containing Irish potato flour were poorly rated especially on crust colour and aroma. Generally, the overall acceptability scores of all the bread were high and none was rejected. The study concluded that acceptable bread with better nutrient profile, bread volume and sensory properties could be produced from flour blends containing 65% wheat flour, 25% sweet or cassava flour and 10% full fat melon seed meal.

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