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Physicochemical Characteristics and Baking Quality of Nigerian Grown Rain-Fed Wheat Varieties

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Abstract Grain physical characteristics of some Nigerian grown Rain fed wheat varieties along with proximate composition, flour extraction, wet and dry gluten, and baking quality of their flours were determined. Flours of the wheat cultivars were extracted with laboratory Brabender Quadrumat Senior mill and used for Bread baking by the straight dough method. Baking parameters and sensory evaluation using 9 point hedonic scale of bread baked from flours of the wheat cultivars were investigated. Data obtained from the study were statistically analyzed using Analysis of Variance (ANOVA) and where differences existed, mean separated using Least Significant Difference (LSD) test, at a 5% level of probability ($p<0.05$). The results for physical characteristics showed that 1000-grain weight ranged from 27.80-38.10g. The grain length ranged from 5.57-6.32mm, the width ranged from 2.30-2. 56mm while the density of the entries ranged from 0.96-1. 36. Flour extraction rate of the wheat cultivars ranged generally from 68.8-79.3%. Wet and dry gluten contents ranged from 32.4-46.2% and 12.4-15.0% respectively. Moisture content differs significantly for all samples ranging between 8.4-13.3%. Crude protein, fat, fibre, ash and carbohydrate ranged from 13.9-16.9%, 1.3-1.9%, 0.3-0.9%, 0.4-0.8% and 70.1-73.6%, respectively. The bread characteristics evaluated for the Nigerian rain fed grown wheat showed good baking quality as the control except for loaf volume where the control had the highest volume. The result for sensory evaluation showed that all bread samples were rated good and accepted by panels. This shows that Nigerian grown wheat can perform well as the imported wheat in terms of bread quality.

Keywords: *physical characteristics, bread, baking, Nigerian wheat, Rain-fed wheat*

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1. Introduction

It is no longer news that many developing countries including Nigeria and other countries whose climate do not favour the cultivation of wheat have been searching for partial or whole substitution of it with other cereal grains or other starching materials in bread baking. Wheat importation has detrimental effects on the Nigerian economy. In order to reduce the impact on the economy, Nigeria released policy mandating the flour mills to partially substitute wheat flour with 40% cassava flour for bread making [1]. Since it is well known fact that no other crop can achieve the baking properties of wheat, hence, composite flour has become the subject of numerous studies [2].

The research into composite flours started as far back as in the 1960s by Food and Agriculture Organization (FAO) of the United Nations (UN) in order to reduce wheat importations by developing countries [2,3,4].

Olaoye et al. [5] reported that many crops in developing countries possess inherent nutritional values and therapeutic properties that could be exploited for enhancement of human nutrition and well-being. Such nutritional values could be transformed into human use by wheat-composite flour technology for bread production.

Ohimain [1] reported that most of the studies revealed that wheat can be substituted by 5 - 10% without significant detrimental effects on bread making and quality but beyond 20%, additives may be required to maintain bread quality such as emulsifiers, enzymes, hydrocolloids and other improvers.

Olapade et al. [6] investigated Bread-making potentials of composite flours containing 90% wheat and 10% acha enriched with 0-15% cowpea flour and results showed that bread samples improved protein content and acceptable sensory attributes produced from wheat-acha cowpea composite flour at 10% maximum level of inclusion of cowpea flour.

Substitution of wheat with cassava [7,8,9,10], cassava and soybean [11], thermally processed hypoallergenic lupine flour [12], *Moringa oleifera* leaf powder [13], Sorghum [14] have been reported. As of 1993, there were about 1200 publications on composite flour [15].

All attempts have not been very successful as the quality of bread from wheat is still very much appreciated rather than bread from other cereal or composite flours. Therefore, alternative of finding a way of cultivating wheat in developing countries such as Nigeria is paramount.

Most developing countries whose general climate does not favour the cultivation of wheat have resorted to try its cultivation in some areas in their countries that have similar favourable climate. For instance in Nigeria, the experimental station of Lake Chad Research Institute for the cultivation of wheat are located in Baga, Gembu, Biu and plateau highlands, Jos whose climate is similar to temperate regions favourable for the cultivation of aforesaid crop.

Physicochemical properties of Indian wheat varieties of *Triticum aestivum* revealed variations in the physical properties like thousand kernel weight (TKW) and hardness values and could have implications for the millers to optimise milling conditions and obtain maximum efficiency of good quality flour [16]. Similar studies have been conducted by Elemo et al. [17] on five different Nigerian grown wheat grains {Atilla (ATL), Cettia (CET), Reyna 28 (REY), Seri MSH (SER) and Norman (NOR)} and the results revealed variations in their rheological characteristics with bread loaves of good and acceptable quality.

Belderok et al. [18] reported that wheat (*Triticum aestivum* L.) originated from the Levant region of the near East and Ethiopian Highlands, but now being cultivated worldwide. Wheat grain is grown on more land area than any other commercial food crop and world trade in it is greater than for all other crops combined [19]. It is the world leading sources of energy, protein and fiber and globally the leading source of vegetable protein in human food [20]. It is also the key factor enabling the emergence of city-based societies at the start of civilization being the first crops that could be easily cultivated on a large scale and provides long-term storage of food. It is a staple food used to make flour for leavened, flat and steamed breads, biscuits, cookies, cakes, breakfast cereal, pasta, noodles, couscous [21] and for fermentation to make beer [22], and other alcoholic beverages [23].

Bread is a baked product whose ingredients are flour, water, salt, and yeast. It belongs to the traditional diet, especially that of the poor. It is believed to be the most complete and cheap food and basic auxiliary food in times of extreme food poverty [24]. After baking, bread usually presents some pleasant characteristics such as a brownish and crunchy crust; a pleasant aroma, a soft and elastic crumb texture, and a moist mouth feel [25]. Bread provides also essential dietary minerals, mostly magnesium, calcium, potassium, sodium, and iron. It could be an ideal supplier of micronutrients in those cases where it is eventually fortified with them [26]. This is especially valid for countries with increased bread consumption. Baking quality is a criterion used to determine the quality and suitability of wheat. The baking quality depends on types of wheat uses and processing conditions, for instance the strong (hard) wheat are considered of the higher quality and suitable for bread making, where most of cakes made from soft wheat flour. Baking quality is determined by the rheological properties of wheat flour [27]. The rheological property of wheat flour is essential because it determines other physical characteristics such as dough (baking) volume and sensory attributes [28]. Physicochemical properties of wheat flours provide fundamental characteristics of its corresponding starches [29].

Wheat for baking needs to be sound, clean, well matured, and free from foreign material and also be undamaged [30]. Wheat is essentially a temperate crop but the low temperature nexus of the harmattan and the rain pattern of such area have made its production in the Nigerian sub-optimal environment possible for both rain-fed and irrigated wheat production especially in the northern part of the country such as Jos, Kebbi, Kano, Hadejia, and in Borno States by Lake Chad Research Institute, Maiduguri. Wheat quality can best be described in terms of end-user, nutritional quality, milling, baking and rheology quality. Therefore, the objectives of this study was to determine the quality of Nigerian grown wheat by determining the physical characteristics of the rain-fed bread wheat varieties grown in Nigeria, and to also determine the chemical composition, the physico-chemical characteristics, and the bread baking quality of the rain-fed bread wheat varieties.

2. Materials and Methods

2.1. Source of Materials

The 12 varieties of wheat used were Attila 7, Pavon 78, Faris 30, Crow's', Croc 1, Amna 4, Reyna 28, Sidraa 1, Mouka 4, Reyna 15, Tevee's', Norman. The six top-most yielding rain-fed bread wheat entries selected namely Attila 7, Pavon 78, Crow's', Croc 1, Mouka 4, Reyna 15, out of the twelve bread wheat entries earlier listed and one (1) imported wheat flour which served as the control were evaluated in this study. The evaluated wheat varieties were, obtained from Lake Chad Research Institute, Maiduguri, (LCRIM) from germplasm evaluations under the rain fed conditions at Gembu and Jos in 2019; while the imported wheat flour was obtained from Golden Penny Company, Nigeria.The other ingredients that were used for baking the bread which included the butter, baker's yeast, salt, sugar and transparent bread polythene bags were purchased from Maiduguri Monday Market of Borno State, Nigeria.

2.2. Sample Preparation

Ten (10) kg of each six top-most yielding rain-fed bread wheat entries out of the twelve bread wheat varieties were collected in sacks from the seed store of LCRIM which was already threshed, sorted, cleaned and further sealed with a hand-sack sewing machine. 10 kg of the imported wheat flour was purchased from Golden Penny Company, Borno State, Nigeria. All the samples were kept in a clean, dry plastic and air tight container at room temperature before use.

2.3. Physical Characteristics Determinations

The physical characteristics of wheat grains which includes, grain weight, kernel length and thickness were determined using standard methods. The 1000 grain weight of the wheat samples were determined by counting 100 grains manually from each sample and weighing using a precision balance (sensitive weighing balance Model FA2004A). The weight obtained was multiplied by 10 as specified by Nkama and Muller [31]. The length and thickness of the wheat samples were obtained by randomly selecting and measuring 10 grains of each wheat sample using a micrometer screw guage [32,33]. The density of each grain sample was obtained by the formula:

$$Density = \frac{\text{mass}}{\text{volume}}(g/ml) \quad (1)$$

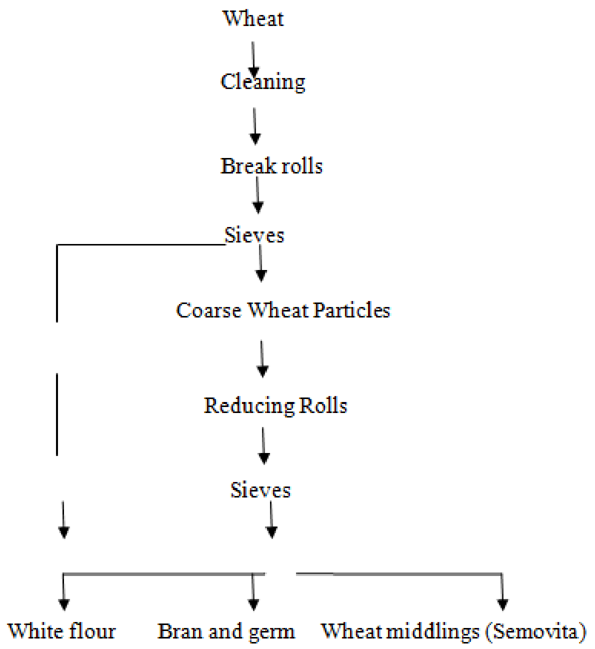

Figure 1. Flow chart for flour extraction [34]

2.4. Flour Extraction

Flour extraction was performed by Laboratory Brabender Quadrumat Senior mill (Model D47055 Type 880200; Duisburg, Germany) at Lake Chad Research Institute, Maiduguri. The wheat samples were passed through the laboratory brabender mill at 15% moisture content. The laboratory mill operates just like the commercial industrial wheat mill except this is a smaller prototype version that is used for milling smaller quantities less than 10g. Each of the wheat grain was milled with the aid of the break roll and cracked open while the germ and the bran was removed from the kernel and collected at a separate outlet. The rolls were followed by a sifter and purifier for separating and classifying the ground fractions. The wheat endosperm was milled and passed through a series of 6 successive sieves of increasing fines both of soft and coarse sieves where sieving on a rotary shaking occurs where coarse materials were returned to the reduction rolls by use of 6 plated and air currents. This process of milling and sieving was continuously carried out until soft and finer flour was obtained which was also collected in the flour outlet. The remaining course flour particles were also collected at a separate outlet for granular middlings or semovita while the bran was collected in a separate outlet.The flour extraction yield was determined by the method described by Hlynka [35] and Aluko *et al*. [36]. The flowchart for the flour extraction is shown in Figure 1.

2.5. Gluten Content Determinations

The wet and dry gluten was determined using standard glutomatic methods of A.A.A.C [37] by hand washing procedure. 10 grams of flour was mixed with a pinched salt and dough of flour was made with water and was allowed to stand for one hour. The ball of dough was washed under running tap water to remove the starch. The remainder of the mass was recorded after washing and was taken for wet gluten and the one kept in hot air oven set at 100°C to dry for 24 hours was taken for dry gluten. The calculation for the gluten contents is as follows:

$$\text{Wet gluten content} = \frac{\text{Total gluten}(g)\text{X}100}{10g} \quad (2)$$

$$\text{Dry gluten content} = \frac{\text{Dry gluten}(g)\text{X}100}{10g} \quad (3)$$

$$\text{Gluten index} = \frac{\text{Wet gluten on sieve}(g)\text{X}100}{10g} \quad (4)$$

All the weights for wet, dry and gluten index were recorded [38].

2.6. Proximate Composition

Standard methods of AOAC [39] were also followed to determine the moisture, crude fat, crude protein and ash contents in the different wheat samples. Carbohydrate was determined by difference, [40]. Duplicate determinations were carried out in each case.

2.7. Bread Making

Bread samples were produced using the straight dough method [41]. The ingredients were mixed in a laboratory mixer (Table 1) was followed by a proofing or rest period of about 60 min. The dough was punched down and mixed again and then re molded and scaled to 250g dough pieces into cylindrical shape aluminum bread baking pans. The dough was proofed again in a proofing cabinet at 30°C for 90 minutes and 85% relative humidity, and baked at 250°C for 25 minutes [42]. The baked bread samples were removed from the oven and allowed to cool down before placing in a polythene bags at room temperature.

Table 1. Formulation of the Bread using flours of some wheat cultivars

S/N	Ingredients	Quantity (%)
1	Flour	100
2	Yeast	2
3	Sugar	5
4	Salt	1
5	Shortening	2

Source: Erdogdu-Arnocky *et al*., [43].

The bread making was done using straight dough method as shown in Figure 2.

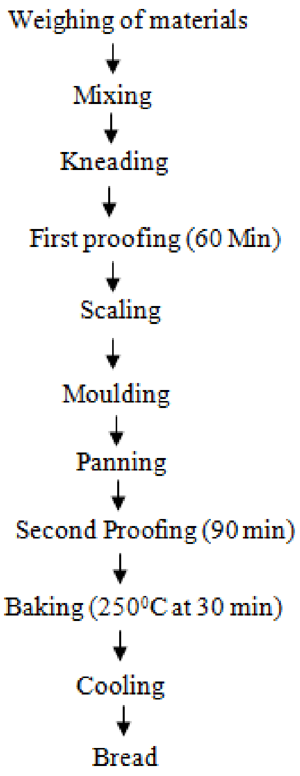

Figure 2. Flow chart for the production of bread, using the straight dough method [44]

2.8. Bread Quality Determination

The bread baking quality was determined and the rheology was done using the Mixolab to determine the baking quality characteristics of the wheat flours [45].

Loaf weight: The loaf weight (in grams) was taken using a laboratory scale (CE- 410I,) Camry Emperors, China).

Loaf volume: The loaf volume was determined using Rape seed displacement method [46], done by loading millet grains into an empty calibrated box to the marked level and unloading. The bread sample was then placed in the box and the measured millet loaded again. The volume of the leftover grains from the box was taken, using a measuring cylinder, and recorded as the loaf volume in cm^3.

(iii) Specific loaf volume: The specific volume (volume per unit weight) in cm^3/g was thereafter calculated as

$$\text{Specific volume} = \frac{\text{loaf volume}}{\text{loaf weight}} \quad (5)$$

Textural properties of bread samples: This was determined using a Universal testing machine (Testometric M500). Parameters determined were force at peak, force at break and energy to break.

2.9. Sensory Evaluation

The sensory evaluation was carried out using the 9-point hedonic scale with a panel of 25 trained persons and the resulting loaves were evaluated in terms of the volume, weight, crust colour and crumb colour, chewability, taste, flavor and overall acceptability [47].

2.10. Statistical Analysis

The resulting data were analyzed using Analysis of Variance (ANOVA) and mean separation done using Least Significant Difference (LSD) test, at 5% level of probability ($p<0.05$) as described by Ihekoronye and Ngoddy [48]

3. Results and Discussion

3.1. Physical Characteristics of Wheat Cultivars

The physical characteristics of the twelve bread wheat entries are shown in Table 2. Physical properties of grain such as wheat play very important role in the quality of grain, and final products such as flour. The kernel size is related to the kernel weight which correlates positively with flour yield [49]. The results were within the range reported by various workers on wheat grains [50,51].

Table 2. Grain physical characteristics of the twelve rain-fed bread wheat cultivars[1]

Sample name	1000 grain weight (g)	Kernel length (mm)	Kernel thickness (mm)	Kernel density (g/ml)
Attila 7	30.38bc	5.91abc	2.37ab	1.11bcd
Pavon 78	29.42bc	5.57c	2.40ab	0.98d
Faris 30	27.80c	6.23a	2.37ab	1.01cd
Crow's'	33.47ab	6.32a	2.45ab	1.32ab
Croc 1	32.21bc	6.12ab	2.56a	1.21abc
Amna 4	30.15bc	5.57c	2.41ab	0.96d
Reyna 28	31.64bc	6.14ab	2.30b	1.09cd
Sidraa 1	27.87c	5.75bc	2.38ab	1.12bcd
Mouka 4	29.67bc	6.09ab	2.43ab	1.17bcd
Reyna 15	38.10a	6.27a	2.48ab	1.36a
Tevee's'	29.40bc	5.59c	2.42ab	1.00cd
Norman	28.10bc	5.27bc	2.47ab	1.00cd

[1]Mean of triplicate determinations
[a-d]Mean within each column not followed by the same superscripts are significantly different (P<0.05).

The result for the physical properties of the wheat grains are shown in Table 2. The result of 1000 grain weight indicated that there were significant differences among samples (P<0.05). The results of 1000-grain weight showed that the values ranged from 27.80-38.10g with Reyna 15 having the highest value while Faris 30 had the lowest grain weight of 27.80g. The result of grain length indicated that there were significant differences among samples. The grain length ranged from 5.57-6.32mm with crow's' having the highest value of 6.32mm while Pavon and Amna4 had the lowest length. The result of grain thickness indicated that there were no significant differences among samples except for Reyna 28 and Croc 1. The thickness of the width ranged from 2.30-2.56mm with Reyna 28 having the lowest thickness while Croc1 had the highest thickness value. The result of grain density indicated that there were significant differences among samples. The result for the density of the entries ranged from 0.96-1.36g/ml with Reyna 15 having the highest density value while had the Pavon 78 had the lowest value for density with 0.96g/ml. The rain-fed wheat genotypes differed significantly (P<0.05) in which Reyna 15, Crow's' and Croc I exhibited the highest grain physical qualities with respect to kernel length, thickness, weight and density (Table 1). The result showed that there were generally significant differences among all the twelve samples entries studied for all parameters. As the result indicates, the values are within the range reported by Nkama *et al*. [52] and Nkama *et al.* *[53]* for various Nigeria grown wheat varieties.

3.2. Proximate Composition of Wheat Cultivars

The results of proximate composition of wheat cultivars are shown in Table 3 and the results were within the range reported by various workers [45,50,51,54]. Moisture content differs significantly for all samples ranging between 8.4%-13.3% but significantly higher moisture for the commercial flour (Control).Crude protein, fat, fibre, ash and carbohydrate ranged from 13.9%-16.9%, 1.3%-1.9%, 0.3%-0.9%, 0.4%-0.8% and 70.1% -73.6%, respectively. The moisture content of the wheat samples showed significant differences among the samples. The moisture content ranged between 8.4% and 13.3%. The crow's' wheat sample had the lowest moisture contents of 8.4% while the control sample had the highest moisture content of 13.3%. The moisture contents of the wheat samples are generally low allowing for good storage stability. [55] reported that a moisture content of 15% permits the good growth of mould while over 17% moisture allows the growth of both mould and bacteria in wheat flour.

From the Table 3, it can be seen that Nigerian grown wheat has a protein content of greater than 11.0% which makes it suitable for bread production. Among the rain-fed genotypes, Crow's' had significantly higher protein content than other genotypes except Croc-l, that also exceeded Mouka and Control, The protein content of the wheat samples indicated that there was significant differences among the samples and the result for the protein ranged from 13.9% to 15.9%. This shows that the control wheat had the lowest protein content of 13.9% while the crow's' wheat had the highest protein content of 15.9%. The protein quality criteria are related to the gluten portion of the wheat protein, Nkama *et al*. [52]. For the production of leavened yeast bread, wheat flour with a protein content of 11.0% is usually preferred [50,56]. Schofield [57] reported that bread making quality is indicated quantitatively by loaf volume which increased linearly with the flour protein. This result shows that Nigerian wheat are suitable for bread production as the result showed that the Nigerian grown wheat have protein contents above 11%.

The result for fat indicated significant dhifferences among the wheat samples. The fat content ranged from 0.6 % to 1.9%. pavon 78 wheat had the lowest fat content of 0.6% while the control wheat had the highest fat content of 1.9%.

The result for the ash content showed that there were no significant differences among the samples except for the control and Mouka which differed significantly from the other wheat samples. The result for ash ranged from 0.4% to 0.8% and this indicated that mouka wheat sample had the least ash content while the Atilla 7 and Crow's' had the highest ash contents of 0.8%.

The result for crude fibre showed that there were significant differences among the wheat samples. The crude fibre content ranged from 0.5% to 1.9% where the wheat samples Pavon 78 and Reyna 15 had the lowest crude fibre content of 0.5% while the control wheat had the highest crude fibre content of 1.9%.

The result for carbohydrate showed that there were no significant differences among the wheat samples. The carbohydrate content ranged from 70.1% to 73.6% where the control had the lowest carbohydrate content of 70.1% while Reyna 15 had the highest carbohydrate content.

Table 3. Proximate Composition of Six Best Yielding wheat cultivars[1]

Samples	Moisture (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	Carbohydrate (%)
Attila 7	9.9b	15.8b	1.6a	0.7b	0.8a	71.2a
Pavon 78	9.2bc	15.8b	0.6c	0.5c	0.7a	73.2a
Reyna 15	8.9c	15.8b	0.5bc	0.5c	0.7a	73.6a
Croc 1	8.5c	16.5ab	1.5a	1.5a	0.7a	71.9a
Crow's'	8.4c	16.9a	0.9b	0.9b	0.8a	72.3a
Mouka	9.8b	15.0c	1.3ab	1.3ab	0.4b	73.2a
Control sample	13.3a	13.9d	1.9a	1.9a	0.5b	70.1a

[1]Mean of triplicate determinations
[a-c]Mean within each column not followed by the same superscripts are significantly different (P<0.05).

All the test entries were significantly higher than the control with respect to these parameters except for fat. Crow's', was the best in terms of protein, while Croc-1 and Mouka-4 gave the highest fibre and ash contents, respectively. The carbohydrate content among all entries did not differ significantly (P>0.05).

3.3. Flour Extraction, Gluten Content and Flour Yield

Table 4 showed the flour extraction, wet and dry gluten and proximate composition of the six best yielding wheat entries and imported wheat flour which served as the control. The result indicated significant (p<0.05) difference among the sample with respect to flour extraction and gluten contents. Flour extraction rate of the entries ranged generally from 68.8%-79.3% but Reyna 15 and Crow's' gave a significantly higher flour extraction than the other entries. Reyna 15 had the highest flour extraction rate while Pavon 78 had the least flour extraction rate. Nkama *et al*. [52] reported values between 71.70% and 78.18% for flour extraction yield. The average yield reported for straight grade flour is about 72% [56]. Similar results have also been reported by Aluko *et al*. [36], Dexter *et al*, [58], and Nkama *et al*., *[53]*.

Table 4. Flour Extraction, Wet and Dry Gluten of Six Best Yielding wheat cultivars[1]

Samples	Flour extraction (%)	Wet gluten (%)	Dry gluten (%)
Attila 7	69.9bc	34.0c	12.9b
Pavon 78	68.8c	32.4c	12.4b
Reyna 15	79.3a	46.0a	14.8a
Croc 1	73.7b	40.0b	12.9b
Crow's'	78.1a	40.0b	14.6a
Mouka	72.3bc	46.2a	15.0a
Control sample	-	41.1b	14.2a

[1]Mean of triplicate determinations
[a-c]Mean within each column not followed by the same superscripts are significantly different (P<0.05).

The result also indicated significant difference in the gluten contents of rain-fed genotypes (P<0.05). The quantity and quality of the gluten forming proteins namely glutenins and gliadins are the most important factors in determining the wheat suitability for any end-use and it is invariably responsible for the differences in baking performance between flours [59,60]. The wet gluten was significantly higher in Reyna 15 and Mouka4 while for the dry gluten Crow's' and Control had higher values in rain-fed genotypes. Wet and dry and gluten contents ranged from 32.4%-46.2% and 12.4%-15.0% respectively. Reyna 15 and Mouka-4 had significantly higher wet gluten while Pavon 78 had the least wet gluten content. The dry gluten content was higher for Mouka with 15.0% followed by Croc's' and the commercial flour (Control) which were equally higher while pavon78 had 12.4% as the dry gluten content. Aluko, *et al*. [36] also reported similar result for wet and dry gluten contents for Nigerian wheat grains.

3.4. Physico-Chemical Indices of Flour and Bread Baking Parameters

Table 5 shows the physico-chemical indices of the wheat flour and bread textural properties of the six best yielding entries with the control. The result showed the water absorption, mixing tolerance, gluten index, viscosity and retro gradation of the samples were at close range values.

Ibidapo *et al*. [45] reported that the force at peak (in Newton) is a measure of the pressure that build up on a slice of the bread sample just before piercing through, as well as the force at breaking point (also in Newton) is an indication of the sample softness or hardness. The energy to break, in Newton meter (Nm), is also an indication of how hard or easy it is to break through the sample. Therefore, from the result, the force at peak for the wheat flour samples ranged from 1.3819 N for the control, Crow's', and Reyna15 to 1.3819 for Attila 7. The result for force at breaking point for the wheat flour samples ranged from 57.1 for the control to 64.8 for Pavon 76, while the result for the energy to break for the wheat samples ranged from 5.60 for the control, Crow's', and Reyna15, and 76.9 for Attila 7. It can be generally observed that the control had comparably lower values along with two of the local wheat bread samples namely Crow's', and Reyna15, which indicates that the control, Crow's', and Reyna15 had a softer and spongier crumb texture compared to the other wheat samples.

Table 5. Physico-Chemical Indices of Flour and Bread Textural Properties of Six Best Yielding Entries and the Control

Samples	WAC (%)	Absorption	MTI (Bu)	Gluten Index (%)	Viscosity (NSm^{-2})	Amylase	Retro gradation	Force at break (N)	Energy to break (NM)	Force at peak (N)
Attila 7	64.7	8	30	95.3	6	7	8	62.7	76.9	1.3819
Pavon 78	64.5	8	30	96.4	5	7	8	64.8	64.8	1.3296
Reyna 15	67.4	9	30	97.5	8	8	8	57.0	56.0	1.0039
Croc 1	65.7	8	20	89.3	7	8	8	57.3	56.2	1.0793
Crow's'	67.1	9	20	96.2	8	8	8	57.2	56.0	1.0039
Mouka	65.9	8	30	97.4	7	7	8	58.9	56.6	1.0754
Control sample	65.7	8	32	98.1	7	7	8	57.1	56.0	1.0039

Key: WAS= water absorption capacity, MTI= mixing tolerance index

The bread baking test is regarded primarily as a method of evaluating the protein quality of wheat as it relates to the gluten content which is responsible for the elasticity and volume of the dough and bread respectively. Table 6 showed the baking performance of the wheat flour samples in terms of the loaf volume, loaf weight, mixing time and optimum water absorbed. The optimum water absorbed by the flour to form dough ranged between 430-400ml, with Atilla 7 and Pavon 78 having the least optimum water volume while Croc1 had the highest optimum water volume value. The optimum mixing time was between 15-25min, with Reyna 7 and Crow's' having the least optimum mixing time of 15 minutes while Atilla and Pavon 78 had the highest optimum mixing time value of 25 minutes. This indicates that the Nigerian wheat flour samples require higher water uptake and adequate mixing time for a homogenous and better dough formation. Other workers have shown similar values for wheat that optimal water uptake and mixing time. Sliwinski *et al*., [61] and Abang Zaidel *et al*., [62] have indicated that for adequate dough development, mixing time and water uptake are paramount in bread production. In an optimized bread baking system, enough of yeast, sugar, fat, oxidant and optimum mixing time are employed [63].

The dough weight ranged between 1.45-150kg, with Atilla 7, Reyna 15 and Pavon 78 having the least dough weight while Croc1, Cow's', Mouka and the control had the highest dough weight value. All the dough samples were proofed at a constant time of 180min and baked for a constant time of 25 mins. The resulting weight for the baked loaves was between 280-290g, with Atilla 7 and Pavon 78 having the least loaf weight volume while the control sample had the highest loaf weight value. The loaf volume ranged from 1367-1800cm^3, with Pavon 78 having the least loaf volume while the control had the highest loaf volume value. The specific loaf volume adequately measures the bread baking performance and the result indicates that the value for Nigerian grown wheat ranged between 4.88 for Pavon 78 which had the least specific loaf volume and 6.21cm^3/gm for the control sample had the highest specific loaf volume value. Bijik [38] reported similar values for specific loaf volume. Shittu *et al*. [10] reported that loaf volume is affected by the quantity and quality of protein in the flour that was used for baking and also by the proofing time, baking time and baking temperature. Lin *et al*. [64] reported that the China Grain Product Research and Development Institute in1983 documented that specific loaf volume for standard bread ranges from 3.5-6.0 cm3/g. It can therefore be observed that the specific loaf volume for the bread from the Nigerian and control wheat samples were within the range of values. Similar results were also reported by Ibidapo *et al*. [45] for Nigerian grown wheat.

During fermentation, the carbon dioxide released by the yeast is trapped in the gluten network of the dough which subsequently expands in size. The extent to which the dough rises is determined both by the quantity and quality of its gluten network, thereby giving a well formed and raised dough with good volume [36]. The lower loaf weight and loaf volume for the Nigerian wheat could be attributed to the low refined process and non inclusion of additives in the production of the Nigerian wheat flour unlike the imported wheat flour which is more refined and processed. Despite these factors, the bread characteristics evaluated for the Nigerian rain fed grown wheat showed good baking quality, as the control except for loaf volume where the control had the highest volume. This shows that Nigerian grown wheat can perform well as the imported wheat in terms of bread quality.

Table 6. Bread baking parameters of the six best yielding wheat cultivars and the control[1]

Samples	Optimum water volume (ml)	Optimum mixing time (min)	Total dough weight (kg)	Scalled dough weight (kg)	Proof time (min)	Baking time (min)	Loaf weight (g)	Loaf volume (cm^3)	Specific loaf volume (cm^3/g)
Attila 7	400	25	1.45	250	180	25	280	2875.0	10.37
Pavon 78	400	25	1.45	250	180	25	280	2867.0	10.35
Reyna 15	430	15	1.45	250	180	25	285	3025.0	10.71
Croc 1	436	20	1.50	250	180	25	285	2912.5	10.43
Crow's'	432	15	1.50	250	180	25	285	3012.5	10.66
Mouka	430	20	1.50	250	180	25	282	2887.5	10.13
Control sample	431	20	1.50	250	180	25	290	4000.0	13.79

[1]Mean of several determinations.

Table 7. Sensory scores of bread from flours of six best yielding wheat cultivars and the control[1]

Samples	Appearance/ loaf shape	Crust colour	Crumb colour	Taste	Texture	chewability	Flavor	Overall acceptability
Attila 7	7.7	7.4	7.2	5.7	7.7	7.3	7.6	7.8
Pavon 78	7.7	7.1	6.8	5.7	7.5	7.1	7.6	7.7
Reyna 15	8.1	8.0	7.7	6.9	8.0	7.7	8.0	7.4
Croc 1	7.7	7.7	7.5	6.8	7.9	7.6	8.0	6.6
Crow's'	7.8	7.9	7.6	6.9	7.9	7.7	8.0	7.9
Mouka	7.5	7.7	7.6	6.9	7.9	7.6	8.0	7.6
Control sample	8.3	8.0	7.7	7.0	8.2	8.1	8.0	7.9

[1]Mean score of 25 panelists where 1- dislike extremely and 9 like- extremely.

3.5. Sensory Acceptability Scores

Table 7 shows the sensory acceptability scores of the bread samples from the rain fed and the control. Attributes evaluated include bread appearance, crust color, crumb color, texture, taste, chewability, flavor and overall acceptability. The result indicated that the values were closely ranged and the bread samples were all accepted by the panels for all parameters determined. The appearance/ loaf shape ranged between 7.5 to 8.3 with Mouka having the least loaf shape while the control sample had the highest loaf shape. The crust colour of the loaves produced ranged between 7.4 to 8.0 with Atilla 7 having the least crust colour while Reyna 15 and the control sample had the highest crust colour. The result for crumb colour ranged between 6.8 to 7.7 with pavon 78 having the least crumb colour while the Reyna 15 and control sample had the highest crumb colour. The taste of the loaves ranged between 5.7 to 7.0 with Atilla 7 and Pavon 78 having the least rating for taste while the control sample had the highest taste score. The texture ranged between 7.5 to 8.2 with Pavon 78 the least texture while the control sample had the highest loaf texture. The chewability of the loaves indicated that the values ranged between 7.1 to 8.1 with Pavon 78 having the least chewability score while the control sample had the highest score for chewability. The flavor ranged between 7.6 to 8.0 with Atilla 7 and Pavon 78 having the least flavor scores while the Reyna 15, Croc 1, Crow's' Mouka and the control sample had the highest flavour. The result for the overall acceptability showed that Croc1 had the least score while the control sample and crow's' had the highest score. Generally, the control sample had the highest rating for all parameters determined followed by Reyna and Crow's'.

4. Conclusion

This study showed the physical, proximate, functional, and baking characteristics of Nigerian grown wheat under rain-fed conditions and the results for the physical, proximate, functional, properties were high and are within the range obtained for the improved wheat. The bread baking quality of the flour also showed good and increased comparability with the imported flour especially Reyna 15 and Crow'S' which indicated highest values for the bread quality parameter coupled with high yeild. Although the imported flour showed outstanding results, generally, all wheat samples grown in Nigeria were accepted and highly rated for sensory quality attributes. This indicated that high yielding wheat can be grown in Nigeria under rain fed conditions. The wheat grown in Nigeria can be compared favourablily with the imported wheat and coupled with improved processing technologies, the Nigerian wheat flour can be used in the production of baked products such as cakes, biscuits, pancakes, and other baked products especially bread.

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References

[1] Ohimain, E. I. (2014). The Prospects and Challenges of Composite Flour for Bread Production in Nigeria.Global Journal of HUMAN-SOCIAL SCIENCE: H Interdisciplinary 14 (3/1): 33-42.

[2] Seibel, W. (2006). Composite flours. In Future of Flour: A Compendium of Flour Improvement.Popper, L (ed). Verlag AgriMedia, pp. 193-198

[3] Oyeku, O.M., Kupoluyii, C.F., Osibanjo, A.A., Orji, C.N., Ajuebor, F.N., Ajiboshin, I.O. and Asiru, W.B.(2008). An economic assessment of commercial production of 10% cassava-wheat composite flour bread. Journal of Industrial Research and Technology 2(1): 20-30.

[4] Owuamanam, C.I. (2007). Quality of bread from wheat/cassava flour composite as affected bystrength and steeping duration of cassava in citric acid. Nat. Sci. 5, 24-28.

[5] Olaoye, O. A., & Ade-Omowaye, B. I. O. (2011). Composite flours and breads: potential of local crops in developing countries. In V. R. Preedy, R. R. Watson, & V. B. Patel, (Eds.), Flour and breads and their fortification in health and disease prevention (pp.183-192). London, Burlington, San Diego: Academic Press, Elsevier.

[6] Olapade, A.A. and Oluwole, O.B (2013). Bread Making Potential of Composite Flour of Wheat-Acha *(Digitaria exilis staph)* Enriched with Cowpea *(Vigna unguiculata L. walp)* Flour. Nigerian Food Journal 31 (1): 6-12.

[7] Lagnika, C., Houssou, P. A. F., Dansou, V., Hotegni, A. B., Amoussa, A. M. O., Kpotouhedo, F. Y., Doko, S. A. and Lagnika, L. (2019). Physico-Functional and Sensory Properties of Flour and Bread Made from Composite Wheat-Cassava. Pakistan Journal of Nutrition 18(6): 538-547.

[8] Oluwale B. A., Ilori, M. O., Ayeni, Y. and Ogunjemilua, E. M. (2018). Assessment of Cassava Composite Flour Inclusion in Bread Production in Southwestern Nigeria. Journal of Food Processing & Technology 9(11): 1000760.

[9] Eddy, N. O., Udofia, P. G. and Eyo, D. (2007). Sensory evaluation of wheat/cassava composite bread and effect of label information on acceptance and preference. African Journal of Biotechnology 6 (20): 2415-2418.

[10] Shittu, T. A., Raji, A. O. and Sanni, L. O. (2007). Bread from composite cassava-wheat flour: I. Effect of baking time and temperature on some physical properties of bread loaf. Food Research International 40: 280-290.

[11] Udofia P. G., Udoudo P. J. and Eyen N. O. (2013).Sensory evaluation of wheat-cassava-soybean composite flour (WCS) bread by the mixture experiment design. African Journal of Food Science 7(10): 368-374.

[12] Guillamón, E., Cuadrado, C., Pedrosa, M. M., Varela, A., Cabellos, B., Muzquiz, M. and Burbano, C. (2018). Breadmaking properties of wheat flour supplemented with thermally processed hypoallergenic lupine flour. Spanish Journal of Agricultural Research. 8(1): 100-108.

[13] Sengev, I. A., Abu, J. O., and Gernah, D. I. (2012). Effect of *M. oleifera* leaf powder supplementation on the quality characteristics of wheat bread. Intercontinental Journal of Food Science and Nutrition 1(1): 01-05.

[14] Abdelghafor, R. F., Mustafa, A. I., Ibrahim, A. M. H. and Krishnan, P. G. (2011). Quality of Bread from Composite Flour of Sorghum and Hard White Winter Wheat. Advance Journal of Food Science and Technology 3(1): 9-15.

[15] Dendy, D.A.V. (1993). Review of composite flour technology in the context of Tanzania. A paper presented at the workshop. Sorghum and millets marketing and utilization, Arusha Tazania, 3-5 May 1993.

[16] Baljeet, S. Y., Yogesh, S. and Ritika, B. Y. (2017). Physicochemical and rheological properties of Indian wheat

varieties of *Triticum aestivum. Quality Assurance and Safety of Crops & Foods*, 2017; 9 (4): 369-381.

[17] Elemo, G. N., Osibanjo, A. A., Ibidapo, O. P., Ogunji, A. O., Asiru, W. B., Turaki, Z. and Olabanji, O. G. (2017). Rheological characteristics and baking quality of floursfrom Nigerian grown wheat. African Journal of Food Science 11(12): 376-382.

[18] Belderok, R. B., Mesdag, H., Donner, D. A. (200G). *Bread-Making Quality of Wheat*. Springer Pub. Pp. 3. ISBN 0-7923-6383-3.

[19] Curtis, R. M. (2002). *Bread Wheat*. Food and Agriculture Organization of the United Nations.

[20] USDA (2012). *United States Department of Agriculture*. National Nutrient Database for Standard Reference. USA.

[21] Cauvain, S. P. & Cauvain P. C. (2003).*Bread Making*. CRC Press, p. 540. ISBN 1-85573-553-9.

[22] Palmer, J. J. (2001). *Flow to Brew*. Defenestrative Pub Co., Pp. 233. ISBN 0-9710579-0-7.

[23] Neill, R. (2002). *Booze: The Drinks Bible for the 21st Century*. Octopus Publishing Group.

[24] Kourkouta, L., Koukourikos, K., Iliadis, C., Ouzounakis, P., Monio, A. and Tsaloglidou, (2017). Bread and Health. A. Journal of Pharmacy and Pharmacology 5: 821-826.

[25] Martin, P. (2004). Controlling the Breadmaking Process: The Role of Bubbles in Bread. *Cereal Foods World*. 49(2), 72-75.

[26] Isserliyska, D.; Karadjov, G.; Angelov, A. (2001). Mineral Composition of Bulgarian Wheat Bread. *Eur. Food Res. Technol.*, 213(3), 244-245.

[27] Ktenioudaki, A., F. Butler, and E. Gallagher, 2010. Rheological properties and baking quality of wheat varieties from various geographical regions. *Journal of Cereal Science* 51: 402-408.

[28] Muller, H.G. 1975. *Cereal Chem*.52 (3, II) 89r.

[29] Ee, K. Y., Eng, M. K. and Lee, M. L. (2020). Physicochemical, thermal and rheological properties of commercial wheat flours and corresponding starches. Food Science and Technology Campinas, 40(Suppl. 1): 51-59.

[30] Cornell, F.I,J., and Hovelling, A. W. 1998. *Wheat; Chemistry and Utilization*. Lancaster, Pennsylvania. My Technomic Publishing Company, Inc.

[31] Nkama, I and Muller, H. G. (1989). Studies in aflatoxin in rice. Description and evaluation of a new apparatus for the separation of husk from dehulled rice contaminated with aflatoxin. *J.Sci, Food Agric* 46: 311-318.

[32] Gariboldi, F. (1973). *Rice testing methods and equipments*. FAO Industries services, agricultural service division, Food and Agriculture Organisation, Rome.

[33] Adeyemi, I. A., Commey, S. N., Fakorede, M. A. B., Fejemisin, J M. (1987). Physical Characteristics and Starch Pasting Viscosity of Twenty Nigerian Maize Varieties. Niger. J. Agron., 2: 65-69.

[34] LCRIM (2017). Lake Chad Research Institute, Maiduguri, Nigeria Annual Report

[35] Hlynka, J. (1964). Wheat Chemistry and Technology. American Association of Cereal Chemists. Minnesota, U. S. A.

[36] Aluko, R. E. Olugbemi, L. B, Orakwe, F. C., and Dunmade, V. D. (1990). Baking Quality of Nigerian Grown Wheat. In: Wheat in Nigeria: Production, Processing and Utilisation. Edited by A. J Rayar, B. K. Kaigama, J. O. Olukosi and A. B. Anaso. LCRI, IAR and UNIMAID, Nigeria.

[37] A. A. C. C. (1988). *Official Methods of Analysis.* 14th Edition. American Association of Cereal Chemists, St. Paul. MN, USA. AACC. Inc.

[38] Bijik, E. H. (2001). Study on the Baking Quality of Blends of Hard Red Winter Wheat and Local Wheat Flour. M. Sc Thesis. Unimaid ,Nigeria.

[39] A. O. C. C. (1984). *Official Methods of Analysis.* 14th Edition. American Association of Cereal Chemists, St. Paul. MN, USA. AACC. Inc.

[40] Egan, F. I., Kirk, R. S. and Sawyer, R. (1981). Pearsons Chemical Analysis of Foods. 8th Edition, Church hill, Livingstone, Edinburg .Pp 511 - 536.

[41] Chuahan, G. S., Zilman, R. R. and Eskin, N. A. M.(1992). "Dough mixing and bread making properties of quinoa-wheat flour blends," *International Journal of Food Science and Technology*, vol. 27, no. 6, pp. 701-705.

[42] Giami, S. Y., Amasisi, T. and Ekiyor, G.(2004). "Comparison of bread making properties of composite flour from kernels of roasted and boiled African bread fruit (*Treculia Africana decne*) seeds," *Journal of Material Research*, vol. 1, pp. 16-25.

[43] Erdogdu-Arnoczky, N., Czuchajowska, Z. and Pomeranz, Y. (1996). Functionality of Whey and Casein in Fermentation and in Breadbaking by Fixed and Optimized Procedures. Cereal Chemistry 73(3):309-316.

[44] Nkama, I. and Sopade, P. A. (1990). Strategies for agro-based food industries: raw material supply, food processing and sanitation. In: Proceedings of a workshop 31 May to 1June 1990 by the North Eastern Chapter of the Nigerian of Food Science and Technology held in the University of Maiduguri, Nigeria. University of Maiduguri, 1990, 58 - 91.

[45] Ibidapo, P.O., Osibanjo, A.A., Asiru Wahab, B., Kayode O.F., Ojo, O.E. and Elemo, G.N. (2019). Proximate Composition and Bread Making Performance of Selected Wheat Varieties Grown in Nigeria. Journal of Nigerian Institute of Food Science and Technology www.nifst.org NIFOJ Vol. 36 No. 2, pages 88-95.

[46] A. A.C.C. (2000). Approved methods of the American Association of Cereal Chemists, 10th ed. Methods 44-15 A, 44-40. The Association, St. Paul, MN, US.

[47] Larmond, E. (1976). Tecture Measurements in meat by sensory evaluation. *J. Texture studies*. 7, 87-93.

[48] Ihekoronye, A.I. and Ngoddy, P.O. (1985). Integrated Food Science and Technology. Macmilian Publishers, New York. Pg 296-301.

[49] Pomeranz, Y. (1986). Composition and functionality of wheat flour components. In: Wheat, Chemistry and Technology. Vol. 2 (Pomeranz, Y. ed). Am. Assoc. of Cereal Chemists, ST. Paul, Mn.

[50] Pomeranz, Y (1971). *Wheat Chemistry and Technology*. American Association of Cereal Chemist. Intc. St. Paul, Minnesota.

[51] Kent, K.L (1983). *Technology of Cereals, An Introduction for Students of Food Science and Agriculture*. 3rd Edition, Pergamon Press, Oxford, pp13-14 and 23-28.

[52] Nkama, I., C. A. Negbenebor and F. N. Ezuiloh. (1990). Quality Evaluation if some Nigerian Wheat Cultivars. In; Wheat in Nigeria: Production, Processing and Utilisation. Edited by A. J. Rayar, B. K. Kaigama, J. O. Olukosi and A. B. Anaso. LCRI, IAR and UNIMAID.

[53] Nkama, I Danbaba, N., Jarma, M., AminuKano, M. and Ikwelle, M. C. (1998). End Uses of Improved and locally produced Wheat Cultivars in Nigeria. In: Wheat in Nigeria.: Prospects and Constraints. Valencia, J. A., Salako, E. A., Ikwelle, M. C., Aminukano, M., Abubakar, I. U., Miko, S. and Jayyum J. (Eds).

[54] Anon, (1982). U.S Wheat: 1982 Crop Quality Reports. Sponsored by U.S. Wheat Associates Inc with Foreign Agricultural Services, USDA.

[55] Fraizer, W. C. (1976). Food Microbiology. 2nd Edition. McGraw-Hill Boo Company, New York.

[56] Anon, (1984). U.S Wheat: 1982 Crop Quality Reports. Sponsored by U.S. Wheat Associates Inc with Foreign Agricultural Services, USDA.

[57] Schofield, J. D. (1994). Wheat Properties: Structure and Functionality in Milling and Bread Making. In: Wheat Production, Properties and Quality. W. Bushuk and V. F. Rasper, Eds. Blakie Academic and Press professional. Glasgow. Pp 73-106.

[58] Dexter, j. e., Kilborn, R. H. and Preston, K. R. (1989). Wheat Quality in Canada. *Canadian Institute of Food Science and Technol.* 22 (4).

[59] MacRitchie, F. (1987). Evaluations of the Contributions from Wheat Proteins Fractions to Doughnut and Breadmaking. *J. Cereal Sci.*, 6: 259-268.

[60] Bennion, E. B. and Bamford, G. S. T. (1979). *The Technology of Cake Making*. 4th Edn. Leonard Hill Books.

[61] Sliwinski, E.L., Kolster, P., Prins, A. and Van Vliet, T. (2004).On the relationship between gluten protein composition of wheat flours and large deformation properties of their doughs. Journal of Cereal Science 39: 247-264.

[62] Abang Zaidel, D.N., Chin, N.L. and Yusof, Y.A. (2010). A review on rheological properties and measurements of dough and gluten. Journal of Applied Sciences 10: 2478-2490.

[63] Pomeranz, Y and Shellenberrger, J. A. (1971). *Bread: Science and Technology*. 3rd Edn. Avi Publishing Company. West Port, Conn.

[64] Lin, L., Liu, H., Yu, Y., Lin, S.D. and Mau, J. (2009). Quality and antioxidant property of buckwheat enhanced wheat bread. Food Chemistry 37: 461-467.