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The Assessment of the Physical and Pasting Properties of Grains

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Abstract

The study analyzed the physical and pasting properties of grains. Grain length, thickness, width, weight, shape, appearance, and pasting properties were examined. There was no significant difference in the weight, size, appearance, and shape of the grains (p=0.05). There was significant difference (p=0.05) in the mean axial dimensions of the grain samples. The physical properties of grains play significant roles to select the appropriate sorting and cleaning equipment and the axial dimensions are considered in selecting and designing the right size of the screen perforations. There was a significant difference (p = 0.05) in pasting properties of the grain samples. Rice had the highest peak (293.57 ± 9.30 RVU) and the highest breakdown, 104.14 ± 33.96 RVU. Maize had the lowest breakdown (27.09 ± 14.93 RVU). The Final Viscosity was highest in maize (354.97 ± 27.10 RVU) and relatively

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lowest in groundnut (181.66 ± 37.51 RVU). The setback showed relatively lowest and highest mean values in cowpea (67.89 ± 4.95 RVU) and acha (138.10 ± 61.88 RVU), respectively. Groundnut (6.22 ± 0.20 min) and acha (5.02 ± 0.14 min) had the relative highest and lowest average peak time, respectively. The pasting temperatures were relatively highest in groundnut.

Key words: Grains, physical examination, pasting properties, cereals, legumes

1. INTRODUCTION

Grain size, shape, appearance, and pasting properties are important components of the yield and quality of grains, and have been considered since cereals were initially domesticated. Identifying the physical and pasting characteristics of grains is very significant to optimize the design parameters of industrial and agricultural equipment used in their handling, production, and storage processes. It is essential to determine and distinguish the physical and pasting properties of these agricultural products as they play an important role in the designing and development of the required machines and their operations such as separating, cleaning, and sorting.

After harvest, dry grains have longer shelf-life than other basic agricultural foods, such as starchy tubers and fruits. This shelf stability made grains well suited for industrial farming; they can be harvested mechanically, conveyed by sea or rail, stored for long in silos, milled for use as flour, and pressed for oil extraction. Consequently, more major universal commodity markets are existent for rice, soybean, canola, maize, cowpeas, and other grains, than for tubers, fruits and vegetables.

Cereal production involves numerous processes, such as sowing, harvest, cleaning, sorting, transport, storage, and processing. Sound knowledge of the physical properties of the processed materials is required at each stage of the process of production and during modeling. Shape is one of the major discriminating factors in grains and seeds, which enables the distinguishing of one type of seeds from another. The axial dimensions, shape and sizes, play a key role in grain cleaning and sorting, and influence the bulk behavior of seeds/grains during handling. Seed shape may be described in three main ways; by calculating the shape factor, by comparing the seed to a geometric figure, and by the use of virtual models (Zdistaw *et al.,* 2015).

In the presence of water, when heat is applied to starch-based foods, series of changes occur; known as gelatinization and pasting. Pasting properties are among the most important properties that influence quality and aesthetic considerations in the food manufacturing as they affect texture and digestibility and the end use of starch-based food commodities (Adebowale *et al*., 2008). It is a predicting index for the ability of any food to form a paste when subjected to heat applications.

Peak viscosity is the highest viscosity developed soon after or during the heating process. It is an index of the capacity of starch-based foods to freely swell before their physical breakdown (Adebowale, 2008). High peak viscosity is an index for high content of starch (Osungbaro, 1990). Trough viscosity is the minimum value of viscosity in the constant phase of temperature of the Rapid Visco Analyzer (RVA) pasting profile. Simply put, trough viscosity is that point at which the viscosity of the paste reaches its lowest during either cooling or heating processes. It is a measure of the capacity of the paste to stand breakdown during cooling.

This study examined the physical and pasting properties of grains, including cowpea, maize, acha, rice, groundnut, sorghum, and millet, which are among the commonly consumed grains and also used for various purposes in industries, especially the food industries.

2. MATERIALS AND METHODS

This chapter reports the materials and methods used for analyses and survey during the course of this research. The research analyses were done at NAFDAC Office, Independent Layout, Enugu; Root Crop Research Institute, Umudike, Umuahia, Abia State; and Food Science and Technology Food Chemistry Laboratory, Federal University of Technology Owerri, Imo State.

2.1. Sources of Raw Materials:

The raw materials for this study, cowpea, maize, acha, rice, groundnut, sorghum, and millet were obtained from markets in all the three Local Government Areas in Owerri (Owerri North, Owerri West, Owerri Municipal): Orie Uratta, Orie Umuorii, and Ekeobi markets (Owerri North): Nkwo Ukwo (Ihiagwa), Obinze, and Umuerim markets (Owerri West): Ekeonunwa, Ama-Hausa markets, and Relief, (Owerri Municipal).

2.2. Sample Selection and Preparation

Three sample representatives were randomly collected for each grain from different markets in every local government area in Owerri around November 2016 and July 2017. Samples were selected during harmattan and rainy seasons. The samples were examined physically and milled into flour of $\leq$118 μm particle size using Art's-Way's portable roller mill (PRM30: USA) and then labeled accordingly as directed by AOAC (2000).

2.3. Physical Examination

A cup each of the sample representatives was weighed using Yongkang Jieli sensitive weighing balance (100 gramme to 1000 gramme: China) with 0.01g accuracy. Their values were reported in gramme. A IP54 (UK) Louisware Electronic Digital Slide Caliper, with 0.02mm accuracy was used to determine the axial dimension (length, thickness, width) of the grain samples. The shapes and appearance were visually examined as recommended by Codex Alimentarius Commission (Codex Alimentarius Commission, 2007).

2.4. Pasting Properties

As described by AOAC (2005), the pasting properties of the flour samples were evaluated with a Rapid Visco Analyzer model RVA-3D. RVA, a recent development (AOAC, 2005). Three grams each of the flour samples was added to an RVA canister. About twenty-five milliliters (25 ml) of distilled water was included and inserted into the analytical machine. An already programmed heating system and cooling regimen were used, with samples held for 1 minute at 50^0C, heated to temperature of 95^0C in 3.7 min, and held for 2.5 minutes at 95^0C. Then cooled to 50^0C and again held at that temperature for 2 minutes. Parameters recorded were peak viscosity (PV), pasting-temperature (PT), hot-paste viscosity (TV), also known as viscosity at trough or minimum viscosity at 95^0C, setback (SB), final viscosity (FV) at 50^0C or cool paste viscosity, and breakdown (BD) (PV minus TV).

3. RESULTS AND DISCUSSIONS

The results and discussions of the survey of mycotoxins and their impacts on the proximate compositions and functional properties of the grain samples are reported in this chapter and a detailed discussion followed.

3.1. Mean Values of the Physical Examination of Grains

Tables 1 and 2 show the results of the physical examination of the grain samples. The weight (g/250ml) did not differ significantly ($p< 0.05$). The length (mm), the width (mm) and the grains' thickness (mm) did not differ significantly ($p< 0.05$). However the average values of the length, width, and thickness were 7.52, 3.13 and 2.02 mm respectively for the rice grain.

The physical appearance and shape are shown in Table 2. The rice grain was white in colour and cylindrical, while the cowpea appeared white in colour and kidney-shaped. Similarly, the acha was white in colour but finger-shaped.

Table 1: Mean Values of the Weight and Size (Axial dimension) of Grain Samples

Grains	Weight (g/250ml)	Length (mm)	Thickness (mm)	Width (mm)
Rice	$183.83^c \pm 0.77$	$7.52^c \pm 0.66$	$2.07^c \pm 0.40$	$3.13^d \pm 0.56$
Cowpea	$178.60^d \pm 0.77$	$16.77^b \pm 1.10$	$8.95^a \pm 1.71$	$12.25^a \pm 1.87$
Acha	$134.44^f \pm 0.57$	$1.94^f \pm 0.06$	$0.38^d \pm 0.05$	$0.89^e \pm 0.12$
Maize	$178.52^d \pm 0.85$	$15.57^b \pm 0.92$	$5.35^b \pm 0.49$	$9.45^b \pm 1.55$
Millet	$198.56^b \pm 0.41$	$3.31^e \pm 0.37$	$1.06^d \pm 0.17$	$1.80^e \pm 0.18$
Sorghum	$204.04^a \pm 0.92$	$5.96^d \pm 0.81$	$2.00^c \pm 0.28$	$4.45^c \pm 0.75$
Groundnut	$159.07^e \pm 0.86$	$20.14^a \pm 1.36$	$8.61^a \pm 0.91$	$11.96^a \pm 1.41$
LSD	3.07	1.19	0.83	0.96
Grand mean	176.72 ± 22.16	10.17 ± 6.78	4.06 ± 3.43	6.28 ± 4.64

The Standard Deviation (± SD) showed how spread out the values of axial dimensions of the samples are around the mean.
*P = 0.05

Table 2: Appearance and Shape of Grain Samples

Grains	Appearance	Shape
Rice	White	Cylindrical
Cowpea	Whitish Cream	Kidney-shaped
Acha	White	Finger-shaped
Maize	White	Large and Flat
Millet	Yellowish White	Ovoid
Sorghum	Red	Spherical
Groundnut	Red	Long-shaped

The results of physical examination of the grain samples are shown in Table 1 and 2. Results in Table 1 show the width, length, and thickness of the grain samples, as well as the weight (gram) of the grains per metric cup (250 ml). There was no significant difference in the weight and size of the grains (p = 0.05). There was no difference in appearance and shape of the grains. There was significant difference (p=0.05) in the mean axial dimensions of the grain samples, as shown by ANOVA and LSD results. The physical properties of grains play significant roles to select the appropriate sorting and cleaning equipment and the axial dimensions are considered in selecting and designing the right size of the screen perforations (El Fawal *et al.*, 2009). Physical properties are among the major parameters for determining grain quality (Chinaza *et al.,* 2019). Finding the physical characteristics of grains is very imperative to enhance the design parameters of agricultural equipment used in their manufacturing, control, handling and storage processes (El Fawal *et al.*, 2009).

3.2. Pasting Properties of the Grain Samples

The results of the pasting properties of the grain flours are shown in Table 3. Rice had the highest peak, trough, and breakdown. Groundnut had the lowest peak and trough. The setback showed relatively lowest and highest mean values in sorghum. Table 3 shows a summary of the mean values of the pasting properties.

Table 3: Mean Values of the Pasting Properties of the Grain Samples.

Grains	Peak 1 (RVU)	Trough 1 (RVU)	Break Down (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak time (min)	Pasting Temp (°C)
Rice	$293.57^{a} \pm 9.30$	$190.36^{b} \pm 29.13$	$104.14^{a} \pm 33.96$	$267.90^{c} \pm 23.84$	$78.53^{d} \pm 4.85$	$5.31^{cd} \pm 0.40$	$78.08^{d} \pm 1.14$
Cowpea	$165.55^{f} \pm 3.30$	$106.72^{f} \pm 5.35$	$59.70^{e} \pm 1.86$	$233.26^{d} \pm 2.55$	$67.89^{g} \pm 4.95$	$5.62^{c} \pm 0.11$	$73.49^{e} \pm 1.77$
Acha	$234.03^{c} \pm 9.97$	$147.42^{c} \pm 3.16$	$85.33^{b} \pm 6.74$	$286.79^{b} \pm 63.90$	$138.10^{a} \pm 61.88$	$5.02^{d} \pm 0.14$	$70.64^{f} \pm 0.78$
Maize	$257.02^{b} \pm 8.35$	$229.18^{a} \pm 12.43$	$27.09^{g} \pm 14.93$	$354.97^{a} \pm 27.10$	$124.98^{b} \pm 25.01$	$5.94^{b} \pm 0.30$	$80.60^{c} \pm 0.83$
Millet	$191.53^{e} \pm 14.38$	$118.68^{e} \pm 18.49$	$67.04^{c} \pm 6.84$	$195.21^{f} \pm 28.38$	$70.83^{f} \pm 11.38$	$5.42^{c} \pm 0.23$	$83.03^{b} \pm 0.51$
Sorghum	$198.30^{d} \pm 27.07$	$140.22^{d} \pm 23.23$	$61.55^{d} \pm 5.97$	$227.69^{e} \pm 10.16$	$72.93^{e} \pm 16.30$	$5.64^{c} \pm 0.56$	$80.05^{c} \pm 1.38$
Groundnut	$123.61^{g} \pm 11.45$	$94.34^{g} \pm 9.88$	$37.20^{f} \pm 11.75$	$181.66^{g} \pm 37.51$	$95.17^{c} \pm 27.70$	$6.22^{a} \pm 0.20$	$84.93^{a} \pm 1.02$
LSD	2.41	1.95	1.80	2.09	1.01	0.32	1.17
Grand mean	209.09 ± 55.04	151.57 ± 50.61	63.15 ± 28.61	249.64 ± 63.75	92.63 ± 37.78	5.60 ± 0.48	78.69 ± 4.87

* Viscosity was measured in Rapid Visco Analyzer units (RVU). 1 RVU = 12 centipoise (cp)
The Standard Deviation (± SD) showed how spread out the values of pasting properties of the samples are around the mean.

There was a significant difference (p = 0.05) in pasting properties of the grain samples. From Table 3, it was observed that rice had the highest peak (293.57 ± 9.30 RVU) and the highest breakdown, 104.14 ± 33.96 RVU. Groundnut had the lowest peak and trough. Peak viscosity is the maximum viscosity established during or soon after the heating lot. It is an index of the ability of the starch-based foods to swell freely before their physical breakdown (Adebowale *et al.,* 2008). High peak viscosity is acceptable index of high starch content (Osungbaro, 1990). This explains why rice had the highest peak. Maize had the lowest breakdown (27.09 ± 14.93 RVU). Trough viscosity is the least viscosity value in the constant temperature phase of a Rapid Visco Analyzer pasting profile. In simple terms, trough viscosity is the point at which the viscosity reaches its minimum during either heating or cooling processes. It evaluates the ability of the paste to stand breakdown during cooling (Adebowale *et al.,* 2008). The values found in this study were similar to the range of values of 80.3 – 117.2 RVU of Ofada rice reported by Danbaba *et al.* (2012). The breakdown viscosity is a known index of the firmness of the starch and a measure of the easiness with which the swollen starch granules can be disintegrated (Kaur *et al*., 2007). Final Viscosity was highest in maize (354.97 ± 27.10 RVU) and relatively lowest in groundnut (181.66 ± 37.51 RVU). The Final viscosity is frequently used to express the quality of a particular starch-based flour as it shows the ability of the grain flour to form a gelatinous paste when cooked and cooled. It also provides a measure of the resistance of the paste to shear force during stirring (Adebowale *et al*., 2008). The dissimilarities in the final viscosity may be due to the modest kinetic influence of cooling on viscosity as well as the re-association of starch particles in the flour samples. The setback showed relatively lowest and highest mean values in cowpea (67.89 ± 4.95 RVU) and acha (138.10 ± 61.88 RVU), respectively. Groundnut (6.22 ± 0.20 min) and acha (5.02 ± 0.14 min) had the relative highest and lowest average peak time, respectively. Peak time measures the cooking time. The pasting temperatures were relatively highest in groundnut and lowest in acha as shown in Table 3. The elevated pasting temperature value of the groundnut blend could be ascribed to the cushioning effect of fat on starch which affects the gelatinization process (Egouletey and Aworh, 1991). A high pasting temperature shows high water-binding capacity, high gelatinization tendency, and low swelling property of starch-based flour because of the high degree of the associative forces between starch granules (Adebowale *et al.,* 2008). Pasting temperature is one of the parameters which offer an indication of the energy costs involved, least temperature requisite for sample cooking, among others.

4. CONCLUSION

Grain length, thickness, width, weight, shape, appearance, and pasting properties are important components of grain yield and quality. Axial dimensions (size and shape) and pasting properties are among the most important properties that influence quality and aesthetic considerations in the food manufacturing as they affect texture and digestibility and the end use of starch-based food commodities. There was no significant difference in the weight and size of the grains (p = 0.05). There was no difference in appearance and shape of the grains. There was significant difference (p=0.05) in the mean axial dimensions of the grain samples. The physical properties of grains play significant roles to select the appropriate sorting and cleaning equipment and the axial dimensions are considered in selecting and designing the right size of the screen perforations. There was a significant difference (p = 0.05) in pasting properties of the grain samples. Rice had the highest peak (293.57 ± 9.30 RVU) and the highest breakdown, 104.14 ± 33.96 RVU. Maize had the lowest breakdown (27.09 ± 14.93 RVU). The Final Viscosity was highest in maize (354.97 ± 27.10 RVU) and relatively lowest in groundnut (181.66 ± 37.51 RVU). The setback showed relatively lowest and highest mean values in cowpea (67.89 ± 4.95 RVU) and acha (138.10 ± 61.88 RVU), respectively. Groundnut (6.22 ± 0.20 min) and acha (5.02 ± 0.14 min) had the relative highest and lowest average peak time, respectively. Peak time measures the cooking time. The pasting temperatures were relatively highest in groundnut and lowest in acha as shown in Table 3.

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