Influence of Soaking on Moisture – Dependent Physical Properties of Some Selected Grains Essential to Design of Grain Drinks Processing Machine

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Influence of Soaking on Moisture – Dependent Physical Properties of Some Selected Grains Essential to Design of Grain Drinks Processing Machine

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Abstract

The influence of soaking on moisture - dependent physical properties of some selected grains essential to design of an automatic continuous grain drinks processing machine was studied. Three grain types were used for the study, they are white maize (*Zea mays*), white guinea corn (*Sorghum bicolor*) and large seeded soya beans (*Glycine max)*. The white maize and sorghum were soaked for 36 hours while the soya beans was soaked for 12 hours in accordance to standard procedure. The result obtained showed that moisture content level of the grains increased with increased in soaking time from 12.4% to 20.5% W.b. for corn when soaked, 11.3% to 20.6% W.b. for sorghum and 10.9% to 20.5% W.b. for soya beans. The entire grains dimension increased with increase in moisture content. Soya beans had the highest increased in surface area with increase in moisture level (10.9% to 20.5%) from 76.6 mm^3 to 167.81 mm^3 (119.07% increase), while sorghum had the least increase in surface area with increase in moisture level (11.3% to 20.6%) from 40.08 mm^3 to 55.75 mm^3 (39.09% increase). Furthermore, soya beans had the highest decrease in bulk density from 780.44 kg/m^3 to 667.32 kg/m^3 while corn had least decrease of 768.44 kg/m^3 to 762.21 kg/m^3 with increase in moisture level. These properties of the grains were found to be important factors to be considered in the design of the hopper, delivery tube, blending chamber and the grain reservour. The result thus, obtained fully describes the influence of soaking of the grains on their moisture - dependent physical properties that are essential to the design of grain drinks processing machine.Therefore, the knowledge of the physical properties of the grains will provide a rational approach to the design of the machine.
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1. Introduction

Steeping is one of the unit operations involve in production of beverages from grains. It can be achieve by soaking the grains under control temperature with or without sulfur for 2 hrs to 72hrs [1]. During this operation the grains swell up as result of moisture absorption and this alter their physical properties which are very essential factor in the design of technological processing (mechanical operation, storage, and handling e.t.c). There is need to ensure optimal design of such processes, the interaction between biological materials and the physical effect acting on them, as well as the general laws governing the same, most be known [2].In order to design grain drinks processing machine that is capable of blending soaked grains, mixing of the slurry with water, extracting the aqueous, scrapping, conveying and expelling of the paste out of the machine without stopping the machine, there is need to know some of the engineering properties of some selected grains that will be process using the machine. According to[3] in order to design equipment in handling, processing and oil extraction from the grains, there is need to know various engineering properties of the grains as function of moisture content. The size, shape and mechanical behavior of grain are important in designing of separating, sizing, grinding and oil extracting machine also knowledge of various engineering properties of grains is an important factor which can provide an essential requirement for design of equipment and facilities for harvesting, threshing,conveying, separation, drying, storing and processing the grain seed [4]. The objective of this study was to study influence of soaking of grains on their moisture - dependent physical properties that are essential to design of grain drinks processing machine.

2. Methodology

2.1 Material Preparations

The materials used are maize (white maize), sorghum (white guinea corn) and soya bean (large seeded). The grains were obtained from Bida central market in Niger State, Nigeria. The grains samples were cleaned, sorted and soaked with water at room temperature for a conventionally accepted recommended duration of 36 hours for samples of maize and sorghum [5] while those of soya beans were soaked in the same quantity of water at room temperature for 12 hours [1]. One hundred samples of each of the grains were randomly selected for the experiment. The

Agriculture Science Developments Vol(3), No (7), July, 2014.

selected physical properties determined include length, width, thickness, geometric and arithmetic mean diameter, sphericity, surface area, volume and bulk density.

3. Determination of Physical Properties of the Grains

3.1 Determination of Grains Moisture Content

The grains moisture content were determine using a microprocessor digital moisture meter (MC7821), as reported by [6] and the results is presented.

3.2 Determination of Linear Dimensions

The linear dimensions namely; length (L), width (W), and thickness (T) of the seeds were determine using a micrometer screw gauge (Model 436-2SM) to an accuracy of 0.01 mm [8] and the results are presented in table 1

3.3 Determination of Geometric and Arithmetic Mean

The geometric mean diameter (De), and arithmetic mean diameter (Da) were determined using these equations reported by (8) as follows:

$$De = (LWT)^{1/3}. \quad (1)$$

$$Da = (\frac{L+W+T}{3}) \quad (2)$$

where, De is the geometric mean (mm)

$Da$is the arithmetic mean (mm)

$N$is the total number of the samples

$L$is the length of the grain (mm)

$W$is the width of the grain (mm)

$T$is the thickness of the grain (mm)

3.4 Determination of the Grains Sphericity

The sphericity (Sp) of the grains was determined using equations reported by [6] and [9], as:

$$Sp = \frac{(LWT)^{1/3}}{L} (3)$$

where, Sp is the sphericity of the grains (%)

$L$is the length of the grain (mm)

$W$is the width of the grain (mm)

$T$is the thickness of the grain (mm)

3.5 Determination of Single Kernel Volume and Surface Area

The single kernel volume (Vu) and surface area (S) of the grains were determined as follows using the following equations reported by [7] and [8].

$$Vu = 0.25(\left(\frac{\pi}{6}\right) L(W+T)^2)(4)$$

$$S = \frac{\pi B L^2}{(2L-B)}(5)$$

$$B = (WT)^{1/2}(6)$$

Where, Vu is the single kernel volume (mm^3)

$L$is the length of the grain (mm)

$W$is the width of the grain (mm)

Agriculture Science Developments Vol(3), No (7), July, 2014.

$T$is the thickness of the grain (mm)

$S$is the single kernel surface area (mm^2)

$B$is the square root of the product of grain width and the thickness

3.6 Determination of Grains Mass, Volume and Bulk Density

The grains mass, volume and bulk density were determine using the method and equations reported by [6] and [7] as follows; the mass was determined using a digital weighing balance while the bulk density was determined by filling a standard container with the grains, striking off the top level without the seed being compacted in and then the content was weighed. The volume of the container was measured and taken as the volume of the content. The bulk density was then calculated as the ratio between the kernel weight and the volume of the cylinder as shown below.

$$V_C = \pi r_c^2 h_c \qquad (7)$$

$$\rho_b = \frac{W_k}{V_c} \qquad (8)$$

Where, V_C is the volume of the standard container (mm^3)

$r_c$is the radius of the container (0.072) (mm)

$h_c$is the height of the container (0.05) (mm)

$\rho_b$is the bulk density of the grain (kg/mm^3)

$W_k$is the weight of the grains inside the container (kg)

$\pi$is constant

4.0 RESULTS

The results of the experiment is presented in Table 1

Table 1: The Effects of Change in Moisture Content Levels of Soya Beans, Sorghum and Corn on their Physical Properties

Parameters	Soya Beans	Soya Beans	Sorghum	Sorghum	White Corn	White Corn
M.C (%)	10.90	20.50	11.30	20.60	12.40	20.50
L(mm)	6.67 ± 1.11	12.71±1.5	4.10 ± 0.26	5.46±0.47	10.6±0.89	12.10±1.13
W(mm)	5.41±0.4	7.46±1.55	4.07 ± 0.19	4.46± 0.12	9.30± 1.13	9.82±1.12
T(mm)	4.11± 0.55	5.31±0.51	2.81± 0.56	3.70± 0.81	3.88± 0.24	5.66±1.13
D_e(mm)	5.28± 0.56	7.94± 0.91	3.61± 0.31	4.48± 0.40	7.26± 0.30	8.74±0.59
D_a(mm)	5.40± 0.59	8.49± 0.96	3.67± 0.23	4.48± 0.26	7.94± 0.30	9.19± 0.69
S_p	85.8 ±5.50	72.47±0.30	84.4±8.20	82.05±7.70	68.18±4.90	72.12± 7.60
S(mm^2)	76.0614.37	167.81±37.31	40.08±6.57	55.75±11.68	138.75±12.81	203.4±31.18
V_U (mm^3)	96.09±0.1	330.18± 0.2	23.95± 0.1	67.27± 0.23	221.7±0.2	342.4± 0.3
V(mm^3)× 10^{-5}	8 ±2.4	27 ±9.5	2.5±4.7	4.84±1.34	24 ±3.5	40.6±8.0
ρ_b	780.4± 0.01	667.32± 0.005	787.17± 0.004	749.39±0.001	768.49± 0.005	762.21± 0.005

5.0 Discussion and Conclusions

5.1. Discussion

Effect of Increase in Moisture Level on Linear Dimension of the Grains:

The results obtained from effect of increased in moisture content level on physical properties of the selected grains is presented in Table 1. Soya beans had the highest increased in linear dimensions with increased in length from 6.67 mm to 12.71 mm, while white corn had a lower increased in length from 10.63 mm to 12.10 mm and least increased in width from 9.30 mm to 9.82 mm.

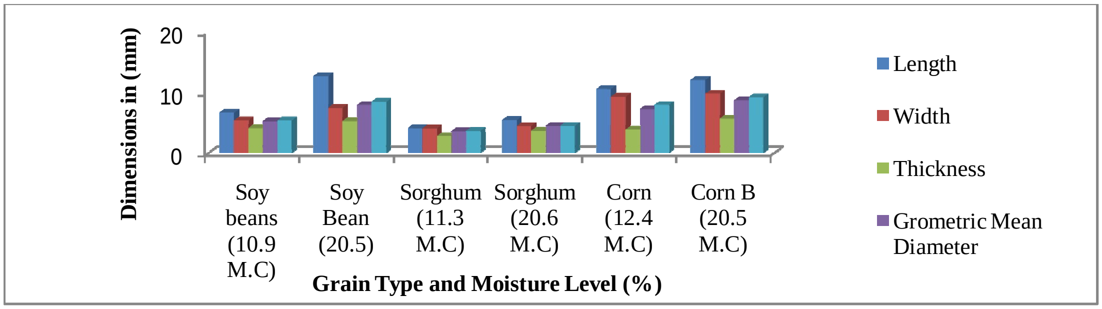

Figure 1: Relationship between Increased in Moisture Content of Grains, Linear Dimensions, Geometric Mean and Arithmetic Mean

As shown in Figure1 all the grains dimension increase as moisture level increased. Soya beans had the highest increased in length, width, geometric mean, and arithmetic mean of 6.04 mm (90.6%), 2.05 mm (37.9%), 2.66 mm (50.38%) and 3.09 mm (57.22%) respectively, with the lowest increase in thickness of 1.2 mm (29.2%) as the moisture content increased from 10.9% to 20.5% wet basis. While the least increased in length, width, geometric mean, and arithmetic mean of 1.45 mm (13.62%), 0.52 mm (5.6%), 1.48 mm (20.38%) and 1.25 mm (15.74%) respectively, with the highest increase in thickness of 1.78 mm (45.88%) were observed with white corn as the moisture content increased from 12.4% to 20.5% wet basis. Similar findings were reported for sweet corn [10], and Swam 1 variety of maize seed [7]. The uneven expansion of the grains along their different axis could be due to different cell arrangement in their kernels. This agreed with the result of an earlier finding by [9] were the uneven expansion of the grains along the different axis could be due to different cell arrangement in the biological material. The grains dimension is very important factor to be considered when determining the size of perforated holes on conical centrifuge and designing of size reduction equipment. This also agreed with the result of an earlier study by [11], were the dimensions of grains were found to be an important factor in determining sieve apertures and other parameters in machine design.

Effect of Increase in Moisture Level on Sphericity of Grain

The results obtained from effect of increased in moisture level on sphericity of the selected grains is presented in Table 1. White Corn had the highest increased in shericity from 68.18% to 72.12%, while soya beans and sorghum had a decrease in sphericity from 85.81% to 72.47% and 84.4% to 82.05% respectively.

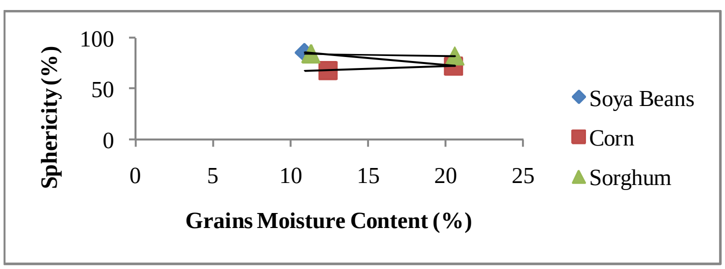

Figure 2: Relationship between Increased in Moisture Content and Sphericity of Grains

From Figure 2 the values of sphericity of soya beans decreases with increase in moisture level (10.9% to 20.5%) from 85.81% to 72.47% (15.55% decrease), and that of sorghum also decreases with increase in moisture level (11.3% to 20.6%) from 84.4% to 82.05% (2.78% decrease). However, increased in sphericity from 68.18% to 72.12% (5.78% increased) with increased in moisture content (12.49% to 20.5%) was observed with corn. The high values of the sphericity of the grains indicate that the grains will roll rather than slide in the grains hopper, delivery tube and feeding drum. Similar findings were reported by [12] ; [7], that grains with high sphericity values at high moisture level might be expected to roll rather slide on the surface of processing equipment and this is a property quite important in the design of grain hopper and grain conveying equipment.

Effect of Increase in Moisture Level on Volume of Grain

The results obtained from effect of increased in moisture level on volume of the selected grains is presented in Table 1. Soya beans had the

Agriculture Science Developments Vol(3), No (7), July, 2014.

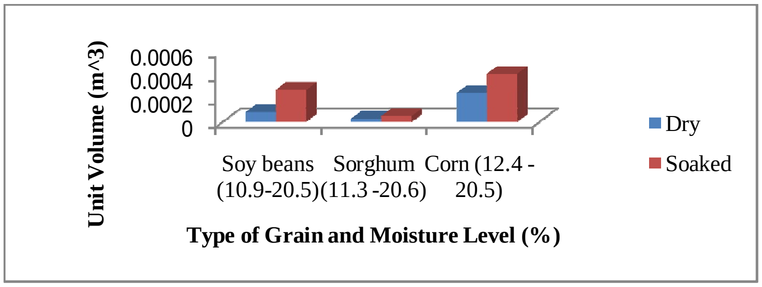

Figure 3: Relationship between Increased in Moisture Content and Unit Volume of Grains

From Figure 3 the volume of soya beans increases with increase in moisture level (10.9% to 20.5%) from 8.05 10^{-5} m^3 to 2.7 10^{-4} m^3(234.7% increase), while that of sorghum also increases with increase in moisture level (11.3% to 20.6%) from 2.555 10^{-5} m^3 to 4.84 10^{-4} m^3(89.8% increase) and corn had the lowest increase in volume with increase in moisture level (12.4% to 20.5%) from 2.43 10^{-4} m^3 to 4.06 10^{-4} m^3(67.17% increase). The change in volume is higher in soya beans and least in white corn. This could be as result of more swelling of soya bean seed with increase in moisture level than other grains under the study. Similar results have been reported for popcorn [13]; safflower [14] and rape seed [15].

Effect of Increase in Moisture Level on Surface Area of Grain

The results obtained from effect of increased in moisture level on surface area of the selected grains is presented in Table 1. Soya beans had the highest increased in surface area of 91.21 mm^3, while sorghum had a lower increased in surface area of 15.67 mm^3.

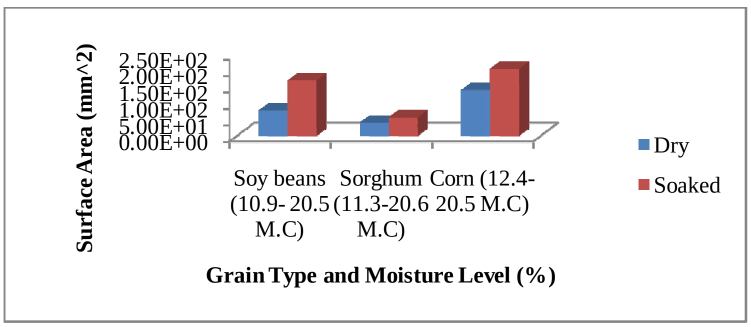

Figure 4: Relationship between Increased in Moisture Content and Surface Area of Grains

As presented in Figure 4. the surface area of soya beans increases with increase in moisture level (10.9% to 20.5%) from 76.6 mm^3 to 167.81 mm^3 (119.07% increase), and that of corn also increases with increase in moisture level (12.4% to 20.5%) from 138.75 mm^3 to 203.4 mm^3 (46.59% increase), and sorghum had the least increase in surface area with increase in moisture level (11.3% to 20.6%) from 40.08 mm^3 to 55.75 mm^3 (39.09% increase). It was observed that the increased is higher in soya beans and least in white sorghum. This could be as result of more swelling of soya bean and its softness compared to the other grains under the study. Similar relationships were reported for popcorn [13]; sweet corn [10].

Effect of Increase in Moisture Level on Bulk Density of Grain

The results obtained from effect of increased in moisture level on bulk density of the selected grains is presented in Table 1. Soya beans had the highest decrease in bulk density of 113.12 kg/m^3 (14.49%), while white corn had the least decrease in bulk density of 6.23 kg/m^3 (0.0812%).

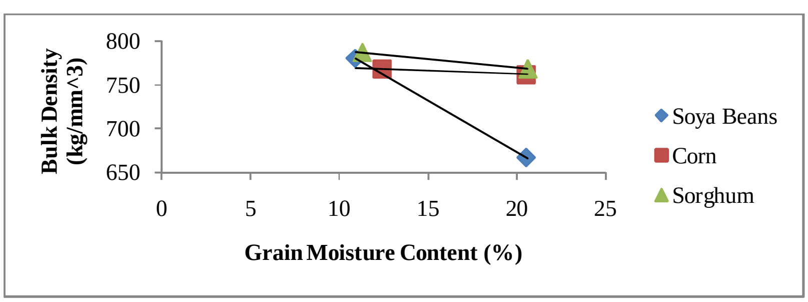

Figure 5: Relationship between Increased in Moisture Content and Bulk Density of Grains

From Figure 5 the bulk density of the grains was observed to decrease with increase in moisture level from 780.44 kg/m^3 to 667.32 kg/m^3 for soya beans, 768.44 kg/m^3 to 762.21 kg/m^3 for corn and 787.17 kg/m^3 to 749.39 kg/m^3 for sorghum. This decrease may be due to higher rate of increase in volume relative to the increase in weight. This is an important factor to be considered when designing the machine reservoir, retaining cylinder and feed hopper. Similar relationship has been reported for rape seed [15], and saftlower [14].

5.2. Conclusions

The test on the physical properties of the grains was concluded. The results obtained were discussed and the following conclusions were made.

1. All the grains dimension increase as moisture content level increased. Soya beans had the highest increased in length, width, geometric mean, and arithmetic mean of 6.04 mm (90.6%), 2.05 mm (37.9%), 2.66 mm (50.38%) and 3.09 mm (57.22%) respectively, with the lowest increase in thickness of 1.2 mm (29.2%) as the moisture content increased from 10.9% to 20.5% wet basis. While the least increased in length, width, geometric mean, and arithmetic mean of 1.45 mm (13.62%), 0.52 mm (5.6%), 1.48 mm (20.38%) and 1.25 mm (15.74%) respectively, with the highest increase in thickness of 1.78 mm (45.88%) were observed with white corn as the moisture content increased from 12.4% to 20.5% wet basis.
2. Soya beans had the highest decrease in sphericity with increase in moisture content level (10.9% to 20.5%) from 85.81% to 72.47% (15.55% decrease), while corn had highest increased in sphericity from 68.18% to 72.12% (5.78% increased) with increased in moisture content level (12.49% to 20.5%). The grain sphericity is a property quite important in the design of the hopper, delivery tube and the grain reservoir.
3. Soya beans had the highest increases in volume with increase in moisture level (10.9% to 20.5%) from 8.05×10^{-5} m^3 to 2.7×10^{-4} m^3 (234.7% increase), while corn had the least increase in volume with increase in moisture level (12.4% to 20.5%) from 2.43×10^{-4} m^3 to 4.06×10^{-4} m^3 (67.17% increase). The grains volume is very important factor to be considered when designing the volume of the reservoir and blending chamber.
4. Soya beans had the highest increased surface area with increase in moisture level (10.9% to 20.5%) from 76.6 mm^3 to 167.81 mm^3 (119.07% increase), while sorghum had the least increase in surface area with increase in moisture level (11.3% to 20.6%) from 40.08 mm^3 to 55.75 mm^3 (39.09% increase)
5. Soya beans had the highest decrease in bulk density from 780.44 kg/m^3 to 667.32 kg/m^3 while corn had least decrease of 768.44 kg/m^3 to 762.21 kg/m^3 with increase in moisture level.
6. The grains physical properties are very important factors to be considered when determining the size of perforated holes on conical centrifuge, feed hopper, reservoir, retaining cylinder, volume of blending chamber and designing of size reduction equipment (blending blade).

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