Studies on Physiochemical Properties of food grains Wheat (Triticum), Jowar (Sorghum Bicolor) and Mustard seeds (Brassica nigra)

[1]Suman Mokenapalli, [2]Cherukupalli Siri, [3]V. Bhasker and [4]V.V. Basava Rao

[1]Research Scholar, [2]Student, [3]Asst Professor, [4]Sr.Professor
Department of Food Technology,
University College of Technology, Osmania University, Telangana, India

---***---

Abstract - *Wheat (Triticum) is a grass widely cultivated for its seed, a cereal grain that is a worldwide staple food. Jowar (Sorghum Bicolor) is also called as Sorghum. It is a grass species which is cultivated for its grain which belongs to the family Poaceae. Mustard seeds (Brassica nigra) mustard seeds are used as a spice in India. The physiochemical properties of food grains are mainly responsible for the final quality of the product. In the present study the physical and chemical properties for the food grains like length, breadth, density, bulk density, porosity, and true density, angle of repose, geometric mean diameter, sphericity, protein, fat, ash, and crude fiber were determined. The length and breadth of grains were measured using the vernier calipers and screw guage. The moisture content of the taken samples was estimated using hot air oven equipment. The fat content estimated using soxtron equipment and the ash was estimated with muffle furnace. The density, bulk density, porosity, and true density of wheat, jowar and mustard seeds of food grains were found using standard methods given by AOAC, 1990. The angle of repose, geometric mean diameter and sphericity of grains were also measured. Finally, the results were analyzed in significance for the designers and processors in designing food processing equipment.*

Key Words: Wheat, Jowar, Mustard seeds, Physiochemical properties, process equipment

1. INTRODUCTION

The physiochemical properties of food grains are mainly responsible for the final quality of the product. These properties are important for the design and processing of the food. The physiochemical properties of food grains have some characteristics which are essential for nutritional value of food grains. Food grains like cereals, legumes, millets and oilseeds are the important food crops that contribute to most of the world staple food. Food grains provides many nutrients and energy for healthy life physiochemical properties of food grains include length, breadth, moisture content, density, bulk density, porosity, true density, angle of repose, geometric mean diameter and sphericity. Knowledge of the physical and chemical properties of the food grains is being used in the Cooking, Baking, Sorting, Grading, Milling, and Extrusion.

The physiochemical properties of the food grains like wheat, jowar and mustard seeds plays a very important role in safety and quality of the product. The physiochemical properties are very important in marketing process from production to consumption. The length and breadth of the food grains effects on product quality, storage space, packing density of the grains. Low moisture in food grains helps to increase the shelf life and reduce the microbial attack. High moisture content causes the growth of bacteria and decreases the nutritional content in it. Bulk density and density is used to know the efficiency of storage of grains in bins, bags and silos.

Grain size is used to study the porosity. Bulk density and density is determined to know the efficiency of storage of grains in bins, bags and silos. Bulk density also affects the processes such as mixing, milling and packaging. Porosity influences the storage capacity of grains. Higher porosity allows grains of higher storage volume. Angle of repose is an important parameter for flow ability.

2. MATERIALS

2.1. Materials: The food grains such as Wheat, Jowar and Mustard seeds are obtained from the Ushodhaya market in Vidya nagar, Hyderabad.

The equipment used such as vernier calipers and screw guage are obtained from 〖JIT〗_® Chuar Brand. The equipment for fat analysis SoxTRON Sox-4 is obtained from Tulin equipments. The equipment for protein analysis is obtained from KjelTRON Tulin equipment's

2.2 METHODS

2.2.1. PHYSICAL PROPERTIES

i. **Length**:

The length of grains effects the processing efficiency, cooking quality, texture, mouthfeel and overall consumer acceptance. So it is important to measure the length of food grains. The length of grain is determined using the vernier calipers. The grain is fixed length wise between the jaws in vernier calipers. The main scale, vernier scale and least count are noted (Method No: FSSAI 03.058:2023). The length is calculated using formula

$$L = \{M.S.R + (L.C + V.S.R)\} \rightarrow (1)$$

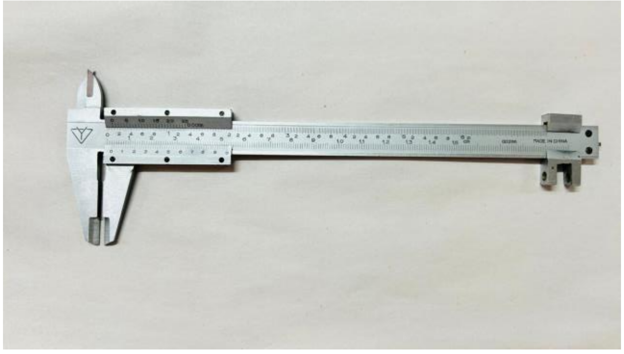

Figure 1: vernier calipers

ii. Breadth:

The breadth of the grains is determined using the screw guage. Measuring the grains breadth helps in assessing the uniformity of grains. Measuring dimensions helps in determining the packing density and storage space of the product. The grain is fixed breadth wise between the jaws of the screw guage. The head scale, pitch scale and least count are noted. (Method No: FSSAI 03.058:2023). The breadth is calculated using the formula

$$Breadth = \{H.S.R + (P.S.R + L.C)\} \rightarrow (2)$$

Figure 2: screw guage

iii. Density:

Density is defined as the ratio of the weight by volume. To determine the density first take 10ml of toluene in a measuring jar and then slowly add the grains of the sample weighed 10grams into the jar and observe that the level of toluene rises and this is noted as the rise in volume. Now the ratio of the weight of the sample taken to rise in volume gives the density of the grains, it is given by

$$Density\left(\frac{g}{ml}\right) = \frac{weight\ of\ sample\ taken}{rise\ in\ volume} \rightarrow (3)$$

iv. Bulk Density:

Bulk density is defined as the mass of the particles of the food material divided by the bulk volume. Bulk density is also called as apparent density. The bulk density is important in separating and grading of grains. The bulk density values of bajra, ragi and rice were determined by standard method which is given by (AOAC 1990).

$$Bulk\ density\left(\frac{g}{cm^3}\right) = \frac{weight\ of\ grains}{volume\ of\ the\ container} \rightarrow (4)$$

v. Porosity(ε):

Porosity is the measure of the void spaces or open spaces within a material, and it is usually expressed as a percentage. It indicated the number of pores in the bulk of food grains. The percentage of porosity is measured using the following relation (Mohsenin, 1986):

$$Porosity(\%) = \frac{true\ density - bulk\ density}{true\ density} \times 100 \rightarrow (5)$$

vi. True Density:

True density of grains was determined as the ratio of grain sample weight to the true volume of the sample. The true density of the food grains was determined using the following relationship.

$$\rho_t = \left(\frac{100}{100-\varepsilon}\right)\rho_b \rightarrow (6)$$

vii. Angle Of Repose:

When the grains are poured onto a surface, a heap is formed. The repose angle is influenced by the grain properties (moisture content, morphology, and particle distribution etc). The angle of repose is the steepest angle relative to the horizontal plane on which a material can be piled without the surface material sliding (IS: 6663-1972).

$$Angle\ of\ repose = \tan^{-1}\frac{2h}{D} \rightarrow (7)$$

viii. Sphericity:

Sphericity is defined as the surface area of a sphere of the same volume as that of the particle divided by the actual surface area of the particle. This shows the shape character of particle relative to the sphere.

$$Sphericity = \frac{lwt^{1/3}}{l} \rightarrow (8)$$

ix. Geometric Mean Diameter:

A measure of the central tendency of particle size composition of substrate materials sometimes used as an index of quality of spawing gravels. It helps in characterizing the grains physical properties including flow ability, porosity, packing density. It is crucial in food processing for control over grains size distribution which impacts products quality. The size such as length, width and thickness of the food grains are measured. The following equation is used to measure the geometric mean diameter of grains in mm (Mohsenin, 1986).

$$Geometric\ mean\ diameter = lwt^{1/3} \rightarrow (9)$$

2.2.2. CHEMICAL PROPERTIES: PROXIMATE ANALYSIS:

i. Moisture Content:

Weigh approximately 5 grammes of material accurately in a moisture dish that has previously been dried and tarred. Place the dish in a hot air oven set to 105°C and leave for at least 2 hours to dry. Let cool in a desiccator before weighing. Repeat the heating, cooling, and weighing steps until the difference between two consecutive readings is less than 2 mg. document the lowest weight. (Method No: FSSAI 03.006:2023). The moisture content was calculated using the following formula

Moisture content (%) =

$$Moisture\ content = \frac{w_3 - w_2}{w_1} \times 100 \rightarrow (10)$$

Figure 3: Hot air oven

ii. Determination Of Ash Content

About five grams of the sample was weighed accurately into a porcelain crucible. This was moved to a muffle furnace heated to 600°C and left for about 4 hours. It had turned to white ash at this point. The crucible and its contents were cooled to around 100°C in air before being weighed at room temperature in desiccators. The proportion of ash was computed using the following formula. (AOAC 1995)

$$\%\ of Ash = \frac{weight\ of\ ash}{weight\ of\ sample} \times 100 \rightarrow (11)$$

Figure 4: Muffle furnance

iii. Determination of Protein Content:

Proteins are polymers of amino acids, the majority of which are of amino acids having general formula $NH_2CHRCOOH$ may be distinguished from fats & carbohydrates is being the only macro nutrient in food containing nitrogen. (AOAC 976.05(2005))

<u>Reagents:</u>

- Concentrated H_2SO_4
- Catalyst titrates
- 40% NaOH solution
- 0.1 N NaOH
- 0.1 N H_2SO_4
- Methyl red indicator

<u>Procedure:</u>

Add 0.55g of material to the instrument's digestion tube, followed by 25ml of concentrated H2SO4 and 1-2 catalyst stabilisers. Adjust the temperature to 370°C and allow the solution to digest for 4-6 hours, or until it becomes blue. Remove the tube from the 0.1N H2SO4 solution in a titration flask and place it on the distillation unit. Attach a tube holding digested sample to distillation until the start button is pressed to effect a metered addition of NaOH. To initiate steam distillation, add 5 drops of yellow colour. This is the end. Now fill the burette with 25ml of 0.1N HCl and 0.1N NaOH.

$$\%Nitrogen = \frac{1.4 \times normality \times blank\ sample \times kjeldhal\ factor}{weight\ of\ sample} \rightarrow (12)$$

$$\%\ Protein = (Nitrogen\% \times conversion\ factor) \rightarrow (13)$$

Figure 5: Kjeldhal

iv. Estimation of Fat Content:

Parameters required for SoxTRON fat solvent extraction system.

CHEMICALS REQUIRED:

- petroleum ether
- Extraction time: Approx. 45mins to 1hr
- Solvent recovery time: Approx. 30 to 45mins
- Temperature: initial extraction time the temperature should be 120^0c solvent recovery time temperature should be 250^0c.

PROCEDURE:

- Place collection vessels and samples in an oven set to 100 degrees Celsius.
- After removing moisture from collection jars, install the desiccator at room temperature.
- Weigh the empty collecting vessels and record the weight as W1. This is the initial weight of the collection vessel. Now, put the thimble in the S.S.Spring thimble holder and place it on the collection containers.
- Weigh the sample and transfer it to the thimble. Assume the sample weight is 3 grammes. Pour the solvent into the collection vessels at a volume that is 3/4th of the vessel's volume
.
- Load collection vessels into the system. Turn on the system and set the boiling point of the solvent to the desired temperature. The boiling temperature may be 100 degrees Celsius higher than the solvent's maximum boiling point.
- Allow about 45-60 minutes to complete the process. After the process, raise the temperature to solvent recovery temperature.
- Rinse the sample twice to collect any remaining fat.
- Removed all collection vessels and placed them in a hot air oven. After 15-20 minutes, remove all the beakers and set them in a desiccator for 5 minutes.
- Remove all thimble holders and weigh collecting jars. This is the final weight of the collection containers, W2. To calculate the quantity of fat in a sample, use the following formula and substitute W, W1, and W2. (AOAC Official Method, 2003)

$$\%fat = \frac{W_2 - W_1}{W} \times 100 \rightarrow (14)$$

Figure 6: SoxTRON

v. Estimation Of Fiber Content:

The method is based on the solubilisation of non-cellulosic compounds by sulphuric acid and KOHsolution. Determine separately the sample moisture by heating in an oven at 105°C to constant weight.Cool in a desiccator then weigh accurately 1gm of grinded sample.

Approximately with 1g and 1.25% sulphuric acid upto the 150ml notch crucible, after preheating by the hotplate in order to reduce the time requirement for browning. Add 3 to 5 drops of n-octanol as antifoam agent. Boil 30mins exactly from the onset of browning. Connectto vacuum for draining sulphuric acid. Wash 3 times with 30ml of hot deionised water connecting each time to compressed air for stirring the content of crucible. After draining the last wash, add 150ml of preheated KOH 1.25%, 3-5 drops of antifoaming agent n-octanol. Boil for 30mins, filter and wash three times with water by stirring each time by compressed air to coolthe crucibles and remove the alkali residues. Then wash three times the crucible content with 25ml of acetone. Remove the acetone, stirring each time by compressed air. Remove the crucibles and determine the dry weight after drying in an oven at 105°C for an hour or upto a constant weight. When ash content is also required, the crucibles are placed in a muffle furnace, at 550⁰C for 3 hours and reweighed after cooling in a desiccator.

The difference in weight in comparison to the previous weight represents the crude fibre content without ash. (AOAC, 2005)

$$\%\ Crude\ fibre = \frac{F_1 - F_2}{F_0} \times 100 \rightarrow (15)$$

3. RESULTS AND DISCUSSION

Physiochemical properties have significant importance in designing, processing, handling, transportation and storage. The length, breadth and density are important in sorting, grading and separation process in food grain processing. Quality of food grains is also depend on the bulk density of grains. Porosity and density of grains are important which affect the hardness of kernel, milling, drying rate etc. Angle of repose is useful in determining the slope stability and structure. Sphericity is very important for garins as it affects the flow ability, density and porosity. The grains which have high sphericity will flow more easily, pack together with great effiency and has less void spaces between each other. These will have impact on storage, processing, and transportation of grains. The post harvest moisture content of Wheat is 14-20%. The wheat taken from the market is of 11.45% moisture. The post harvest moisture content of jowar is 12- 14%. The ragi taken from the market is dried which is of 9.158% moisture content. The post harvest moisture content of mustard seeds is 9- 15%. The rice taken from the market is dried which is of 7.13%. Different physical properties such as length, breadth, moisture content, density, bulk density, porosity, true density, angle of repose, geometric mean diameter, sphericity, ash content, protein, fat and crude fibre were determined and results obtained are presented in the table 1 and table 2

Table 1: physical properties of food grains

Physical properties	**Wheat**	**Jowar**	**Mustard seeds**
Length(mm)	6.78	4.398	1.82
Breadth(mm)	3.45	4.204	1.49
Density (g/ml)	2.13	0.573	0.91
Bulk density(g/cm^3)	789.66	812.4	695
Porosity (%)	37.39	0.4267	10.9
True density(kg/m^3)	1263	1448.39	1337
Angle of repose	21.52	27.1	23.31
Sphericity	0.01038	0.834	1.436
Geometric mean diameter(mm)	3.52	1.603	3.11

Table 2: Chemical properties of food grains

Chemical properties	**Wheat**	**Jowar**	**Mustard seeds**
Moisture content (%)	11.45	9.158	7.13
Ash(g)	1.42	1.06	3.73
Protein(g)	10.59	9.97	19.51
Fat(g)	1.47	1.73	40.19
crude fibre(g)	11.23	10.22	14.10

4.Conclusion:

It can be stated that the relevance of analysing physical attributes are recognised as the basic data in constructing the machinery and equipment used during harvesting and in post-harvest such as storage operations. These are important in sorting, grading and many other processing operations to produce the high quality product. Physical properties, such as length, breadth, density, bulk density, porosity, True density, angle of repose, geometric mean diameter, sphericity, protein, ash, and fat, crude fibre were determined. The moisture content of wheat, jowar and mustard seeds are 11.45%, 9.158%, and 7.13%.

5. Nomenclature:

$M.S.R$ = main scale reading

$L.C$ = Least Count

$V.S.R$ = Vernier Scale Reading

$H.S.R$ = Head Scale Reading

$P.S.R$ =Pitch Scale Reading

ρ_b = Bulk density, g/cm^3

ρ_t= True density, g/cm^3 and

ε = Porosity, per cent

h=Height of the pile

D=diameter of the pile

l Is length

w is width

t Is thickness

w_3 Is weight of petriplate and sample before drying, g

w_2 Is weight of petriplate and sample after drying, g

w_1 Is weight of sample taken, g

W = Weight of sample

W_1 = Weight of empty collection vessel

W_2 = Weight of collection vessel containing fat

F_1 is weight of the residue in the crucible after digestion

F_2 is weight of the ash in the crucible

F_0 is weight of the sample in the crucible

6. References:

1. Dasoju Saideep Varma, Bhasker Vellanki, Comparative Study of Tray Dryer, Hot Air Oven and Tapered Fluidized Bed Dryer for Drying Wheat and Paddy Volume 3, Issue 1 Jan-Feb 2021

2. C. Ononogbo, O.C. Nwufo, C.A. Okoronkwo, N.V. Ogueke, J.O. Igbokwe and E.E. Anyanwu Equipment Sizing and Method for the Application of Exhaust Gas Waste Heat to Food Crops Drying Using a Hot Air Tray Dryer February 2020, Vol 13(05), 502 – 518

3. Adzimah Kwasi Stephen and Seckley Emmanuel., Improvement on the Design of a Cabinet Grain Dryer American J. of Engineering and Applied Sciences 2 (1): 217-228, 2009

4. AOAC. Official Methods of Analysis. Association of Official Analytical Chemists International. In: Horwitz, W. (Ed.), 18th Ed. AOAC Press, Arlington, VA, USA, 2005.

5. Juliano, B.O., and Perez (1984) Results of a collaborative test on the measurement of grain elongation of milled rice during cooking. J. Cer. Sci 2. 281-292.

6. IS 4333 (Part II): 2002 Methods of Analysis of food grains Part II Moisture

7. AOAC Official Method 926.06 Macaroni Products Preparation of Samples

8. AOAC Official Method 925.10 Solids (Total) and Loss on Drying (Moisture) in Flour Air Oven Method.

9. Mohsenin NN. Physical Properties of Plant and Animal Materials. Gordon and Breach Inc., New York 1980, 51-87.

10. Chandra D, Chandra S, Pallavi and Sharma AK. Review of Finger millet (Eleusine coracana L.) A power house of health benefiting nutrients, Food Science and Human Wellness. 2016; 5(1):149-155.

11. Shivabasappa RS, Roopa bai, Sridevi H, Sharanagouda, Udaykumar N. Engineering properties of finger millet (Eleusine coracana L.) grains, International Journal of Agricultural Engineering. 2012; 5(2):178-181.

12. Agricultural statistics at a glance (2016) . Department of agriculture cooperation and farmers welfare, Ministry of agriculture and farmers welfare, GOI.

13. Chhabra, N. and Kaur, A. (2017). Studies on physical and engineering characteristics of maize, pearl millet and soybean. Journal of Pharmacognosy and Phytochemistry, 6(5): 01-05.

14. Nazni, P. and Bhuvaneswari, J. (2015). Analysis of physicochemical and functional characteristics of finger millet (Elusine coracana L) and little millet (P. sumantranse). International Journal of Food and Nutritional Sciences, 4(3), 109-114.

15. Sunil, C. K., Venkatachalapathy, N., Shanmugasundaram, S., Pare, A. and Loganathan, M. (2016). Engineering properties offoxtail millet(Setaria italic L): VarietyHMT 1001. International Journal of Science, Environment and Technology, 5(2): 632-637.

16. Ramashia, S. E., Gwata, E. T., Meddows-Taylorc, S., Anyasia, T. A. and Jideani, A. I. O. (2017). Some physical and functional properties of finger millet (Elusine coracana) obtained in sub-Saharan Africa. FoodResearch International, 104: 110-118.

17. Rathore S, Singh K, Kumar V. Millet grain processing, uilization and its role in health promotion: a review, International Journal of Nutrition and Food Sciences. 2016; 5(5):318-329.

18. Swami AM, Sadawarte SK, Patil BM, Sawate AR and Wandhekar SS. Studies on physico-chemical properties of wheat, finger millet and guar gum. The Pharma Innovation Journal 2021; 10(5): 1237-1240

BIOGRAPHIES

Mr. SUMAN MOKENAPALLI Research Scholar at the Department of Food Technology, College of Technology, Osmania University, has advanced academic research by conducting field knowledge. He is interested in the preservation of food grains through drying and product development.

Ms. Cherukupalli Siri M.Tech Student at the Department of Food Technology, College of Technology, Osmania University.

Mr. V Bhasker is working as Assistant Professor in Food Technology, University College of Technology, Osmania University, Hyderabad, India. He has 13 years of Teaching Experience. He has published in 17 Technical Papers in reputed Journals.

Prof. V V Basava Rao is working as Professor in Chemical Engineering, at University College of Technology, Osmania University, Hyderabad, India. He has 28 years teaching and 4 years of industrial experience. He has supervised 17 PhDs and published 67 Technical Papers in reputed Journals.