Journal of Food Processing & Technology

Ghadge and Prasad, J Food Process Technol 2012, 3:8
DOI: 10.4172/2157-7110.1000175

Research Article Open Access

Some Physical Properties of Rice Kernels: Variety PR-106

Prashant N. Ghadge[1]* and K. Prasad[2]

[1]Department of Food Engineering, MGM College of Food Technology, Aurangabad – 431003 (M.S.) India
[2]Sant Longowal Institute of Engineering & Technology, Longowal – 148106 (Punjab) India

Abstract

The objective of this work was to determine some of the physical properties of PR-106 type of rice variety which may influence the rice processing operations. The physical properties Length or Longitudinal (L), Width (W), Thickness (T), Mass (M) and Volume (V) were measured at a moisture content of 13.34 ± 0.53% (dry basis) and the following results were obtained: the average split length, width, thickness, unit mass and volume were 6.61 mm, 1.75 mm, 1.40 mm, 0.017 g, and 0.051 cm^3 respectively. The calculated physical properties like the geometric mean diameter, surface area, porosity, sphericity, true density and aspect ratio were 2.52 mm, 20.10 mm^2, 47.07%, 38.28%, 1.521 g/ml and 26.58% respectively. The static coefficient of friction varied on three different surfaces from 0.217 on galvanized steel sheet, 0.239 on Plywood to 0.249 on glass with splits perpendicular to direction of motion, while the angle of repose was 34.86°.

Keywords: Rice (*Oryza sativa L.*); Physical properties; Porosity; Bulk density; Static friction

Notation: L: Lenth of seed (mm); W: Width of seed (mm); T: Thickness of seed (mm); M: Unit mass; V: Volume; D_4: Geometric mean dimension (mm); S_p: Sphericity (%); S_α: Surface area (mm^2); R_α: Aspect ratio (%); ρ_b: Bulk density (g/ml); ρ_t: True density (g/ml); ε: Porosity (%); ϕ: Angle of repose (degrees); H: Height of the heap (mm); D: Diameter of the heap (mm); μ: Static coefficient of friction

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereals cultivated worldwide, constituting the basic food for large number of human beings, sustaining two-thirds of the world population [1]. According to FAOSTAT, 2008, India accounts second in the production of rice after China with total production of 141 MT and 187 MT respectively. However, the area under cultivation of the rice is about 44,000,000 hectares and 29,495,000 hectares in India and China respectively. The yield of rice is 32,075 hectogram per hectare and 80,538 hectogram per hectare respectively. This shows lower yield of rice in India, which could be increased by using high yielding varieties. Archaeological evidence indicates that rice was a part of the Indian diet by 8000 BC [2]. Agricultural activity during the second millennium BC included rice cultivation in the Kashmir and Harrappan regions [3]. In India, rice consumption is generally accomplished in various forms like whole cooked grain, as dish meal, where rice is served normally in two ways, white rice and parboiled grains. It is the main base for preparation of many indigenous fermented food products (like idli, dosa, uttapam, sake-an alcoholic beverage), sweets (anarasa, khir), khichadi, pulav, puffed and extruded products.

The marketing values of rice as an agricultural product depend on its physical qualities after the harvesting. The percentage of whole grain is the most important parameter for the rice processing industry (Marchezan, 1991)[4]. Broken grain has half the market value of head rice (head rice=75-100% of whole kernel) (Trop Rice International Rice Research Institute, 2004). As enlisted above, the machinery and operations when improperly designed may generate rice kernel cracking and breakage and consequently a low marketing price. The knowledge of the physical properties of the agricultural products is of fundamental importance during the harvesting of grains, transporting, design and dimensioning of correct storage procedure, manufacturing and operating different equipments used in post harvesting main processing operations of these products. The information related to porosity and specific gravity, within other physical characteristics of the agricultural products, are of paramount importance for studies involving heat and mass transfer and air movement through the bulk grain. In addition, together with moisture content, volume, specific gravity and porosity are the basic parameters for studying the drying and storage of agricultural products and to preview the quality loss of the material until its marketing time. The specific gravity could be defined as the ratio between the mass of a body and its volume. This concept applied to the individual grain, it determines the real specific gravity of the individual grain. When this concept is applied to the bulk grain determines the bulk density. According to Mohsenin [5], porosity is defined as the ratio of the inter-granular void space volume and the volume of the bulk grain. The porosity can be determined through the direct method by measuring the added liquid to fulfill the void space of bulk grain. Several authors, through the years, pointed out the need for knowledge of other physical properties. For example, the static and dynamic friction coefficients, such as grains on the equipment wall and on the silo wall surfaces are necessaries and fundamentals for a rational and safe design of grain moving equipment, processing and storage [5-9]. This property develops an important role on silo wall pressure and grain flowing behaviors. The friction coefficient is defined as the ratio between the friction forces (force due to the resistance of movement) and the normal force on surface of the material used in the wall. For biological products, according to Mohsenin [5], two types of friction coefficients are considered, the static coefficient determined by the force capable to initiate the movement and the dynamic coefficient determined by the force needed to maintain the movement of the

***Corresponding author:** Prashant N. Ghadge, Department of Food Engineering, MGM College of Food Technology, Aurangabad – 431003 (M.S.) India, E-mail: pnghadge20@rediffmail.com

Received December 19, 2011; **Accepted** July 05, 2012; **Published** July 11, 2012

Citation: Ghadge PN, Prasad K (2012) Some Physical Properties of Rice Kernels: Variety PR-106. J Food Process Technol 3:175. doi:10.4172/2157-7110.1000175

grains in contact with the wall surface which depends on the type and nature of the material in contact.

The physical properties of rough rice have been previously studied. Taking into account the data shortage in a scientific literature in the variety specific area, the objective of this work is to determine some gravimetric, geometric, and frictional properties of rice kernels PR-106, which is very common variety in the Punjab state and rest of the India.

Practical Applications

The machinery and operations when improperly designed may generate rice kernel cracking and breakage and consequently a low marketing price. The knowledge of the physical properties of the agricultural products is of fundamental importance during the harvesting of grains, transporting, design and dimensioning of correct storage procedure, manufacturing and operating different equipments used in post harvesting main processing operations of these products [6,10]. Information related to porosity and specific gravity, within other physical characteristics of the agricultural products, are are of paramount importance for studies involving heat and mass transfer and air movement through the bulk grain. Effect of different processing methods on physical characteristics of whole pigeon pea is studied by Ghadge et al. [11]. The different processing methods affect the physical characteristics of whole legume. Faster reconstitution of precooked, frozen and cabinet dried samples was due to increased porosity as indicated by lowest bulk density and relatively higher water absorption and higher sedimentation values. Higher sedimentation value also indicates higher dispersability, which reveals the importance of physical properties. Therefore, present paper provides important information on the physical properties of incredibly produced variety of rice PR-106.

Materials and Methods

This work was carried out in the Department of Food Engineering & Technology, located at the Sant Longowal Institute of Engineering & Technology, Longowal- Punjab, India.

Sample preparation

The rice (*Oryza sativa* L.) of variety PR-106 was procured from Punjab Agricultural University, Ludhiana. The kernels were cleaned in an air classifier to remove lighter foreign matter such as dust, dirt, chaff, immature and broken kernels. The initial moisture content of the kernels was determined using hot air oven method [12].

Physical characteristics

The shape of the rice was found to be cylindrical with three perpendicular dimensions, length (L), width (W) and thickness (T). The physical dimensions were determined randomly measuring the length, width and thickness of 100 kernels using dial type vernier caliper (Mitutoyo Corporation, Japan) having least count 0.02 mm.

The geometric mean dimension (D_e) of kernels was found using the relationship given by Mohsenin [5] as:

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

The criteria used to describe the shape of the seed are the sphericity and aspect ratio. Thus, the sphericity (S_p) was accordingly computed [5] as:

$$S_P = \frac{(LWT)^{1/3}}{L} \times 100 \quad (2)$$

The aspect ratio (R_a) was calculated [13] as:

$$R_a = \frac{W}{L} \times 100 \quad (3)$$

The weights of the kernels were recorded using electronic balance (Ishida Co. Ltd., Japan) to an accuracy of 0.001 g.

The surface area (S_a) was calculated using the relationship (Equation 4) given by McCabe et al. [14]:

$$S_a = \pi D_e^2 \quad (4)$$

The kernel density of kernel is defined as the ratio of mass of seed to the solid volume occupied [15]. The seed volume was determined using liquid displacement technique. Toluene was used in spite of water so as to prevent the absorption during measurement and also to get the benefit of low surface tension of selected solvent [16,17]. Kernel density was evaluated using the methods suggested by Williams et al. [18]. The porosity (ε) of bulk seed was computed from the values of kernel density (ρ_t) and bulk density (ρ_b) using the relationship (Equation 5) given by Mohsenin [5]:

$$\varepsilon = \frac{\rho_t - \rho_b}{\rho_t} \times 100 \quad (5)$$

The angle of repose (φ) considered as the angle in degrees with the horizontal at which the material will stand forming a heap, was determined using relationship [5,19] as:

$$\phi = \tan^{-1} \frac{(2H)}{D} \quad (6)$$

The static coefficient of friction (μ) was determined for three structural materials namely glass, plywood and galvanized steel sheet. A plastic cylinder of 50 mm diameter and 60 mm height was placed on an adjustable tilting flat plate faced with the test surface and filled with the sample of about 100 g. The cylinder was raised slightly so as not to touch the surface. The structural surface with the cylinder resting on it was inclined gradually, until the cylinder just started to slide down. The angle of tilt was noted and tangent of the angle is reported as coefficient of static friction [20-22].

Statistical analysis

In the present study, the results are expressed as mean and standard deviation (S.D.) of two determinations.

Results and Discussions

A summary of the results for all the parameters measured and determined is shown in Table 1. The frequency distributions of the physical properties are shown in Figure 1. The moisture content of the kernels at the time of experiment was 13.34 ± 0.53% dry basis. The moisture content found can help to suggest the stability in storage of rice.

The longitudinal dimension or Length (L) for the kernels ranged from 5.90 to 7.30 mm with the mean value as 6.61 ± 0.038 mm (Table 1). However, a greater percentage (55%) of the seed longitudinal dimension lies between 6.3 and 6.9 mm with 24% between 6.0 and 6.3 mm. For the width (W), the distribution was 34% and 28% between 1.7–1.8 and 1.5–1.6 mm, respectively. A similar trend was observed for the seed thickness (T) as 67% and 23% for 1.2–1.4, 1.4–1.5 mm, respectively. Although, Mohsenin [5] had effectively highlighted the imperativeness of the axial dimensions in machine design, the comparison of the data with existing work on the other seeds can be sufficient in making symmetrical projections towards process equipment adaptation.

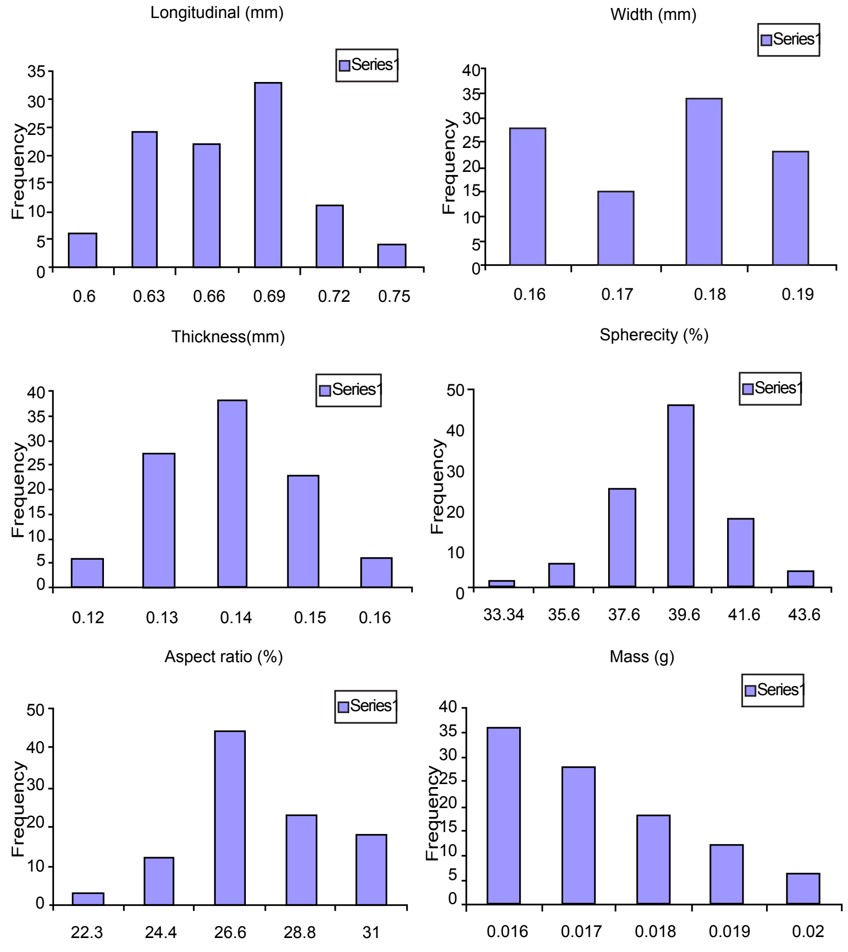

Figure 1: Frequency Distribution of Physical Properties of PR-106 Rice Kernels.

Physical Properties of PR–106	No. of observations	Unit of measurement	Mean Value	Min value	Max value	Standard Deviation
Length	100	mm	6.61	5.90	7.30	0.038
Width	100	mm	1.75	1.60	1.90	0.011
Thickness	100	mm	1.40	1.20	1.60	0.010
GMD*	100	mm	2.52	2.30	2.70	0.009
Surface area	100	mm^2	20.10	17.30	23.50	0.015
Volume	10	cm^3	0.051	0.050	0.054	0.002
Unit mass	10	gm	0.017	0.015	0.020	0.001
True density	10	g/ml	1.521	1.517	1.528	1.58
Bulk density	10	g/ml	0.805	0.795	0.897	0.35
Porosity	10	%	47.07	45.67	47.85	1.53
Sphericity	100	%	38.28	33.33	43.57	1.915
Aspect ratio	100	%	26.58	22.24	30.65	2.137
Mass of 1000 kernel	100	gm	17.40	15.30	19.70	0.002
Angle of repose	5	Degrees	34.86	32.95	35.85	0.597
Coefficient of static frictions for:						
Glass	5	--	0.249	0.236	0.258	0.009
Plywood	5	--	0.239	0.228	0.251	0.012
Galvanized steel	5	--	0.217	0.209	0.231	0.010

* Geometric mean dimension

Table 1: Some Physical Properties of Rice Kernels.

It is seen from (Table 1) that the sphericity and aspect ratio of the kernels varied from 33.33 to 43.57 (±1.915)%, 22.24 to 30.65 (±2.137)%, respectively. Within the ranges, 46% of the aspect ratio is from 37.6–39.6% with 25% of the value having a range of 35.6–37.6% (Figure 1, Table 1). The lower sphericity values thus suggest that the kernels tend towards a cylindrical shape [23]. Thus, the lower values of the aspect ratio and sphericity generally indicate a likely difficulty in getting the kernels to roll than that of peas like spheroid grains. They can, however, slide on their flat surfaces. This tendency to either roll or slide should be necessary in the design of hoppers for milling process. However, the surface area ranged from 17.30 to 23.50 (±0.015) mm^2, respectively. The surface area is a relevant tool in determining the shape of the seeds. This will actually be an indication of the way the kernels will behave on oscillating surfaces during processing [24].

The average kernel weight was 0.017 g, although the weight varied between 0.015 and 0.020 (±0.001) g. Weight is an important parameter to be used in the design of cleaning grains using aerodynamic forces [25]. The volume of kernels ranged from 0.050 to 0.054 ml with mean value of 0.051 ± 0.002 ml. The true density value lies within 1.517 to 1.528 g/ml. However, the mean value was 1.521 ± 1.58 g/ml. The value of true density indicates that, the kernel density is higher than water, which is the important property in case of food grains during wet cleaning, as kernels does not float on water. The porosity of the kernels was found to be 47.07 ± 1.53%.

The frictional properties examined for the kernels are the angle of repose and the coefficient of static friction. Essentially, the angle of repose was 34.86 ± 0.5970. This phenomenon is imperative in food grain processing, particularly in the designing of hopper for milling equipment. The co-efficient of static friction found was 0.249 on glass, 0.239 on plywood and 0.217 on a galvanized steel sheet. It is observed that obtained values of coefficient of static frictions for rice kernels are lower. This fact was expected because the milling operation makes the grain surface smoother which agrees with Mohsenin [5], who affirms that the friction and consequently its coefficient are affected mainly by the nature and type of the surface in contact.

Conclusions

1. The physical properties of L, W, T, M and V were measured at a moisture content of 13.34 ± 0.53% (dry basis) and the following results were obtained: the average split length, width, thickness, unit mass and volume were 6.61 mm, 1.75 mm, 1.40 mm, 0.017 g and 0.051 cm^3 respectively. There was no much more difference in width and thickness of rice kernels which is attributed to cylindrical shape of rice kernels.

2. The calculated physical properties like the geometric mean diameter, surface area, porosity, sphericity, true density, aspect ratio were 2.52 mm, 20.10 mm^2, 47.07%, 38.28%, 1.521 g/ml, 26.58% respectively. The lower sphericity is due to cylindrical shape of rice kernels.

3. Higher values of static coefficient of friction were observed on glass surface. The static coefficient of friction varied on three different surfaces from 0.324 on galvanized steel sheet, 0.454 on Plywood to 0.461 on glass with kernels perpendicular to direction of motion, while the angle of repose was 34.86°.

4. All standard deviation of all the measured parameters ranged between 0.01 and 2.14 showing near uniform dispersion about their respective mean values.

References

1. Zhout Z, Robards K, Heliwell S, Blanchard C (2002) Ageing of stored rice: changes in chemical and physical attributes. Journal of Cereal Science 35: 65-78.
2. Nene YL (2005) Rice Research in South Asia through Ages. Asian Agri-History 9: 85-106.
3. Wayne Smith C (2000) Sorghum: Origin, History, Technology, and Production. John Wiley and Sons. ISBN 0471242373.
4. Marchezan E (1991) Grãos inteiros em arroz (Whole rice kernels in rice). Lavoura Arrozeira 44: 3-8 Porto Alegre, Brazil
5. Mohsenin NN (1986) Physical properties of plant and animal materials. Vol1 Physical characteristics and mechanical properties, Gordon and Breach Science Publishers, New York.
6. Ghadge PN, Vairagar PR, Prasad K (2008a) Some Physical properties of Chickpea Splits (Cicer Arietinum L.). Agricultural Engineering International: the CIGR Ejournal. Manuscript FP 07 039 Vol X January, 2008.
7. Suthar SH, Das SK (1996) Some physical properties of karingda [*Citrullus lanatus* (Thumb) Mansf] seeds. Journal of Agricultural Engineering Research 65: 15-22.
8. Milani AP (1993) Determinação das propriedades de produtos armazenados para projetos de pressões e fluxo em silos (Determination of the stored products properties for silo pressures and flow design). Doctorate Thesis (Doctorate in Structure Engineering), Engineering School of São Carlos. University of São Paulo, São Carlos, SP, Brazil.
9. Lawton PJ (1980) Coefficients of friction between cereal grain and various silo wall materials. Journal of Agricultural Engineering Research 25: 75–86.
10. Afonso Junior PC (2001) Aspectos físicos, fisiológicos e de qualidade do café em função da secagem e do armazenamento (Coffee physical, physiological aspects and coffee quality in function of drying and storage). Doctorate Thesis in Agricultural Engineering (351 p). Agricultural Engineering Department, Federal University of Viçosa, Viçosa, MG, Brazil.
11. Ghadge PN, Shewalkar SV, Wankhede DB (2008b) Effect of Processing Methods on Qualities of Instant Whole Legume: Pigeon Pea (*Cajanus cajan L.*). Agricultural Engineering International: the CIGR E-journal. Vol. X. Manuscript FP 08 004.
12. Gupta RK, Das SK (2000) Fracture resistance of sunflower seed and kernel to compressive loading. Journal of Food Engineering 46: 1-8.
13. Maduako JN, Faborode MO (1990) Some physical properties of cocoa podsin relation to primary processing. Ife Journal of Technology 2: 1-7.
14. McCabe WL, Smith JC, Harriorth P (2005) Unit operations of chemical engineering. New York: McGraw-Hill Book Company.
15. Deshpande SD, Bal S, Ojha TP (1993) Physical properties of soybean. Journal of Agricultural Engineering Research 56: 89-98.
16. Sitkei G (1986) Mechanics of Agricultural Materials. Elsevier Science Pub Co Inc, New York.
17. Ogut H (1998) Some physical properties of white lupin. Journal of Agricultural Engineering Research 69: 273-277.
18. Williams PC, Nakoul H, Singh KB (1983) Relationship between cooking time and some physical characteristics in Chickpea (Cicer arietinum L.). Journal of Science of Food and Agriculture 34: 492-496.
19. Kaleemullah S (1992) The effect of the moisture content on the physical properties of the ground nut kernels. Tropical Sciences 32: 129-136.
20. Dutta SK, Nema VK, Bhardwaj RK (1988) Physical properties of gram. Journal of Agricultural Engineering Research 39: 259-268.
21. Fraser BM, Verma SS, Muir WE (1978) Some physical properties of fababeans. Journal of Agricultural Engineering Research 23: 53-57.
22. Shepherd H, Bhardwaj RK (1986) Moisture-dependent physical properties of pigeon pea. Journal of Agricultural Engineering Research 35: 227-234.
23. Omobuwajo TO, Sanni LA, Olajide JO (2000) Physical properties of ackee apple (*Blighia sapida*) seeds. Journal of Food Engineering 45: 43-48.

24. Alonge AF, Adigun YJ (1999) Some physical and aerodynamic properties of sorghum as relates to cleaning. In proc. 21st annual Conference of the Nigerian Society of Agricultural Engineers (NSAE) at federal Polytechnic, Bauchi, Nigeria.

25. Oje K, Ugbor EC (1991) Some physical properties of oil bean seed. Journal of Oil Bean Seed 50: 305-313.

26. Achaya KT (1984) Everyday Indian Processed Foods. National Book Trust India.

27. Kaur M, Singh N, Sodhi NS (2005) Physicochemical, cooking, textural and roasting characteristics of chickpea (*Cicer arietinum L.*) cultivars. J Food Eng 69: 511-517.

28. Keramat JM, Jafari A, Rafiee S, Keyhani AR, Mirasheh R, et al. (2007) Some Physical properties of Date Fruit (cv. Lasht). International Commission of Agricultural Engineering. E-journal. Manuscript FP 07 019. Vol. IX.

29. Konak M, Carman K, Aydin C (2002) Physical properties of Chick Pea seeds. Biosystems Engineering 82: 73-78.

30. Ajayi OA, Clarke B (1997) High velocity impact of maize kernels. Journal of Agricultural Engineering Research 67: 97–104.

31. Saxena MC, Singh KBE (1987) The chickpea, Wallingford, UK: CAB Intl, 409.

32. Shitanda D, Nishiyama Y, Koide S (2002) Compressive strength properties of rough rice considering variation of contact area. Journal of Food Engineering 53: 53-58.

33. Simonyan KJ, El-Okene AM, Yiljep YD (2007) Some Physical Properties of Samaru Sorghum 17 Agricultural Engineering International: the CIGR Ejournal Manuscript FP 07 008 Vol IX.

34. Singh C (1983) Modern Techniques of raising field crops. Oxford & IBH Publishing Co Pvt Ltd, New Delhi 523-524.

35. Singh RP (1990) Status of chickpea in world. International Chickpea Newsletter 22: 10-16.

36. Turhan M, Sayar S, Gunasekaran S (2002) Application of Peleg model to study water absorption in chickpea during soaking. J Food Eng 53: 153-159.