J Krishi Vigyan 2018, 7 (Special Issue) : 125-128 DOI : 10.5958/2349-4433.2018.00173.3

Physical Properties of Maize (*Zea mays* L.) Grain

G B Yenge, V P Kad and S M Nalawade

Dr. Annasaheb Shinde College of Agricultural Engineering and Technology,
Mahatma Phule Krishi Vidyapeeth, Rahuri - 413 702 (Maharashtra)

ABSTRACT

Physical properties of grains are necessary for the designing the facility of storage, handling and processing of agricultural products. Physical and mechanical properties of maize grains were determined as a function of moisture content in the range of 10-30 per cent using standard techniques. The average size, sphericity and density ranged from 8.08 to 8.46 mm, 0.654 to 0.717 and 1219 to 886.47 km/m^3 as the moisture content increased from 10-30 per cent. With increase in moisture content the size of maize grains increased from 8.08 to 8.46 mm and sphericity from 0.654 to 0.717. The density increased from 634.85 to 650.81 km/m^3 respectively.

Key Words: Maize, Moisture content, Physical properties.

INTRODUCTION

The maize (*Zea mays* L.) is a native of America. Maize is most important crop of world. The world average yield of 27.8 q/ha maize rank first among cereals and is followed by rice, wheat and millets with average grain yield of 22.5, 16.3 and 6.6 q/ha respectively. Based on the endosperm type, maize varieties may be grouped into dent, flint, floury, waxy, amylase, pop and sweet. In India, mostly cream yellow type maize grown is used for varied uses, ranging from chapattis making to pop corn, roasted ears, or as green vegetable to starch extraction. With regard to maturity the maize varieties can be grouped into three categories (1) very early maturity types, maturing in 65-75 d *e.g. sathi, Kathri* and *Teen pakhia.* (2) medium early maturing varieties subjected to a limited degree of improvement e.g. Basi, KT-41, Jaunpur, Rudrapur Local and (3) late maturing varieties.

Physical properties are important in many aspects associated with the design of machines and the analysis of the behavior of the product during agricultural process operations such as handling, planting, harvesting, threshing, cleaning, sorting and drying. Solutions to problems in these processes involve knowledge of their physical and engineering properties. Size of maize grains is useful in selecting sieve separators and in calculating power during the milling process. They can also be used to calculate surface area and volume of kernels which are important during modeling of grain drying, aeration, heating and cooling. Bulk density, true density, and porosity can be useful in sizing grain hoppers and storage facilities. Grain bed with low porosity will have greater resistance to water vapor escape during the drying process, which may lead to higher power to drive the aeration fans. Cereal grain kernel densities have been of interest in breakage susceptibility and hardness studies (Ghasemi *et al*, 2008).

Differences in grain moisture content can result in a significant variation in the processing characteristics of the grain. Hence, the objective of this study was to determine some physical properties of maize grains, as a function of moisture content in the range of 10 to 30 percent which can help out in the design of handling, storage, drying and milling equipment.

MATERIALS AND METHODS

The Maize seeds of variety Affrican tall were procured from local market *Krishi Utpanna Bazar Samiti, Nava Mondha*, Parbhani. The seeds were cleaned and graded using standard mesh sieves.

Corresponding Author's Email: vikramkad2014@gmail.com

The scalper screen or top sieve for cleaning was 11.5 mm while the grader screen or bottom sieve was 8.5 mm. The Maize seeds retained between the scalper and grader screen were selected for investigations. These seeds were cleaned by hand picking to remove the stalks, broken grains, stones and pebbles, other foreign seeds, weed seeds which had passed through the scalper openings and retained on the grader screen.

Sampling and replicating

The seed was sampled by weighing 800 g cleaned and graded Maize-seed on electronic weigh balance with an accuracy of 0.1 g. The seed was kept in polythene bags for storage. The samples were replicated thrice.

Determination of moisture content

The initial moisture content was determined by the standard air oven method. Weighed product of finely ground grain was heated in an air oven for one hour at $130^0 \pm 1^0C$ and from the loss in weight, the moisture content in the product was determined by the following formula

$$\text{Moisture content (\%)} = \frac{\text{Loss in weight of sample}}{\text{Initial weight of sample}} \times 100$$

… (1)

The initial moisture content of the Maize seeds was found 8.5 per cent. The experiment was conducted in the moisture range of 10 to 30 per cent.The initial weight of sample was worked out by using material balance equation. The higher moisture content levels, (10, 15, 20, 25, 30 per cent. with accuracy of ± 0.5 per cent at each level were obtained by adding calculated amount of distilled water, which was calculated with the help of material balance equation.

$$\text{Water to be added} = \frac{\text{Dry matter} \times \text{(Difference in moisture content (d.b.))}}{100}$$

… (2)

The conditioned samples were kept in air tight containers for 24 h, keeping uniform conditions of temperature and humidity. The samples were shaken well for one minute after every six hours. After 24 h the samples were evaluated for their physical characteristics for each level of moisture content.

Determination of physical properties

Size

Size is the geometric mean diameter. The dimension *viz.* length, width and thickness were measured with a vernier caliper to calculate its geometric mean diameter by the formula (Ingale *et al*, 2016).

$$\text{Size} = \left(a \times b \times c\right)^{1/3}$$

Where,

[a= length (cm); b= width (cm) c= thickness (cm)]

…(3)

Twenty five seeds were chosen randomly from each replication sample. These observations were taken at five different moisture contents, with the samples triplicates size was measured in cm

Sphericity

Outer dimensions *viz.* length, width and thickness are measured to find out the geometric mean diameter. The length of the largest oil mension of Maize seeds is the diameter of the smallest circumscribing circle. The sphericity was calculated by the formula.

$$\text{Sphericity} = \frac{\left(a \times b \times c\right)^{1/3}}{a}$$

… (4)

Where,

[a= length (cm); b= width (cm) c= thickness (cm)]

True density

It is the ratio of the sample of grain to its volume. True density was determined by adding known weight of grains in a 100 ml fractionally graduated measuring cylinder containing a fixed volume of toluene and noting the increase in volume, and calculated as

$$\text{True density} = D = \frac{W}{V} \qquad \ldots (5)$$

Where,

[D =True density (kg/m^3), W = weight of sample (kg), V = volume of sample (m^3)]

Toluene was selected for this purpose as it has sufficiently high boiling range and is not absorbed by the grain and it has low viscosity.

RESULTS AND DISCUSSION

The average values of geometric mean diameter of maize grains were calculated at different moisture contents are given Table 1. It was observed that size and sphericity increase linearly with the increase in moisture content.

It was clear that as the moisture content increased from 10 to 30 per cent, size of maize grains increased (Fig 1). The linear dimensions are highly dependent on the moisture content of the grains

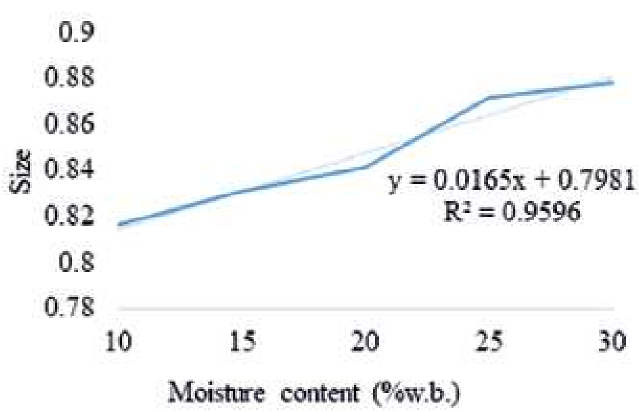

Fig 1. Effect of moisture content on size of maize grains

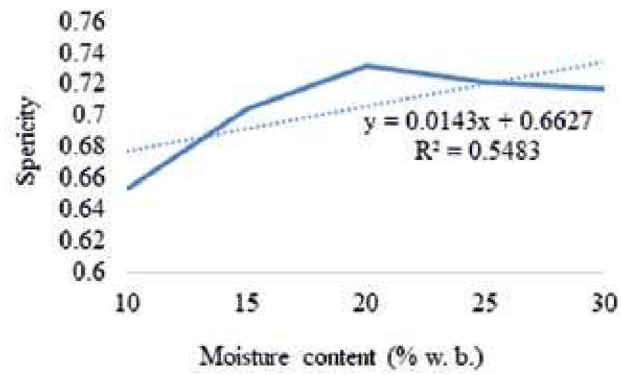

Fig 2. Effect of moisture content on sphericity of maize grains

(Fig 2). The results were in agreement with the earlier findings for custard apple seeds (Kad *et al,* 2015), moth gram (Nimkar *et al*, 2005) lentil seeds (Amin *et al*, 2004), millet (Baryeh, 2002), areca nut kernels (Kaleemullah and Gunasekar, 2002). The high sphericity of the caper fruit is the indicative of the tendency of shape towards a sphere. Similar results of the effect of grain moisture on sphericity have been reported for moth gram (Nimkar *et al*, 2005).

The variation of true density with moisture content of maize grains is shown in Fig. 3. True density of maize grains at different moisture levels varied from 1219.990 to 886.473 kg/m^3 with increasing moisture content. The results were similar to those reported for karanja kernel (Pradhan *et al*, 2008); linseed (Selvi *et al,* 2006); cocoa beans (Bart-Plange and Baryeh, 2005) and sweet corn seed (Coskun *et al,* 2005). The decrease in bulk density with an increase in moisture content is mainly due to the increase in volume than the corresponding increase in mass of the material. It facilitates the same weight of material to occupy more volume of the cylinder thus decreasing the bulk density.

Table 1. Size and sphericity of maize grains at different moisture contents.

Sr. No.	Properties	Moisture content (% w. b.)					R2 value
		10	15	20	25	30	
1	Size (cm)	0.816	0.831	0.841	0.872	0.878	0.9596
2	Sphericity	0.654	0.704	0.732	0.721	0.717	0.5483
3	Density (kg/m3)	650.81	646.64	642.508	638.41	634.857	0.9991

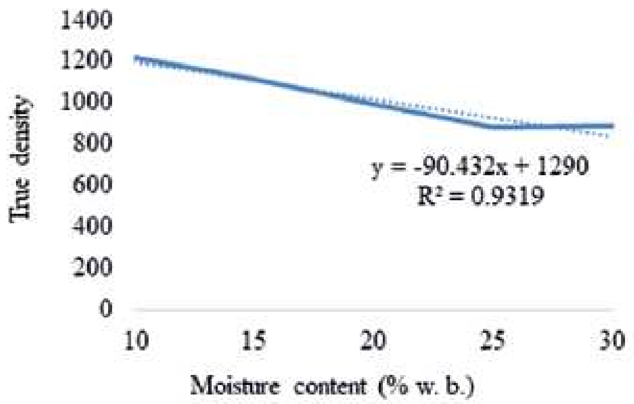

Fig 3. Effect of moisture content on true density of maize grains

CONCLUSION

The moisture content of maize grains affected the different physical properties. All physical increased with increase moisture content. With increase in moisture content the size of maize grains increased from 8.08 to 8.46 mm and sphericity from 0.654 to 0.717. The density increased from 634.85 to 650.81 km/m^3 respectively.

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Received on 04/10/2018 *Accepted on 20/12/2018*