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Physical Properties of Three Maize Varieties

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ABSTRACT

Physical properties of kernels, grains, and seeds are necessary for the design of equipment to handle, transport, process and store the crop. An experiment was conducted at College of Agricultural Engineering, Bapatla during 2012-13 to evaluate the physical properties of maize kernels (DHM 117, DHMM 115, and PIONEER B12) as function of moisture content (12 to 20 % w.b.) The maize kernel length, width, thickness, geometric mean diameter, surface area, sphericity and kernel volume increased linearly with increase in moisture content. But the bulk density decreased with increase in its moisture content from 12 to 20 % wb, while true density porosity and thousand grains mass increased with increasing moisture content.

Key words : Maize, Moisture Content, Physical Properties.

Maize (*Zea mays L*) is also known as corn, is the world's third most important cereal crop after wheat and rice. It has very high yield potential and is commonly known as "Queen of cereals". Maize contains about 10% proteins, 4% oil, 70% carbohydrates, 2.3% crude fiber, 10.4% albuminoides and 1.4% ash. Maize has significant quantities of vitamin A, nicotinic acid, riboflavin and vitamin E. World produces about 856 million tons of maize, whereas India produces about 21.76 million tons (2011-12), (www.indiastat.com). It is grown over an area of 8.33 lakh hectares in Andhra Pradesh with total production of 36.58 lakh tones (www.indiastat.com).

Information on physical properties of maize, like other agricultural materials, is necessary to design equipment for grading, handling, processing and storage *etc*. To design machines for cleaning, grading, sorting and packing *etc*., size and shape such as geometric mean diameter and sphericity are necessary to be known. The surface area and porosity are required to evaluate the rate of heat transfer for heating and drying and thus to design heat exchangers and driers *etc*. Bulk density, true density and porosity are required for the design of aeration, storage, transport and separation systems. True and bulk density data have also been used to determine the dielectric properties of cereal grains. It has been established that the properties of crops vary with their moisture contents. (Barnwal *et al.,* 2012)

In recent years, physical properties have been studied for various crops such as barley grains (Tavakoli *et al.,* 2009), pearl millet seeds (Ojediran *et al*., 2010), cucurbit seeds (Milani *et al*., 2007), pigeon pea (Baryeh and Mangope 2002), and wheat (Karimi *et al.,* 2009). Information on physical properties of maize varieties grown in Andhra Pradesh is not available. Hence, the present study was carried out with the objective to determine the physical properties of three popular varieties of maize grown in Andhra Pradesh in relation to moisture content.

MATERIAL AND METHODS

Raw material and sample preparation:

Three varieties of maize cobs namely, DHM 117, DHMM 115, and PIONEER B12, were selected and procured from different parts of Andhra Pradesh for conducting the research work. The maize cobs were manually shelled and cleaned to remove all foreign matter such as surface dust, dirt, stones and chaff. The initial moisture content of the samples was determined for all the samples using standard procedure (AOAC).The maize samples of 100 grams were taken from each variety of maize and the desired moisture content of samples were achieved by adding "Q" amount of distilled water, as calculated from the following relationship

$$Q = \frac{W_t(M_f - M_i)}{(100 - M_f)} \quad (1)$$

Where, Q = Weight of required water (g), W_t = Total weight of sample (g), M_f = Final moisture content (%) and M_i = Initial moisture content (%).

The samples were then transferred to separate polyethylene bags, and the bags were sealed tightly. The samples were kept at 5 ^{0}C in a refrigerator for a week to enable the moisture to be distributed uniformly throughout each sample. Before starting a test, the required quantities of the samples were taken out of the refrigerator and allowed to warm up to the room temperature for about 2 h. This rewetting technique was to attain the desired moisture content in the grain samples. All the physical properties of the grain samples were determined at the desired moisture content (12, 14, 16, 18 and 20 (% wb). (Tavakoli *et al.,* 2009).

Determination of physical properties of maize grains

Physical parameters like length, width, thickness, geometric mean diameter, sphericity, surface area, volume, thousand kernel weight, bulk density, true density, and angle of repose of maize samples were estimated as per the following procedure.

Determination of axial dimensions, geometric mean diameter, sphericity, surface area and volume

Ten maize grains from each sample were randomly selected and their length, breadth and thickness were measured with a digital calliper. (Seifi *et al.,* 2010 and Barnwal *et al.,* 2012). These values were used to calculate the derived geometric mean diameter, sphericity, surface area and volume using standard relationships.

Calculation

$$\text{Sphericity, } S_p = \frac{(LWT)^{1/3}}{L} \quad (2)$$

$$\text{Surface area} = \Pi D_g^2 \quad (3)$$

$$\text{Volume} = 0.25[\frac{\pi}{6} L(W+T)^2] \quad (4)$$

Where, L = Length of the maize grain, (mm), W = Width of the maize grain, (mm), T = Thickness of the maize grain and Dg= Geometric mean diameter.

Determination of Thousand grain weight

Thousand grain weight was measured by weighing 250 grains in an electronic balance with an accuracy of 0.01g and then multiplied by 4 to give weight of 1000 kernels (Barnwal *et al.* 2012)

Determination of bulk density

The average bulk density of the maize samples were determined by using the standard test weight procedure by filling a container of 1000 ml with samples of 100 ml by tapping twice for uniform packing and to minimise wall effect and then weighed the contents.(Singh and Goswami, 1996).

Bulk density, kg/m^3 =

$$\frac{\text{weight of the grain content, kg}}{\text{volume m}^3} \quad (5)$$

Determination of true density

The average true density was expressed as the ratio of weight of 10 grain samples to volume of toluene displaced, was determined by using the toluene displacement method. The volume of toluene (C_7H_8) displaced was found by immersing a weighed quantity of maize samples in the toluene (Barnwal *et al.* 2012).

True density, g/mm^3=

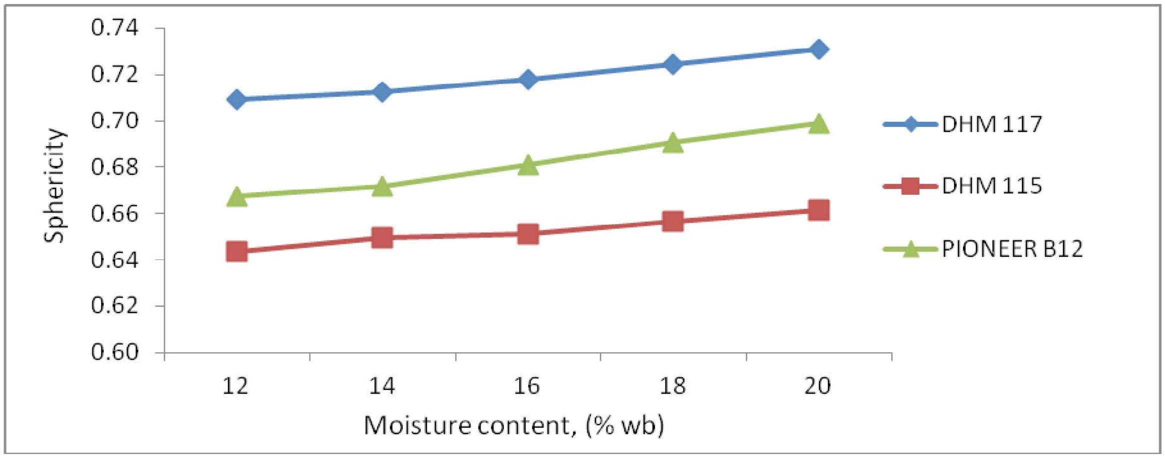
$$\frac{\text{weight of 10 grain samples}}{\text{volume of toluene displaced in measuring flask}} \quad (6)$$

Determination of porosity

The porosity was calculated from bulk and true densities by the following equation (Mohsenin, 1970)

$$\text{Porosity} = (1 - \frac{\text{Bulk density}}{\text{True density}}) \times 100. \quad (7)$$

Fig.1 Effect of moisture content on sphericity for different varieties of maize



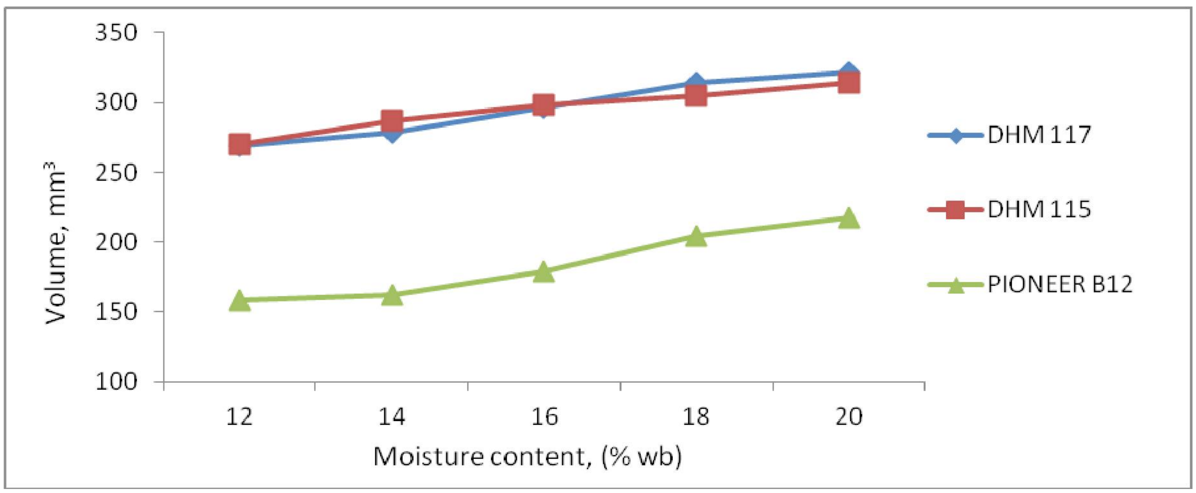


Fig.2 Effect of moisture content on volume for different varieties of maize

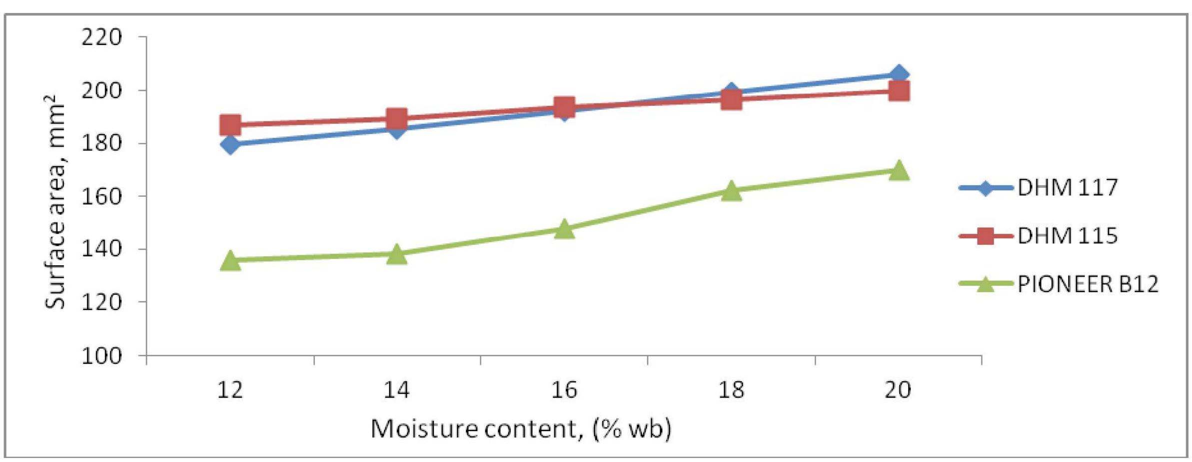


Fig.3 Effect of moisture content on surface area for different varieties of maize

RESULTS AND DISCUSSION

Effect of moisture content on sphericity of maize samples

The observations revealed that variation in sphericity among the maize varieties. It was observed that sphericity for DHM 117 was greater (0.731) than other varieties at each moisture content levels (fig 1). It was noted that the sphericity of maize samples increased with the increase in moisture content. The increase in the sphericity might be due to moisture absorption and filling of capillaries and voids upon of moisture and subsequent swelling. As the moisture content increased, the length, width and thickness of grains were increased. Due to this, sphercity was increased.

The sphericity versus moisture content for all the maize varaities showed linear trends

DHM 117 $\phi = 0.0055M + 0.7026$

ϕ $R^2 = 0.9812$ **(8)**

DHM 115 $\phi = 0.0075M + 0.6098$

$R^2 = 0.9693$ **(9)**

PIONEER B12 $\phi = 0.0083M + 0.6572$

$R^2 = 0.9874$ **(10)**

Similar increasing trend for sphericity with moisture content for maize and paddy grains was observed by other reasearchers also (Barnwal *et al.,* 2012, Seifi *et al.,*2010 and Zereiforoush *et al.,* 2011).

Effect of moisture content on volume and surface area of maize samples

The observations revealed variation in volume and surface area among the maize varieties. It was observed that volume and surface area for PIONEER B12 was lesser than other varieties at each moisture content levels (fig 2 & 3). The grain volume and surface area of samples increased linearly with increase in moisture content from 12 to 20 (% wb). This volumetric expansion may be attributed to the expansion in the dimensions which contributed to increase in weight of maize grains, thereby resulting to the increase in volume. The increase in surface area is due to the increase in three principal dimensions of maize (Seifi *et al.,* 2010).The realtionship between volume and moisture content folllowed a linear trend generalized expression for each of these varieties.

DHM 117 $V = 14.194M + 253.54$

$R^2 = 0.9818$ **… (11)**

DHM 115 $V = 10.713M + 262.7$

$R^2 = 0.9704$ **… (12)**

PIONEER B12 $V = 16.128M + 136.08$

$R^2 = 0.9565$ **… (13)**

The realtionship between surface area and moisture content was linear and was represented by the following regression equations.

DHM 117 $S = 6.7277M + 172.33$

$R^2 = 0.9993$ **… (14)**

DHM 115 $S = 3.3036M + 183.22$

$R^2 = 0.9953$ **… (15)**

PIONEER B12 $S = 9.1976 M + 123.24$

$R^2 = 0.9564$ **… (16)**

The increasing trend in volume and surface area with increase in moisture content has been reported for wheat, barnyard millet, barely and maize was observed by other reasearchers (Karimi *et al.,* 2009, Singh *et al.,* 2010, Tavakoli *et al.,* 2009 and Seifi *et al.,* 2010).

Effect of moisture content on thousand grain weight of maize samples

Variations of thousand grain weight at different levels of moisture content are shown in fig 4. It was observed that the thousand grain weight of all varieties of maize samples increased with increase in moisture content from 12 to 20 (% wb). This increase was be due to the absorption of moisture by the maize grains.

Equations show a linear realtionship between thousand grain weight (g or mg)and moisture contents.

DHM 117 $TGW = 9.571M + 325.92$

$R^2 = 0.9978$ **… (17)**

DHM 115 $TGW = 9.0477M + 307.75$

$R^2 = 0.8948$ **… (18)**

PIONEER B12 $TGW = 9.9263M + 228.46$

$R^2 = 0.9646$ **… (19)**

Similar increasing trends in thousand grain weight with increase in moisture content were reported for pearl millet, corn, sweet corn and pigeon pea (Ojediran *et al.*, 2010, Seifi *et al.*, 2010, Coskun *et al.*, 2005, and Baryeh, 2002).

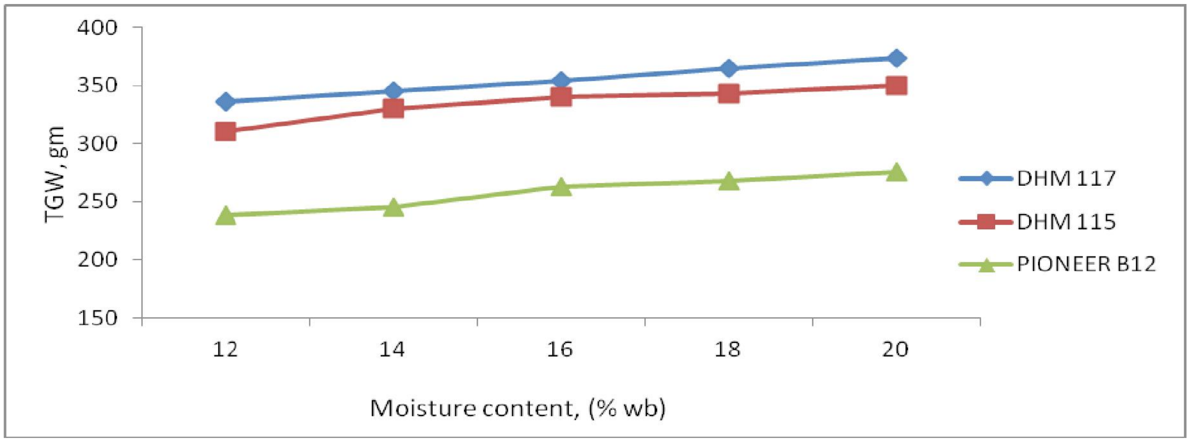


Fig.4 Effect of moisture content on thousand grain weight for different varieties of maize

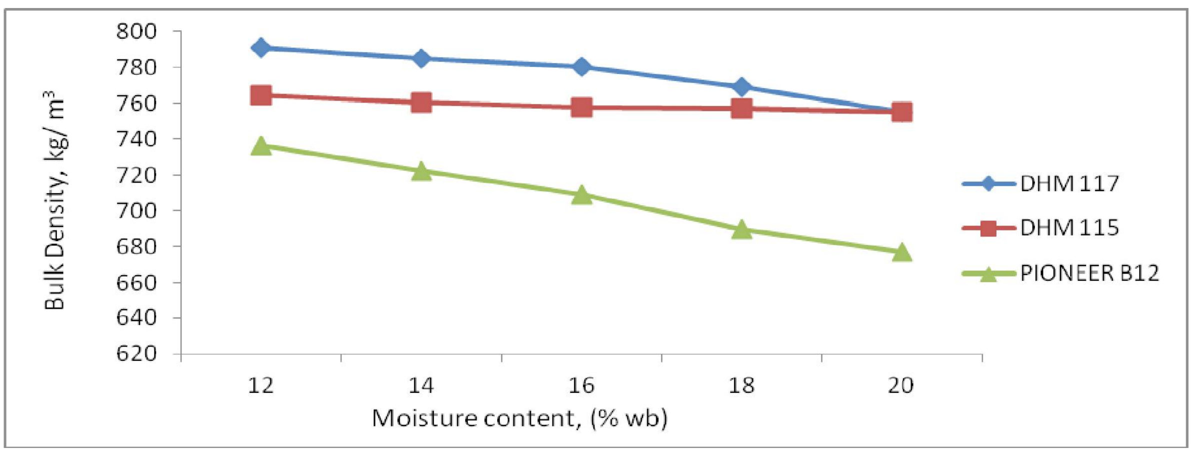


Fig.5 Effect of moisture content on bulk density for different varieties of maize

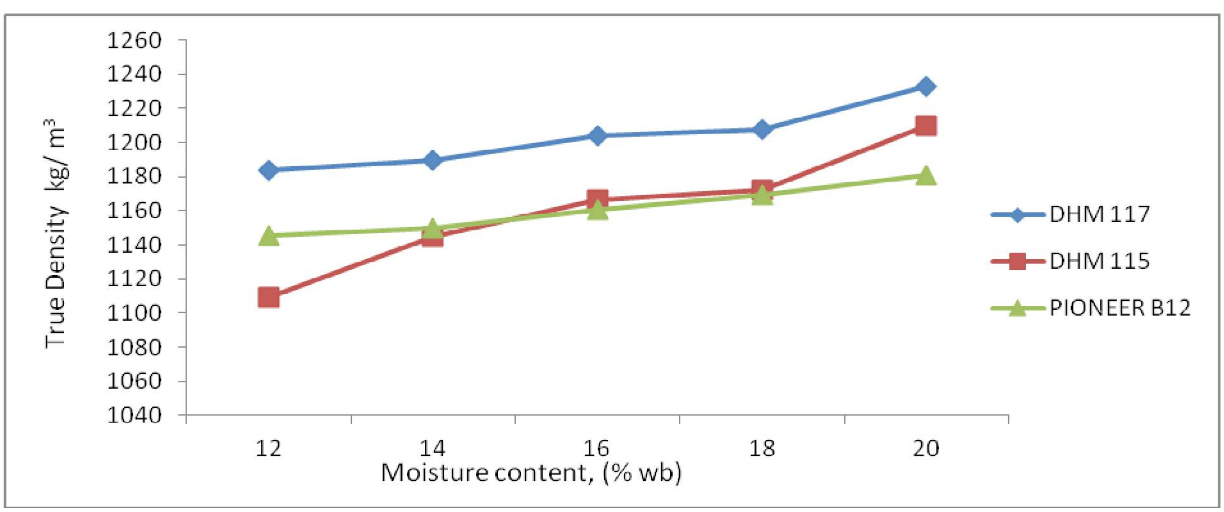


Fig.6 Effect of moisture content on true density for different varieties of maize

Effect of moisture content on bulk density and true density of maize samples

Variations of bulk density at different levels of moisture content are shown in fig 5. Bulk density for all the varieties of maize grains were decreased with the increase in moisture content from 12 to 20 (% wb) all followed a linear trend. The decrease in bulk density is due to increase in inter-granular space with increase in moisture content.

Equations shows a linear correaltion between bulk density and its moisture contents.

DHM 117 $\rho_b = 8.77M + 802.5$
$R^2 = 0.9544$ **… (20)**

DHM 115 $\rho_b = 2.2393M + 765.91$
$R^2 = 0.937$ **… (21)**

PIONEER B12 $\rho_b = 15.123M + 752.28$
$R^2 = 0.9959$ **… (22)**

Variations of true density at different levels moisture content are shown in fig 6. True density for all the varieties of maize grains were increased with increase in moisture content from 12 to 20 (% wb). The increase in the true density with increase in the moisture content was mainly due to the larger increase in grain volume as compared to their masses.

Equations show a linear realtionship between true density and moisture contents.

DHM 117 $\rho_t = 1.9528M^2$ to $0.1341M + 1182.3$
$R^2 = 0.9632$ **… (23)**

DHM 115 $\rho_t =$ to$0.8447M^2 + 28.007M + 1085.8$
$R^2 = 0.9561$ **… (24)**

PIONEER B12 $\rho_t = 0.8361M^2 + 4.0431M + 1139.9$ $R^2 = 0.993$ … **(25)**

Similar increasing trends in true density with increase in moisture contents were reported for rice, corn, sweet corn and barnyard millet and kernal (Kibar *et al.,* 2010, Seifi *et al.,* 2010, Coskun *et al.,* 2005 and Singh *et al.,* 2010).

Effect of moisture content on porosity of maize samples

Porosity depends upon the bulk density and true densities; variation in porosity depends on these factors only. With the increase in the moisture content from 12 to 20 (% wb) the porosity also increased as shown in fig 7.

Equations show a linear realtionship between porosity and moisture contents.

DHM 117 $\varepsilon = 1.3359M + 31.425$
$R^2 = 0.9595$ **… (26)**

DHM 115 $\varepsilon = 1.5518M + 29.775$
$R^2 = 0.9392$ **… (27)**

PIONEER B12 $\varepsilon = 1.7764M + 33.756$
$R^2 = 0.9974$ **… (28)**

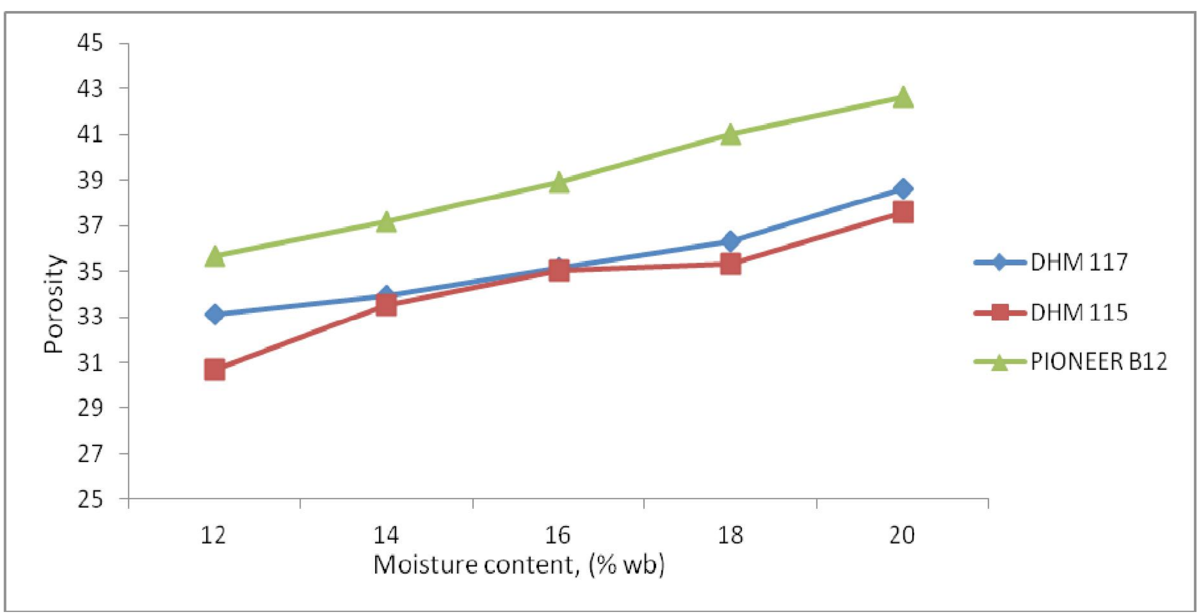


Fig .7 Effect of moisture content on porosity for different varieties of maize

Similar increasing trends in porosity with increase in moisture content were reported for barely, Cucurbit seeds and rice (Ozturk and Esen 2008, Milani *et al.,* 2007 Kibar *et al.,*2010).

SUMMARY AND CONCLUSIONS

1. Sphericity, volume and surface increased linearly from 0.71 to 0.73, 0.64 to 0.73, 0.67 to 0.70, 269.09 to 322.06, 269.80 to 314.49, 158.39 to 217.86 mm^3 and 179.36 to 206.05, 186.79 to 199.89, 135.96 to 170.04 mm^2 for all three varieties (DHM117, DHM 115 and PIONEER B12) of maize respectively with increase in moisture content from 12 to 20 (% wb).
2. Bulk density decreased from 791.0 to 755.40, 764.76 to 755.26 and 736.63 to 677. 27 kg/m^3 respectively, while the true density and porosity increased from 1183.46 to 1232.57, 1109.13 to 1210.00, and 1145.46 to 1180.73 kg/m^3, 33.14 to 38.64, 30.70 to 37.56, and 35.67 to 42.64 for all three varieties (DHM117, DHM 115 and PIONEER B12) of maize respectively with increase in moisture content from 12 to 20 (% wb).
3. Thousand grain weight is increased from 335.87 to 373.73, 310.81 to 349.97 and 238.07 to 276.17 g for all three varieties (DHM117, DHM 115 and PIONEER B12) of maize respectively with increase in moisture content from 12 to 20 (% wb).

LITERATURE CITED

Anonymous 2013 Production of maize in India [online], Available at: http://www. indiastat. com, [Accessed 23, April, 2013].

Bareyeh E A and Mangope B K 2002 Some physical properties of QP-38 variety pigeon pea. *Journal of Food Engineering.* 56:59-65.

Barnwal P, KadamDM and Singh K K 2012 Influence of moisture content on physical properties of maize. *Institute of Agrophysics*, Polish Academy of Sciences.26:331-334.

Coskun M B, Yalcin I and Ozarslan C 2005 Physical properties of sweet corn seed. *Journal of Food Science*, 74(4): 523-528.

Karimi M, Kheiralipour K, Tabatabaeefar A, Khoubakht G M Naderi M and Heidarbeigi K 2009 The effect of moisture content on physical properties of wheat. *Pakistan Journal of Nutrition,* 8(1):90-95.

Kibar H, Ozturk T and Esen B 2010 The effect of moisture content on physical and mechanical properties of rice. *Spanish Sournal of Agricultural Research,* 8(3):741-749.

Milani E, Razavi M S A, Koocheki A, Nikzadeh V, Vahedi N, Moeinfard M and Gholamhosseinpour A 2007 Moisture dependent physical properties of cucurbit seeds. *International Agrophysics*, 21:157-168.

Mohsenin N N 1970 Physical Properties of Plant and Animal Materials, 2nd ed. Gordon and Breach Science Publishers,New York.

Ojediran J O, Adamu M A and George D L J 2010 Some physical properties of pearl millet seeds as a function of moisture content. *Africian Journal of General Agriculture,* 6(1):39-46.

Ozturk T and Esen B 2008 Physical and mechanical properties of barley. *Agricultura Tropica ET Subtropica*, 41(3):117-121.

Seifi M R and Alimardani R 2010 Comparision of moisture dependent physical and mechanical properties of two varieties of corn. *Australian Journal of Agricultural Engineering,*1(5):170-178.

Seifi M R and Alimardani R 2010 Moisture content effect on some physical and mechanical properties of corn. *Journal of Agricultural Science,* 2(4):125-134.

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