J Agric. Res., 2016, Vol. 54(4):773-785
ISSN: Online: 2076-7897, Print:0368-1157
http://www.jar.com.pk

EFFECT OF GRAIN MOISTURE CONTENT ON PHYSICO-ENGINEERING PROPERTIES OF WHEAT

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ABSTRACT

A laboratory experiment was conducted in the Department of Farm Structures, Sindh Agriculture University, Tandojam, Pakistan during 2015 to examine the effect of grain moisture on the physical and engineering properties on two wheat varieties (TD-1 and TJ-83). The properties evaluated were axial dimensions, arithmetic mean diameter, geometric mean diameter, equivalent diameter, seed weight, seed volume, true density, bulk density, porosity and surface area. The moisture was kept constant (±0.5) at 10, 15 and 20 percent for both varieties. The results revealed that axial dimensions, diameters, seed mass, seed volume, true density, porosity and surface area in both varieties increased with increase in moisture while bulk density decreased with increase in moisture. The change in wheat grain with increasing moisture has the practical application of processing, threshing and storage which must be considered while designing equipment.

KEYWORDS: ***Triticum aestivum*** **L.; physical and engineering properties; grain; moisture content; TD – 1; TJ-83, Pakistan.**

INTRODUCTION

Wheat (*Triticum aestivum* L.) contains a large fraction of dietary protein and is important food for the world's population. Wheat is adapted to a wide range of climatic conditions varying from temperate to sub-tropical and tropical regions. Being a staple food in Pakistan, it is a largest food grain source of the country. The wheat has natural ability to control weight and is rich source of Magnesium. The whole wheat rather than refined wheat is good choice for obese patients. The regular consumption of wheat grain promotes healthy blood sugar (1). In Sindh province wheat is currently planted on about 0.9 million hectares with an average annual contribution of about 3.0 million tons (4). Major commercial varieties grown in Sindh are TD-1, TJ-83, Sarsabz, Kiran-95, Imdad and SKD - 1 and major growing districts

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in Sindh are Hyderabad, Khairpur, Mirpurkhas, Nawabshah, Naushahro-Feroze and Dadu. Currently, China and India are leading countries in producing wheat following USA, France, Russia, Australia, Canada, Pakistan, Germany and Turkey.

Identification of physical and engineering characteristics of cereal grains is very important to optimize the design parameters of agricultural equipment used in its production, handling and storage processes. These properties play an influential role in designing and developing specific machines for different operations such as sorting, separating and cleaning and also to determine the optimum seed metering device and precision sowing machine to suite every size of grains. The physical properties of wheat seed at various moistures should be determined before designing a machine (22). The knowledge of basic physical characteristics of any seed is of importance for engineering design for storage structure and processes purpose. New uses may be exploited by using the important background information provided (10). Optimum values of the basic physical, engineering and nutritional properties of wheat grains are known for design parameters in agricultural equipments (13). Geometric characteristics, such as size and shape during separation and cleaning of grains are considered as one of the most important physical properties. In theoretical calculation, agricultural seeds are assumed to be spherical, because of their oval or irregularly shape (16, 18). The engineering properties of wheat seeds are based on the functions of moisture and equipment designed (22). Engineering properties can be useful in sizing storage facilities; while heat rate may be affected during ventilation and drying operations (8).

Present study was initiated to assess the impact of moisture content on physical and engineering properties of wheat grain. So that machine designers and engineers can utilize this information to design the equipment required.

MATERIALS AND METHODS

This laboratory experiment was conducted during 2015 in the Department of Farm Structures, Sindh Agriculture University, Tandojam, Pakistan. Two Popular and commercial leading varieties of wheat (TD-1 and TJ-83) were selected for evaluation of physical and engineering properties. The samples of grain were obtained from Latif Experimental Farm, Sindh Agriculture University, Tandojam. Grains were manually cleaned and hand sorted to eliminate foreign materials. Moisture levels as 10, 15, and 20 percent (db) were obtained by rewetting of different samples and was calculated as,

$$Ww = \frac{Wt\ (Mf\text{-}Mi)}{(100\text{-}Mf)} \quad \ldots\ldots\ldots (1)$$

Twenty random samples of wheat grain were taken from each sample of different moistures for measuring seed dimensions (average mean) using micrometer screw gauge. The geometric mean diameter (G_m) and arithmetic mean diameter (d_e) were determined by equations accustomed by Mohsenin (16).

$$G_m = (LWT)^{1/3} \ldots\ldots (2)$$

$$d_e = \frac{L+W+T}{3} \ldots\ldots (3)$$

Mathematical equations accustomed (7, 20), were used to calculate equivalent diameter (D_E)

$$D_E = \frac{F_1 + F_2 + F_3}{3} \ldots\ldots\ldots (4)$$

Where,

$F_1 = d_e$
$F_2 = G_m$

$$F3\ (Square\ mean\ diameter) = \left(\frac{LW+WT+TL}{3}\right) \ldots\ldots\ldots (5)$$

The mass of seeds was weighed individually using electronic balance whereas volume of seed was determined by water displacement method. The true (particle) density was calculated by dividing mass and volume of individual seeds

$$\rho t = \frac{M}{V} \quad \ldots\ldots\ldots (6)$$

Mass of seed was divided by volume of container for determining Bulk Density (β) for both varieties.

$$\beta = \frac{m}{V_C} \quad \ldots\ldots\ldots (7)$$

The porosity (ψ) of wheat seed at various moistures were calculated using following relationship,

$$\Psi = \left(1 - \frac{\beta}{\rho t}\right) x\ 100 \quad \text{.....(8)}$$

Surface area of the seed is an important attribute. It can help designers to estimate the hopper, processing chamber and chute. The results showed expression of analogy with a sphere of some geometric mean diameter using the formula cited by (3, 11, 15).

$$S = \pi\ G_m{}^2 \quad \text{..... (9)}$$

RESULTS AND DISCUSSION

Axial dimensions

The axial dimensions of wheat grains for both varieties increased with an increase of moisture proportion (Table 1). The average seed length of TD - 1 increased from 7.33 mm at 10 percent to 8 mm at 20 percent moisture. Seed length of TJ - 83 increased from 7.31 mm at 10 percent to 7.89 mm at 20 percent moisture. Grain width of TD - 1 increased 3.83mm at 10 percent to 4mm at 20 percent moisture. The width of TJ-83 increased from 3.67mm at 10 percent to 3.81 mm at 20 percent moisture. Similarly, thickness of TD - 1 increased 3 mm at 10 percent to 3.17mm at 20 percent moisture against 2.83mm to 3.05mm in TJ-83. These results are in line to those of Majdi and Taha (14) who reported that axial dimensions and mean diameter increased with increasing moisture. Changes in axillary dimensions with increasing moisture are useful to be considered while designing equipment.

Geometric mean diameter

An increase was found in geometric mean diameter with 4.32mm at 10 percent to 4.60 at 20 percent moisture in TD-1 Variety (Table 1, Fig. 1).

Table 1. Physical dimensions of wheat seeds (TD-1 and TJ-83) at different moistures.

Variety	Moisture content (%)	L (mm)	W (mm)	T (mm)	G_m (mm)	d_e (mm)	D_E (mm)	S (mm^2)
TD-1	10	7.33	3.83	3.00	4.32	4.72	3.91	58.59
	15	7.74	3.91	3.09	4.47	4.91	4.05	62.74
	20	8.00	4.00	3.17	4.60	5.06	4.16	66.44
TJ-83	10	7.31	3.67	2.83	4.17	4.60	3.81	54.6
	15	7.70	3.75	2.95	4.34	4.80	3.96	56.13
	20	7.89	3.81	3.05	4.44	4.92	4.04	61.89

L = Seed length, W = Width, T = Thickness, Gm = Geometric mean diameter, DE= Arithmetric mean diameter, DE = Equivalent diameter, S = Surface area.

Similar trend was observed in TJ-83 variety (4.17mm to 4.44mm). The equations 10 and 11 represent linear relations of these values with increasing seed moisture. Similar trend in geometric mean diameter was observed earlier for wheat seed (22). The geometric mean diameter of wheat grain with increasing moisture shows the capacity of absorbing water and increase laterally.

$$G_{TD-1} = 0.028M + 4.043, \quad R^2 = 0.998 \quad (10)$$

$$G_{TJ-83} = 0.027M + 3.911, \quad R^2 = 0.978 \quad (11)$$

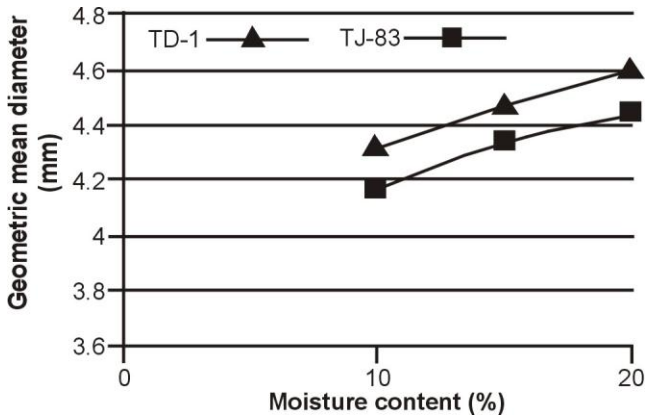


Fig.1. Geometric mean diameter of wheat varieties affected by moisture content.

Arithmetic mean diameter

The arithmetic mean diameter of TD-1 variety increased for 4.72 mm at 10 percent to 5.06mm at 20 percent moisture content (Table 1 Fig. 2).

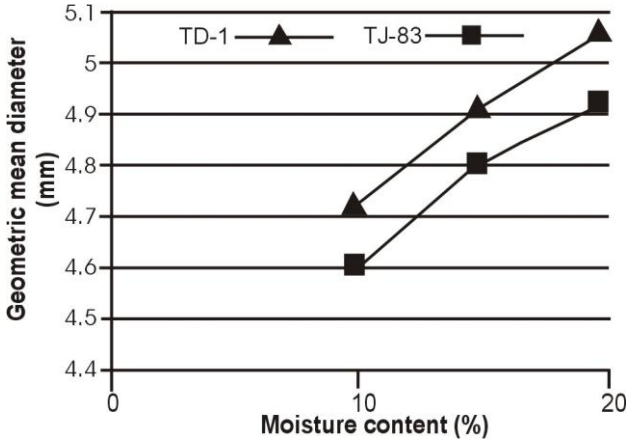


Fig. 2. Arithmetic mean diameter of wheat varieties affected by moisture content

Similar trend was observed in TJ-83 variety (4.60 to 4.92mm). The results indicated significant influence when moisture content increased. The equation 12 and 13 represent linear relations of these values with increasing moisture content. Similar findings were observed earlier for hemp, wheat and cowpea seed (9, 21, 22). Present results indicate that TD-1 variety has the capacity to absorb more water and increase laterally than TJ-83 variety.

$$A_{TD-1} = 0.034M + 4.386, \quad R^2 = 0.995 \quad (12)$$
$$A_{TJ-83} = 0.032M + 4.293, \quad R^2 = 0.979 \quad (13)$$

Equivalent diameter

The equivalent diameter of TD-1 variety also increased from 3.91mm at 10 percent 4.16mm at 20 percent moisture content (Table 1 Fig. 3).

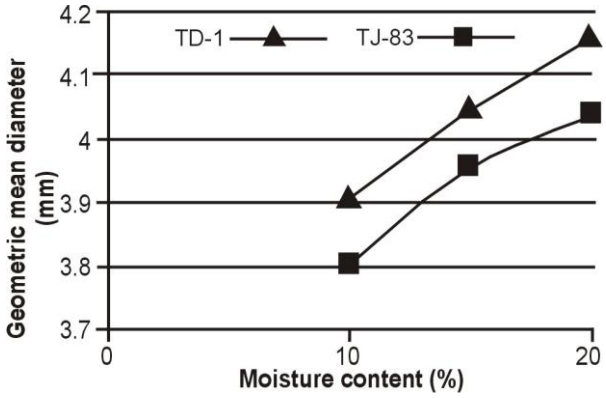


Fig. 3. Equivalent diameter of wheat varieties affected by moisture content

Similar trend (3.81-4.04mm) was observed with increasing moisture content in TJ-83 variety. The linear relationship of equivalent diameter values of both varieties with respect to moisture contents is represented in equations 14 and 15. Similar findings were observed reported by previous workers for hemp, wheat and cowpea seed (9, 21, 22).

$$E_{TD-1} = 0.025M + 3.665, \quad R^2 = 0.995 \quad (14)$$
$$E_{TJ-83} = 0.023M + 3.591, \quad R^2 = 0.970 \quad (15)$$

Seed mass

The mass of single grain of TD - 1 variety increased from 0.056 to 0.073 g with moisture ranging from 10 to 20 percent while mass of TJ - 83 variety increased from 0.05 to 0.057 (Table 2, Fig. 4).

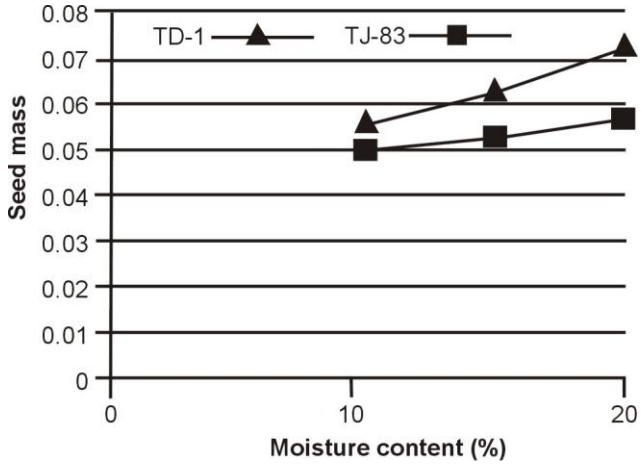


Fig. 4. Mass of wheat varieties affected by moisture content

The positive change was due to increase in moisture content. Similar trend of increasing seed mass with increasing moisture content was also observed for wheat seed (14). The linear relationship of these values is represented below. This indicates that practical application of seed mass is in the design of equipment for cleaning, separation, conveying and elevating unit operation during milling.

$$MS_{TD-1} = 0.001M + 0.038, \quad R^2 = 0.989 \qquad (16)$$

$$MS_{TJ-83} = 0.000M + 0.042, \quad R^2 = 0.993 \qquad (17)$$

Seed volume

Seed volume of TD - 1 variety slightly increased from 0.06 to 0.063 cm^3 at moisture ranging from 10 to 20 percent while in TJ - 83 it increased from 0.05 to 0.051cm^3 (Table 2, Fig. 5).

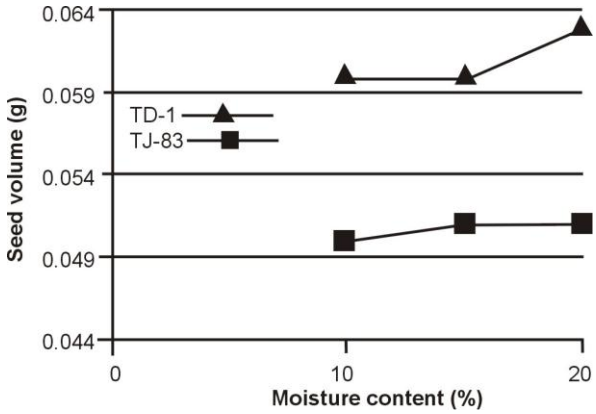


Fig. 5. Seed Volume of wheat varieties affected by moisture content

Similar findings were also observed previously (5, 14). The linear relationship of these seed volume values with respect to moisture contents is represented below.

$$V_{TD\text{-}1} = 0.000M + 0.056, \quad R^2 = 0.75 \quad (18)$$
$$V_{TJ\text{-}83} = 1E\text{-}04M + 0.049, \quad R^2 = 0.75 \quad (19)$$

True density

True density of wheat seed of TD - 1 variety increased from 0.933 to 1.22 g/cm^3 with moisture ranging from 10 to 20 percent against 1.0 to 1.14g/cm^3 in variety TJ-83 (Table 2, Fig. 6).

Table 2. Moisture content effects on engineering properties of wheat seed

Variety	Moisture content (%)	Seed mass (g)	Seed volume (cm^3)	True density (g/cm^3)	Bulk density (g/cm^3)	Porosity (%)
TD-1	10	0.056	0.060	0.933	0.650	31
	15	0.063	0.060	1.000	0.580	42
	20	0.073	0.063	1.220	0.530	57
TJ-83	10	0.050	0.050	1.000	0.640	36
	15	0.053	0.051	1.060	0.590	44
	20	0.057	0.051	1.140	0.550	48

Similar results have been reported by Nalbandi *et al.* (18). The linear relationship of these values with respect to moisture content is represented below. True density plays an important role while designing silos and storage bins which are essential to storage.

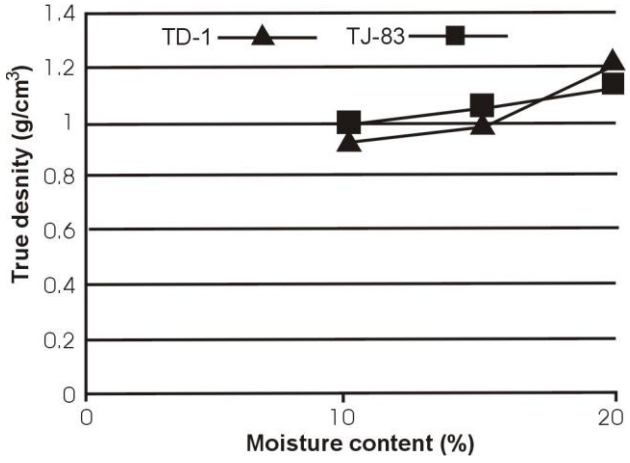


Fig. 6. True density of wheat varieties affected by moisture content.

$$T_{TD-1} = 0.028M + 0.620, \quad R^2 = 0.913 \quad (20)$$
$$T_{TJ-83} = 0.014M + 0.856, \quad R^2 = 0.993 \quad (21)$$

Bulk density

Both weight and volume increased with increasing moisture. Rate of volume was observed to be higher, thus bulk density decreased. Bulk density of seed of TD-1 decreased from 0.65 to 0.53 g/cm^3 with increasing moisture (10 to 20 %) (Table 2, Fig. 7) against 0.64 to 0.55 g/cm^3 bulk density of TJ-83.

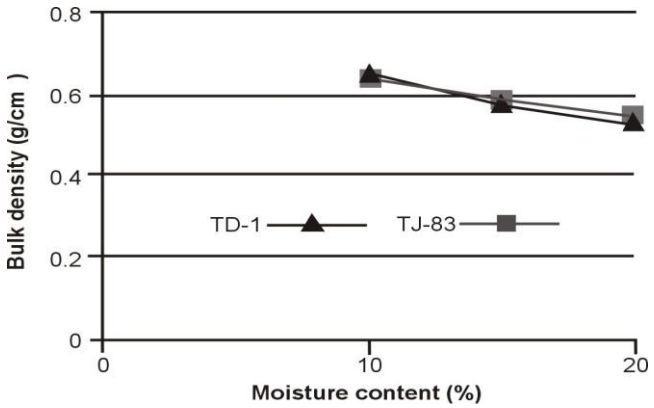


Fig. 7. Bulk density of wheat varieties affected by moisture content

Some scientists (12) have also report that bulk density of wheat seed decreased from 0.72 to 0.66kg/m^3 with increasing moisture. The changes in bulk density have practical applications in heat transfer problems in predicting physical structure and chemical composition.

$$B_{TD-1} = -0.012M + 0.766, \quad R^2 = 0.990 \quad (22)$$
$$B_{TJ-83} = -0.009M + 0.728, \quad R^2 = 0.995 \quad (23)$$

Porosity

Porosity of wheat seed variety TD - 1 increased from 31 to 57 percent with increasing moisture ranging from 10 to 20 percent while porosity of seed in TJ - 83 increased from 36 to 48 percent (Table 2, Fig. 8).

Similar findings have been reported earlier (12, 17) that porosity of seed in varieties shiraz, karoun and shiroudy and Barbunia increased with increase in moisture contents. The linear relationship of these values with respect to moisture contents is represented below. It was observed that volume, size

and shape increased when grain gained more moisture which created more contact with each other, reducing pore space.

$$P_{TD-1} = 2.6M + 4.3, \quad R^2 = 0.991 \quad (24)$$
$$P_{TJ-83} = 1.2M + 24.66, \quad R^2 = 0.964 \quad (25)$$

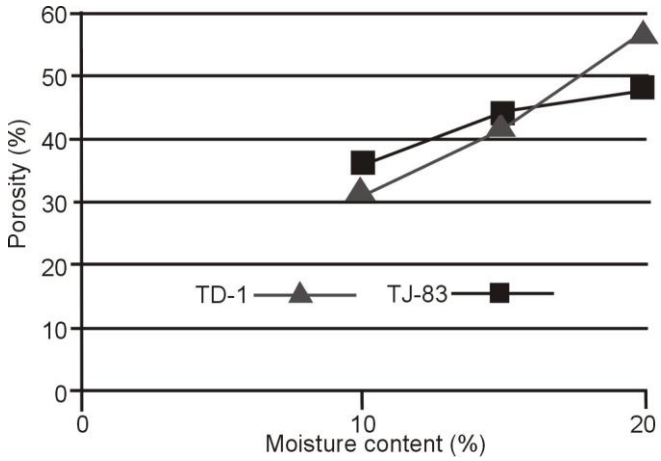


Fig. 8. Porosity of wheat varieties affected by moisture content

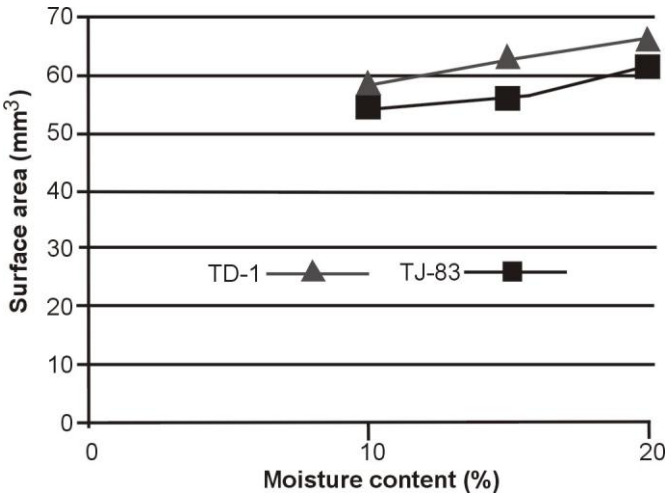


Fig. 9. Surface area of wheat varieties affected by moisture content

$$S_{TD-1} = 0.785M + 50.81, \quad R^2 = 0.998 \quad (26)$$
$$S_{TJ-83} = 0.729M + 46.60, \quad R^2 = 0.899 \quad (27)$$

Surface area

The surface area of variety TD-1 also increased from 58.59mm^2 at 10 percent increased to 66.44mm^2 at 20 percent moisture content. Similar trends of increasing were observed in variety TJ-83 increased from 54.60mm^2 at 10 percent moisture content to 61.89mm^2 at 20 percent moisture content. The same has been reported, that the surface area of seed increased with increase in moisture (6). The linear relationships of these values with respect to moisture contents are represented below. Accurate measurement of surface area is essential in operations as bandling, sorting and heat transfer.

CONCLUSION

The study conclude that moisture content had significant difference at various levels. Increase in moisture content will adversely affect the post-harvest operations such as cleaning, separation, conveying, heat transfer, storage purpose etc. while decrease in moisture will lead to weight loss whereas that can also affect nutritional values of grain. Provided information is necessary while designing equipment's for post-harvest operations related to wheat grain.

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Received: August 11, 2015 Accepted: November 10, 2015

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Abid Ali Abro	**:**	**Analysed the data**
Zaheer Ahmed Khan	**:**	**Analysed the data**
Noor Hussain Walhari		**Prepared writeup**