International Scholars Journals

International Journal of Enology and Viticulture Vol. 6 (8), pp. 001-008, August, 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Moisture-dependent physical properties of black grape (*Vitis vinifera* L.) seed

Ahmet Kiliçkan*, Necmiye Üçer and Ibrahim Yalçin

Department of Agricultural Machinery, Faculty of Agriculture, Adnan Menderes University, Aydin, Turkey.

Accepted 15 July, 2019

The physical properties of black grape seed were evaluated as a function of moisture content. The average length, width and thickness were 5.66, 3.46 and 2.61 mm, respectively, at 8.26% d.b. moisture content. In the moisture range from 8.26 - 26.14% dry basis (d.b.), studies on rewetted black grape seed showed that the thousand seed mass increased from 23.39 - 24.82 g, the projected area was 13.58 - 18.07 mm^2, the sphericity 0.656 - 0.692 and terminal velocity was 7.33 - 7.68 m s^{-1}. The static coefficient of friction of black grape seed increased linearly against surfaces of four structural materials, namely, rubber (0.340 - 0.393), aluminium (0.196 - 0.270), stainless steel (0.247 - 0.337) and galvanised iron (0.322 - 0.397) as the moisture content increased from 8.26 - 26.14% d.b. The bulk density decreased from 626.1 - 613.1 kg m^{-3}, true density from 1104.9 - 1052.6 kg m^{-3} and porosity from 43.34 - 41.76%, respectively, with an increase in moisture content from 8.26 - 26.14% d.b.

Key words: Black grape seed, physical properties, moisture content, terminal velocity.

INTRODUCTION

Grape (*Vitis vinifera* L.) is one of the world's largest fruit crops (Shaker, 2006) . World production of grape was 67 million metric tonnes from 7.3 million hectares in 2007. Turkey has about 484000 ha of grapes harvesting areas and produces 3.6 million metric tonnes per year (FAO, 2007).

Grape pomace is the solid waste product leftover from wine and juice processing and generally consists of pulp, skins, and seeds. Depending on the condition of the grape at harvest and the type of press used, 13.5 - 14.5% of the grapes crushed becomes grape pomace waste with extreme waste production as high as 20%. One product produced from grape pomace waste is the grape seed oil, which has the following nutritional properties:

Cholesterol free, low in saturated fats, contains linoleic acid and high-density lipoprotein, and rich in Vitamin E and antioxidants (Roberts et al., 2008).

Fresh grape seeds are highly perishable, and dehydration is a useful means to increase the shelf- life of seeds for further use. Cold mechanical pressing of dried seeds is an environmentally friendly method to extract oil, where no chemicals are used (Roberts et al., 2008).

To design equipment for aeration and storage, there is a need to know various physical properties as a function of moisture content (Altunta et al., 2005).

Recently, scientists have made great efforts in evaluating basic physical properties of agricultural materials and have pointed out their practical utility in machine and structural design and in control engineering (Amin et al., 2004). Recent scientific developments have improved the handling and processing of bio-materials through mechanical, thermal, electrical, optical and other techniques, but little is known about the basic physical characteristics of bio-materials. Such basic information is important not only to engineers but also to food scientists, processors, plant breeders and other scientists who may find new uses (Mohsenin, 1970).

Several investigators determined the physical properties of seeds at various moisture contents such as

*Corresponding author. E-mail: akilickan@hotmail.com. Tel: +90 256 7727023. Fax: +90 256 7727233.

Abbreviations: A_p, Projected area, mm^2; L, length of seed, mm; m_{1000}, thousand seed mass, g; M_c, moisture content, % d.b. ; M_f, final moisture content of sample, % d.b.; M_i, initial moisture content of sample, % d.b.; P_f, porosity, %; Q, mass of water to added, kg; T, thickness of seed, mm; V_t, terminal velocity, m s^{-1}; W, width of seed, mm; W_i, initial mass of sample, kg; α, angle of tilt, degree; μ, static coefficient of friction; ρ_b, bulk density, kg m^{-3}; ρ_t, true density, kg m^{-3}; ϕ, sphericity of seed; $_{al}$, aluminium; $_{gi}$, galvanised iron; $_{ru}$, rubber; $_{ss}$, stainless steel.

Shepherd and Bhardwaj (1986) for pigeon pea; Amin et al. (2004) for lentil seed; Ogunjimi et al. (2002) for locust bean seed; Konak et al. (2002) for chickpea seeds. However, no published work seems to have been carried out on the physical properties of black grape seed and their relationship with moisture content. The objective of this study was to investigate some moisture-dependent physical properties of black grape seed namely, linear dimensions, thousand seed mass, projected area, sphericity, bulk density, true density, porosity, terminal velocity, and static coefficient of friction against different materials.

MATERIALS AND METHODS

The dry seeds of black grape cultivar, local variety were used for all the experiments in this study. The seeds were cleaned manually to remove all foreign matter such as dust, dirt, stones and chaff as well as immature, broken seeds. The initial moisture content of the seeds was determined by oven drying at 105 ± 1°C for 24 h (Gupta and Das, 1997; Özarslan, 2002). The initial moisture content of the seeds was 8.26% dry basis (d.b.).

The samples of the desired moisture contents were prepared by adding the amount of distilled water as calculated from the following relation (Yalçin, 2007; Kiliçkan et al., 2010):

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

The samples were then poured in to separate polyethylene bags and the bags sealed tightly. The samples were kept at 5°C in a refrigerator for a week to enable the moisture to distribute uniformly throughout the sample. Before starting a test, the required quantity of the seed was taken out of the refrigerator and allowed to warm up to the room temperature for about 2 h (Yalçin and Özarslan, 2004; Baümler et al., 2006).

All the physical properties of the seeds were assessed at moisture levels of 8.26, 12.30, 19.98 and 26.14% d.b. with ten replications at each moisture content.

To determine the average size of the seed, 100 seeds were randomly picked and their three linear dimensions namely, length L, width W and thickness T were measured using a micrometer reading to 0.01 mm (Özarslan, 2002).

The sphericity of seeds ϕ was calculated by using the following relationship (Mohsenin, 1970):

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

The one thousand seed mass was determined by means of an electronic balance reading to 0.001 g (Baryeh, 2002).

The projected area of a seed was measured by a scanner connected to a computer. For this purpose, a special computer program was used (Özarslan, 2002; Yalçin and Özarslan, 2004). The average bulk density of the black grape seed was determined using the standard test weight procedure (Singh and Goswami, 1996) by filling a container of 500 ml with the seed from a height of 150 mm at a constant rate and then weighing the content. No separate manual compaction of seeds was done. The bulk density was calculated from the mass of the seeds and the volume of the container (Yalçin, 2007; Kiliçkan et al., 2010).

The true density defined as the ratio between the mass of black grape seed and true volume of seed was determined using the toluene displacement method. Toluene was used in place of water because it is absorbed by seeds to a lesser extend. The volume of toluene displaced was found by immersing a weighed quantity of black grape seed in the toluene (Singh and Goswami, 1996).

The porosity of black grape seed at various moisture contents was calculated from bulk and true densities using the relationship given by Mohsenin (1970) as follows:

$$P_f = (1 - \rho_b / \rho_t) \times 100 \quad (3)$$

Where: P_f *is* the porosity in percentage, ρ_b is the bulk density in kg m^{-3} and ρ_t is the true density in kg m^{-3}

The terminal velocities of seeds at different moisture contents were measured using a cylindrical air column (Joshi et al., 1993; Baryeh, 2002; Yalçin, 2007). For each experiment, a sample was dropped into the air stream from the top of the air column, through which air was blown to suspend the material in the air stream. The air velocity near the location of the seed suspension was measured by the hot wire anemometer having a least count of 0.01 m s^{-1}.

The static coefficient of friction of black grape seed against four different structural materials namely; rubber, aluminium, stainless steel and galvanised iron were determined. These are common material used for handling and processing of grains and construction of storage and drying bins. A polyvinylchloride cylindrical pipe of 50 mm diameter and 50 mm height was placed on an adjustable tilting plate, faced with the test surface and filled with the seed sample. The cylinder was raised slightly so as not to touch the surface. The structural surface with the cylinder resting on it was raised gradually with a screw device until the cylinder started sliding down and the angle of tilt α was read from a graduated scale. Other researchers have used this method for other grains and seeds (Singh and Goswami, 1996; Dutta et al., 1988; Baryeh, 2002). The coefficient of friction was calculated from the following relationship:

$$\mu = \tan \alpha \quad (4)$$

Where: μ is the coefficient of friction and α is the angle of tilt in degrees.

RESULTS AND DISCUSSION

Seed dimensions and size distribution

The mean dimensions of 100 seeds measured at 8.26% d.b. moisture content are: length 5.66 ± 0.35 mm, width 3.55 ± 0.34 mm, and thickness 2.61 ± 0.18 mm. About 82% of the seeds have a length ranging from 5.0 - 6.0 mm; about 90% of the seed are having a width ranging from 3.0 to 4.0 mm; and about 88% have a thickness ranging from 2.20 - 2.80 mm at 8.26% d.b. moisture content.

One thousand seed mass

The one thousand seed mass m_{1000} increased linearly from 23.39 - 24.82 g as the moisture content increased from 8.26 - 26.14% d.b. (Figure 1). An increase of 6.11% in the one thousand seed mass was recorded within the

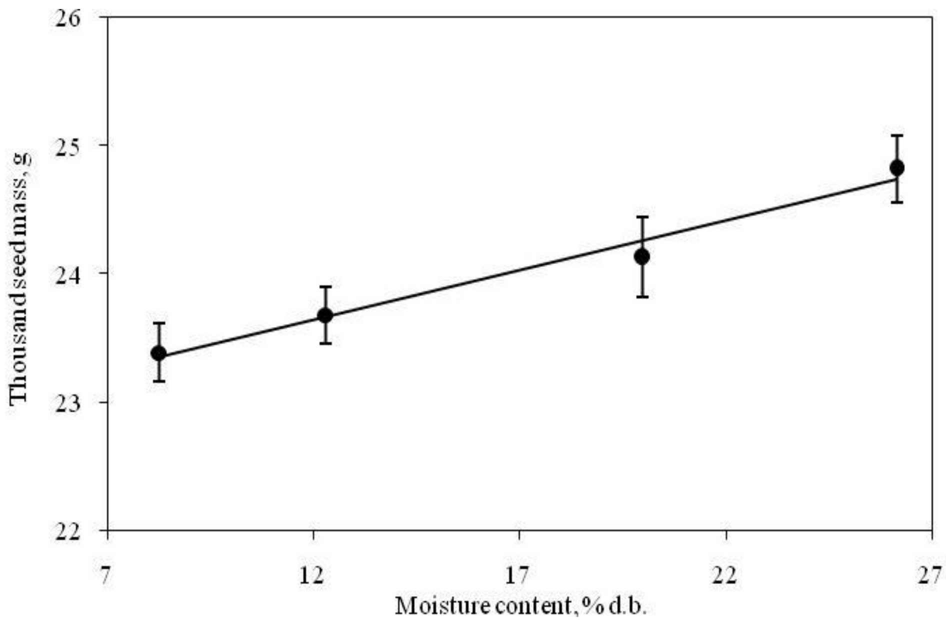

Figure 1. Effect of moisture content on thousand seed mass.

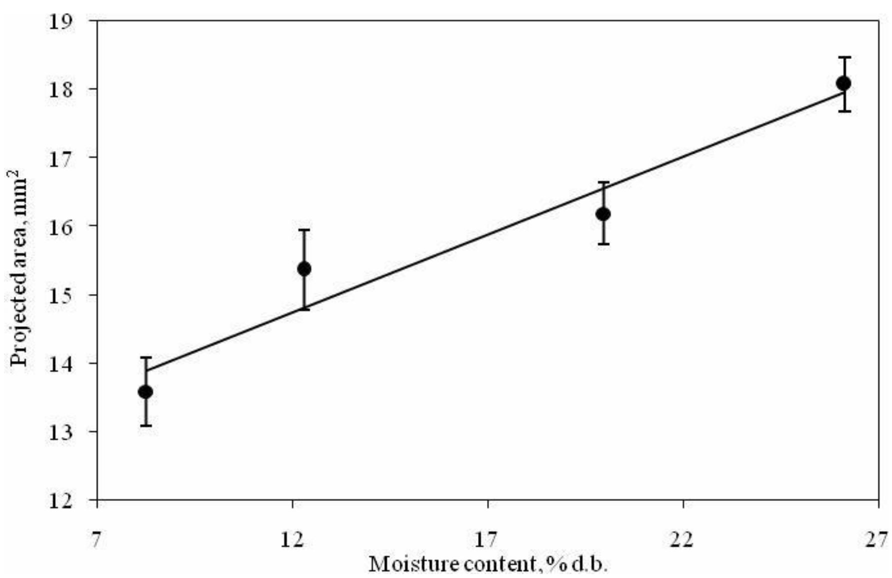

Figure 2. Effect of moisture content on projected area.

above (8.26 - 26.14% d.b) moisture range. The linear equation for one thousand seed mass can be formulated to be:

$$m_{1000} = 22.716 + 0.0773 M_c \quad (R^2 = 0.9782) \quad (5)$$

A linear increase in the one thousand black grape seed mass as the seed moisture content increases has been noted by Singh and Goswami (1996) for cumin and Ixtaina et al. (2008) for chia.

Projected area of seed

The projected area of black grape seed (Figure 2) increased from 13.58 - 18.07 mm^2, while the moisture content of seed increased from 8.26 - 26.14% d.b. The variation in projected area A_p in mm^2 with moisture content of black grape seed can be represented by the following equation:

$$A_p = 12.002 + 0.2277 M_c \quad (R^2 = 0.9468) \quad (6)$$

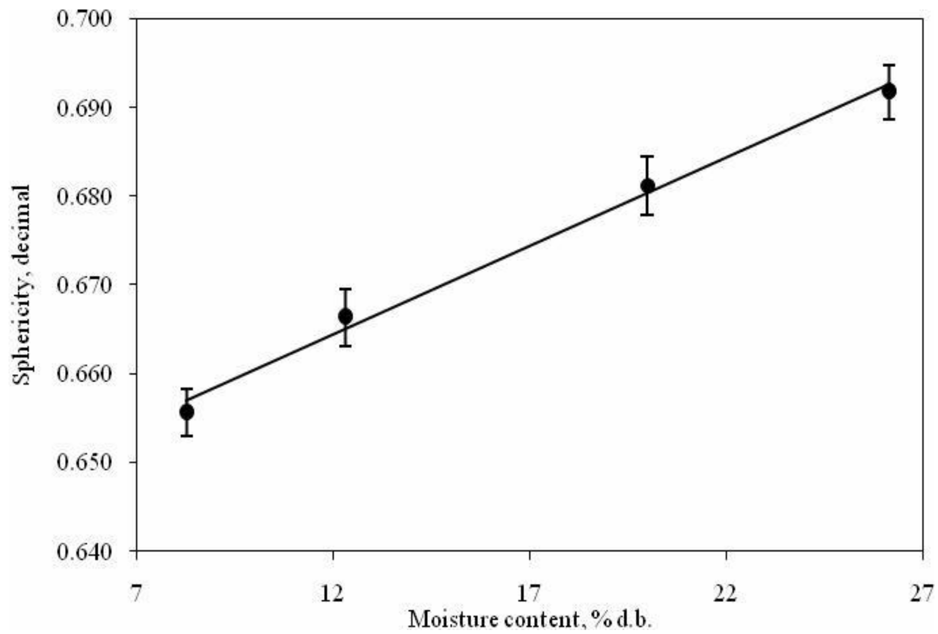

Figure 3. Effect of moisture content on sphericity.

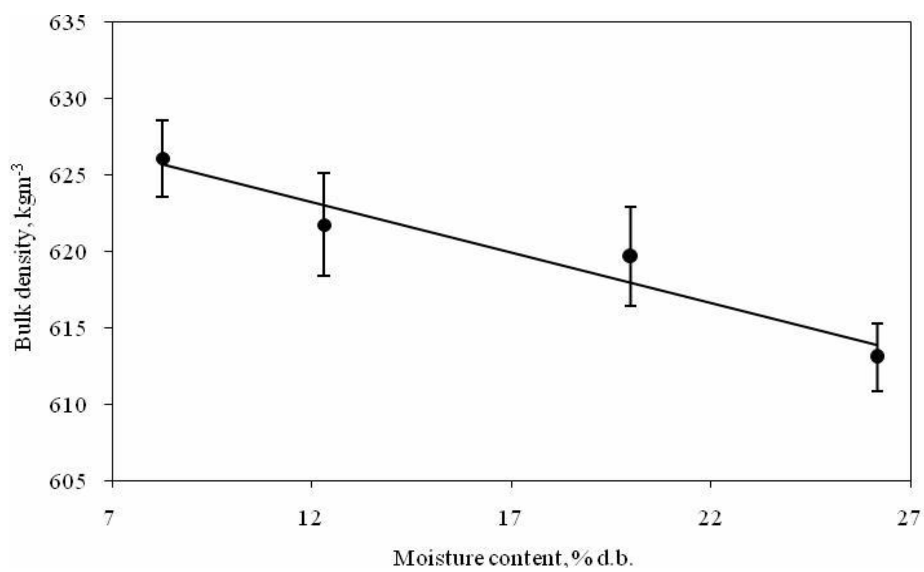

Figure 4. Effect of moisture content on bulk density.

Similar trends have been reported by Abalone et al. (2004) for amaranth, I ik (2008) for sira bean grains and Tang and Sokhansanj (1993) for lentil.

Sphericity

The sphericity of black grape seed increased from 0.656 - 0.692 with the increase in moisture content (Figure 3). The relationship between sphericity and moisture content M_C in % d.b. can be represented by the following equation:

$$\phi = 0.6405 + 0.002 M_c \quad (R^2 = 0.9933) \tag{7}$$

Similar trends have been reported by Altunta et al. (2005) for fenugreek seed, Baümler et al. (2006) for safflower and Solomon and Zewdu (2009) for Niger seed.

Bulk density

The values of the bulk density for different moisture levels varied from 626.1 - 613.1 kg m^{-3} (Figure 4). The bulk density of seed was found to bear the following

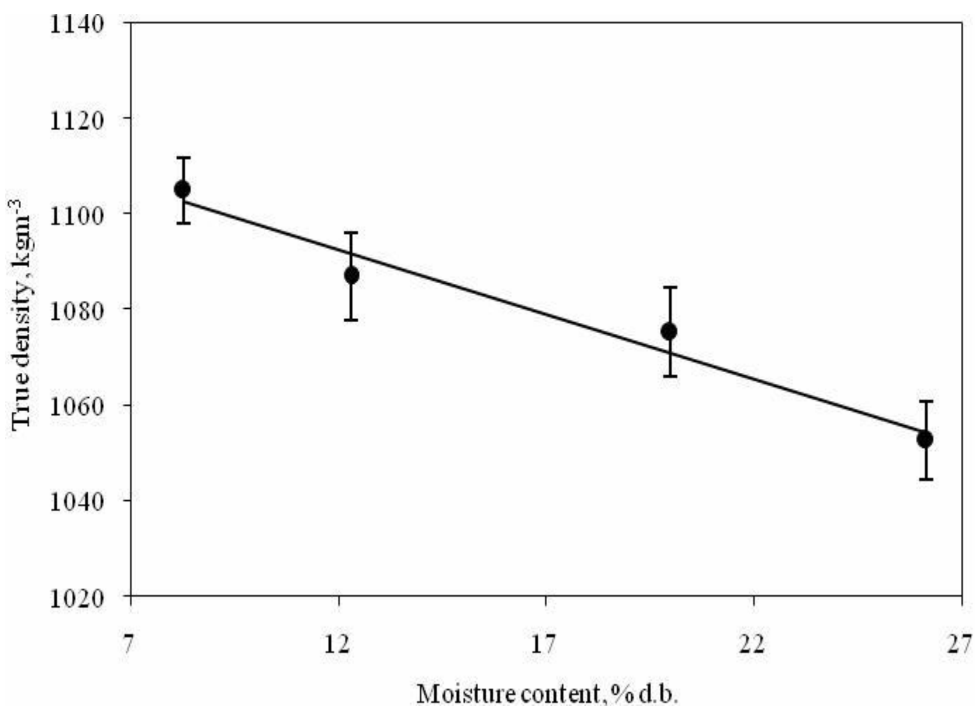

Figure 5. Effect of moisture content on true density.

relationship with moisture content:

$$\rho_b = 631.14 - 0.6599 M_c \quad (R^2 = 0.94) \quad (8)$$

A similar decreasing trend in bulk density has been reported by Dursun and Dursun (2005) for caper, Abalone et al. (2004) for amaranth, Kiani et al. (2008) for red bean seed.

True density

The true density varied from 1104.9 - 1052.6 kg m^{-3} when the moisture level increased from 8.26 - 26.14% d.b. (Figure 5). The true density and the moisture content of seed can be correlated as follows:

$$\rho_t = 1125 - 2.7053 M_c \quad (R^2 = 0.9657) \quad (9)$$

The results were similar to those reported by Abalone et al. (2004) for amaranth, Shepherd and Bhardwaj (1986) for pigeon pea and Nimkar et al. (2006) for horse gram.

Porosity

The porosity of black grape seed decreased from 43.34 - 41.76% with the increase in moisture content from 8.26 - 26.14% d.b. (Figure 6). The relationship between porosity and moisture content can be represented by the following equation:

$$P_f = 43.952 + 0.083 M_c \quad (R^2 = 0.9784) \quad (10)$$

Singh and Goswami (1996), Gupta and Das (1997) and Yalçin and Özarslan (2004) reported similar trends in the case of cumin, sunflower and vetch, respectively. Since the porosity depends on the bulk and true densities, the magnitude of variation in porosity depends on these densities only.

Terminal velocity

The experimental results for the terminal velocity of black grape seed at various moisture levels are shown in Figure 7. The terminal velocity was found to increase linearly from 7.33 - 7.68 m s^{-1} as the moisture content increased from 8.26 - 26.14% d.b. The relationship between terminal velocity and moisture content can be represented by the following equation:

$$V_t = 7.2063 + 0.0485 M_c \quad (R^2 = 0.9737) \quad (11)$$

Similar results were reported by Suthar and Das (1996), Singh and Goswami (1996), Yalçin et al. (2009), Nimkar et al. (2005) and Ramakrishna (1986) in the case of karingda, cumin, onion, moth gram and melon seeds, respectively.

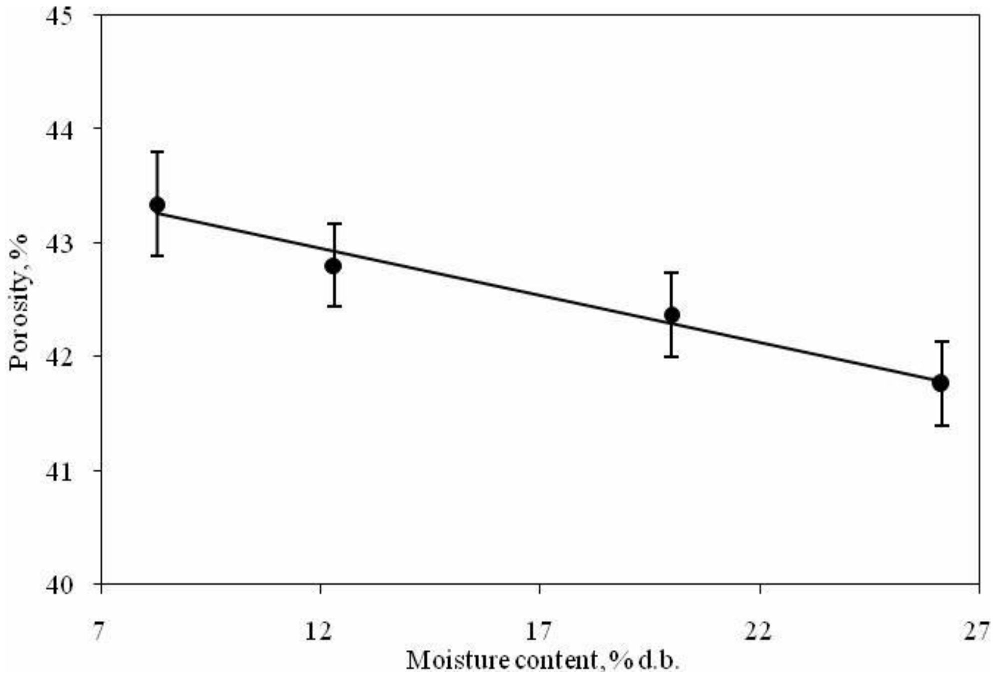

Figure 6. Effect of moisture content on porosity.

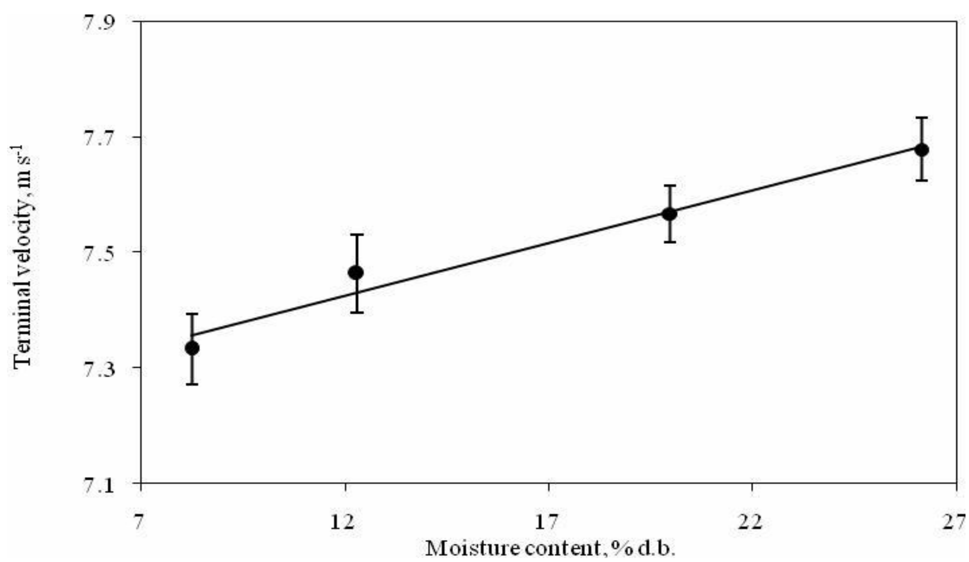

Figure 7. Effect of moisture content on terminal velocity.

Static coefficient of friction

The static coefficient of friction of black grape seed on four surfaces (rubber, aluminium, stainless steel and galvanised iron) against moisture content in the range 8.26 - 26.14% d.b. are presented in Figure 8. It was observed that the static coefficient of friction increased with increase in moisture content for all the surfaces. This is due to the increased adhesion between the seed and the material surfaces at higher moisture values. Increases of 15.59, 37.76, 36.44 and 23.29% were recorded in the case of rubber, aluminium, stainless steel and galvanised iron, respectively as the moisture content increased from 8.26 - 26.14% d.b. As the moisture content of the seed increased, the static coefficients increased significantly. This is due to the increased adhesion between the

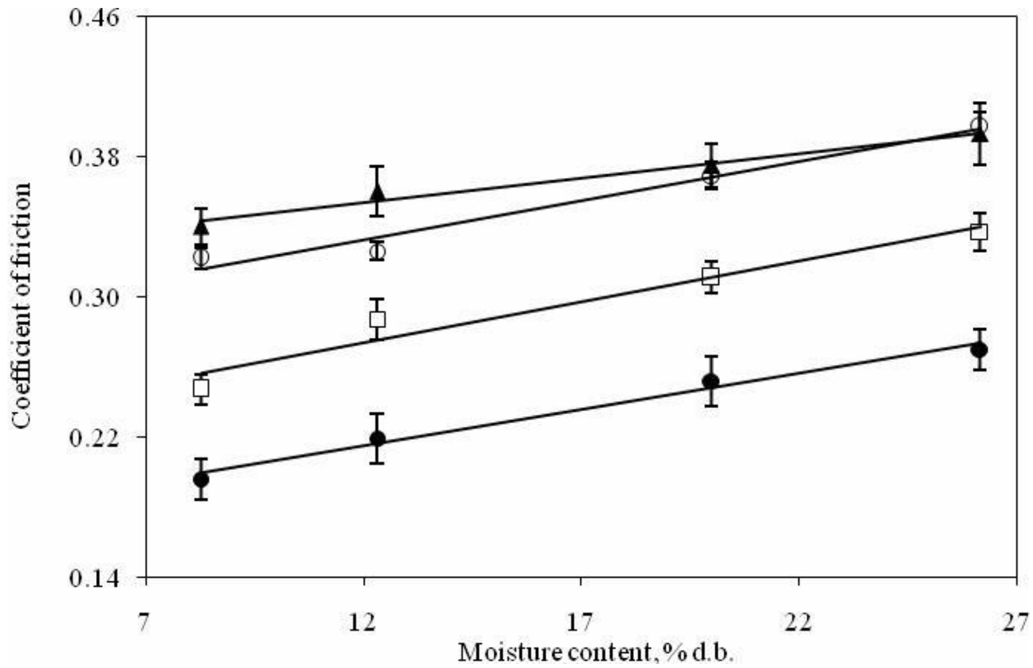

Figure 8. Effect of moisture content on static coefficient of friction; , rubber; , aluminium; , galvanized iron; , stainless steel.

product and the surface at higher moisture values. The relationships between static coefficients of friction and moisture content on rubber μ_{ru}, aluminium μ_{al}, stainless steel μ_{ss} and galvanised iron μ_{gi}, can be represented by the following equations:

$$\mu_{ru} = 0.3206 + 0.0028M_c \quad (R^2 \text{ of } 0.9729) \qquad (12)$$

$$\mu_{al} = 0.1655 + 0.0041M_c \quad (R^2 \text{ of } 0.9854) \qquad (13)$$

$$\mu_{ss} = 0.2177 + 0.0047M_c \quad (R^2 \text{ of } 0.9466) \qquad (14)$$

$$\mu_{gi} = 0.2792 + 0.0045M_c \quad (R^2 \text{ of } 0.9736) \qquad (15)$$

Similar results were found by Sahoo and Srivastava (2002), Singh and Goswami (1996), Çarman (1996), Gurhan et al. (2009) and Garnayak et al. (2008) for okra, cumin, lentil, black kabuli chickpea and jatropha seeds, respectively.

Conclusions

(1) The thousand seed mass increased from 23.39 - 24.82 g and the sphericity increased from 0.656 - 0.692 with the increase in moisture content from 8.26 - 26.14% d.b.

(2) The projected area increased from 13.58 - 18.07 mm^2. The bulk density decreased linearly from 626.1 - 613.1 kg m^{-3}, the true density decreased from 1104.9 - 1052.6 kg m^{-3} and the porosity decreased from 43.34 - 41.76%.

(3) The terminal velocity increased from 7.33 - 7.68 m s^{-1}. The static coefficient of friction increased for all four surfaces, namely, rubber (0.340 - 0.393), aluminium (0.196 - 0.270), stainless steel (0.247 - 0.337) and galvanised iron (0.322 - 0.397).

REFERENCES

Abalone R, Cassinera A, Gaston A, Lara MA (2004). Some physical properties of amaranth seeds. Biosyst. Eng., 89(1): 109-117.

Altunta E, Özgöz E, Ta er ÖF (2005). Some physical properties of fenugreek (*Trigonella foenum-graceum* L.). J. Food Eng., 71: 37-43.

Amin MN, Hossain MA, Roy KC (2004). Effects of moisture content on some physical properties of lentil seeds. J. Food Eng., 65(1): 83-87.

Baümler E, Cuniberti A, Nolasco SM, Riccobene IC (2006). Moisture dependent physical and compression properties of safflower seed. J. Food Eng., 73: 134-140.

Baryeh EA (2002). Physical properties of millet. J. Food Eng. 51: 39-46.

Çarman K (1996). Some physical properties of lentil seeds. J. Agric. Eng. Res., 63(2): 87-92.

Dutta SK, Nema VK, Bhardwaj RK (1988). Physical properties of gram. J. Agric. Eng. Res., 39: 259-268.

Dursun E, Dursun I (2005). Some physical properties of caper seed. Biosyst. Eng., 92(2): 237-245.

FAO, 2007. http://faostat.fao.org/sita/567/desktopDefault.aspx?PageID=567#ancor.

Garnayak DK, Pradhan RC, Naik SN, Bhatnagar N (2008). Moisture-dependent physical properties of jatropha seed (*Jatropha curcas* L.). Industrial Crops Products. 27(1): 123-129.

Gupta RK, Das SK (1997). Physical properties of sunflower seeds. J. Agric. Eng. Res., 66: 1-8.
Gürhan R, Ozarslan C, Topuz N, Akba T, Simsek E (2009). Effects of moisture content on physical properties of black kabuli chickpea (*Cicer arietinum* L.) seed. Asian J. Chem., 21(4): 3270-3278.
I ik E (2008). Effect of moisture content on some physical and mechanical properties of sira bean grains. Trans. ASABE., 51(2): 573-579.
Ixtaina V, Nolasco SM, Tomas MC (2008). Physical properties of chia (Salvia hispanica L.) seeds. Industrial Crops Prod., 28*:* 286-293.
Joshi DC, Das SK, Mukherjee RK (1993). Physical properties of pumpkin seeds. J. Agric. Eng. Res., 54(3): 219-229.
Kiliçkan A, Üçer N, Yalçın (2010) Some physical properties of spinach seed. Afr. J. Biotechnol., 9(5): 648-655.
Kiani MKD, Minaei S, Maghsoudi H, Varnamkhasti MG (2008). Moisture dependent physical properties of red bean (*Phaseolus vulgaris* L.*)* grains. Int. Agrophys., 22(3): 231-237.
Konak M, Çarman K, Aydın C (2002). Physical properties of chick pea seeds. Biosyst. Eng., 82(1): 73-78.
Mohsenin NN (1970). Physical properties of plant and animal materials. Gordon and Breach Science Publishers. New York.
Nimkar PM, Mandwe DS, Dudhe RM (2005). Physical properties of moth gram. Biosyst. Eng., 91(2): 183-189.
Nimkar PM, Gurjar RL, Kaul NT, Namrata CW (2006). Physical properties of horse gram (Dolichos biflorus). J. Food Sci. Technol., 43(2): 133-136.
Ogunjimi LAO, Aviara NA, Aregbesola OA (2002). Some engineering properties of locust bean seed. J. Food Eng., 55(2): 95-99.
Özarslan C (2002). Physical properties of cotton seed. Biosyst. Eng., 83(2): 169-174.
Ramakrishna P (1986). Melon seeds-evaluation of the physical characteristics. J. Food Sci. Technol. 23: 158-160.
Roberts JS, Kidd DR, Zakour OP (2008). Drying kinetics of grape seeds. J. Food Eng., 89: 460–465.
Sahoo PK, Srivastava AP (2002). Physical properties of okra seed. Biosyst. Eng., 83(4): 441-448.
Shaker ES (2006). Antioxidative effect of extracts from red grape seed and peel on lipid oxidation in oils of sunflower. J. Food Sci. Technol., 39(8): 883-892.
Singh KK, Goswami TK (1996). Physical properties of cumin seed. J. Agric. Eng. Res., 64(2): 93-98.
Shepherd H, Bhardwaj RK (1986). Moisture dependent physical properties of pigeon pea. J. Agric. Eng. Res., 35: 227-234.
Suthar SH, Das SK (1996). Some physical properties of karingda [*citrullus lanatus* (thumb) mansf] seeds. J. Agric. Eng. Res., 65(1): 15-22.
Solomon WK, Zewdu AD (2009). Moisture-dependent physical properties of niger (*Guizotia abyssinica Cass.*) seed. Industrial Crops Prod., 29: 165-170.
Tang J, Sokhansanj S (1993). Geometric changes in lentil seeds caused by drying. J. Agric. Eng. Res., 56(4): 313-326.
Yalçın , Özarslan C (2004). Physical properties of vetch seed. Biosyst. Eng*.,* 88(4): 507-512.
Yalçin (2007). Physical properties of cowpea (*Vigna sinensis* L.) seed. J. Food Eng., 79: 57-62.
Yalçin , Çetin M, Özarslan C (2009). Physical properties of onion (*Allium cepa* L.) seed. Asian J. Chem., 21(2): 1341-1349.