The European Journal of Plant Science and Biotechnology ©2013 Global Science Books

Moisture Dependence of Some Physical and Morphological Properties of Chard (*Beta vulgaris* L. var. *cicla*) Seeds

Mehtap Ozbakir[1*] • Onur Karaagac[2] • Ahmet Balkaya[1]

[1] Ondokuz Mayıs University, Faculty of Agriculture, Department of Horticulture, 55139, Samsun, Turkey
[2] Black Sea Agricultural Research Institute, Samsun, Turkey

***Corresponding author*: * mehtap_ozbakir@hotmail.com**

ABSTRACT

Various physical properties of chard (*Beta vulgaris* L. var. *cicla*) seed were determined as a function of moisture content. The lengths of the major, medium and minor axes varied from 5.50 to 4.71, 4.88 to 4.03 and 4.28 to 3.53 mm, respectively, as the moisture content increased from 14.1 to 22.2% (dry basis). In the same moisture range, the arithmetic and geometric mean diameters increased from 4.09 to 4.89 and 4.06 to 4.86 mm, respectively. Studies on rewetted chard showed that the sphericity decreased from 1.152 to 1.135, whereas and projected area increased from 63.23 to 88.17 mm^2, respectively, with increase in moisture content from 14.1 to 22.2% (dry basis). The bulk density and true density decreased from 277.78 to 242.72 kg/m^3 and 740.74 to 689.66 kg/m^3, whereas angle of repose increased from 23.96 to 26.57°, respectively. The static coefficients for friction of chard seeds were determined steel, plywood, wood, glass and galvanized sheet at various moisture contents. The static coefficient of friction increased on five structural surfaces namely, steel (0.300-0.422), galvanized sheet (0.393-0.530), plywood (0.499-0.712), wood (0.576-0.859) and glass (0.200-0.285) in the moisture range from 14.1 to 22.2% (dry basis).

Keywords: chard, physical properties, moisture content, seed dimensions

Abbreviations: **a**, major axis, mm; **A**, **B**, regression coefficients; **b**, minor axis, mm; **B**, diameter of the spherical part of the seed; **c**, medium axis, mm; **D_a**, aritmethic mean diameter, mm; **Dg**, geometric mean diameter, mm; **M_f**, final moisture content of sample, % d.b.; **M_i**, initial moisture content of sample, % d.b.; **Q**, mass of water to added, **R^2**, coefficient of determination; **S**, surface area, mm^2; **V**, seed volume, mm^3; **W_i**, initial mass of sample, kg; **θ**, angle of repose, deg; **μ**, static coefficient of friction; **pb**, bulk density, kg m^{-3}; **pt**, true density, kg m^{-3}; **Φ**, sphericity, %
Subscripts: **M_{gl}**, glass; **M_{gs}**, galvanized sheet; **M_{pl}**, plywood; **M_{st}**; steel; **M_{wo}**, wood

INTRODUCTION

Chard is a member of the *Chenopodiceae* family that can be successfully grown as a green vegetable. It is a biennial vegetable species. This crop which is a subspecies of *Beta vulgaris* has developed and selected for its broad leaves and wide petioles. Chard is also known by the names silver beet, perpetual spinach, spinach beet, crab beet, and seakale beet (Traunfeld 2010).

Chard is grown commercially in Europe (especially France, Italy and Poland) and North America. It is also a popular garden vegetable in the areas, the Mediterranean and Asia (George 1985; Kołota and Czerniak 2010). Presently, chard production in Turkey is about 5.211 tons (TUIK 2010). Chard is a common vegetable grown for fresh consumption in Turkey.

Chard is a good source of vitamins A and C (Şalk *et al.* 2008). The leaf blades are prepared like spinach, and the midribs may be cooked in the same way as asparagus (Gillet *et al.* 1998; Pokluda and Kuben 2002). Chard is also an attractive ornamental that adds to the beauty of a garden. The mean content of mineral substances in 100 grams fresh stalks 379 mg of potassium, 213 mg of potassium calcium, 81 mg of magnesium, 46 mg of phosphorus ascorbic acid is very important among the vitamins in chard (30 mg/100 g of fresh mass (f.m.) in leaves) (Anonymous 2011).

Physical properties of chard seeds are essential for the design of equipment and facilities for the harvesting, handling, conveying, separation, drying, aeration, storing and processing of spinach seeds. Various types of cleaning grading and separation equipment are designed on the basis of their physical properties as a function of moisture content (Sezer *et al.* 2011; Karaağaç *et al.* 2011). It seems that there is not much published work relating to moisture dependent physical properties of chard seed.

To design equipment for aeration and storage, there is a need to know various physical properties as a function of moisture content. To optimize the equipment design for sowing, storing, and other processes of chard seed, its physical properties must be known. Bulk density affects the structural loads. The angle of repose is important in the designing of storage and transporting structures. The coefficient of friction of the seed against various surfaces is also necessary in designing the conveying, transporting, and storing structures (Kasap and Altundaş 2006).

The physical properties have been studied for various crops, such as sugar beet seeds by Kasap and Altundaş (2006) and Dursun *et al.* (2007), spinach seeds by Kılıçkan *et al.* (2010) in recent years. However, no published work has been carried out on the physical properties of chard seed and their relationship with moisture content.

It is necessary to determine its physical properties as a function of moisture content. The objective of the study was to research the effect of moisture content on physical properties of chard seed namely, size, sphericity, volume, surface area, bulk density, true density, angle of repose, and static coefficient of friction in the moisture range from 14.1 to 22.2% (these moisture ranges were preferred for big and large seeds).

Received: 13 October, 2011. Accepted: 20 April, 2012.

Original Research Paper

MATERIALS AND METHODS

This study was conducted at the Faculty of Agriculture of Ondokuz Mayis University in Samsun province, Turkey. The dry seeds of chard cultivar 'Arzumhan' were used for all the experiments in this study. The seeds used were obtained from the production year of 2009 and purchased from the seed producers. The samples were manually cleaned to remove all foreign matter such as dust, dirt, stores and chaff as well as immature and broken seeds. The initial moisture content of the samples was determined by oven drying at 105 ± 1°C for 24 h (Suthar and Das 1996; Karaağaç *et al.* 2011). Samples of the desired moisture levels were prepared by adding calculated amounts of distilled water, thorough mixing and then sealing in separate polyethylene bags. The samples were kept at 5°C in a refrigerator for a week to obtain uniform moisture distribution throughout the samples. Before each test, the required quantities of the samples were taken out of the refrigerator, and allowed to warm up at room temperature for analysis (Singh and Goswami 1996; Kasap and Altundaş 2006; Dursun *et al.* 2007).

The samples of the desired moisture contents were prepared by adding the amount of distilled water as calculated from the following relation (Altuntaş and Yıldız 2007; Sezer *et al.* 2011):

$$Q = \frac{Wi\,(Mf - Mi)}{(100 - Mf)} \quad (1)$$

where Q is the mass of water added in kg, W_i is the initial mass of a sample in kg, M_i is the initial moisture content of a sample in % wet basis, and M_f is final moisture content of the samples in % wet basis.

The physical properties of the seeds were investigated at three moisture levels of 14.1, 18.03 and 22.2% d.b. (**Table 1**). These values are with in the range of moisture contents encountered for chard seed from harvest to storage.

To determine the average seed size, a sample of 100 seeds was randomly picked and the three principal dimensions namely, major, medium and minor axes were measured using a micrometer with an accuracy of 0.01 mm (Dursun *et al.* 2007). The average diameter of seed was calculated by using the arithmetic mean and geometric mean of the three axial dimensions. The arithmetic mean diameter *Da* and geometric mean diameter *Dg* of the seed were calculated by using the following relationships (Mohsenin 1970)

$$D\alpha = \frac{a + b + c}{3} \quad (2)$$

$$Dg = (abc)^{1/3} \quad (3)$$

where a is the major axis, b is the minor, and c is the medium axis in mm.

Jain and Bal (1997) have stated seed volume given by:

$$V = \frac{\pi B^2 a^2}{6(2a - B)} \quad (4)$$

where

$$B = (bc)^{0.5} \quad (5)$$

The sphericity value (Φ_m) of seeds was calculated using the following formula (Mohsenin 1970):

$$\Phi = \frac{abc^{1/3}}{a} 100 \quad (6)$$

The one thousand seed mass was determined by means of digital electronic balance (Kern and Sahn Gmbh D-72336 Model) at an accuracy of 0.001 g (Sezer *et al.* 2011). The weights of 10 samples representing each of moisture content and containing 100 randomly selected seeds were averaged to evaluate 1000-seed mass (Öğüt 1998).

Jain and Bal (1997) stated that surface area, (*S*) may be given by:

$$S = \frac{\pi B a^2}{2a - B} \quad (7)$$

The bulk density of chard seed was determined using standard test weight procedure (Singh and Goswami 1996), by filling a 500 ml container with the seeds from a height of 150 mm at a constant rate, and then weighing the content (Karaağaç *et al.* 2011). 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.

The true density, as a function of moisture content, was determined using the toluene displacement method. Toluene (C_7H_8) was used in place of water because it is absorbed by seeds to a lesser extent. The volume of toluene displaced was found by immersing a weighed quantity of chard seed in the toluene (Dursun *et al.* 2007). The experiments were replicated five times

The filling angle of repose is the angle with the horizontal at which the material will stand when piled. This was determined by using a topless and bottomless cylinder of 150 mm diameter and 250 mm height (Razavi and Milani 2006). The cylinder was placed on a wooden table, filled with chard seeds and raised slowly until it forms a cone of a circular plate. The angle of repose was calculated from the measurement of the height (H) and diameter of the cone (D).

$$\theta = \text{Arctan}\,(2H/D) \quad (8)$$

The static coefficients of friction of chard seeds against five different structural materials, namely steel, plywood, wood, glass and galvanized sheet. A polyvinylchloride cylindrical pipe of 50 mm in a diameter and 50 mm in height was placed on an adjustable tilting plate, faced with the test surface and filled with the seed sample. The structural surface with the cylinder resting on it was raised gradually with a screw device until the cylinder just started to slide down and the angle of tilt was read from graduated scale (Singh and Goswami 1996; Suthar and Das 1996). The coefficient of friction was calculated from the following relationship (Coşkun *et al.* 2006):

$$\mu = \tan\alpha \quad (9)$$

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

Data analysis

All measurements were obtained in 10 replicates at the three moisture contents selected. In order to determine physical dimensions, 100 seeds were randomly selected and analyzed at each moisture level. The effect of moisture level on the different physical properties of chard seed was determined using the regression equations and coefficients (R^2). Statistical analysis was conducted with Microsoft Excel and 'SAS-JMP' 5.01 software programs. Each one of the variables analyzed regression curves of linear type was obtained.

$$Y = \beta_1 x + \beta_0 \quad (10).$$

RESULTS AND DISCUSSION

Seed dimensions

The three axial dimensions increased with moisture content. The major axis, medium axis and minor axis of seeds ranged from 4.71 to 5.50, 4.03 to 4.88, and 3.53 to 4.28 mm, respectively as the moisture content increased from 14.1 to 22.2% d.b. (**Table 1**).

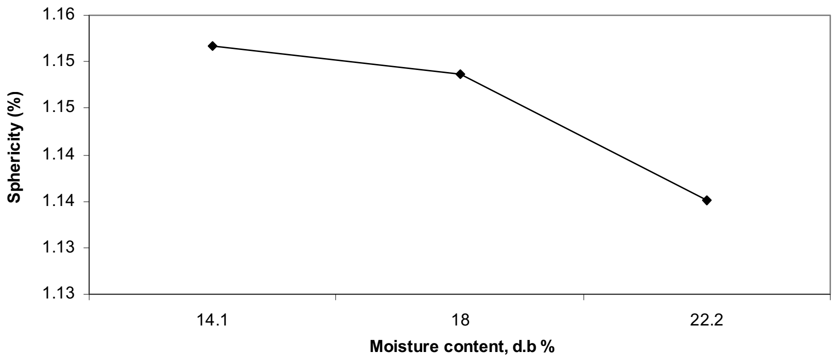
The average diameters increased with moisture content. In the same moisture range, the arithmetic and geometric mean diameters increased from 4.09 to 4.89 mm and 4.06 to 4.86 mm as the moisture content increased from 14.1 to 22.2% d.b., respectively (**Table 1**).

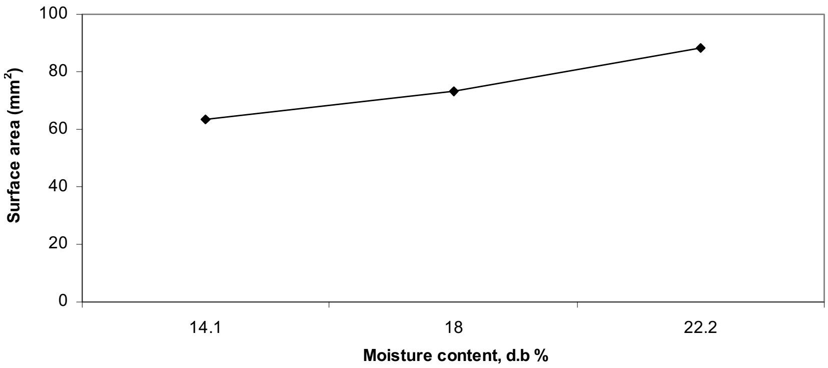
All the dimensions were significantly and positively correlated to seed moisture content. This result indicates that the chard seeds expand in major, medium and minor axis within the moisture contents 14.1-22.2%, respectively.

Similar results have been reported by some researchers (Dursun *et al.* 2007; Kılıçkan *et al.* 2010). Dursun *et al.* (2007) found that the the major axis, medium axis and minor axis of seeds ranged from 4.61 to 5.30, 3.82 to 4.36,

Table 1 Mean and standard error values for the axial dimensions of chard seeds.

Moisture contents (%)	Major axis (a)	Medium axis (b)	Minor axis (c)	Arithmetic mean diameter (mm)	Geometric mean diameter (mm)
14.1	4.71 ± 0.09	4.03 ± 0.04	3.53 ± 0.06	4.09 ± 0.06	4.06 ± 0.04
18.0	5.05 ± 0.05	4.37 ± 0.04	3.82 ± 0.05	4.41 ± 0.05	4.38 ± 0.05
22.2	5.50 ± 0.03	4.88 ± 0.07	4.28 ± 0.09	4.89 ± 0.06	4.86 ± 0.03





and 2.20 to 2.38 mm, respectively as the moisture content increased from 8.4 to 14.0% d.b. In other research, Kılıçkan *et al.* (2010) reported seed length to range from 3.5 to 4.5 mm, seed width to range from 3.2 to 3.8 mm and seed thickness to range from 2.2 to 2.8 mm at 12.01% d.b. moisture content.

Sphericity

Sphericity changes with the increase in moisture content. The relation between sphericity and moisture content of chards are shown in **Fig. 1**. The sphericity of the chard seed decreased linearly from 1.15 to 1.14 with the increase in moisture content (**Fig. 1**).

The relationship between sphericity and moisture content can be represented by the following regression equation:

$$\Phi = 1.1054 - 0.0080 \, Mc \; (R^2 = 0.952)$$

Similar trends have been reported by Dursun *et al.* (2007) for sugar beet seed. Dursun *et al.* (2007) have reported sugarbeet seed decreased linearly from 0.734 to 0.717 with the increase in moisture content.

Surface area

The chard seeds surface areas (S), are shown in **Fig. 2**. The surface area of chard seed 63.23 to 88.17 mm^2, while the moisture content of seed increased from 14.1 to 22.20% d.b.

The variation in surface area with the moisture content of sugarbeet seed can be represented by the following equation:

$$S = 33.8789 + 17.8809 \, Mc \; (R^2 = 0.925)$$

Similar trends have been reported by Kılıçkan *et al.* (2010), Dursun *et al.* (2007) for spinach, sugar beet seed. Kılıçkan *et al.* (2010) found that the projected area of spinach seed increased from 6.28 to 7.81 mm^2, while the moisture content of seed increased from 11.93 to 21.52% d.b. Otherwise, Dursun *et al.* (2007) found that the projected area of sugarbeet seed increased from 12.1 to 15.6 mm^2 while the moisture content of seed increased from 8.4 to 14.0% d.b.

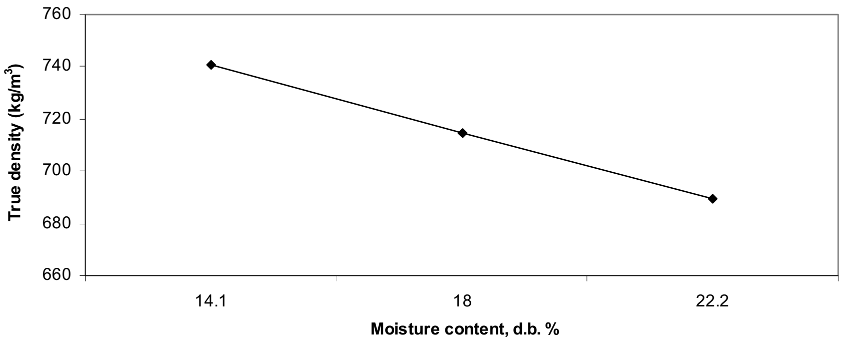
Bulk density

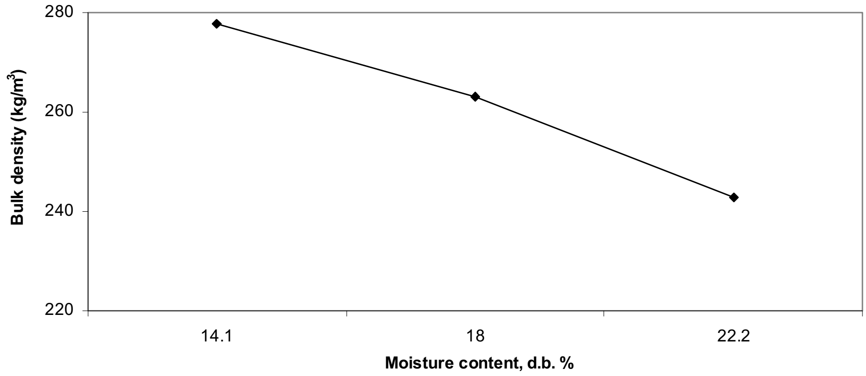
The bulk density of chard seed at different moisture levels for varied from 277.78 to 242.72 kg m^{-3} d.b. (**Fig. 3**), indicated a decrease in bulk density with an increase in moisture content.

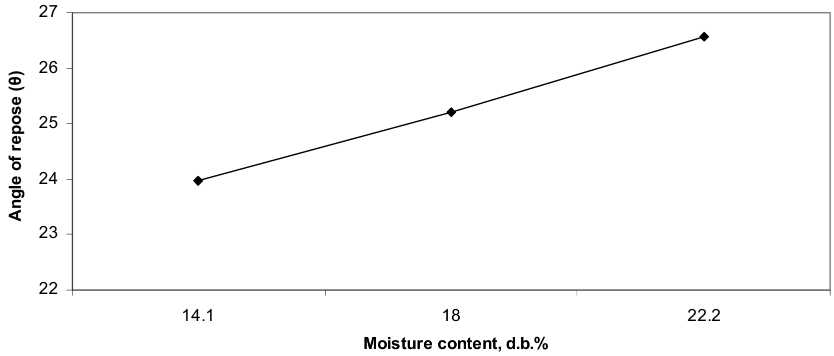
The decrease in bulk density with increase in moisture content shows that the increase in mass resulting from the moisture gain of the sample is lower than the accompanying volumetric expansion of the bulk. The relationship between bulk density and moisture content can be represented by the following equation:

$$P_b = 296.2774 - 17.5297 \, Mc (R^2 = 0.991)$$

The negative linear relationship between bulk density and moisture content has been reported by Kılıçkan *et al.* (2010), Kasap and Altundas (2006), Dursun *et al.* (2007) for spinach, sugar beet seed, respectively. Dursun *et al.* (2007) reported that bulk density decreased from 447 to 418 kg m^{-3} as the moisture content increased from 8.4 to 14.0% d.b. Kılıçkan *et al.* (2010) found, for spinach seed, that the val-







ues of bulk density for different moisture levels varied from 538.9 to 893.1 kg m^{-3}.

Kasap and Altundas (2006) determined that the bulk density of sugarbeet seeds at different moisture levels for 'Gina' and 'Leila' varied from 125.92 to 120.02 kg m^{-3} and from 148.70 to 114.06 kg m^{-3}, respectively.

True density

The true density of chard seeds at different moisture levels for varied from 740.74 to 689.66 kg m^{-3} (**Fig. 4**). The effect of moisture content on true density of sugarbeet seed showed a decrease with increasing moisture content (Kasap and Altundas 2006). The linear relationship between moisture content (Mc) and true density (ρt) was described by the regression equations:

$P_t = 765.9794 – 25.5428$ Mc (R^2= 0.987)

The results were similar to those reported by Kılıçkan *et al.* (2010) for spinach, Kasap and Altundas (2006) for sugar beet and Dursun *et al.* (2007) for sugar beet seed. Kılıçkan *et al.* (2010) reported the true density for spinach from 893.1 to 784.6 kg m^{-3}. In other research, Kasap and Altundas (2006) found the true density of sugarbeet seeds at different moisture levels for 'Gina' and 'Leila' sugarbeet varieties varied from 916.70 to 827.39 kg m^{-3} and from 852.81 to 832.20 kg m^{-3}, respectively. Similarly, Dursun *et al.* (2007) determined 962 to 851 kg m^{-3} when the moisture content increased from 8.4 to 14.0% d.b. for sugar beet seed.

Angle of repose

The obtained results for the angle of repose for chard seed with respect to the moisture content are shown in **Fig. 5**. A linear increase was observed from 23.96 to 26.57° in the moisture range 14.1 to 22.2% (dry basis).

The relationship between the moisture content (M_c) and the angle of repose (θ) was represented by following regression equations:

θ =22,6403+ 1,3013 Mc (R^2= 0.962)

These results were similar to those reported by Dursun *et al.* (2007) for sugarbeet seed, Kasap and Altundas (2006) for sugarbeet seeds. The angle of repose for sugarbeet seed increased from 19.31° to 21.27° and from 21.05° to 21.32°, for 'Gina' and 'Leila' respectively (Kasap and Altundas 2006). Dursun *et al.* (2007) were reported the angle of repose for sugarbeet seed increased from 17.6° to 25.0° in the moisture range of 8.4–14.0% d.b.

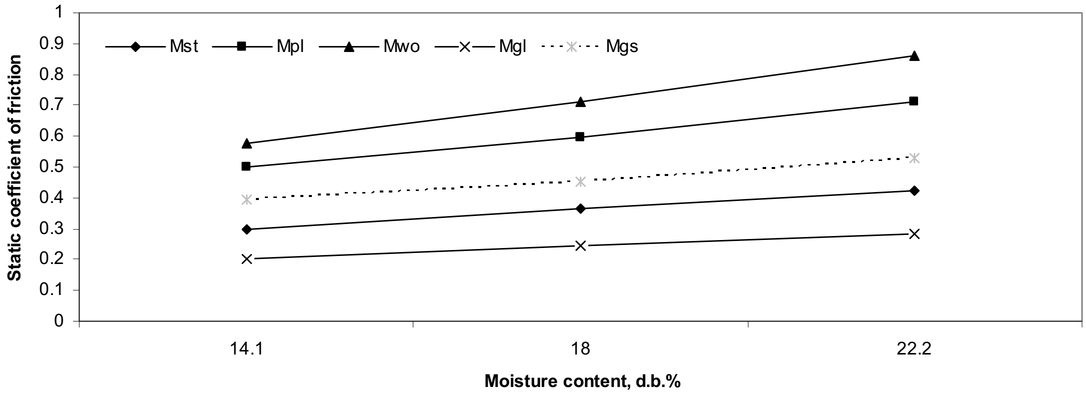


Table 2 Mean and standard error values for static coefficient of friction of chard seeds as a function of seed moisture contents.

Coefficient of friction	Chard seed (%)		
	14.1	18.0	22.2
Steel	0.300 ± 0.008	0.367 ± 0.010	0.422 ± 0.07
Plywood	0.499 ± 0.005	0.598 ± 0.014	0.712 ± 0.008
Wood	0.576 ± 0.06	0.712 ± 0.013	0.859 ± 0.010
Glass	0.200 ± 0.002	0.246 ± 0.005	0.285 ± 0.004
Galvanized sheet	0.393 ± 0.001	0.451 ± 0.006	0.530 ± 0.005

Static coefficient of friction

The static coefficient of friction increased with increase in moisture content on all surfaces (**Fig. 6**). Results from some physical parameters such as static coefficient of friction on sheet, plywood, wood, glass and galvanised sheet surfaces were compared. At all moisture contents, the static coefficient of friction was 300 to 0.422 for steel, 0.393 to 0.530 for galvanized sheet, 0.499 to 0.712 for plywood, 0.576 to 0.859 for wood and 0.200 to 0.285 for glass in the moisture range from 14.1 to 22.2% (dry basis) (**Table 2**).

The relationships between static coefficients of friction and moisture content on steel (M_{st}), plywood (M_{pl}), wood (M_{wo}), glass (M_{gl}) and galvanized sheet (M_{gs}) can be represented by following equations:

$$M_{st} = 0.2412 + 0.0609\ Mc\ (R^2= 0.965)$$

$$M_{pl} = 0.3903933 + 0.1062\ Mc\ (R^2= 0.998)$$

$$M_{wo} = 0.4324667 + 0.1417\ Mc\ (R^2= 0.987)$$

$$M_{gl} = 0.1583 + 0.0427\ Mc\ (R^2= 0.972)$$

$$M_{gs} = 0.3203 + 0.0687\ Mc\ (R^2= 0.992)$$

Similar results were found by other researchers (Suthar and Das 1996; Baryeh 2002; Demir *et al*. 2002).

Suthar and Das (1996) found that the static coefficient of friction of seeds against surfaces of three structural materials varied from 0.91 to 0.34 with plywood, 0.80 to 0.29 with mild steel and 0.67 to 0.23 with galvanized iron. Baryeh (2002) found that the coefficient of static friction increased from 0.39 to 0.66, 0.29 to 0.58 and 0.25 to 0.49 for plywood, galvanised iron and aluminium, respectively. Demir *et al.* (2002) found that the coefficient of dynamic friction increased from 0.36 to 0.5, 0.31 to 0.43 and 0.22 to 0.35 on rubber, plywood and galvanized steel, respectively, for the same moisture range.

CONCLUSION

Various physical properties of chard seed were evaluated as a function of moisture content. All the dimensions of chard seed (*Beta vulgaris* L. var. *cicla*) such as of the major, medium and minor axes increased with increase in moisture contents. Arithmetic and geometric mean diameter, surface area of chard seeds increased linearly with increase in the seed moisture content with high correlation. The sphericity of chard seeds changed from 1.15 to 1.14 with the decreased in the moisture content. The bulk density and true density for different moisture levels decrease with the decreased in moisture content. In the moisture content range studied angle of repose increased from 23.96 to 26.57°. The static coefficients for friction of chard seeds were determined steel, plywood, wood, glass and galvanized sheet at various moisture contents and increased with the increase in the moisture content.

In this study, the physical parameters of chard seeds are explained in the form of regression equations as a function of moisture content. Once the moisture is known, the physical parameters can be obtained from these equations. High correlation coefficients were found with a significance level of 92%.

REFERENCES

Anonymous (2011) USDA National Nutrient Database for Standard Reference, Release 23. Available online: www.ars.usda.gov/Services/docs.htm?docid=8964

Altuntas E, Yıldız M (2007) Effect of moisture content on some physical and mechanical properties of faba bean (*Vicia faba* L.) grains. *Journal of Food Engineering* **78 (1)**, 174-183

Baryeh EA (2002) Physical properties of millet. *Journal of Food Engineering* **51**, 39-46

Coşkun MB, Yalçın İ, Özarslan C (2006) Physical properties of sweet corn seed (*Zea mays saccharata* Sturt.). *Journal of Food Engineering* **74**, 523-528

Demir F, Doğan H, Özcan M, Haciseferoğullari H (2002) Nutritional and physical properties of hackberry (*Celtis australis* L.). *Journal of Food Engineering* **54**, 241-247

Dursun İ, Tuğrul KM, Dursun E (2007) Some physical properties of sugar beet seed. *Journal of Stored Products Research* **43**, 149-155

Gillet MI, Ferreres F, Tomas-Barberan FA (1998) Effect of modified atmosphere packaging on the flavonoids and vitamin C content of minimally processed Swiss chard (*Beta vulgaris* ssp. *cicla*). *Journal of Food Chemistry* **46**, 2007-2012

George Raymond AT (1985) *Vegetable Seed Production*, University of Bath, London, 318 pp

Jain RK, Bal S (1997) Properties of pearl millet. *Journal of Agricultural Engineering Research* **66**, 85-91

Karaagac O, Ozbakir M, Balkaya A (2011) Moisture dependent physical properties of pinto bean (*Phaseolus vulgaris* var. *Pinto*) seed. Türkiye IV. Tohumculuk Kongresi Bildiriler Kitabı 14–17 Haziran, Samsun, pp 114-120 (in Turkish)

Kasap A, Altuntaş E (2006) Physical properties of monogerm sugarbeet (*Beta vulgaris* var. *altissima*) seeds. *New Zealand Journal of Crop and Horticultural Science* **34**, 311-318

Kılıçkan A, Üçer N, Yalçın İ (2010) Some physical properties of spinach (*Spinacia oleracea*L.) seed. *African Journal of Biotechnology* **9 (5)**, 648-655

Kolota E, Czerniak K (2010) The effects of nitrogen fertilization on yield and nutritional value of Swiss chard. *Acta Scientiarum Polonorum Hortorum Cultus* **9 (2)**, 31-37

Mohsenin NN (1970) Physical properties of chickpea seeds. *Biosystems Engineering* **82**, 73-78

Öğüt H (1998) Some physical properties of white lupin. *Journal of Agricultural Engineering Research* **69 (3)**, 273-277

Pokluda R, Kuben J (2002) Comparison of selected Swiss chard (*Beta vulgaris* ssp. *cicla* L.) varieties. *Horticultural Science (Prague)* **29 (3)**, 114-118

Razavi SMA, Milani E (2006) Some physical properties of the watermelon seeds. *African Journal of Agricultural Research* **1 (3)**, 65-69

Sezer İ, Balkaya A, Karaağaç O, Öner F (2011) Moisture dependent of some physical and morphological properties of dent corn (*Zea mays* var. *indentete* Sturt) seeds. *African Journal of Biotechnology* **10 (15)**, 2857-2866

Singh KK, Goswami TK (1996) Physical properties of cumin seed. *Journal of Agricultural Engineering Research* **64**, 93-98

Suthar SH, Das SK (1996) Some physical properties of karingda (*Citrullus lanatus* (Thumb) Mansf) seeds. *Journal of Agricultural Engineering Research* **65**, 5-22

Şalk A, Arın L, Deveci M, Polat S (2008) *Special Vegetable Growing*, Namık Kemal Üniversitesi Ziraat Fakültesi, 485 pp (in Turkish)

Traunfeld J (2010) Vegetables and Fruits, Smetana J, Nixon B, Yen P (Eds), University of Maryland Extension Master Gardeners, March. Available online: www.growit.umd.edu

TUIK (2010) Tarımsal Yapı ve Üretim. Available online: http://www.tuik.gov.tr