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SOME PHYSICAL PROPERTIES OF MASH BEAN (Phaseolus aureus L.)SEEDS CULTIVATED IN TURKEY

M. Uğur YILDIZ

Technician Training Center, Program of Agricultural Machinery, Selçuk University, Karaman, Turkey

ABSTRACT

The mash bean (Phaseolus aureus L.) seeds were analyzed for physical properties. Physical properties such as length, width, thickness, weight, geometric mean diameter, sphericity, volume, thousand seed weight, bulk density, terminal velocity, projected area and porosity were measured at four moisture content levels (6.66 %, 11.00 %, 15.24 % and 18.59 %). Also the coefficient of static friction on iron sheet and galvanized iron sheet were determined. The values of length, width, thickness, mass, geometric mean diameter, sphericity, volume, 1000 seed weight, bulk density, terminal velocity, projected area and porosity were found as 4.45-4.95 mm, 3.84-4.00 mm, 3.81-4.08 mm, 0.048-0.070 g, 4.02-4.30 mm, 0.906-0.870, 30.37-34.95 mm^3, 49.2-60.1 g, 771.3-679.1 kg m^{-3},6.22-6.54 ms^{-1}, 0.140-0.213 cm^2 and 35.08- 47.1%, respectively. The coefficient of static friction increased from 0.270 to 0.322 and 0.302 to 0.367 for galvanized iron sheet and iron sheet respectively.

***Key words**: mash bean, Phaseolus aureus, Leguminoseae, physical properties*

TÜRKİYE' DE TARIMI YAPILAN MAŞ FASÜLYESİ (Phaseolus aureus L.) TOHUMLARININ BAZI FİZİKSEL ÖZELLİKLERİ

ÖZET

Bu çalışma Maş fasulyesi tohumlarının fiziksel özelliklerinin belirlenmesi için yapılmıştır. Dört nem seviyesinde(% 6.66, % 11.00, % 15.24 ve % 18.59) uzunluk, genişlik, kalınlık, ağırlık, geometrik ortalama çap, küresellik, hacim, bin tane ağırlığı, hacim ağırlığı, son hız, projeksiyon alanı ve porozite değerleri saptanmıştır. Ayrıca çelik ve galvanizli sac levhalarda statik sürtünme katsayısı belirlenmiştir. Nem seviyelerine bağlı olarak, uzunluk, genişlik, kalınlık, ağırlık, geometrik ortalama çap, küresellik, hacim, bin tane ağırlığı, hacim ağırlığı, son hız, projeksiyon alanı ve porozite değerleri sırasıyla 4.45-4.95 mm, 3.84-4.00 mm, 3.81-4.08 mm, 0.048-0.070 g, 4.02-4.30 mm, 0.906-0.870, 30.37-34.95 mm^3, 49.2-60.1 g, 771.3-679.1 kg m^{-3},6.22-6.54 ms^{-1}, 0.140-0.213 cm^2 ve %35.08- 47.1 olarak bulunmuştur. Statik sürtünme katsayısı değerleri ise galvanizli ve çelik sac levhalarda sırasıyla 0.270 ile 0.322 ve 0.302 ile 0.367 arasında, nem seviyesine bağlı olarak artmıştır.

***Anahtar kelimeler:** Maş fasulyesi, Phaseolus aureus , fiziksel özellikler*

Nomenclutare

L	length of mash bean seed (mm)
W	width of seed (mm)
T	thickness of seed (mm)
M	weight of seed (g)
$Ø$	sphercity of seed
M_c	moisture content of seed (%) d.b.
M_{1000}	thousand seed weight (g)
ρ_b	bulk density of mash bean (kg m^{-3})
p_1	initial pressure (kg cm^{-2})
p_2	final pressure (kg cm^{-2})
V_t	terminal velocity of seed (m s^{-1})
P_a	projected area of seed (cm^2)
R^2	determination coefficient
V	volume (mm^3)
ε	porosity of seeds (%)
μ_s	coefficient of static friction

INTRODUCTION

Phaseolus aureus (bundo, mongo, mash bean, golden gram, green gram, lack gram, mungo bean,) is a common food legume widely grown and eaten throughout many parts of the world (Sing, 2000; Kataria *et al.,* 1989). Varieties of mash bean are grown throughout Australia, China and USA (Anonymous, 2003b). Mash bean is for mainly food used as the sprouts. They are extensively used in Oriental dishes (Anonymous, 2003a). It is erect bushy annual widely cultivated in warm regions of India and Indonesia and United States for forage and especially its edible seeds. At the same time, it is source of bean sprouts used in Chinese cookery (Anonymous, 1998). Pressure cooking had a greater effect than ordinary cooking. The physiological actions of dietary fibre are likely based on its physiological properties such as water and oil capacities (Leterme *et al* 1998; Lopez *et al*., 1997; Oliveira *et al.,*1991; Betancur-Ancone *et al*.,2004).

No detailed study concerning physical properties of mash bean seeds have been reported hitherto. Whereas the physical properties of used equipment must be known for plantation, harvesting, transportation, storage and other processing of mash bean. The aim of this work is to determine the proximate composition and some physical properties such as projected area, bulk density, grain density and dimensions.

MATERIAL AND METHODS

Seeds

Mash bean (*Phaseolus aureus* L.) seeds were obtained from Karaman (Ermenek) in Turkey in September 2003 harvest season. The mash seeds were transported in polypropylene bags and held at room temperature. The seeds were cleaned in an air screen cleaner to remove all foreign matters such as dust, dirt, stones, immature and damaged seeds and broken seeds. The initial moisture content of seeds was determined by using a standard method (Brusewitz, 1975). The remaining material was packed in a 3000 ml hermetic glass vessel and kept in cold storage until use.

Physical properties

Mash bean (*Phaseolus aureus* L.) seed was assessed at 6.66, 11.00, 15.24 and 18.59 % moisture contents (d.b.) respectively, because the processing with these products is usually carried out between these moisture content values (Brusewitz,1975). Samples were kept in the refrigerator for a week by shaking at the internal periods. Then, the seeds were kept at the room temperature for analyses, and moisture content of samples was established.

All physical properties of mash bean have been determined for 10 repetitions at the moisture content of 6.66, 11.00, 15.24 and 18.59 % respectively.

To determine the size of the grains, ten groups of samples consisting of 100 grains have been selected randomly. 10 grains have been taken from each group and their linear dimensions - length, width and thickness- and projected areas have been measured. A micrometer was used for measuring linear dimensions with an accuracy of 0.01mm.

Projected area of grains was determined by using a digital camera (Kodak DC 240) and Sigma Scan Pro 5 program (Trooien & Heerman, 1992; Ayata, Yalçın & Kirişçi, 1997).

The weight of grains and a thousand grain weight were measured by an electronic balance with an accuracy of 0.001g. To evaluate 1000 grain weight, 100 randomly selected grains from the bulk were averaged.

Geometric mean diameter (*Dg*), sphericity (*Ø*) and seed volume (*V*) values were found using the following formula; (Mohsenin 1970; Jain & Bal 1997)

$$D_g = (LWT)^{0.333}$$
$$Ø = (LWT)^{0.333}/L$$
$$V = \pi B^2 L^2 / 6(2L-B)$$

Where $B = (WT)^{0.5}$

The bulk density (ρ_b) was determined with a weight per hectoliter tester which was calibrated in kg per hectoliter (Desphande, Bal & Ojha, 1993; Suthar & Das 1996; Jain & Bal 1997). The grains were removed by a strike off stick. The grains were not compacted in any way.

The porosity of the bulk (ε) at different moisture contents were measured using a porosity device (Day, 1964; Çarman, 1996). It consists of two identical tanks, one containing air under pressure (p_1) and the other one containing the samples of seed. When the valve between the two tanks opened, the air pressure in the two tanks equalized to a value p_2. Porosity was calculated from the following equation;

$$\varepsilon = [(p_1-p_2)/p_2]*100$$

The terminal velocities of mash bean seed at different moisture content were measured using an air column. For each test, a sample was dropped into the air stream from the top of the air column, up which air was blown to suspend the material in the air stream. The air velocity near the location of the grain suspension was measured by electronic anemometer having a least count of 0.1 m s^{-1} (Joshi, Das & Mukherji, 1993; Hauhout-O'hara et al., 2000).

The coefficient of static friction was measured by using iron sheet and galvanized iron sheet surfaces. For this measurement one end of the friction surface is attached to an endless screw. The grain was placed on the surface and it was gradually raised by the screw. Vertical and horizontal height values were read from the ruler when the grain started sliding over the surface, then using the tangent value of that angle the coefficient of static friction was found. Baryeh (2001), Dutta, Nema & Bhardwaj (1988), Suthar and Das (1996) have used similar methods.

Randomized plots of factorial experimental design was used for the data analyse (Minitab, 1991).

RESULT AND DISCUSSION

Mash bean seeds dimensions and mass distribution

Some properties of mash bean seeds at 6.66 %, 11.00 %, 15.24 % and 18.59 % moisture content were given in Table 1. Distribution percentage of seeds dimension properties are given in Fig 1.

Table 1. Some properties of mash bean seeds at different moisture contents d.b. %.

Properties	6.66	11.00	15.24	18.59
Mass (g)	0.048±0.001	0.056±0.001	0.068±0.001	0.070±0.001
Length (mm)	4.45±0.041	4.69±0.047	4.86±0.030	4.95±0.032
Width (mm)	3.84±0.026	3.93±0.021	4.00±0.020	3.94±0.027
Thickness (mm)	3.81±0.028	3.95±0.024	4.02±0.027	4.08±0.027
Geometric mean diameter (mm)	4.02±0.027	4.17±0.025	4.27±0.024	4.30±0.022
Sphericity (-)	0.906±0.005	0.893±0.004	0.880±0.004	0.870±0.004
Volume (mm^3)	30.37±0.597	32.79±0.557	34.73±0.652	34.95±0.587

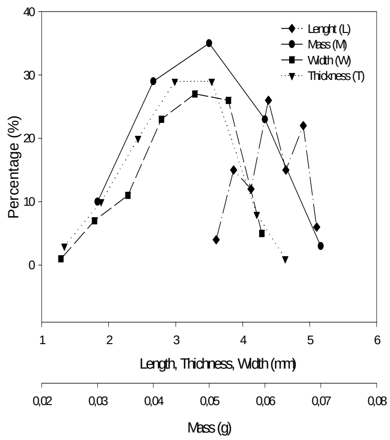

Fig 1. Distribution percentage of curves of length, width, thickness and weight measuring of mash bean seed at the moisture content 6.66% d.b.

87 % of mash bean seeds have a mass ranging from 0.04 g to 0.06 g, 90 % of mash bean seeds have a length from 3.74 mm to 5.03 mm, 87 % of mash bean seeds have a width from 3.22 mm to 4.21 mm and 88 % of mash bean seeds have a thickness from 3.25 mm to 4.12 mm at a moisture content of 6.66 %.

The values (except for sphericity) given in Table 1 increased by the increase of moisture content. The reasons for this increase were probably due to some tiny air voids on the seeds. Similar results were found by Desphande *et al*. (1993) for soyabeans; Baryeh (2001) for Bambara graundnuts and Gezer *et al*. (2002) for apricot pits and kernels. But, sphericity value decreased with respect to moisture content. Baryeh (2001) reported that sphericity values of Bambara groundnuts at the 5% and 35% moisture content were determined as 0.895 and 0.840, respectively.

The correlation coefficients show that the *L/T, L/W* and *L/M* rations were found highly significant (Table 2). The relationships between length, width, thickness and weight were given by the following equation.

$$L = 1.159\text{x}W = 1.168\text{x}T = 92.708\text{x}M$$

Similar results were reported by Hacıseferoğulları et.al (2003), Gezer et al. (2002), Demir et al. (2002) Çarman (1996) and Joshi et al. (1993).

Table 2. The correlation coefficient between some physical properties of mash been seeds

Particulars	Ratio	Degree of freedom	Correlation coefficient (r)
L/T	1.168	98	0.474**
L/W	1.159	98	0.517**
L/M	92.71	98	0.733**

** *(p< 1%)*

Thousand seed weight

The thousand seed weight values of mash bean seeds at moisture contents of 6.66 % and 18.59 % varied from 49.2 to 60.1 g (Figure 2).

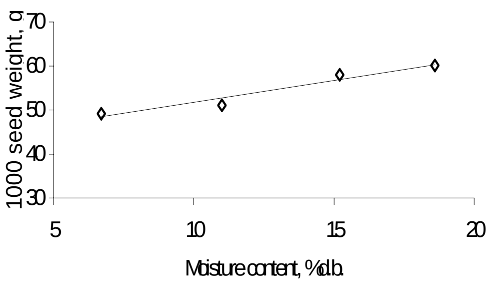

Fig. 2. Seed versus moisture content

An increasing relationship was found between 1000 seed weight and moisture content in mash bean seeds. The equations are as follows;

$$M_{1000} = 41.81 + 0.9934\ M_c \qquad (R^2 = 0.947)$$

Similar results were found by Desphande *et al.* (1993) for soybeans; Singh & Goswami (1996) for cumin seeds and Öğüt (1998) for lupin seeds.

Bulk density

The bulk density values of mash bean seeds at moisture contents of 6.66 % and 18.59 % varied between 771.3 and 679.1 kg m^{-3} (Figure 3). The relationship between bulk density of mash bean seeds and moisture content was found as follows;

$$\rho_b = 827.26 - 7.9733\ Mc \qquad (R^2 = -0.992)$$

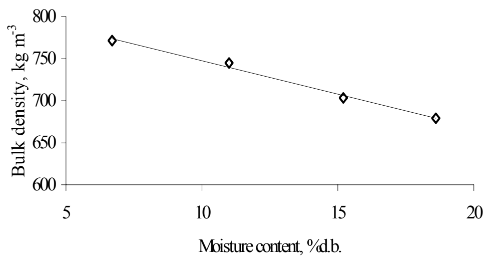

Fig. 3. Bulk density variation with moisture content

As the moisture content increased, the bulk density values decreased. Çarman (1996) for lentil seeds and Desphande *et al.* (1993) for soybean had found similar results. These changes are probably due to the structural properties of the grains.

Porosity

The variations of porosity values depending on moisture content in mash bean seeds were shown in Figure 4. The porosity values of mash bean seeds at moisture contents of 6.66 and 18.59 % varied between 35.01 % and 47.1 %. The relationship between porosity value and moisture content was found;

$$\varepsilon = 28.247 + 1.0258\ M_c \qquad (R^2 = 0.998)$$

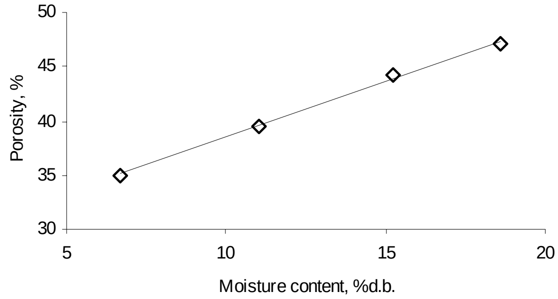

Fig. 4. Porosity variation with moisture content

Gupta & Das, (1997) for sunflower, Çarman (1996) for lentil and Singh & Goswami (1996) for cumin seeds stated that as the moisture content increased so the porosity value increased.

Projected area

Projected areas values of mash bean seeds at moisture contents of 6.66 and 18.59 % varied from 0.140 to 0.213 cm^2 (Fig.5).

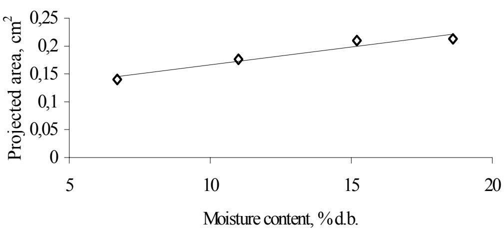

Fig.5. Projected area variation with moisture content

As moisture content increased, so did the projected areas. The relationship between projected area and moisture content of mash bean seeds was found as follows;

$P_a = 0.102 + 0.0064\,M_c \qquad (R^2 = 0.939)$

Desphande *et al.*, (1993) for soybean, Çarman, (1996) for lentil, Öğüt, (1998) for lupin have found similar results.

Terminal velocity

Terminal velocities values of mash bean seeds at moisture contents of 6.66 and 18.59 % varied between 6.22 and 6.54 ms^{-1} (Figure 6). The relationship between terminal velocity and moisture content was found as the following:

$V_t = 6.0398 + 0.0253\,M_c \qquad (R^2 = 0.945)$

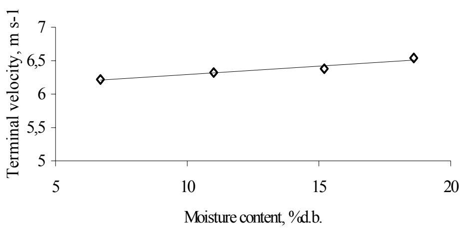

Fig.6. Terminal velocity variation with moisture content

As the moisture content of grains increased, so the values of terminal velocity increased. Ramakrishna, (1986) for melon, Joshi *et al.*, (1993) for pumpkin and Çarman, (1996) for lentil found similar results.

Coefficient of static friction

The variation of the coefficient of static friction with moisture content in mash bean seeds is given in Figure 7, for iron sheet and galvanized iron sheets. It can be seen from the figure 7 that the coefficient of static friction values on an iron sheet and one galvanized iron sheet increased with the increase of moisture content. The coefficient of static friction increased from 0.270 to 0.322 and from 0.302 to 0.367 for galvanized iron sheet and iron sheet respectively. This relationship was found as follows;

$\mu_s = 0.2587 + 0.0054\,M_c$ ($R^2 = 0.912$) (for iron sheet)

$\mu_s = 0.2391 + 0.0043\,M_c$ ($R^2 = 0.989$) (for galvanized iron sheet)

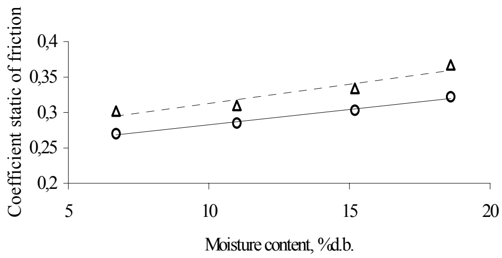

Fig. 7. Coefficient of static friction versus to moisture content (0, Galvanized iron sheet; Δ, iron sheet).

Joshi *et al.* (1993); Tsang-Mui- Chung,Verma & Wright, (1984); Çarman (1996) and Öğüt (1998) reported that as the moisture content increased so the coefficient of static friction increased.

CONCLUSIONS

a. All the dimensions of the mash bean seed, width, thickness, mass, geometric mean diameter increase with increase in moisture content.
b. The 1000 seed weight increases linearly with increase moisture content.
c. Sphericity decreases non-linearly with increase in moisture content.
d. The porosity increases with increases in moisture content
e. Bulk density decreases with increase in moisture content.
f. Coefficient of static friction is highest for iron sheet and galvanized iron sheet, in descending order.

REFERENCES

Anonymous, 1998. Webster's Revised Unabridged Dictionary, MICRA, Inc.

Anonymous, 2003a. USDA Nutrient Databases. (http://www.hpschmid.com/products/beans/)

Anonymous,2003b.Bean. http://www.tiscali.co.uk/)

Ayata, M., Yalçın, M., & Kirişçi, V., 1997. *Evaluation of soil-tine interaction by using image processing system*. National Symposium on Mechanisation in Agriculture, Tokat, Turkey, 267-274 .

Baryeh,E.A., 2001. Physical properties of bambara groundnuts. *Journal of Food Engineering* 47,321-326.

Betancur-Ancona,D., Peraza – Mercado,G., Moguel-Ordonez,Y., Fuertes-Blanco,S., 2004. Physicochemical characterization of lima bean (*Phaseolus lunatus*) and Jack bean (*Canavalia ensiformis)* fibrous residues. *Food Chemistry* 84,287-295.

Brusewitz, G.H., 1975. Density of rewetted high moisture grains. *Transactions of the ASAE,**18***, 935-938.

Çarman, K., 1996. Some physical properties of lentil seeds. *Journal of Agricultural Engineering Research, 63*, 87-92

Day,C.L. 1964**.** Device for measuring voids in porous materials**.** *Agricultural Engineering, 45*: 36-37

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

Desphande, S. D., Bal, S., & Ojha, T. P., 1993. Physical properties of soybean. *Journal of Agricultural Engineering Research, 56,* 89-98.

Dutta, S.K., Nema, V. K., & Bhardwaj, R. J., 1988. Physical properties of grain. *Journal of Agricultural Engineering Research, 39*, 259-268.

Gezer, İ., Hacıseferoğulları, H.,Demir, F., 2002. Some Physical properties of Hacıhaliloğlu Apricot pit and its kernel. *Journal of Food Engineering*, 56, 49-57

Gupta, R. K., & Das, S. K., 1997. Physical properties of sunflower seeds. *Journal of Agricultural Engineering Research, 66*, 1-8.

Hacıseferoğulları,H., Gezer,İ., Bahtiyarca,Y., Mengeş,H.O., 2003. Determination of some chemical and physical properties of Sakız faba bean (*Vicia faba* L. var. Major). *Journal of Food Engineering* 60,475-479.

Hauhouout-O`hara, M., Criner, B.R., Brusewitz, G.H., & Solie, J.B., 2000. Selected physical characteristics and aerodynamic properties of cheat seed for separation from wheat. *The GIGR Journal of Scientific Research and Development*. Vol:2.

Jain, R. K., & Bal, S., 1997. Physical properties of pearl millet, *Journal of Agricultural Engineering Research, 66*, 85-91.

Joshi, D. C., Das, S. K., & Mukherji, R. K., 1993. Physical properties of pumpkin seeds. *Journal of Agricultural Engineering Research, 54,* 219-229.

Kataria,A., Chauhan,B.M., Punia,D., 1989. Antinutrients in amphidiploids (black gram x Mung bean):varietal differences and effect of domestic processing and cooking. *Plant Foods Hum Nutr.*39(3),257-266.

Leterme,P., Froidmont, E., Rossi,F. & hewis,A., 1998. The high water-holding capacity of pea iner fibres affects the ileal flow of endogenous amino acids in pigs. *Journal of Agricultural and Food Chemistry,* 46,1927-1934.

Lopez,G., Ros,G., Rincon,F., Periago,M., Martinez,C., Ortuno,J., 1997. Propiedades funcionales de la fibra dietetica. Mecanismos de accion en el tracto gastrointestinal. *Archivos Latinoamericanos de Nutricion* 47(3), 203-207.

Minitab 1991. *Minitab Reference Manuel* (release 10.1), Minitab Inc. Michigan State University.

Mohsenin, N. N., 1970. *Physical properties of plant and animal material*. New York: Gordon and Breach Sciense Publishers.

Oliveira,S., Reyes,F.G., Sgarbier,V.C., Areas,M.A. & Ramalho,A.C., 1991. Nutritional attributes of a sweet corn fibrous residue. *Journal of Agricultural and Food Chemistry* 9,740-743.

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

Ramakrishna, P., 1986. Melon seeds-evaluation of the physical characteristics. *Journal of Food Sciense and Technology, 23*, 158-160

Singh, K. K., & Goswami, T. K., 1996. Physical properties of cumin seed. *Journal of Agricultural Engineering Research,64*, 93-98.

Singh,V.P., 2000. Planting geometry maize (*Zea mays*) and blackgram (*Phaseolus mungo*) intercropping system under rainfed low hill valley of Kumaon. *Indian Journal of Agronomy* 45(2), 274-278

Suthar, S. H., & Das, S. K., 1996. Some physical properties of karingda seeds. *Journal of Agricultural Engineering Research, 65*, 15-22.

Trooien, T.P., & Heermann, D.F., 1992. Measurement and simulation of potato leaf area using image processing I, II, III. *Transactions of the ASAE, 35 (5),* 1709-1722.

Tsang-Mui-Chung, M., Verma, L. R., & Wright, M. E., 1984. A device for friction measurement of grains. *Transaction of the ASAE, 27,* 1938-1941.