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Moisture Dependent Engineering Properties of Wild Apricot *(prunus armeniaca L.)* Pits

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Abstract

The physical and mechanical properties of apricot pit are the most important parameters for designing and development of handling, grading, sizing, processing, decorticating, oil expression and packaging equipments. Such as dimensions, geometric mean diameter, sphericity, bulk density, true density, porosity, thousand pit volume, thousand pit weights, angle of repose, angle of internal friction and cracking strength at two conditions of moisture content (wb) of wild apricot pits at 12 % and 16 %. The mean length, width and thickness at moisture content of 12 % (wb) and 16 % (wb) were found to be 22.60 mm, 17.71 mm, 10.55 mm and 22.61 mm, 17.73 mm, and 10.58 mm, respectively. Similarly, equivalent diameter 16.16 mm, 16.18 mm, spherisity 0.71 and 0.72, angle of repose 32.98º and 33.23º, angle of internal friction 30.25º and 30.35º, bulk density 0.5512g/mm^3 and 0.5389 mm^3, true density 1.0282 g/mm^3 and 1.169 g/mm3, porosity 46.34 % and 48.23 %, thousand pit volume 2534 mm^3 and 2957 mm^3, thousand pit weight 1572.5 g and 1594 g, cracking strength 594.78 N and 568.96 N, respectively at 12 % (wb) M.C and 16 % (wb) M.C of pit. ANOVA indicated that length, width, thickness, equivalent diameter, sphericity, angle of repose and angle of internal friction of wild apricot pit were not significantly dependent on moisture content**.** But true density, bulk density, thousand kernel weight, thousand kernel volume and cracking strength varied significantly with moisture content at 5% level of significance.

Highlights

- Some important physical properties at two conditions of moisture content (wb) of wild apricot pits at 12 % and 16 %.
- Length, width, thickness, equivalent diameter, sphericity, angle of repose and angle of internal friction of wild apricot pit were not significantly dependent on moisture content.
- True density, bulk density, thousand kernel weight, thousand kernel volume and cracking strength varied significantly.

Keywords: wild apricot, physical properties, mechanical properties, moisture content

Introduction

Bitter apricot (*Prunus armeniaca*) refers to a species of Prunus, classified with the plum in the subgenus Prunus. Wild apricot (Chulu) is a wild variety of apricot (Khubani) and required dry temperate climate tree susceptible to frost. It is found almost naturalized in the north-western Himalayas particularly in the valleys at altitudes up to 2500 m. The seeds of bitter apricot are buried under the earth for three months i.e. from July to October owing to its hard shells. During October they are sown in the nurseries, and by January the seedlings appear.

As known, the fruit of apricot is not only consumed fresh but also used to produce dried apricot, frozen apricot, jam, jelly, marmalade, pulp, juice, nectar, extrusion products etc. Moreover, apricot kernels are used in the production of oils, benzaldehyde, cosmetics, active carbon and aroma perfume (Yildiz, 1994). Apricot is rich in minerals such as potassium and vitamins such as b-carotene, which is the precursor substance of vitamin A, which is necessary for epithelia tissues covering our bodies and organs, eye-health, bone and teeth development and working of endocrine glades. Moreover, vitamin A plays important role in reproduction and growing functions of our bodies in increasing body resistance against infections.

Turkey, Iran, Italy, Pakistan and France are the principal apricot countries. Also the India ranks 9th position in apricot production. In India, apricot is grown commercially in the hills of Himachal Pradesh, Jammu and Kashmir, Uttaranchal, Uttar Pradesh and to a limited extent in north eastern hills and in Nilgiris. Kinnaur and Lahaul Spiti in Himachal Pradesh, Ladakh in Jammu and Kashmir, and Badrinath, Chamoli and Ghadhawal in Uttaranchal are the main production places of the apricot. Sharmagz Kaisha, Moorpark, Turkey, St. Ambrose, Kaisha, Nugget, Castle, Saffeida, Charmagz thease are the few important varieties cultivated in India. The agriculture of apricot needs extensive labor and energy. Apricot pits are separated into shells and kernels in the regional conglomerates which have washing, sorting and breaking and separation units. The resulting shells are generally used as fuel (Sooch *et al.*, 2013).

The physical properties of apricot are important for the design of equipments for harvesting and post-harvesting technology transporting, storing, cleaning, separating, sorting, sizing, packaging and processing it into different food purposes. Since, currently used systems have been generally designed without taking these criteria into consideration, the resulting designs lead to inadequate applications. These results a reduction in work efficiency, and increase in product loss. It is important to have an accurate estimate of shape, size, volume, density, surface area and other physical and mechanical properties that may be considered as engineering parameters for product, when biomaterials are studied either in bulk or individually. Also, mechanical damage to seeds which occurs in harvesting, threshing, and handling can seriously affect viability and germination power, growth vigour, insect and fungi attack and also the quality of the final products (Mohsenin, 1970). Therefore, determination and consideration of these criteria have an important role in designing of various post harvest handling and processing equipments **(**Kale *et al*., 2011**)**. Many studies have reported on the chemical, physical and mechanical properties of fruits, grain kernels, seeds, pulses, oilseeds, fruits etc in worldwide, as it can be found in literature review but in India there was no sufficient work is to be done on the apricot fruit as well as pit. It is a clear that investigating on physical and mechanical properties of apricot pit is very essential for post harvest processes. so some important physical and mechanical properties of apricot pit such as axial dimension ,1000-unit mass and volume, densities, coefficient angle of repose , angle of internal friction and rupture force were determine.

The objective of this study is to determine some selected engineering (physical and mechanical) properties of wild apricot cultivated in kumaun region of Uttarakhand state of India, to establish a convenient reference data for their mechanization and processing. The knowledge of the engineering properties is useful for engineers, food scientists and breeders (plant and animal). It is also important in data collection in the design of machines, structures, processes and controls; and in determining the efficiency of a machine or an operation. As the moisture content of the material has key effect on the change in physical as well as engineering properties of the biomaterials present study was carried out at two different conditions of moisture content of the pits which is 12 % and 16 % at wet basis (Mohsenin, 1970).

Materials and Methods

Selection of Materials

Apricots of wild varieties which used in this study were produced from the kumaun region of Uttaranchal state of India. For this, the fruits are collected and to be dried in sun drying, then pit of the fruit is separated from the dried flesh. These pits are dried in sun then it was cleaned by using air pressure and separates the waste material before study.

Determination of Moisture Content

Moisture content was determined as recommended by Association of Official Analytical Chemists (AOAC, 1995). This involves measuring the weight of sample before and after oven drying at temperature 130 ± 5º C for 2 hours (for woody material of husk). The moisture content was then estimated on dry basis using equation (1).

$$M_c = \frac{W_1 - W_2}{W_0} \quad (1)$$

W_c = Moisture content of the sample, % (wb), W_0 = Initial weight of the sample taken, g,

W_1 = Weight of the sample and dish with cover before drying, g

W_2 = Weight of the sample and dish with cover after drying, g

Determination of physical properties

Size, Geometrical mean diameter, Sphericity

To determine the size of the apricot pits, 100 pits of wild apricot was randomly selected and then their linear dimensions – length (L), width (W) and thickness (T) measured using a vernier caliper having least count 0.01.

Sphericity was estimated from equation (2) (Mohsenin, 1970).

$$Sphericity = \frac{de}{di} \quad (2)$$

de = diameter of a sphere of the same volume as the object,

di = diameter of the circumscribing sphere or usually the longer diameter of the object.

Thousand pit weight, thousand pit volume, true and bulk density and porosity

Weight of the 1000 pits was obtained with an electric weighing balance (Adventurer OHAUS, Meller, Switzerland: Type PM 2000; Serial No: H52764; sensitivity ± 0.001g). Also the volume of the 1000 pits is calculated by using 1000 ml measuring cylinder. It was determined by filling a 1000 ml container with kernels from a height of about 15 cm, striking the top level.

The Bulk density (B_d) is the ratio of the mass sample of the kernels to its total volume. It was determined by filling a 1000 mL container with kernels from a height of about 15 cm, striking the top level and then was weighed the contents **(**Desphande *et al.*, 1993).

$$\text{Bulk density} = \frac{\text{weight of the pit}}{\text{total volume of the pit}} \quad (3)$$

True density (Td) was determined by using toluene displacement method. As toluene was more advantages instead of water as liquid (Mohsenin, 1970; Ogut, 1998; Sitkei, 1976; Singh and Goswami, 1996).

$$\text{True dinsity} = \frac{\text{weight of pits}}{\text{True volume of the pit}} \quad (4)$$

Porosity is the ratio of volume of pores to the total volume of a sample. The porosity of the pit sample was computed from the bulk density and true density values using the following equation:

$$\in = \frac{\rho_t - \rho_b}{\rho_t} \times 100 \quad (5)$$

where,

$\in$ = porosity, %

ρ_t = true density, kg/m^3

ρ_b = bulk density, kg/m^3

Angle of internal friction and Angle of repose (on wood surface)

Angle of internal friction on wood surface was determined by the tilting surface method (Mingjin *et al.*, 2003) and the angle of repose by the geometrical approach described by (Chukwu and Akande, 2007). Equation (6) (Mohsenin, 1970; Chukwu and Akande, 2007) was used to calculate the angle of repose.

$$\theta = \tan^{-1-1} \frac{H}{r} \quad (6)$$

θr = Angle of repose, H = height of cone, r = Radius of platform.

Determination of Mechanical Properties (Cracking strength, N)

Cracking strength of the apricot pit was determined along the thickness of pit where minimum force required for cracking Ahmadi *et al.*, (2009). Cracking strength was determined by texture analyzer (Stable Microsystem Model TAHD plus(double coloumn) - XTZi, UK) using 75 mm compression platen stainless steel probe (Probe code- P/75) ASAE Standards (1998). 20 pits individually were used for observations. Force calibration was carried out by using 25 kg load cell of the texture analyzer.

Statistical Analysis

The tools used in computation and comparison of data are mean, standard deviation and coefficient of variation using SPSS 11.5 for Windows and MS-Excel. A t-test was used to determine significance differences between means of the two levels of moisture content (12% and 16%) of wild apricot pits.

Results and Discussion

The engineering properties of the wild apricot pits at two levels of moisture content (wb) studied are presented in Table 1. The mean length, width and thickness at moisture content of 12 % (wb) were found to be 22.60 mm, 17.71 mm, and 10.55 mm, respectively. At 16 % (wb) moisture content, the mean length, width and thickness are 22.61 mm, 17.73 mm, and 10.58 mm, respectively. The importance of these dimensions in determining sieve apertures and other parameters in machine design like size grader, decorticator etc. were discussed by (Mohsenin, 1986; Omobuwajo *et al*., 1999; Heidarbeigi *et al*., 2009). The size and shape are, for instance, important in the electrostatic separation of agricultural products from undesirable materials and in the development of sizing and grading machinery. The mean equivalent diameter and sphericity of pits at 12 % M.C are 16.16 mm and 0.71, respectively and 16.18 mm and 0.72 at 16 5% (M.C), respectively. Equivalent diameter and sphericity are properties that relate to shape and are needed for an analytical prediction of the drying behaviors of agricultural grains (Esref and Halil, 2007).

The mean angle of repose and angle of internal friction of wild apricot pit are respectively 32.98° and 30.25° at 13 % (wb) M.C of pit and for 16 % (wb) M.C pits are 33.23° and 30.35°, respectively. The angle of repose determines the maximum angle of a pile of grain in the horizontal plane, and is important in the filling of a flat storage facility when grain is not piled at a uniform bed depth but is peaked (Mohsenin, 1986). The angle of internal friction indicates the angle at which chutes must be positioned in order to achieve consistent flow of material through it (Olajide and Igbeka, 2003). The static coefficient of friction is used to determine the angle at which chutes must be positioned in order to achieve consistent flow of materials through the chute. Also the design of grain hoppers for processing machinery requires data on angle of repose.

The mean values of bulk densities, true density and porosity at 12 % (wb) M.C and 16 % (wb) M.C of pits were found to be 0.5512 g/ml, 1.0282 g/ml, 46.34 % and 0.5389 g/ml, 1.169 g/ml ,48.23 % , respectively. Bulk density and true density can be useful in sizing grain hoppers and storage facilities; they can affect the rate of heat and mass transfer of moisture during aeration and drying processes. Grain densities have been of interest in breakage susceptibility and hardness studies (Heidarbeigi *et al*., 2009).

The mean thousand pit volume, and thousand pit weight of pit are 2534 mm^3 and 1572.5 g, respectively for 12 % (wb) M.C of pits while 2957 mm^3 and 1594 g, respectively for pits having M.C 16 % (wb). Mass, volume and density

Table 1: Selected Physical and mechanical properties of wild apricot pits at 12 % (wb) M.C and 16 % (wb) M.C.

Parameter	12 % (w.b)		16% (w.b)	
	Mean ± SD	Cov[a]	Mean ± SD	Cov[a]
Length, (mm)	22.60 ± 0.84	0.51	22.61 ± 0.69	0.53
Width,(mm)	17.71 ± 0.95	0.48	17.73 ± 0.91	0.56
Thickness, (mm)	10.55 ± 0.75	1.37	10.58 ± 0.43	1.42
Equivalent Diameter, (mm)	16.16 ± 0.73	1.03	16.18 ± 0.86	1.08
Sphericity	0.71 ± 0.021	5.23	0.72 ± 0.036	6.35
Angle of repose, (º)	32.98 ± 1.02	1.68	33.23 ± 0.95	4.27
Angle of internal friction,(º)	30.25 ± 0.83	1.03	30.35 ± 0.69	1.12
Bulk density, (g/ml)	0.5512 ± 0.006	2.36	0.5389 ± 0.058	3.01
True density, (g/ml)	1.0282 ± 0.031	0.10	1.169 ± 0.036	0.12
Porosity,(%)	46.34 ± 1.61	0.62	48.23 ± 1.59	0.73
Thousand pit volume, (ml)	2534 ± 2.83	5.21	2957 ± 1.96	5.73
Thousand pit weight, (g)	1572.5 ± 0.23	0.45	1594 ± 0.92	0.49
Cracking strength, (N)	594.78 ± 16.14	0.92	568.96 ± 12.63	1.36

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Table.2: ANOVA related to Selected Physical and mechanical properties of wild apricot pits with moisture content (α=0.05).

Properties	Variation source	SS	Df	MS	F	p-value	F- crit
Length, (mm)	Between groups	0.0697	1.00	0.0697	0.1378	0.7109	6.7646
	Within groups	100.18	198	0.5060			
	Total	100.25	199				
Width,(mm)	Between groups	0.0226	1.00	0.0226	0.048	0.82	3.8889
	Within groups	93.30	198	0.4712			
	Total	93.32	199				
Thickness, (mm)	Between groups	0.0489	1.00	0.0489	0.0365	0.8448	3.8889
	Within groups	265.30	198	1.339			
	Total	265.34	199				
Equivalent Diameter, (mm)	Between groups	0.0061	1.00	0.006	0.0107	0.9179	3.8889
	Within groups	113.39	198	0.5727			
	Total	113.40	199				
Sphericity	Between groups	0.0003	1.00	0.0003	0.2738	0.6014	3.8889
	Within groups	0.1944	198	0.0010			
	Total	0.1947	199				
Angle of repose, (°)	Between groups	0.0005	1.00	0.0005	0.0279	0.8675	3.8889
	Within groups	3.3058	198	0.0167			
	Total	3.3063	199				
Angle of internal friction,(°)	Between groups	0.0007	1	0.0007	1.1101	0.3514	7.7086
	Within groups	0.0028	4	0.0007			
	Total	0.0036	5				
Bulk density, (g/ml)	Between groups	0.0053	1	0.0053	1584.2	0.0000	7.7086
	Within groups	0.0000	4	0.0000			
	Total	0.0053	5				
True density, (g/ml)	Between groups	0.0387	1	0.0387	96.464	0.0006	7.7086
	Within groups	0.0016	4	0.0004			
	Total	0.0403	5				
Thousand pit volume, (ml)	Between groups	0.0017	1	0.0017	0.2719	0.6295	7.7086
	Within groups	0.0263	4	0.0065			
	Total	0.0281	5				
Thousand pit weight, (g)	Between groups	1812801	1	1812801	4282.2	3.27E-07	7.7086
	Within groups	1693.3	4	423.33			
	Total	1814494	5				
Cracking strength, (N)	Between groups	1552.08	1	1552.08	102.73	0.0005	7.7086
	Within groups	60.4285	4	15.107			
	Total	1612.51	5				

of food materials and agricultural products play an important role in the design of silos and storage bins (Waziri and Mittal, 1997); determining the purity of seeds (Jaeger, 1997); stability of feed pellet and wafers (Gustustafson and Kjelgard, 2000); mechanical compressing of ensilages (Ige, 1997) and maturity evaluation (Fashina, 1996).

The mean cracking strength of the individual pit along the x-axis was found to be 594.78 N and 568.96 N at the condition of 12 % (wb) M.C of pit and 16 % (wb) M.C of pit, respectively. Cracking strength has to do with the behaviour of agricultural products under applied forces. A vast knowledge of such properties is vital to engineers

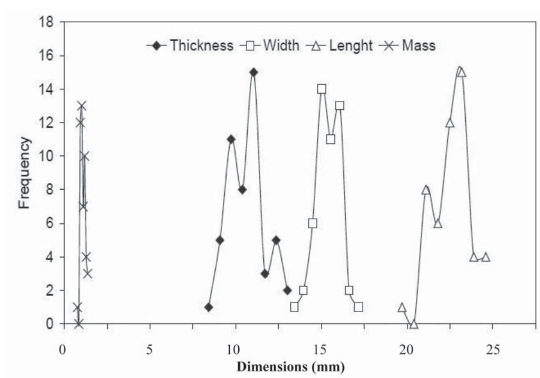

Fig. 1: Frequency distribution in dimensions and mass of wild apricot pits.

handling agricultural products. According to Anazodo (1983), knowledge of mechanical properties of agricultural products (such as strength or hardness) under static or dynamic loading is aimed at textural measurement of unprocessed and processed food material; the reduction of mechanical damage to agricultural produce during handling, processing, and storage; and the determination of design parameters for harvest and post harvest systems. The probability of fracture of a particle under tension depends on the applied macroscopic stress and the size of the particle. A wild apricot pit decorticator product machine designer needs knowledge of the cracking strength of pits for process design and handling. The effect on the farm produce of processing machines could be either beneficial or disastrous depending on the objective of the processing the product. Certain materials could perfectly fit into engineering designs while others could result in failures and negative results leading to wear, tear and plastic deformation.

It was found that the values of all size dimensions, equivalent diameter, spherisity, angle of repose, angle of internal friction, true density, porosity, thousand pit volume, thousand pit weight was increases with increase in moisture content of the pits while the values of bulk density and cracking strength was decreases gradually with increase in moisture content of the pits. This was because of absorption of the moisture by pits (Fathollahzadeh, *et al*).

ANOVA of different properties with moisture content are given in Table. 2. The ANOVA indicated that length, width, thickness, equivalent diameter, sphericity, angle of repose and angle of internal friction of wild apricot pit were not significantly dependent on moisture content as the F-calculated value was less than the F-Table value at 5% level of significance. But true density, bulk density, thousand kernel weight, thousand kernel volume and cracking strength varied significantly with moisture content as it is indicated by the higher value of F-calculated than the F-table value at 5% level of significance.

Conclusion

Some engineering properties of wild apricot pits grown in hilly areas of Uttarakhand state of India, which may be useful in designing equipment for postharvest handling and processing operations were determined. The change in the properties of pits with moisture content was also observed during study hence this appeals important consideration during engineering designing of the equipments or process. Statistical test showed that there are significant differences between the properties of the two different conditions of the wild apricot pits. It was established that the determined properties are vital for the design of postharvest handling and processing equipment for wild apricot pits.

References

Ahmadi Hojat, Hamzeh Fathollahzadeh and Hossein Mobli. 2009. Post harvest physical and mechanical properties of apricot fruits, pits and kernels (c.v. *Sonnati Salmas*) cultivated in Iran. *Pakistan Journal of Nutrition* **8** (3) : 264-268.

Anazodo, U.G.N., 1983. Force-deformation Analysis for Biomaterials in Radial Compression: Maximum Contact Stress. *Nigerian Journal of Technology* **5** (2): 1 – 10.

AOAC, 1995. Official Methods of Analysis, 16th Ed. Association of Official Analytical Chemists, Washington, DC.

Chukwu, O. and F.B. Akande, 2007. Development of an Apparatus for Measuring Angle of Repose of Agricultural Materials. *Assumption Univerasity Journal of Technology* **11**(1): 62–66.

Curray, J. K., 1991. Analysis of Sphericity and Roundness of Quarts Grain. MSc Thesis in Mineralogy. The Pennsylvania State University, U.S.A.

Esref, I. and U. Halil, 2007. Moisture-dependent Physical Properties of White Speckled Red Kidney Bean Grains. *Journal of Food Engineering* **82**: 209 – 216.

Fashina, A.B., 1996. Some Physical and Aerodynamic Properties of Seed as Related to Mechanical Decortications. MSc Thesis, Department of Agricultural Engineering University of Ibadan, Nigeria.

Fathollahzadeh, H., H. Mobli, B. Beheshti, A. Jafari and A.M. Borghei,. 2008**.** Effects of moisture content on some physical properties of apricot kernel (CV. *Sonnati Salmas*). *Agricultural Engineering International: the CIGR Ejournal. Manuscript FP 08 008*.

Gustustafson, T. and P. Kjelgard, 2000. Production and Preservation of Animal Feeds. Hill Book Company, New York. Heidarbeigi, K, H. Ahmadi, K. Kheiralipour and A. Tabatabaeefar, 2009. Some Physical and Mechanical Properties of Khinjuk. *Pakistan Journal of Nutrition* 8 (1): 74 – 77.

Ige, M.T., 1997. Measurement of Some Parameters Affecting the Handling of Losses of Some Varieties of Cowpea. *Agriculture Engineering Research* **22**:127 –133.

Jaeger, W. F., 1997. Mechanical Processing of Grains. *Journal of Food Science* **4**(2): 6 – 8.

Kale. K.B, A.B. Lende, P.B.Kadam, S.V.Rane and A.D.Dhakane. 2011. Modification and performance evaluation of pedal operated rotary type groundnut decorticator-cum-cleaner. *International Journal of Agriculture, Environment & Biotechnology* **4** (1): 67-72.

Mingjin, Y., H. Peixiang, Y. Ling and L. Qingdong, 2003. Experimental Research on Dynamic Friction Coefficients of Coated Rice Seeds. AMA, 34(1):18–20.

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

Mohsenin, N.N., 1986. Physical Properties of Plant and Animal

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X

Materials, 2nd Ed. Gordon and Breach Science Publishers, New York.

Olajide, J.O. and J.C. Igbeka, 2003. Some Physical Properties of Groundnut Kernels. Journal of *Food Engineering* **58**: 201 – 204.

Omobuwajo, O.T., A.E. Akande and A.L. Sann, 1999. Selected Physical, Mechanical and Aerodynamic Properties of African Breadfruit (*Treculia africana*) Seeds. *Journal of Food Engineering* **40**: 241 – 244.

Ryder, G. R., 1996. A Model for Predicting the Effect of Moisture Content on the Modulus of Elasticity of Soybean. Trans. *American Society of Agricultural Enginers* **24**(5): 1338 –1341.

Sooch Sarbjeet Singh and Anand Gautam. 2013. Present Status of Renewable Energy Sources in Punjab, *International Journal of Agriculture, Environment & Biotechnology*, **6**(2): 317-333.

Waziri, A.N. and J.P. Mittal, 1997. Design Related Physical Properties of Selected Agricultural Products. AMA **14** (1): 59 – 62.

