
SOME PHYSICAL PROPERTIES OF SELECTED VEGETABLE

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ABSTRACT

Physical attributes of biomaterial are needed as parameter in computer simulation of deformation of Agricultural and Food material under compressive loading using Discrete Element method. In this study, two vegetable namely chilli pepper (*Capsicum frutescens*) and bell pepper (*Capsicum annum*) were selected and some physical properties (mass, major diameter, intermediate diameter, minor diameter, and volume) at 10.88% w.b and 9.79% w.b moisture content were determined using standard methods. The results of the study show that the frequency distributions of each of the size of the two pepper varieties follow a normal distribution curve. The average geometric mean diameter and sphericity of bell pepper are 43.94mm and 64.23% while that of chilli pepper are 25.55mm and 86% respectively. The mean mass, volume, true density and bulk density for bell pepper were 29.91g, 27.75cm³, 1.117gcm⁻³ and 0.52gcm⁻³ while that of chilli pepper were 8.4g, 8.23cm³, 0.90gcm⁻³ and 0.41 gcm⁻³ respectively. These data are useful in the design and development of handling and processing machines

Keywords: DEM, bell pepper, chilli pepper, physical properties

INTRODUCTION

Physical properties are important in many problems associated with the design of machines and the analysis of the behaviour of the product during agricultural processing operations such as handling, planting, harvesting, milling, threshing, cleaning, grading, sorting and drying. The solution to problems of these processes involves knowledge of the physical properties [1]. This was corroborated by [2] that in the design of any agricultural handling and processing machine, properties of the crop must be taken into account. He listed some of these as the crop size; shape, mass, hardness, volume, angle of repose, moisture content, kernel and bulk density. Weight (Mass) and volume are also useful in mathematical and computer modeling of handling and processing operations where the behaviour of the bulk system is predicted from the microscopic behaviour especially individual crop [3], [4].

Discrete Element Method (DEM) is a numerical method that permits a step –by- step determination of interaction between discrete particle in a medium over a time step. Mechanical properties like particle displacement, inter-particle forces, stresses, strain, deformation and shape change can be modeled using DEM. Knowledge of the physical properties of the bulk materials must be included as parameter in the discrete element modeling [5]. Mass, volume, surface area, dimensions, apparent volumetric, real volumetric, geometric mean diameter, packaging coefficient, porosity, sphericity and static friction angle were measured through experiment. These properties determine the quality and identification of correlation among these properties makes quality control easier [6].

Bell pepper, commonly called as *tatase*, and chilli pepper, commonly called *rodo*, is an important aspect of diet and are widely consumed in almost every part of Nigeria. It is either eaten raw, cooked or used commonly in making paste; pickles and sauce. It is also used as a spice and flavour ingredient in food industries. In Africa, Nigeria is the largest producer or cultivator of pepper and is often selected on the basis of flavour rather than appearance and it is probably true that flavour is inversely related to size and appearance [7]. Pepper due to their high moisture content increases the rate of microbial action in them which make them to be readily subjected to deterioration and post-harvest losses. However, they are usually in short supply during dry season because they are perishable crops which deteriorate within a few days after harvest. Preserving these crops in their fresh state for months has been problem that is yet to be solved [8]. The methods employed in their processing are still traditional. It becomes imperative to characterize the products with a view to understand their microscopic and macroscopic behavior that may affect the design of specific machine to handle their processing.

Due to large scale indigenous production, high rate of consumption, high commercial exploitation of peppers and variation in their characteristics from place to place there is a need for a comprehensive study of their physical properties to develop appropriate technologies for their processing. Development of these technologies will require the properties of the products. The objective of this work is, therefore, to determine some physical properties of two pepper varieties useful in design and development of handling equipment.

MATERIALS AND METHODS

Two varieties of pepper (Bell and Chilli) were randomly selected at local market in Ibadan, Oyo state. Two hundred pieces of each pepper variety were randomly selected and their physical properties were determined.

In order to obtain the moisture content of the two peppers, samples of known masses were kept in an electric oven for 17hours at 50°C. Weight loss on drying to a final constant weight was recorded as moisture content and was replicated five (5) times. The moisture content was calculated on wet basis using equation (1);

$$(1) \quad M.C = \frac{M_o - M_d}{M_o} \times 100$$

Where, M.C is Moisture Content (W.b), M_o is initial mass (g), M_d is final mass (g) of the two peppers.

Mass of individual pepper of the two varieties was determined using an electronic weighing balance with a sensitivity of 0.01g. The mass of the pepper were taken with the stock. Volumes of the peppers were measured by water displacement method [9]. For this purpose, individual pepper was submerged into a known volume of water and the volume of water displaced was recorded.

Three mutually perpendicular axes; "a" major, (the longest intercept), "b" intermediate (the longest intercept normal to a), and "c: minor, (the longest intercept normal to a, b) of the peppers were measured using digital Vernier caliper (Carrera Precision model CP8812-T 12-Inch Titanium Digital LCD Calliper Micrometer, United States) The mean, ranges and standard deviation were then reported for the two peppers. The Sphericity for each pepper was calculated using equation (2) [10], [11], [12].

$$\text{SPH} = \frac{\text{Geometric Mean Diameter}}{\text{Major axis (a)}} \quad (2)$$

The geometric mean diameter for each replication was computed using the equation (3). [13], [14].

$$\text{GMD} = (a b c)^{1/3} \quad (3)$$

Where, a, b, c are major, intermediate and minor diameters of the two peppers respectively.

The bulk density was determined using the mass and volume relationship [15] by filling an empty plastic container of predetermined volume and mass with peppers poured from a constant height and weighed. Then the bulk density was computed using equation (4). This process was replicated ten (10) times.

$$\rho_b = \frac{M}{V} \quad (4)$$

Where, ρ_b is the bulk density (g/cm^3), M is the Mass of pepper (g) and V is the plastic container volume (cm^3)

True density is defined as the ratio of the given mass to volume. The volume and density was determined by water displacement method as described by [16]. To accomplish this, a graduated measuring cylinder was filled with water to certain level. Pepper of known mass was submerged in the cylinder resulting in rise in the level of water. The true density was calculated for each of the ten (10) replications from the equation (5).

$$\rho_t = \frac{\text{Mass of the pepper (g)}}{\text{Volume of Water displaced (cm}^3\text{)}} \quad (5)$$

Porosity (ε) was calculated as the ratio of the differences in the pepper density (true density and bulk density) to the true density using equation (6) value and expressed in percentage [17];

$$\varepsilon = \frac{\rho_t - \rho_b}{\rho_t} \times 100 \quad (6)$$

RESULTS AND DISCUSSIONS

The summary of the result for all the parameters measured were collated, analyzed and presented in table1. Descriptive statistics were used to determine mean value, range of values (maximum and minimum) and Standard Deviation (STDEV.).

The average moisture content of 10.88%w.b and 9.79%w.b were reported for Bell Pepper and Chilli Pepper respectively and this serves as the moisture level at harvest and the

basis at which all measured parameters were obtained. The values obtained from each replication were calculated using Equation (1). The variation among the values obtained for the five replicates fall within 0.2% as recommended under International Seed Testing Association rules [18]. Moisture content determination is important as it is a vital parameter which is an influential factor on all crops processing procedures and other physical properties. It is dynamic and can fluctuate greatly due to changes in seasonal temperature because of the effect of relative humidity.

The average mass of 29.91g and 8.40g were reported for Bell and Chilli Pepper respectively, at harvest moisture level. The average volume obtained for Bell and Chilli Pepper are 27.75cm³ and 8.23cm³ respectively using water displacement method. Bell pepper had the highest values for mass and volume, while chilli pepper had the smallest. The value obtained for major, intermediate and minor diameter ranges from 34.35mm – 109.66mm, 19.03 – 68.08mm and 12.85 – 55.37mm with mean of 69.51mm, 38.93mm and 32.26mm respectively for Bell Pepper. While Chilli Pepper had its major, intermediate and minor diameter ranges from 10.61 – 46.60mm, 10.00 – 39.00mm and 10.91 – 38.48mm with the mean of 30.38mm, 24.43mm and 23.06mm respectively. The skewness and kurtosis analysis for the frequency distribution curve for the 200 readings taken for each dimension shown in Fig. 1 are presented in Table 1. The curves show normal distribution for all the dimensions of the two pepper varieties with the peaks being around the means. This is an indication that the axial dimensions are relatively uniform and these are useful information in the design of separation and size reduction systems. Skewness characterizes the degree of symmetry of a distribution around its mean. Positive skewness indicates a distribution with an asymmetric tail extending towards more positive values (skewed to the right) and vice versa for negative. Kurtosis characterizes the relative peakedness or flatness of a distribution compared to the normal distribution [18]. These properties will be useful in characterizing the peppers and also required in designing machines for their processing.

The sphericity was computed with equation (2) from the data. The average value reported were 64.23%, 86.00% and 10.51mm, 13.83mm as the mean and the standard deviation for Bell pepper and Chilli Pepper respectively. The result for sphericity falls within the range for most seeds as reported by [19], [20] for red pepper (52%), [21] for wild sunflower (54%), [22] for sorrel (68.6%), and [23] for kiwi (69%). Sphericity increases with decrease in size with the small size having the highest sphericity [12]. The pepper with the largest major diameter did not have either the largest intermediate or minor diameter, irregularity in shape and size might be responsible for these. Sphericity is a property required in the design of hopper and chutes and other storage facilities.

The geometric mean diameter for the two vegetable fruits were computed from equation (3) and the average value obtained were 43.95mm for Bell Pepper and 25.55mm for Chilli Pepper with 7.46mm and 4.56mm as standard deviation respectively. It was observed that an increase in pepper size leads to an increase in the geometric mean diameter of that pepper which then result in the pepper with the least or smallest minor diameter or thickness having the least geometric mean diameter. [24]; the geometric mean of axial dimension is useful in defining the characteristics dimension for irregular solid.

The value obtained for bulk density ranges from 0.44g/cm^3 – 0.57g/cm^3 and 0.37g/cm^3 – 0.44g/cm^3 for bell and chilli peppers respectively, which were computed from equation (4). Bulk density is an indicator of quality and predicate of breakage susceptibility and hardness study.

The computation of true density ranged from 1.0070g/cm^3 – 1.6427g/cm^3 with average mean of 1.17403g/cm^3 for bell pepper and 0.7428g/cm^3 – 1.4460g/cm^3 with average mean value of 0.9010g/cm^3 for chilli pepper. This property is useful in computing product yield and the throughput in processing machinery. It is also useful in mathematical conversion of pepper mass to volume and influences its texture. Porosity shows the relationship between bulk and true density and the extent of pore space in the pepper mass. The average value obtained using equation (5) were 54.78% and 53.74% for bell and chilli pepper respectively. This attributes is required in allowing gases such as air, liquid to circulate through a mass of particles in aeration, drying, heating, cooling and distillation operation

CONCLUSION

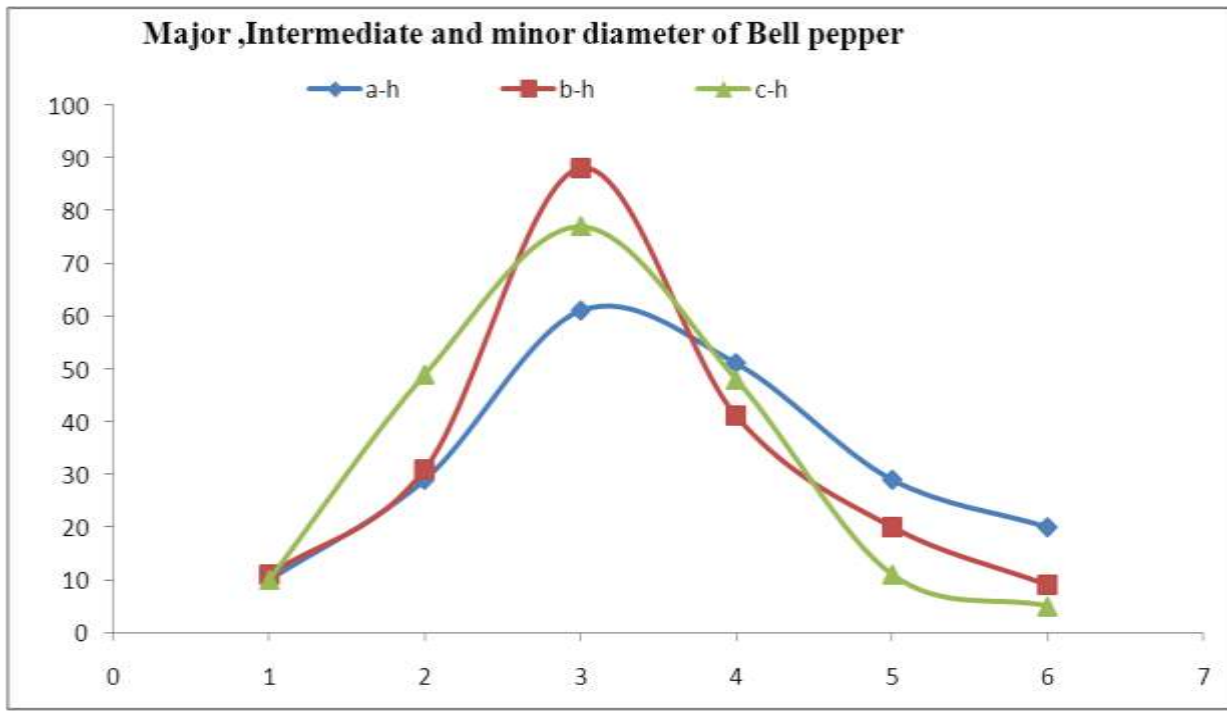
The following observations and conclusions were deduce from the study of the physical attribute of the selected vegetable

1. The average moisture content of 10.88% and 9.79% were reported for bell and chilli pepper as the basis at which all measured parameters were obtained.
2. The average mass and volume of the 200 observed bell and chilli pepper were 29.91g, 8.40g, 27.75cm^3 and 8.23cm^3 respectively.
3. The mean value obtained for major, intermediate and minor diameter for bell pepper are 69.51mm, 38.93mm and 32.26mm while for chilli pepper were 30.38mm, 24.43mm, and 23.06mm respectively.
4. The true density, bulk density and porosity 1.117gcm^{-3} , 0.52gcm^{-3} and 54.78% for bell pepper and 0.90gcm^{-3} , 0.41gcm^{-3} and 53.74% for chilli pepper.

Table 1: Physical Properties of Two Varieties of Pepper (Bell, Chilli)

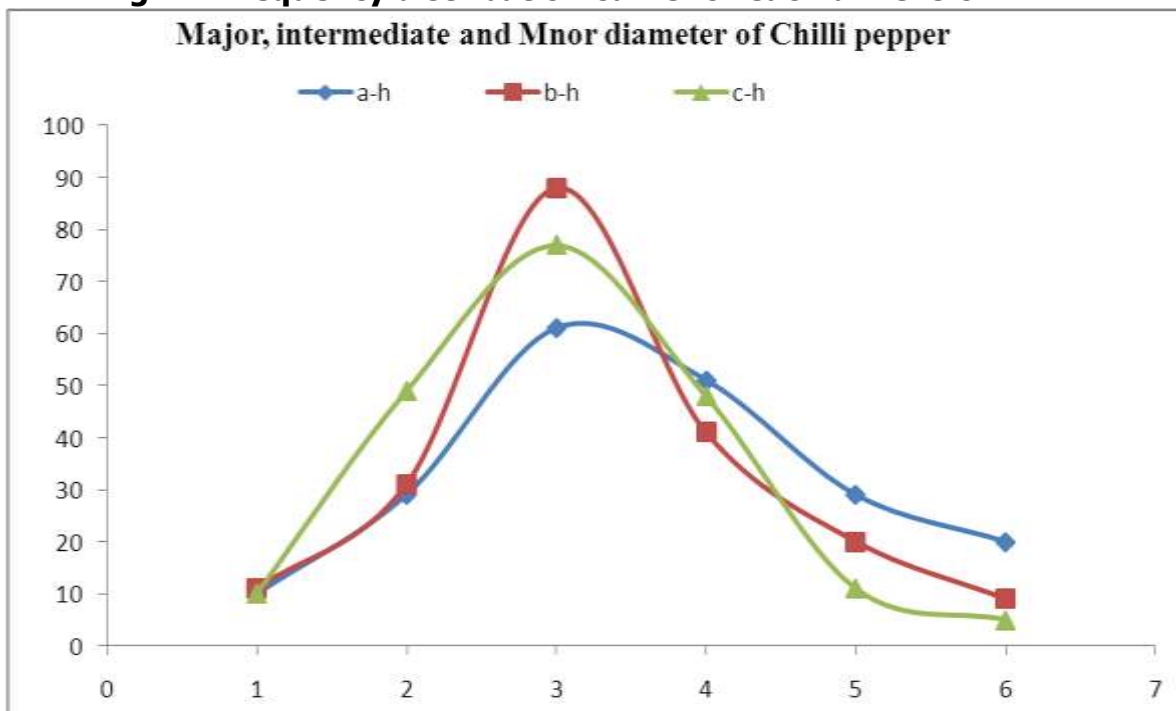
Variety / Statistical Value	Parameter											
	a	b	c	M	V	BD	TD	GMD	SPH	PR	MC	
	(mm)	(mm)	(mm)	(mm)	(mm)	(g)	(cm ³)	(g/ cm ³)	(g/ cm ³)	(g/ cm ³)	(g/ cm ³)	(g/ cm ³)
BELL												
No. of Observation	200	200	200	200	200	10	10	200	200	10	5	
Mean	69.51	38.93	32.26	29.91	27.75	0.52	1.17	43.95	64.23	54.78	10.88	
Maximum	109.66	68.08	55.37	89.77	95.00	0.57	1.64	67.57	89.06	68.85	11.10	
Minimum	34.35	19.03	12.85	12.91	5.00	0.44	1.01	20.33	41.14	43.33	10.54	
STDEV	12.48	8.26	8.09	14.31	15.80	0.042	0.22	7.46	10.51	8.32	0.22	
Skewness	0.215	0.473	0.344	-	-	-	-	-	-	-	-	-
Kurtosis	-0.188	0.395	-0.089	-	-	-	-	-	-	-	-	-
CHILLI												
No. of Observation		200	200	200	200	200	10	10	200	200	10	5
Mean	30.38	24.43	23.06	8.40	8.23	0.41	0.90	25.55	86.00	53.74	9.79	
Maximum	46.60	39.00	38.48	14.89	25.00	0.44	1.45	39.41	129.03	70.98	9.98	
Minimum	10.61	10.00	10.91	3.98	3.00	0.37	0.74	10.50	51.81	44.88	9.67	
STDEV	6.63	5.51	5.00	2.13	3.47	0.020	0.20	4.56	13.83	7.13	0.14	
Skewness	0.042	0.123	0.410	-	-	-	-	-	-	-	-	-
Kurtosis		0.004	0.223	0.498	-	-	-	-	-	-	-	-

a, b, c – Diameter; M – Mass; V – Volume; BD – Bulk Density; TD – True Density; GMD – Geometric Mean Diameter; SPH – Sphericity; Pr – Porosity; MC – Moisture Content..



Major diameter(mm)	34.0- 56.0	56.0 - 65.0	65.0 - 75.0	75.0 - 85.0	85.0 - 89.0	89.0 - 110.0
Intermediate diameter (mm)	19.0 - 28.0	28.0 - 35.0	35.0 - 40.0	40.0 - 45.0	45.0 - 50.0	50.0 - 69.0
Minor diameter(mm)	12.0 - 20.0	20.0 - 25.0	25.0 - 30.0	30.0 - 40.0	40.0 - 45.0	45.0 - 56.0

Fig. 1: Frequency distribution curve for each dimension



Major diameter	34.0- 56.0	56.0 - 65.0	65.0 - 75.0	75.0 - 85.0	85.0 - 89.0	89.0 - 110.0
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Intermediate diameter	19.0	–	28.0	–	35.0	–	40.0	–	45.0	–	50.0	–
Minor diameter	12.0	–	20.0	–	25.0	–	30.0	–	40.0	–	45.0	–
	20.0		25.0		30.0		40.0		45.0		56.0	

Fig. 2:. Frequency distribution for the axial dimensions of the two pepper varieties

REFERENCES

- ¹. Irtwange, J. A (2000). Biotechnology Development in Tropical vegetable. Proceedings of
- ².Kutte, S . k, V. K. Nema and R. K. Bhardwaj. (2001). Physical properties of grain. Journal of Agricultural Engineering research 39, Pp259-268
- ³ Rong, G., Negi, S. C and Jofriet, J. C (1995). Simulation of the flow behavior of solids in bins. Part 2 : Shear bands, flow, corrective inserts and velocity profile. Journal of Agricultural engineering Research,62, 257-269
- ⁴ Raji , A.O and Favier, J.F (2004) Model for the deformation in agriculture and food particulate material under bulk compressive load using discrete element method. I: Theory, model development and validation. Journal of food engineering ,64 (2004),359-371.
- ⁵ Landry, H., Roberge, M and C. Laguë. (2003). DEM Modelling of Solid and semi-solid Manure Handling and Land Equipment as related to selected Physical and Flow properties. Proceedings of Ninth International Animal and food processing wastes. ASAE publication no 701P1203
- ⁶ Jannatizadeh, M.H (2008). A study on some chemical and physico-mechanical properties of three sweet cherry varieties (*prunus avium L.*) in Turkey. Journal of Food Engineering 74: 568 -575
- ⁷ Wikipedia – Free Encyclopedia, (2010); Retrieved from <http://en.wikipedia.org/wiki/capsicum>
- ⁸ Tunde-Akintunde T. Y; T. J. Afolabi and Akintunde B. O (2005); Influence of Drying Methods on Drying of Bell Pepper (*Capsicum annum*). J. Food Engin, 68: 439 – 442
- ⁹ Khanali,M., Ghasemi,M., Varnamkhasti, Tabatabaeefar,A., and H. Mobli. (2007). Mass and volume modelling of tangerine (*Citrus reticulata*) fruit with some physical attributes. International Agrophysis 21, 329-334
- ¹⁰ Henderson, S. M. and Perry, R. L. (1986); Agricultural Processing Engineering 2nd edition. The AVI Publ. Co. Inc., West Point Connecticut. Pp 33.
- ¹¹ Asoegwu, S. N., S. O. Ohanyere, O. P. Kanu and C. N. Iwueke. (2006); Physical Properties of African oil bean seed (*Pentaclethra macrophylla*). Agricultural Engineering International: the CIGR E journal, manuscript FP 05 006. Vol. VIII.

- ¹² Faleye, T. and Atere, A. O. (2009); Determination of Some Physical and Mechanical Properties of Some Cowpea varieties. Proc of 3rd International Conference of WASAE and 9th International Conference of WASAE and NIAE. Pp 239 – 243.
- ¹³ Jain, R. K. and Bail, S. (1997); Properties of Pearl Millet J. of Agricultural Engineering Res. 66: 85 - 91
- ¹⁴ Tunde-Akintunde T. Y and Akintunde B O (2004). Some physical properties of sesame seed. Journal of Biosystems Engineering, 88(1),127–129
- ¹⁵ Keramat Jahromi M., Rafiee S., Jafari A., Tabatabaeefar A., 2007. Determination of dimension and area properties of date (Berhi) by image analysis. Proc. Int. Conf. Agricultural, Food and Biological Engineering and Post Harvest/ Production Technology, 21-24 January, Khon Kaen, Thailand.
- ¹⁶ Oje K and E. C. Ugbor, (1991). Some physical properties of oil bean seed. Journal of Agricultural Engineering Research, 50, 305 - 313
- ¹⁷ Akaaimo D. I. and Raji A.O. (2006): Some Physical and Engineering properties of prosopis Africana seed. Journal of Biosystems Engineering 95 (2) 175 - 205.
- ¹⁸ ISTA, 2009. *International Rules for Seed Testing*. A Publication of the International Seed Testing Association.
- ¹⁹ Mohsenin N.N., 1986. Physical Properties of Plant and Animal Materials. Gordon and Breach Sci., New York, USA.
- ²⁰ Ucer, N ; Kilickan, A and I. Yalcin. (2010). Effect of moisture content on some physical properties red pepper (*capsicum annum.L*) seed. African journal of Botechnology 9 (24), 3555- 3562
- ²¹ Perez, E.E; Crapiste G.H and A.A.Carelli. (2007). Some Physical and morphological properties of wild sunflower seed. Journal of Biosystem engineering 96 (1), 41-45
- ²² Omobuwajo, T. O., Sanni, L. A. and Y.A Salami (2000): Physical properties of sorrel seeds. Journal of Food Engineering, 45, 37 – 41
- ²³ Jahromi,M.H, Jafari,.A, Rafiee,S., Keyhani,A.R, Mirasheh,A., and S.S. Mohtasebi (2007). Some Physical properties of Date Fruit (cv. Lasht). Agricultural Engineering International: the CIGR Ejournal. Manuscript FP 07 019. Vol. IX.
- ²⁴ Henderson, S. M. and Pabis S., (1962); Grain Drying Theory IV: the effect of airflow rate on drying index. J. of Agric. Engn. Res. 7(2): 85 - 89