Moisture related physical properties of drum-roasted cashewnut

■ **S.K. SWAIN, J.P. GUPTA** AND **B.R. NAYAK**

See end of the Paper for authors' affiliation

Correspondence to :

B.R. NAYAK
AICRP on Water Management, Regional Research and Technology Transfer Station (O.U.A.T.), Chiplima, SAMBALPUR (ODISHA) INDIA
Email : biswa.nayak@yahoo. co.in

■ **ABSTRACT :** A study on physical properties of drum roasted cashew nuts of three different sizes was conducted within the moisture content range from 6.75 - 13.52 per cent. The three basic dimensions *i.e.* length, width and thickness of the cashew nuts were found to vary within the range of 25.12 mm to 36.59 mm, 20.56 mm to 25.81 mm and 15.35 mm to 19.42 mm, respectively irrespective of the moisture content and the nut size. The values of equivalent diameter, sphericity and shell thickness were observed to be within the range of 19.35 mm to 25.11 mm, 0.771 to 0.698 and 3.47 mm to 6.35 mm, respectively under the given conditions. The unit weight and bulk density of the nuts were found to vary within the range of 4.11 g to 8.41 g and 0.372 g/mm^3 to 0.421 g/mm^3, respectively.

■ **KEY WORDS :** Roasted cashew nuts, Thickness and equivalent diameter, Bulk density, True density

Today, India is the largest producer, processor, exporter, importer and second largest consumer of cashew nut in the world; thus has a near monopoly in the cashew sector in global market.The cashew nut processing industry in Indian context has been mostly confined to the rural sector, where the conventional manual hand beating method for shelling of drum-roasted cashew nuts is predominantly in practice. This method is very tedious , time consuming and labour intensive with lower output and as such lacks desirable quality control standards for export at international level. In this context the mechanization of cashew nut shelling operation needs to be addressed with priority for development of a simple, low cost and easily maneuverable technology for shelling roasted cashew nut. Knowledge of physical properties of any plant material such as shape, size, volume, surface area, density, porosity and appearance are associated with design of a specific machine or analysis of the behavior of the product in handling of the material (Ige, 1977). It is, therefore, imperative to study the physical properties of drum-roasted cashew nut while making an attempt to design a cashew nut sheller. Kumar (1989) determined the physical characteristics and properties of raw cashew nuts, roasted cashew nuts and cashew kernels following standard technique and procedures. The results indicated that the overall length, breadth and thickness of raw cashew nut, roasted cashew nut and cashew kernels were 26.49 ×21.08 ×15.4 mm, 27.33 × 21.66 × 16.84

mm and 21.62 × 12.40 × 10.39 mm, respectively. The sphericity ranged from 0.75 to 0.88 for roasted cashew nut. The test weight of one hundred roasted cashew nuts were found to be were 196.2, 286.2 and 373 g for small, medium and large size, respectively. The average values of bulk density roasted cashew nuts were found to be 306.36 kg/m^3. The porosity was found to be 45.42 per cent for roasted nuts. The specific gravity of cashew nut ranged from 0.50 to 0.60 for roasted nuts. Balasubramanian (2001) evaluated the physical properties of raw cashew nut as a function of moisture content. It was found that the 100 nut mass and true density of raw cashew nuts increased with increased moisture content. The porosity and bulk density decreased linearly as the moisture content increased. The physical properties of drum-roasted cashew nuts with respect to their size and moisture content have been studied under the present investigation, which would find application for design and development of a cashew nut sheller.

■ **METHODOLOGY**

The drum-roasted cashew nuts were collected from M/s Maa Mangala Cashew Nut Processing Unit, Mendhasala located near Bhubaneswar in 2010. The operating parameters of drum-roasting method *i.e.* feed rate, speed of rotation of roasting drum and the rate of water sprinkling were varied to obtain samples of varying moisture contents which were

allowed to equilibrate for 48 hours at room temperature. The moisture contents of the samples were selected to be 6.75, 7.33, 8.84, 9.41, 10.20, 11.57 and 13.52 per cent considering the practical condition of shelling of drum-roasted cashew nuts. The physical properties such as linear dimensions, equivalent diameter, surface area, unit weight, sphericity, specific gravity, true density, bulk density and porosity of drum roasted cashew nuts were determined for three different sizes on the basis of the length of the nuts (S_1:<30 mm, S_2:30-35 mm and S_3: >35 mm) as suggested by Subramanian (2001) at above mentioned seven levels of moisture contents. For each individual nut the three principal dimensions namely length, width and thickness (l, b, and t) were measured using a digital micrometer, which had accuracy of 0.01 mm. Observations were taken for three different sizes of the nuts under seven levels of moisture contents. The equivalent diameter was expressed as cube root of product of three mutually perpendicular lengths. The volume of individual nut was calculated from the principal dimensions earlier measured. The sphericity was found out as the ratio of diameter of a sphere of same volume as that of the particle and the diameter of smallest circumscribing circle (Mohsenin, 1970). 100 cashew nuts were taken from the lot and weight of the individual cashew nut was measured with the help of electronic balance. The true density was determined by toluene displacement method (Singh and Goswami, 1996). The bulk density represents the apparent density of the cashew nut and was measured using cylindrical container (495 mm in height, 380 mm in diameter and 2 mm in thickness) (ASAE Standards, 2001). The porosity was found out as the percentages of volume of inter nut space to the total volume of the nut in bulk (Thompson *et al.*, 1967). The surface area was determined by graphical method.

■ RESULTS AND DISCUSSION

The results on length, width and thickness of drum-roasted cashew nut with respect to moisture content and size have been presented in Fig. 1-3. The mean values of the length were found to vary within the range from 30.606 to 31.944 mm as the moisture content varied from 6.75 per cent to 13.52 per cent. The mean values of length of the three different sizes (S_1, S_2 and S_3) were observed to be 26.091, 31.847 and 36.065 mm, respectively. The width of the nuts varied from 22.833 to 23.861 mm as the moisture content varied from 6.75 per cent to 13.52 per cent irrespective of nut sizes. The mean width of three sizes of nuts (S_1, S_2 and S_3) was observed to be 21.162, 23.656 and 25.06 mm irrespective of the nut moisture contents. The thickness of the nuts was found to vary from 17.307 to 18.428 mm as the moisture content varied within 6.75 to 13.52 per cent. The mean values of thickness of three different sizes (S_1, S_2 and S_3) were observed to be 16.254, 18.231 and 19.141 mm, respectively.
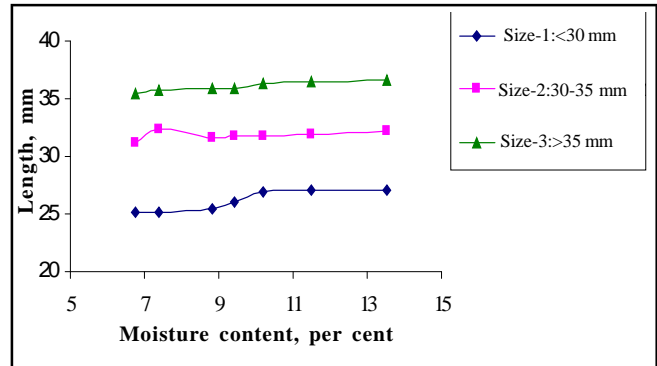

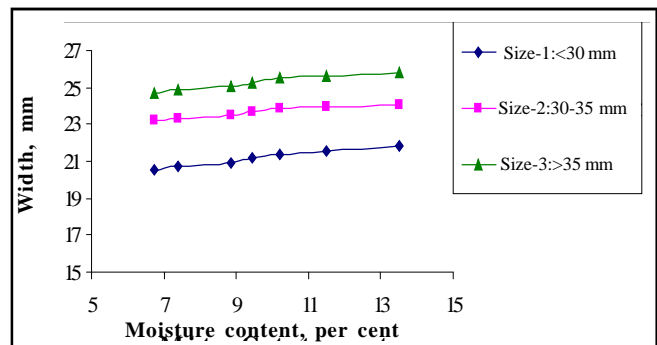**Fig. 1 :** Effect of moisture content and size on length drum-roasted cashew nut

Fig. 2 : Effect of moisture content and size on width of drum-roasted cashew nut
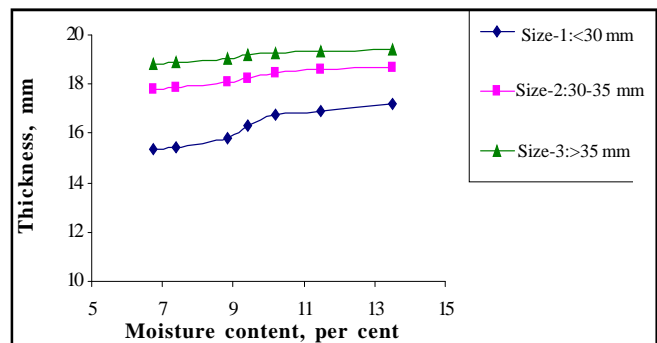

Fig. 3 : Effect of moisture content and size on thickness of drum-roasted cashew nut

The results on effect of moisture content and nut size on equivalent diameter (Fig. 4) were found to be statistically significant. The mean equivalent diameter of cashew nut was observed to increase from 22.238 to 23.367 mm with increase in moisture content from 6.75 to 13.52 per cent irrespective of nut size. The mean equivalent diameters of the three different sizes of cashew nuts (S_1, S_2 and S_3) were found to be 20.159, 23.163 and 25.112 mm, respectively. The results unit weight, shell thickness and true volume of the drum-roasted cashew nuts have been presented in Fig. 5-7. The mean unit
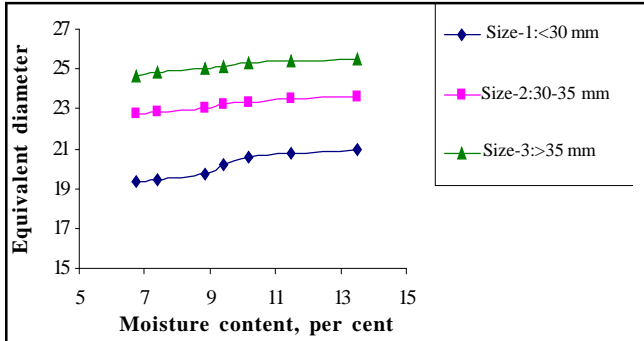
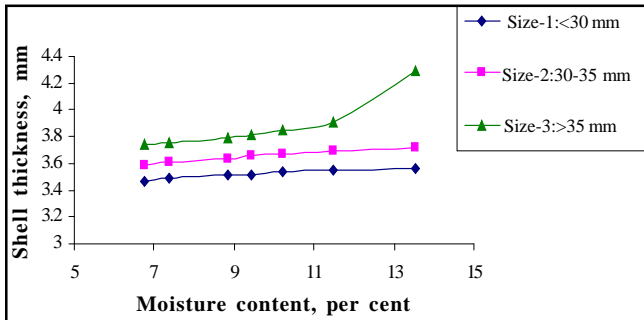**Fig. 4 : Effect of moisture content and size on equivalent of drum-roasted cashew nut**

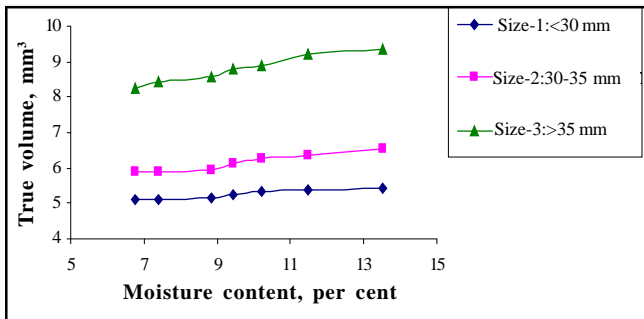**Fig. 5 : Effect of moisture content and size on shell thickness of drum-roasted cashew nut**

Fig. 6 : Effect of moisture content and size on true volume of drum-roasted cashew nut
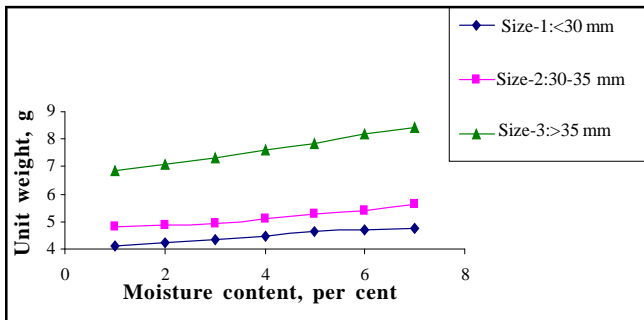

Fig. 7 : Effect of moisture content and size on unit weight of drum-roasted cashew nut

weight of the nuts was observed to vary from 5.263 to 6.273 mg within moisture content range of 6.75-13.52 per cent. The mean unit weight of the nuts of three different sizes (S_1, S_2 and S_3) was found to be 4.47, 5.141 and 7.621 mg, respectively. The shell thickness was found to vary from 3.6 to 3.857 mm with respect to the moisture content variation from 6.75 to 13.52 per cent. The shell thickness of the three different sizes of nuts (S_1, S_2 and S_3) were fond to be 3.52, 3.654 and 3.877 mm, respectively. The mean true volumes of nuts were found to vary within the range 6.41-7.10 mm³ irrespective of the nut size as the moisture content varied within 6.75-13.52 per cent. The mean true volumes of the nuts of three sizes (S_1, S_2 and S_3) were observed to be 5.256, 6.139 and 8.793 mm³ irrespective of the moisture content variation.

The results on effect of moisture content and nut size on sphericity, surface area and specific gravity of the roasted cashew nuts (Fig. 8-10) were found to be statistically significant. The sphericity of the nut was found to vary within 0.731 to 0.736 with the increase of moisture content from 6.75 to 13.52 per cent irrespective of the nut size. The mean values of sphericity of three different sizes of nut S_1, S_2 and S_3 were observed to be 0.773, 0.731 and 0.693, respectively irrespective of moisture content variation within 6.75 to 13.52 per cent. The highest and lowest values of sphericity were noticed at 9.43 per cent moisture content incase of S_1 size and S_3 size, respectively. The mean values of surface area of the
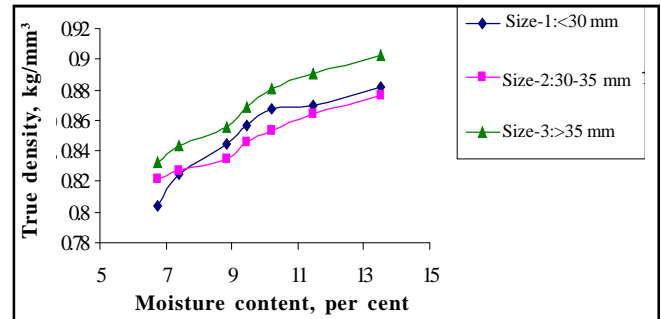

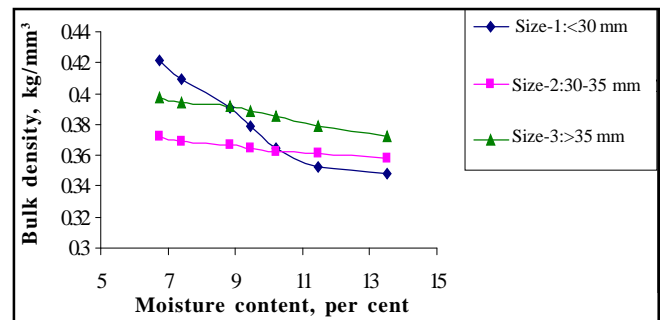**Fig. 8 : Effect of moisture content and size on true density of drum-roasted cashew nut**

Fig. 9 : Effect of moisture content and size on bulk density of drum-roasted cashew nut
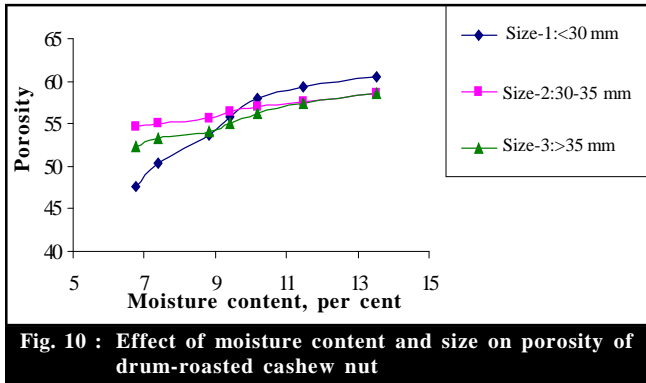
Fig. 10 : Effect of moisture content and size on porosity of drum-roasted cashew nut

per cent to 13.52 per cent. This may be due to higher weight increase of the nut in comparison with its volume expansion on moisture gain. The relation between the values of true density of the nuts with moisture content for three different sizes have been illustrated in equation 1-3.

$$\rho^T (S_1) = 0.011\ M + 0.7436 \quad (R^2=0.88) \quad (1)$$
$$\rho^T (S_2) = 0.0083\ M + 0.7656 \quad (R^2=0.98) \quad (2)$$
$$\rho^T (S_3) = 0.0107\ M + 0.7645 \quad (R^2=0.96) \quad (3)$$

where

$\rho^T (S_1)$ = True density of size S_1, g/mm^3
$\rho^T (S_2)$ = True density of size S_2, g/mm^3
$\rho^T (S_3)$ = True density of size S_3, g/mm^3
M = Moisture content, per cent

nuts increased from 1568.74 to 1726.531 mm2 with increase of moisture content from 6.75 to 13.52 per cent irrespective of the nut size. The mean values of surface area of the three different sizes of the cashew nuts S_1, S_2 and S_3 were observed to be 1278.034, 1686.149 and 1981.743 mm^2, respectively. However, the highest and lowest values of surface area were found as 2046.48 and 1176.69 mm^2 in case of S_3 size nut at 13.52 per cent moisture content and S_1 size at 6.75 per cent moisture content, respectively. The mean values of specific gravity increased from 0.825 to 0.893 with the increase of moisture content from 6.75 to 13.52 per cent irrespective of the nut size. The mean value of specific gravity of three different sizes S_1, S_2 and S_3 were found out to be 0.856, 0.852 and 0.874, respectively. However, the highest and lowest value of specific gravity were recorded in case of S3 size at 13.52 per cent moisture content and S_1 size at 6.75 per cent moisture content, respectively.

The results on true density of the roasted cashew nuts (Fig. 11) with respect to the variation in moisture content and nut sizes were found to be not significant statistically. The mean values of true density of the three different sizes (S_1, S_2 and S_3) were observed to be 0.85, 0.846 and 0.868 g/mm^3, respectively irrespective of the moisture content variation. The true density of the nut was found to increase from 0.820 to 0.887 kg/mm^3 with increase in moisture content from 6.75

The results on effect of moisture content and nut size on bulk density of drum roasted cashew nuts were found to be statistically significant (Fig. 12). The bulk density was found to decrease significantly with increase in moisture content of the drum roasted cashew nut within the range from 6.75 to 11.48 per cent; but increased with further increase in moisture content irrespective of the size of the nut. This shows that the increase in mass resulting from the moisture gain of the sample is lower than the accompanying volumetric expansion of the bulk. Similar trends have been reported for raw cashew nut and other biological materials (Balasubramanian, 2001; Gupta and Prakash, 1992). However, the highest and lowest bulk densities were recorded with size S_1 at 6.75 and 13.52 per cent moisture content, respectively. The relation between the values of bulk density of the nuts with moisture content for three different sizes S_1, S_2 and S_3 have been illustrated in equation 4-.6.

$$\rho^b (S_1) = -0.011\ M + 0.491 \quad (4)$$
$$\rho^b (S_2) = -0.002\ M + 0.3845 \quad (5)$$
$$\rho^b (S_3) = -0.0037\ M + 0.423 \quad (6)$$

where

$\rho^b (S_1)$ = Bulk density of size S_1, g/mm^3
$\rho^b (S_2)$ = Bulk density of size S_2, g/mm^3
$\rho^b (S_3)$ = Bulk density of size S_3, g/mm^3
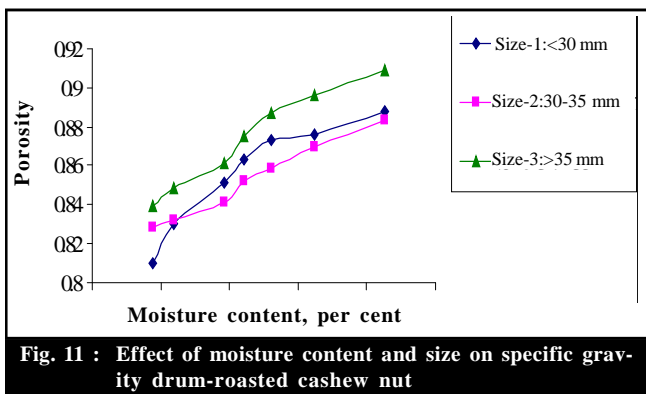M = Moisture content, per cent.

Fig. 11 : Effect of moisture content and size on specific gravity drum-roasted cashew nut
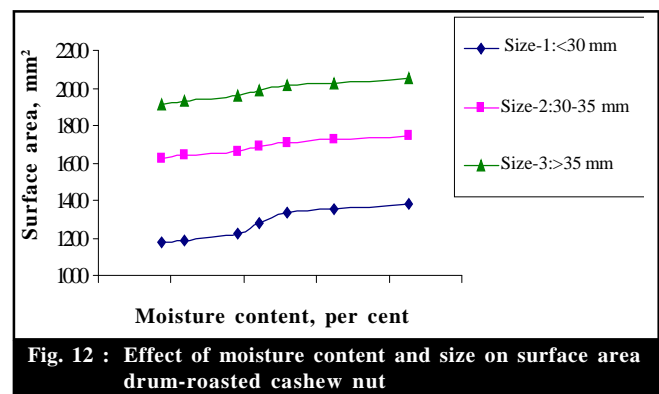

Fig. 12 : Effect of moisture content and size on surface area drum-roasted cashew nut

The results on effect of moisture content and nut size on porosity (Fig. 13) were found to be statistically significant. The porosity was observed to increase linearly from 51.53 per cent to 59.221 per cent with increase in moisture content from 6.75 to 13.52 per cent irrespective of the nut size. Similar trends for raw cashew nut and other grains have been reported (Balasubramanian, 2001; Gupta and Prakash, 1992). The relation between the values of porosity of the nuts with moisture content for three different sizes S_1, S_2 and S_3 have been illustrated in equation 7-9.
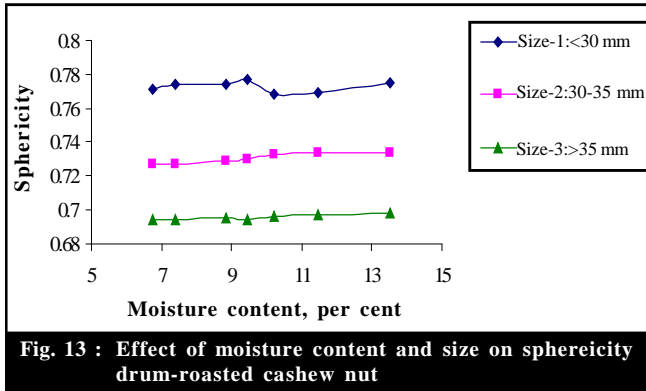

Fig. 13 : Effect of moisture content and size on sphereicity drum-roasted cashew nut

$$P(S_1) = 1.939\,M + 36.353 \qquad (7)$$
$$P(S_2) = 0.602\,M + 50.575 \qquad (8)$$
$$P(S_3) = 0.944\,M + 46.156 \qquad (9)$$
where
$P(S_1)$ = Porosity of S_1 size cashew nut
$P(S_2)$ = Porosity of S_2 size cashew nut
$P(S_3)$ = Porosity of S_3 size cashew nut
M = Moisture content, per cent

Conclusion:

Thus, the findings of the present study revealed that the three basic dimensions *i.e.* length, width and thickness of the cashew nuts were found to vary within the range of 25.12 mm to 36.59 mm, 20.56 mm to 25.81 mm and 15.35 mm to 19.42 mm, respectively irrespective of the moisture content and the nut size. The values of equivalent diameter, sphericity and shell thickness were observed to be within the range of 19.35 mm to 25.11 mm, 0.771 to 0.698 and 3.47 mm to 6.35 mm, respectively under the given conditions. The unit weight and bulk density of the nuts were found to vary within the range of 4.11 g to 8.41 g and 0.372 g/mm^3 to 0.421 g/mm^3, respectively . The effects of the moisture content and nut size on these parameters were found to be significant at 5% level.

Authors' affiliations:
S.K. SWAIN, AICRP on Utilization of Agricultural Energy, College of Agriculture Engineering and Technology, Orissa University of Agriculture and Technology, BHUBANESWAR (ODISHA) INDIA

J.P. GUPTA, Faculty of Agricultural Engineering, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, NADIA (W.B.) INDIA

■ REFERENCES

Balasubramanian, D. (2001). Cashew industries in Mozambique-An overview. *Agric. Mecha. Asia, Africa & Latin America.,* **33**(20): 63-66.

Gupta, R.K. and Prakash, S. (1992). The effect of seed moisture content on the physical properties of JSF-1 sunflower. *J. Oil Seeds Res.*, **9** : 209-216.

Ige, M.T. (1977). Measurement of some parameters affecting the handling losses of some varieties of cowpea. *J. Agric. Engg. Res.,* **22** (2) : 127-133.

Kumar, A. (1989). Studies on cashew nut processing and development of related equipment. Ph.D. Thesis. IIT, Kharagpur, India.

Mohsenin, N.N. (1970). *Physical properties of plant and animal materials.* Garden and Breach Science Publishers. pp175.

Singh, K.K. and Goswami, T.K. (1996). Physical properties of cumin seed. *J. Agric. Engg. Res.,* **64** (2): 93-98.

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