Research Article

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Effect of moisture content on physical properties of cashew nut of different varieties

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Abstract

The physical properties, *viz.,* geometric diameter, surface area, sphericity, volume, bulk density, true density and angle of repose was measured for four cashew varieties *viz.*, *Vengurle 1*, *Vengurle 3*, *Vengurle 4* and *Vengurle 7* at different moisture content (15 to 87% db). For *Vengurle 1* as the moisture content increased, the physical properties *i.e.*, geometric mean diameter, volume, surface area, true density and angle of repose increased from 20.8 to 22.1 mm, 3485 to 4416 mm^3, 1355 to 1540 mm^2, 984 to 1030 kg m^{-3} and 32 to 37^o, respectively. The sphericity and bulk density decreased from 74.2 to 71.4 per cent and 490 to 418 kg m^{-3} respectively. For *Vengurle 3* geometric mean diameter, volume, surface area, true density and angle of repose increased from 27.2 to 28.6 mm, 7912 to 9169 mm^3, 2320 to 2567 mm^2, 1020 to 1048 kg m^{-3} and 33 to 35.5^o, respectively. The sphericity and bulk density decreased from 75.5 to 75.2 per cent and 531 to 470 kg m^{-3} respectively. For *Vengurle 4* the geometric mean diameter, volume, surface area, true density and angle of repose increased from 21.0 to 24.1mm, 3362 to 5113 mm^3, 1391 to 1828 mm^2, 970 to 1030 kg m^{-3} and 32.5 to 38^o, respectively. The sphericity and bulk density decreased from 65.8 to 66.8 per cent, 517 to 462 kg m^{-3}, respectively. For *Vengurle 7* the geometric mean diameter, volume, surface area, true density and angle of repose increased from 24.2 to 24.9 mm, 5102 to 5547 mm^3, 1840 to 1941 mm^2, 998 to 1045 kg m^{-3} and 33 to 38^o , respectively. The sphericity and bulk density decreased from 65.4 to 65.8 per cent, 518 to 438 kg m^{-3}, respectively.

Keywords: Cashew nut, moisture content, physical properties, processing, variety

Introduction

Cashew is one of the most important evergreen tropical crops earning foreign exchange in India, mainly grown in Kerala, Karnataka, Goa, Maharashtra, Tamil Nadu, Andhra Pradesh, Odisha and West Bengal. Maharashtra state topped cashew nut production with 1,83,000 metric tonnes followed by Andhra Pradesh at 92,000 metric tonnes. Maharashtra ranks first in productivity with 1300 kg ha^{-1} followed by West Bengal (950 kg ha^{-1}) and Kerala (900 kg ha^{-1}) (Senthil andMahesh, 2013). The total area under cashew cultivation in India is 1.6 lakh ha, of which more than 18 per cent is in the South Konkan region of Maharashtra, mainly in Sindhudurg and Ratnagiri districts. The raw cashew nut is kidney shaped with soft, leathery outer skin (epicarp) and thin, hard inner skin (endocarp). Between these two walls of the shell is a honeycomb structure, which contains the phenolic material, commercially known as cashew nut shell liquid (CNSL) (Ohler, 1979). The kernel is inside the shell wrapped in a thin brown skin known as the testa. Cashew nut is very nutritious with high amount of energy as it contains protein, minerals, fats, carbohydrate, vitamins and fibre. It also contains some minor elements such as sodium, potassium, sulphur, calcium and iron.

Physical properties of nuts and seeds are often needed for the design of cleaning, de-hulling and drying processing equipment and machinery. These are important in handling, storage and processing procedures. The physical and mechanical properties are affected by numerous factors like variety, moisture content of the nuts, *etc.* (Raji, *et al.,* 2011).

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Various authors have reported the physical properties of cashew nut, faba bean, filbert nuts and kernels, horse gram, pistachio nut and its kernel (Balasubramanian, 2001; Altuntasand Yildiz, 2007; Pliestic *et al.,* 2006; Nimkar *et al.,* 2006; Razavi *et al.,* 2007). Hardly any report is available on physical properties of cashew nuts at varied moisture content and of different varieties. Considering all the above points and importance of physical properties, the present study was undertaken with the objective of determining the physical properties of nuts of different cashew varieties with respect to moisture content.

Materials and methods

The nuts of different cashew varieties *viz., Vengurle 1, Vengurle 3, Vengurle 4* and *Vengurle 7*, developed at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli was bought from the nearby market of Dapoli. *Vengurle 1* is an early variety with medium sized nut (6.15 g); *Vengurle 3* has bold sized nut (9.0 g); *Vengurle 4* is all purpose variety (7.6 g); and *Vengurle 7* has bold sized nut (10 g). The nuts were graded and uniform sized nuts were taken for the study. The moisture content of cashew nuts was measured by hot air oven method. The nuts were steamed in a pressure cooker at 15 psi for 30, 60, 90 and 120 min. The steamed nuts were taken from the pressure cooker after removal of surface moisture, the nuts were kept in pre-weighed moisture boxes and kept in hot air oven at 105 ^{o}C for 24 hours.

The moisture content was calculated as

$$\text{Moisture content (\%) d.b.} = \frac{M2-M3}{M3-M1} \times 100 \quad (1)$$

where M_1 = weight of empty box with lid (g), M_2 = weight of box, lid with sample (g) M_3 = weight of box, lid with sample after 24 hours (g).

The size of the sample was measured in terms of the length, width and thickness of 100 nuts using Vernier caliper of least count 0.01 cm. The geometric diameter, sphericity, volume, surface area, bulk density, true density and angle of repose of the cashew nuts for the four varieties were calculated for a moisture content of 17 to 81 per cent for *Vengurle 1*, 18 to 69 per cent for *Vengurle 3,* and 16 to 86 per cent for *Vengurle 4* and 15 to 87 per cent for *Vengurle 7.* The measurements were replicated thrice.

Geometric diameter and sphericity for 100 nuts was calculated according to Mohsenin (1978) as follows:

Geometric diameter (mm),

$$D_g = (LWT)^{1/3} \quad (2)$$

$$\text{Sphericity } (\phi) = \frac{(LWT)^{\frac{1}{3}}}{L} \quad (3)$$

where, L = length (mm), W = width (mm), T = thickness (mm).

The volume of the cashew nut calculated for 100 cashew nuts at different moisture content was calculated by equation given by Jain and Bal (1997).

$$\text{Volume (mm}^3\text{), } V = \frac{\pi B^2 L^2}{6(2L-B)} \quad (4)$$

where, $B = (WT)^{0.5}$, L - length (mm), W - width (mm), T - thickness (mm).

The surface area of the cashew nut was calculated for 20 cashew nuts by determining the size of the nut at different moisture content according to Baryeh (2001) and Mohsenin (1978).

$$\text{Surface area (mm}^2\text{), } S = \pi D_g^2 \quad (5)$$

where, D_g = geometric diameter (mm)

Bulk density is defined as the total mass of the product divided by total volume occupied by the product. The volume also includes pore volume, particle volume and internal volume. Bulk density considers expansion in all directions with increase in moisture content. The volume of the cashew nuts was measured by a putting the nuts in 1000 mL measuring cylinder. The weight of the nuts was determined by electronic weighing balance having an accuracy of 0.001g. The bulk density was calculated according to Deshpande *et al.* (1991).

$$\text{Bulk density } (\rho_b) = \frac{\text{Weight of sample (kg)}}{\text{Volume occupied by the sample (m}^3\text{)}} \quad (6)$$

The angle of repose (θ) is the angle between the base and the slope of the cone formed on a free vertical fall of the granular material to a horizontal plane. The size, shape, moisture content and

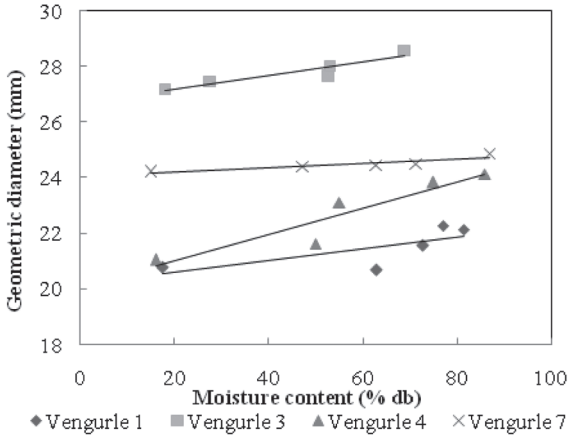
orientation of grains affect the angle of repose. The angle of repose was measured by keeping the nuts in a hollow box of 10 cm diameter and 20 cm height filled with cashew nuts. The diameter and height of the heap formed after removing the box vertically, was measured. The angle of repose was calculated according to Kaleemullah and Gunasekar (2002).

$$\text{Angel of repose, } \theta = \tan^{-1}\frac{2H}{D} \qquad (7)$$

where, H = height (cm) and D = diameter (cm)

Results and discussion

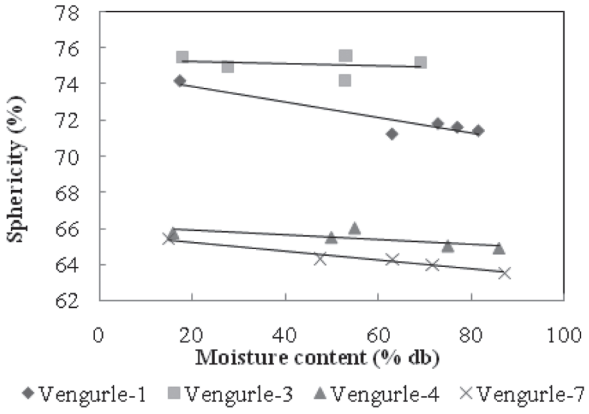
The geometric mean diameter with respect to moisture content in the four varieties of cashew nuts is shown in Fig. 1. The geometric diameter of cashew nut increased as the moisture content increased in the nuts and was highest in *Vengurle 3*. The geometric mean diameter increased from 20.8 to 22.1 mm as the moisture content increased from 17 to 81 per cent db for *Vengurle 1;* 27.2 to 28.6 mm for *Vengurle 3* with moisture content of 18 to 69 per cent db; 21.0 to 24.1 for *Vengurle 4* with moisture contentof 16 to 86 per cent db and 24.2 to 24.9 mm for *Vengurle 7* with the moisture content



Variety	Equation	R^2
Vengurle 1	*y= 0.020x+20.18*	*0.530*
Vengurle 3	*y= 0.024x+26.71*	*0.846*
Vengurle 4	*y= 0.047x+20.08*	*0.871*
Vengurle 7	*y= 0.008x+24.03*	*0.835*

Fig. 1. Effect of moisture content on geometric diameter of cashew nut of different varieties

of 15 to 87 per cent db. Similar behavior was observed by Ozguven and Vursavus (2005), Deshpande *et al.* (1991), Gupta and Das (1997), Joshi *et al.* (1993) and Sutharand Das (1996) in pine nut, soy bean, sunfower seed, pumpkin seed and karingda seeds, respectively.

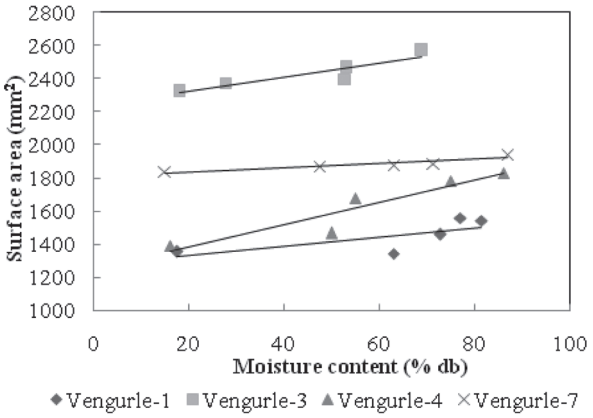


Variety	Equation	R^2
Vengurle 1	*y = -0.043x+74.71*	*0.867*
Vengurle 3	*y = -0.005x+75.33*	*0.038*
Vengurle 4	*y = -0.013x+66.16*	*0.538*
Vengurle 7	*y = -0.024x+65.7*	*0.960*

Fig. 2. Effect of moisture content on sphericity of cashew nuts of different varieties

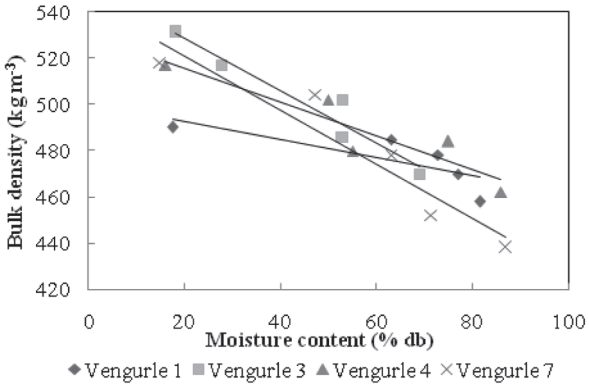
Figure 2 shows the sphericity with respect to moisture content of cashew nuts. It was found that with rise in moisture content, there was a slight decrease in sphericity. The sphericity decreased from 74.2 to 71.4 per cent in *Vengurle 1*; 75.5 to 75.2 per cent in *Vengurle 3;* 65.8 to 64.9 per cent for *Vengurle 4* and 65.4 to 63.2 per cent for *Vengurle 7* with their respective moisture contents. Similar results were observed by Ozguven and Vursavus (2005), Deshpande *et al.* (1991) and Gupta and Das (1997) for soy bean, sunflower seed and raw cashew nut.

The volume of cashew nut at different moisture content was found to increase with increase in moisture content (Fig. 3). The volume of cashew nut increased from 3485 to 4416 mm^3 for *Vengurle 1*; 7912 to 9169 mm^3 for *Vengurle 3*; 3362 to 5113 mm^3 for *Vengurle 4* and 5102 to 5547 mm^3 for *Vengurle 7*, with their respective moisture contents.



Variety	Equation	R^2
Vengurle 1	*y =11.28x+3134*	*0.437*
Vengurle 3	*y =22.32x+7439*	*0.841*
Vengurle 4	*y =26.61x+2794*	*0.869*
Vengurle 7	*y =5.233x+4965*	*0.723*

Fig. 3. Effect of moisture content on volume of cashew nuts of different varieties

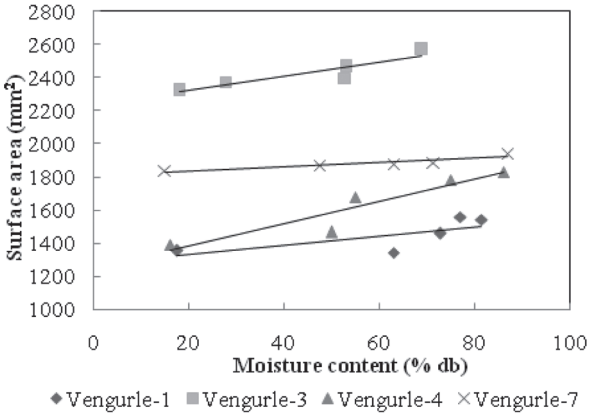


Variety	Equation	R^2
Vengurle 1	*y = -0.382x+500*	*0.616*
Vengurle 3	*y= -1.124x+551*	*0.932*
Vengurle 4	*y = -0.722x+530*	*0.846*
Vengurle 7	*y = -1.168x+544*	*0.899*

Fig. 5. Effect of moisture content on bulk density of cashew nut of different varieties

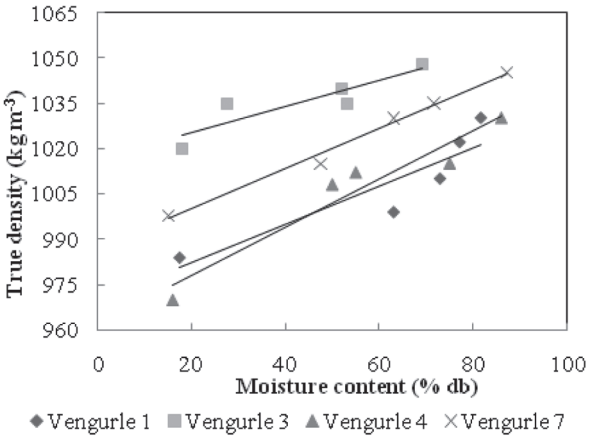
Similar trend was observed for JSF-1 safflower seeds, apricot kernel and *Juniperus drupacea* fruits (Gupta and Prakash, 1992; Gezer *et al.,* 2002; Akinci *et al.,* 2004).

The surface area of cashew nut at different moisture content is given in Fig. 4. The surface area increased from 1355 to 1540 mm^2 for *Vengurle 1;* 2320 to 2567 mm^2 for *Vengurle 3*; 1390 to 1827 mm^2



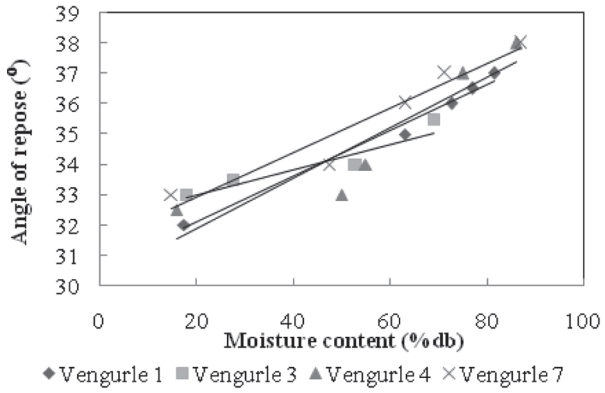
Variety	Surface area	R^2
Vengurle 1	*y =2.813x+1275*	*0.530*
Vengurle 3	*y =4.221x+2237*	*0.843*
Vengurle 4	*y =6.678x+1252*	*0.870*
Vengurle 7	*y =1.231x+1812*	*0.827*

Fig. 4. Effect of moisture content on surface areaof cashew nuts of different varieties



Variety	Equation	R^2
Vengurle 1	*y = 0.635x+969*	*0.817*
Vengurle 3	*y = 0.440x+1016*	*0.797*
Vengurle 4	*y = 0.797x+962*	*0.927*
Vengurle 7	*y = 0.797x+987*	*0.989*

Fig. 6. Effect of moisture content on true density of cashew nut of different varieties



Variety	Equation	R^2
Vengurle 1	*y = 0.075x+30.56*	*0.986*
Vengurle 3	*y = 0.083x+30.20*	*0.829*
Vengurle 4	*y = 0.041x+32.17*	*0.849*
Vengurle 7	*y = 0.073x+31.45*	*0.931*

Fig.7. Effect of moisture content on angle of repose on cashew nut of different varieties

for *Vengurle 4* and 1840 to 1941 mm^2 for *Vengurle 7,* with their respective moisture contents. Similar results for surface area were reported in pigeon pea, bambara ground nuts and millets (Shepherd and Bhardwaj, 1986; Baryeh, 2001; 2002; Baryeh and Mangope, 2002) However, Hsu *et al.* (1991) found the surface area of pistachios decreased with increasing nut moisture content.

The bulk density of cashew nuts of different varieties at different moisture content is depicted in Figure 5. The bulk density decreased with increase in moisture content which can be due to the larger increase in volume than the corresponding increase in mass of the material. The change in bulk density in different cashew nut vatieties varied from 490 to 418 kg m^{-3} (*Vengurle 1*), 517 to 462 kg m^{-3} (*Vengurle 3* and *Vengurle 4*) and 518 to 438 kg m^{-3} (*Vengurle 7*). The negative linear relationship of bulk density with moisture content was also observed by Gupta and Das (1997) for safflower seeds.

True density of cashew nut at different moisture content for the four cashew varieties is shown in Figure 6. The true density increased with increase in moisture content. It increased from 984 to 1030 kg m^{-3} for *Vengurle 1*, 1020 to 1048 kgm^{-3} for *Vengurle 3*, 970 to 1030 kg m^{-3} for *Vengurle 4* and 998 to 1045 kg m^{-3} for *Vengurle 7*. The increase in true density indicated that there is a higher grain mass increase in comparison to its volume increase, as its moisture content increased. This variation of true density with moisture content agrees with the findings for cumin seed, sunflower seeds, guna seeds and coffee beans (Gupta and Das, 1997).

The angle of repose of cashew nut increased linearly with increase in moisture content (Fig. 7). The change in angle of repose was more in *Vengurle 4* (32.5 to 38°); 32 to 37° in *Vengurle 1*; 33 to 35.5° in *Vengurle 3* and 33 to 38° in *Vengurle 7*.

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