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To Study the Physical Properties of Tumeric Rhizomes at Different Moisture Content

KEYWORDS: Turmeric, moisture content, physical properties

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ABSTRACT *Turmeric is the dried rhizome of Curcuma longa L., an herbaceous plant native to tropical south East Asia. It is mainly cultivated in India, Jamaica, Pakistan, China, Peru, Bangladesh, Taiwan, Srilanka, Indonesia and Myanmar. India is the largest producer, exporter, and consumer of turmeric in the world. Within the plethora of spices, turmeric known as "Indian Saffron" plays an important role in Indian cuisine and it also has several medicinal properties. The physical properties of turmeric rhizomes were determined at different moisture contents such as 8, 12 and 16 per cent viz., size, bulk density, true density, and porosity, by using standard procedures. It was found that the physical dimensions of turmeric rhizome were increased with increasing the moisture content. The bulk density and true density of turmeric rhizome at 12 per cent moisture content were 647.5 kg/m3 and 1303.3 kg/m3 respectively. The porosity of turmeric rhizomes was found to be 67.3 per cent.*

INTRODUCTION:

Turmeric (Curcuma longa) rhizomes (Variety: Erode local) were procured in bulk quantity from Erode Cooperative Marketing Society in Erode district of Tamil Nadu, India. Physical properties play an enormous role in designing aspects of equipment for handling, processing and storage. The physical properties of the turmeric rhizomes like size, bulk density, true density, porosity, angle of repose and coefficient of friction were determined at different moisture contents like 8, 12, and 16 per cent.

MATERIALS AND METHODS:

Moisture content

Turmeric rhizomes were distilled with toluene to determine moisture content by Dean and Stark method as per the AOAC, (2000). Moisture content of the sample was calculated by

$$\text{Moisture Content (\%) w.b} = \frac{\text{Volume of water collected (ml)}}{\text{Weight of sample (g)}} \times 100$$

Conditioning of turmeric rhizomes

The initial moisture content was determined by Dean and Stark method as per the (AOAC, 2000). After determining the initial moisture content of the rhizome the quantity of water required to moisten the turmeric rhizome was then calculated using the following formula

$$\Delta G = \frac{G\,(m_f - m_i)}{100 - m_f}$$

Where,

ΔG- Mass of water added (g)

G - Initial mass of grain (g)

m_i - Initial moisture content of the rhizome (% w.b)

m_f – Final moisture content of the rhizome (% w.b)

Drying of turmeric rhizomes

To obtain lesser moisture content of the turmeric rhizomes, an electric tray drier was employed and set up at a temperature of 60°C for drying the samples (Ploto, 2004). As soon as the desired moisture was obtained, turmeric rhizomes were packed in an air-tight polyethylene bags and stored in desiccator throughout the study.

Size

Turmeric rhizomes were randomly selected to measure physical parameters like length, breadth and thickness of each rhizome by using vernier caliper (least count 0.01 cm). Twenty observations were made to get average values of length, breadth and thickness of the turmeric rhizome (Mohsenin, 1970).

Bulk density

Bulk density of turmeric rhizomes was determined (Mohsenin, 1970; Athmaselvi and Varadharaj (2002). The bulk density was expressed as the ratio of weight to volume of turmeric rhizome.

$$\rho_b = \frac{m}{v_c}$$

Where,

ρ_b= Bulk density, kg/m^3

m = Mass of turmeric rhizome, kg

v_c = Volume of the container, m^3

True density

True density of the turmeric rhizomes was determined by the toluene (C_7H_8) displacement method (Mohsenin, 1970; Sacilik and Keskin, 2003). The true density ρ_t was then calculated using the following equation.

$$\rho_t = \frac{m}{v_f}$$

Where,

ρ_t= True density, kg/m^3

m =Mass of turmeric rhizome, kg

v_f = Volume of toluene displaced , m^3

Porosity
Porosity is defined as the per cent voids of an unconsolidated mass of materials (Mohsenin, 1970). The porosity of the turmeric rhizome was computed using the formula given below and expressed in per cent (Sahay and Singh, 2001).

$$\varepsilon = 1 - \left(\frac{\rho_b}{\rho_t}\right) \times 100$$

Where,

ε = Porosity, per cent

ρ_b = Bulk density, kg/m^3

ρ_t = True density, kg/m^3

Angle of repose
The angle of repose (h) was obtained using a cubical metal box of dimensions is 15× 15×15 cm, having a removable front panel. It is calculated from the ratio of the height to the base radius of the heap formed (Sahin and Samnu, 2006).

$$\theta = \tan^{-1}\left(\frac{h}{w}\right)$$

Where,

θ = Angle of repose, degree

H =Height of heap, cm

W = Width of the box, cm

Coefficient of friction
The static coefficient of friction is defined as the frictional forces acting between surfaces of contact at rest with respect to each other (Sahay and Singh 2001). It was determined by platform method. The coefficient of static friction was calculated as the ratio of weights added (frictional force) and material mass (normal force) as given below.

$$\mu_e = \frac{F_e}{N_e}$$

Where,

μ_e = Coefficient of friction

F_e=Frictional force, kg

N = Normal force, kg

RESULTS:
Physical Properties of Dried Turmeric Rhizomes
The turmeric rhizomes were conditioned to 3 different moisture contents viz., 8, 12 and 16 per cent. After conditioning, the physical properties of the turmeric rhizomes were studied and the effect of these initial moisture contents on the physical properties of turmeric rhizomes such as physical dimensions (length, breadth and thickness), bulk density, true density, porosity, angle of repose and coefficient of friction of the rhizome at different moisture contents.

Size
The physical dimensions (length, breadth and thickness) of the turmeric rhizomes at different moisture contents were determined using vernier caliper is given in the Table 1.1 and from the Fig.1.1 it is observed that the physical dimension such as length, breadth and thickness of the turmeric rhizome is increasing with increasing the moisture content. The increase in the dimensions is attributed to expansion due to moisture absorption in the intracellular spaces in the turmeric rhizomes. Further, each dimension appeared to be linearly dependent on the moisture content.

Similar results were reported by Athmaselvi and Varadharaju (2002) and Balasubramanian et al., (2012) for turmeric rhizomes.

Bulk density
The bulk density (ρ_b) of turmeric rhizomes were observed to increase from 644.79 to 650.42 kg m^{-3} with increasing moisture content from 8 to 16 per cent (w.b) as shown in Fig.1.2. The increase in bulk density for turmeric rhizome with increase in moisture content indicated that the increase in mass owing to moisture gain in the sample was higher than accompanying volumetric expansion of the bulk.

A similar increasing trend was observed by Athmaselvi and Varadharaju (2002) for turmeric rhizomes.

True density
The true density (ρ_t) of turmeric rhizomes at different moisture levels varied from 1288.71 to 1334.52 kg m^{-3} (Fig. 1.2). The effect of moisture content on true density of turmeric rhizome showed an increase with moisture content. Similar result was reported by Athmaselvi and Varadharaju (2002). From the Fig.1.2, it was observed that the bulk density was lower than the true density. This could be attributed to the presence of air spaces in rhizome bulk that increases the volume while the mass is the same.

Porosity
The porosity values of the turmeric rhizomes have found to be increased linearly with increase 66.28 to 68.52 per cent in moisture content from 8 to 16 per cent (Fig.1.3)

Similar observations of linear increase in porosity with increase in moisture content have also been reported by Singh and Goswami (1996) that the porosity of cumin seeds increased with increase in moisture content. However, Balasubramanian et al. (2012) have found that the porosity of turmeric rhizomes decreased with the increase in dimension of sample i.e. rhizome grade.

Angle of repose
The angle of repose increased from 42.58 to 44.26° in the moisture range of 8 to 16 per cent (w.b.) (Fig.1.4). The

angle of repose is of paramount importance in designing hopper openings, storage-bin side wall slopes and chutes for bulk transport. Moisture content of the grains is an important factor which influences the angle of repose.

Singh and Goswami (1996) have reported a linear increase in angle of repose with increase in the moisture content for cumin seed. However, Balasubramanian et al. (2012) found the angle of repose of turmeric rhizomes increased with respect to grades (dimensions).

Coefficient of friction

The static coefficient of friction of turmeric rhizomes on four surfaces viz., mica, cardboard, mild steel, stainless steel against 3 different moisture contents were determined (Fig.1.5). It was observed that the coefficient of static friction was increased with increase in moisture content for all the surfaces. This is due to the increased adhesion between the rhizome and the material surfaces at higher moisture values.

The design of hoppers, bulk silos and other storage and handling structures should ensure non-arching (i.e., avoiding stoppage of flow of bulk solids). The coefficient of mobility, which represents the freedom of motion of a substance, is inversely related to the coefficient of friction (tangent of angle of internal friction). The higher the coefficient of friction, the lower the mobility coefficient, and hence the larger the hopper opening and hopper side wall slope and the steeper angle of inclination is required in inclined grain transporting equipment's (Gharibzahedi et al., 2011).

Similar results were observed by Athmaselvi and Varadharaju (2002) and Balasubramanian and Viswanathan (2010) also reported that as the moisture content increased, the coefficient of static friction also increased.

Properties	Moisture Content		
	8%	12%	16%
Length (mm)	48.6±0.38	49.9±0.56	51.3±0.43
Breadth (mm)	8.4±0.04	9.2±0.07	10±0.10
Thickness (mm)	8.3±0.09	8.4±0.10	8.6±0.09
Bulk density (kg/m^3)	643.7±0.008	647.5±0.006	650.4±0.410
True density (kg/m^3)	1288.7±0.015	1303.3±0.020	1334.5±0.020
Porosity (%)	66.2±0.002	67.3±0.003	68.5±0.003
Angle of repose (°)	42.5±0.01	43.6±0.005	44.2±0.006
Coefficient of Friction			
Card board	0.251±0.001	0.270±0.003	0.292±0.006
Mica	0.224±0.003	0.236±0.004	0.244±0.002
Mild steel	0.232±0.001	0.252±0.001	0.271±0.004
Stainless steel	0.208±0.002	0.209±0.005	0.220±0.003

Table 1.1. Summary of Physical Properties of Turmeric Rhizomes

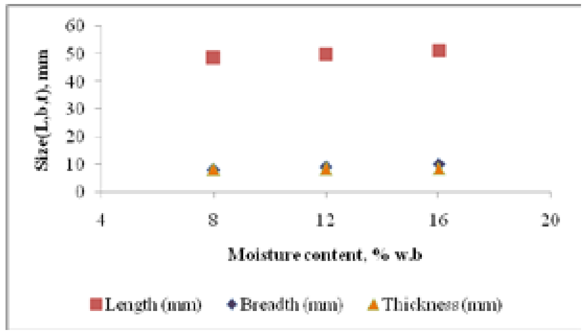

Fig 1.1.Effect of Moisture Content on Physical Dimensions (L, b and t) of Turmeric Rhizomes

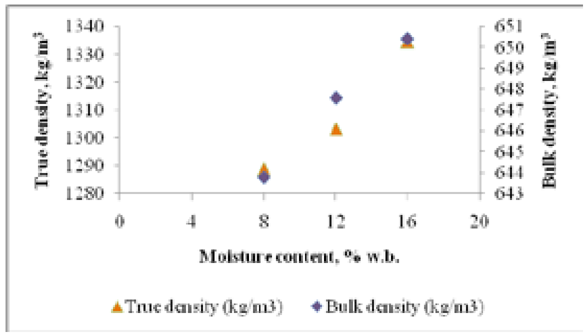

Fig 1.2 Effect of Moisture Content on Bulk density and True Density of Turmeric Rhizomes

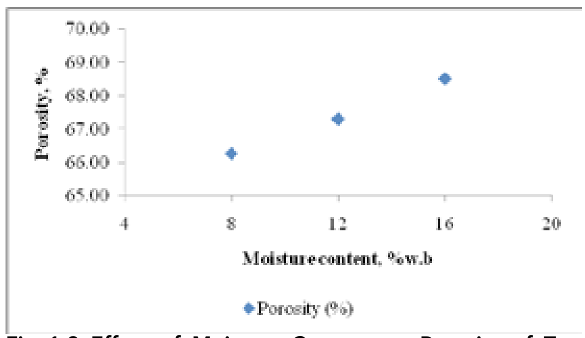

Fig 1.3 Effect of Moisture Content on Porosity of Turmeric Rhizomes

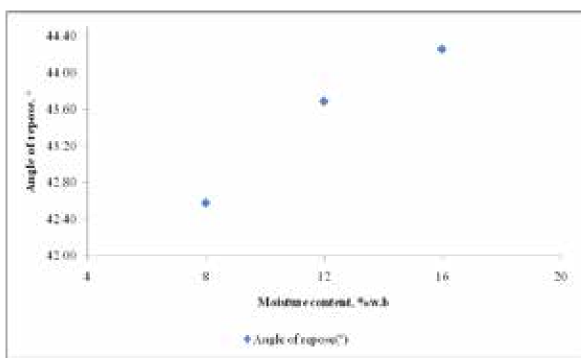

Fig 1.4 Effect of Moisture content on Angle of repose of Turmeric Rhizomes

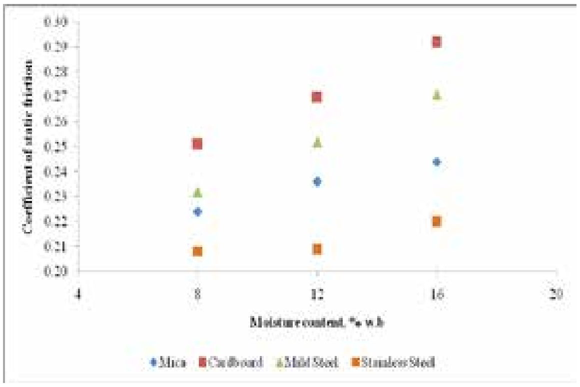

Fig1.5 Effect of Moisture content on Static Coefficient of Friction of Turmeric Rhizomes

Conclusion:

Turmeric rhizomes physical properties were determined at different moisture contents such as 8, 12 and 16 per cent viz., size, bulk density, true density, and porosity, by using standard procedures. It was found that the physical dimensions of turmeric rhizome were increased with increasing the moisture content.

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