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Study of engineering properties of Nutmeg

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Abstract

Nutmeg (*Myristica fragrans Houtt*.) is an important tree spice, which produces two distinctly different spices namely nutmeg and mace. In India, it has occupied an area of about 3763 ha with an annual production of 3457 MT. In late 70's, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth initiated research work on this crop with main aim to test its performance as mixed crop in coconut plantation. Physical properties often required for the designing of cleaning, dehulling and many processing machineries Different engineering properties are analyzed before and after drying. The spatial dimension of the seed such as length 29.45 mm breadth 20.99 mm and thickness19.85 mm of nutmeg were measured. Sphericity of the nutmeg was 0.801. Bulk density was 483.08 Kg/m3. The average value of coefficient of friction was 0.697 and that of internal friction was found to be 0.980. True density was 1005.98 Kg/m3. Porosity was found to be 51.97%. These are the properties of nutmeg before drying. The spatial dimension of the seed such as length 27.47mm, breadth 19.77 mm and thickness19.19mm of nutmeg were measured. Sphericity of the nutmeg was 0.790 respectively. Bulk density was 416.09 Kg/m3. True density was 1017.8 Kg/m3. Porosity was found to be 59%. The dynamic angle of repose was 48.86°. These are the properties of nutmeg after drying.

Keywords: Dehulling, Coefficient of friction, Sphericity

Introduction

Nutmeg (*Myristica fragrans* Houtt.) is an important tree spice, which produces two distinctly different spices namely nutmeg and mace. Nutmeg is the kernel of seed and mace is the dried aril that surrounds the single seed within the fruit. It belongs to the family Myristicaceae.

The nutmeg seed kernel is rich in various quality parameters such as moisture (14.3%), protein (7.5%), ether extract (36.4%), carbohydrates (28.5%), fiber (11.6%), mineral matter (1.7%), calcium (0.12%), phosphorus (0.24%), iron (4.6 mg/100 g), the principle constituents of nutmeg are fixed oil (fat), volatile oil, and starch. (M. Gopalakrishnan, 1992). Oil of nutmeg or mace is employed for flavoring food products and liquor. It is used for scenting soaps, tobacco, and dental creams, and also liniments and hair lotions. Nutmeg butter is used as a mild external stimulant in ointments, hair lotions and plasters and forms a useful application in cases of rheumatism, paralysis and sprains. The nutmeg rind was found to be a rich source of good quality pectin (12.14%) after suitable processing curing the rind has also been used in the manufacturing of beverages, jelly, candy, jam, mixed jam, in canned fruit cocktail, oil and vinegar (Pruthi *et al* 1985).

Material and methods

For drying of nutmeg the local variety from Department of Horticulture were taken, as it was most commonly used for processing. One kg of sample contains about 80-100 nuts. Each nutmeg consists of three parts which are pericarp (rind), mace (aril) and nutmeg (kernel). For every 100 kg of nutmeg there are only 3 – 3.5 kg of mace. For each treatment random sample of nuts were taken.

Spatial dimension

Three dimensions viz. length, breadth and thickness of the seed were, measured by using digital vernier caliper. Dimensions were calculated by noting the dimensions of ten randomly selected seeds of local variety. From these dimensions, flatness ratio, elongation ratio and surface area were calculated.

Flatness ratio was calculated by taking the ratio of length to breadth. Elongation ratio was calculated by taking the ratio of breadth to the thickness. Surface area of seed was calculated by considering the shape of grain as spherical. Geometric mean diameter was taken as the diameter of the Nutmeg. Longest dimension called length ‘L’, second longest dimension perpendicular to L called breadth ‘B’ and third longest dimension perpendicular to both is called thickness ‘T’ of an object.

Size or equivalent diameter

Size or equivalent diameter is the geometric mean of the three dimensions viz. length, breadth and thickness. The size was calculated by using following relationship.

$$D = \sqrt[3]{LBT}$$

Where,
L = Length
B = Breadth
T = Thickness

Sphericity

Assuming that the volume of the solid is equal to the volume of the triaxial ellipsoid with intercept L, B, T and that the diameter of the circumscribed sphere if the longest intercept (L) of the ellipsoid (Mohsenin, 1950), the degree of sphericity was determined as follows.

$$\text{Spericity} = \frac{\sqrt[3]{LBT}}{L}$$

Where,
L = Length
B = Breadth
T = Thickness

$$\text{Spericity} = \frac{\text{Geometric mean diameter}}{\text{Major diameter}}$$

Bulk density

It was determined by filling a specific mass of sample in known volume of cup. The sample was weigh, which required filling the cup. The density of any material may be expressed as below,

$$\text{Bulk density} = \frac{\text{Weight of material}}{\text{Volume of material}}$$

True Density

It was determined by pouring a specific mass of sample in known volume of toluene. Increase in level of toluene was observed and from that volume was determined.

$$\text{True density} = \frac{\text{Weight of material}}{\text{Volume of material}}$$

Porosity

Porosity is also known as packing factor, it was determined from bulk density and true density of grains may be expressed by following expression (Mohsenin, 1970).

$$\text{Porosity} = \frac{\text{True density} - \text{Bulk density}}{\text{True density}}$$

Coefficient of internal friction

For determining the coefficient of internal friction, a box of size 10.0 cm x 10.0 cm x 5 cm was put under the box of size 45 cm x 15 cm x 5 cm. Both the boxes are filed with the sample material. A box having size of 10.0 cm x 10.0 cm x 5 cm was then tied with the cord passing over a pulley attached to a pan. The weights (W_2) were put to cause the sliding of the box. Later, smaller box is made empty and weights (W_1) to cause sliding of it noted. The angle of internal friction could be calculated as,

$$\mu_i = \frac{W_2 - W_1}{W}$$

Where,

μ_i = coefficient of internal friction

W_1= weight to cause sliding of empty smaller box,

W_2= weight to cause sliding of filled smaller box,

W= weight of the material inside the smaller box.

Coefficient of external friction

The coefficient of external friction could be measured by using table provided with changeable surface. The box of size 10.3 cm x 10.3 cm x 5 cm is tied by a chord passing over the pulley and the pan is attached to this chord. The weights were put into the pan until the start to slide. These weights (W1) are noted. Later the box is filled with sample material again weight is put to cause sliding of the box. These weights (W2) are also noted. The coefficient of external friction could be calculated as,

$$\mu_e = \frac{W_2 - W_1}{W}$$

Where,

μ_e = coefficient of external friction

W_1= weight to cause sliding of empty smaller box,

W_2= weight to cause sliding of filled smaller box,

W= weight of the material inside the smaller box.

Results and discussion

The spatial dimension of the seed such as length, breadth and thickness of nutmeg were measured and from that equivalent diameter, sphericity, flatness ratio, elongation ratio, surface area was evaluated. The average values for the physical properties of nutmeg are indicating in Table-1 & 2.

Gravimetric properties

Gravimetric properties such as bulk density, true density and porosity of the local variety were determined by standard procedure prescribed in literature.

Bulk density

The bulk density of local variety of Nutmeg at various moisture level were recorded which is given as follows. The highest value of bulk density obtained before drying was 483.08 kg m^{-3} at 60.75% (db) and lowest value after drying was 416.09 kg m^{-3} at 10.42 % (db).

Table 1: Average values for physical properties of Nutmeg.

Observation	Length, mm	Breadth, mm	Thickness, mm	Equivalent diameter	Sphericity	Flatness ratio	Elongation ratio
	L	B	T	$LBT^{1/3}$	$LBT^{1/3}/L$	L/B	B/T
Before drying	29.45	20.99	19.85	22.99	0.801	1.402	1.057
After drying	27.47	19.77	19.19	21.63	0.790	1.389	1.031

Table 2: Physical properties of local nutmeg seeds.

Physical property	Number of replications	Unit of measurement	Mean value before drying	Mean value after drying
Major diameter	100	mm	29.45	27.47
Intermediate diameter	100	mm	20.99	19.77
Minor diameter	100	mm	19.85	19.19
Sphericity	100	%	80.16	79.02
Roundness	100	%	75.26	74.56
Seed mass	100	g	7.36	6.624
True density	10	Kg m^{-3}	1005.98	1017.8
Bulk density	10	Kg m^{-3}	483.08	416.09
Density ratio	10	%	48.02	40.27
Porosity	10	%	51.97	59.00
Coefficient of static friction	10	-	-	0.697
Coefficient of internal friction	10	-	-	0.980
Dynamic angle of repose on plywood	10	degrees	-	48.86

True density

The true density of local variety at various moisture levels was recorded which is given as follows. The lowest value of true density obtained before drying was 1005.98 kg m^{-3} at 60.75% (db) and highest value after drying was 1017.8 kg m^{-3} at 10.42 % (db).

Porosity

Porosity of local variety was calculated from the values of bulk density and true density at corresponding moisture content, which is as follows. The lowest value of porosity obtained before drying was 51.97 % at 60.75% (db) and highest value was 59% at 10.42 %(db) after drying.

Frictional properties

Frictional properties of nutmeg were measured by using standard method (Kachru *et al*., 1994). The average value of coefficient of static friction was 0.697 and coefficient of internal friction was found to be 0.980. The dynamic angle of repose was 48.86° after drying.

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