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RESEARCH ARTICLE

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Effect of drying on physical 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. The area under nutmeg cultivation in India is 3763 ha with the production of 3457 MT. To design and development of different process equipments there is a need of engineering properties of nutmeg. The properties are also important for developing machineries for mass handling and storage of these nutmegs. By keeping in view the importance of these properties a study on measurement of physical properties of nutmeg was undertaken. The average values of dimensions of nutmeg were 26.33, 21.49 and 18.76 mm length, breadth and thickness, respectively. Where as the average value of sphericity, flatness ratio and elongation were 0.78, 1.35 and 1.05, respectively. The unit volume, surface area and projected area of the nutmeg were found to be 5237.56, 1419.65 and 359.80, respectively. The average value of the bulk density and the true density was 481.8 and 1006.1 Kg/m^3, respectively.

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Key words : Nutmeg, Drying, Physical properties of nutmeg

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. Nutmeg is a native of Moluccas (North-West Borneo) and parts of South-East Asia.

Nutmeg performs well under humid tropical climate and grows upto an elevation of 1000 m above mean sea level (MSL). The Nutmegs are available in the season from July to September. The availability of nutmeg fruits in rainy season is more than the other months of the year. The Nutmeg Fruit consist of three parts *viz.*; kernel, rind or pericarp and mace. The distribution of nutmeg plantation is at Courtallam of Tirunelveli, burlier on eastern slopes of Nilgiris at Tamilnadu, Ernakulam, koottayam, Thiruvanadapuram at kerala. It is also cultivated on small scale in Andhra Pradesh and Assam, Karnataka, Goa and Konkan region of Maharashtra state.

The area under nutmeg cultivation in India is 3763 ha with the production of 3457 MT. The nutmeg was introduced by Portuguese, in Konkan region of Maharashtra.

The chemical composition of nutmeg seed kernel is, moisture content (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/100g), the principle constituents of nutmeg are fixed oil (fat), volatile oil and starch. The flavours and therapeutic action is due to the volatile oil, whose content varies from 6 to 16% (Gopalkrishnan, 1992). Oil of nutmeg is used for flavouring food products and liquor.

The traditional method of drying of nutmeg is drying on the Chula. This is a cumbersome, unhygienic and laborious method. This method leads to the contamination of products by smoke and dusts. The other method is an

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open sun drying, which requires large drying time. These methods have uncontrolled temperature of drying which deteriorate the final quality of the nutmeg.

To design and development of different process equipments there is a need of engineering properties of nutmeg. The properties are also important for developing machineries for mass handling, storage and drying of these nutmegs. By keeping in view the importance of these properties, a study on measurement of physical properties of nutmeg before and after drying was undertaken at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli Dist. Ratnagiri (Maharashtra).

MATERIALS AND METHODS

The experiment of measurement of physical properties of nutmeg and drying was carried out at Department of Agril. Process Engineering, College of Agricultural Engineering and Technology, Dr. BSKKV, Dapoli Dist. Ratnagiri (Maharashtra).

The materials required for the study were; Nutmeg: The nutmeg kernel of variety 'Kankan Sugandha' was used for the experiment. The numeg has three different parts like pericarp (rind), mace (aril) and kernel. The measuresment of physical properties of nutmeg were done with the help of different equipments like digital vernier caliper, weighing balance, measuring cylinder and toluene solution, etc. A tray dryer with following specification was used for the drying study. Hot air convection air dryer of M/s Quality Instrument and Equipment, Kudal used for drying of nutmeg. The dimensions of tray dryer were 52.5 x77 x71 cm. The tray dryer had 12 trays for placing nutmeg. Maximum temperature attained was 110^0C temperature. The trays of tray dryer had dimensions of 44 x 46 cm.

The Engineering properties of nutmeg were determined by measuring the dimensions of the nutmeg like length, breadth and thickness. These dimensions were measured with the help of digital vernier caliper. These dimensions were used to determine the sphericity, flatness ratio, elongation ratio, unit volume, projected area, and surface area of the nutmeg kernel. The drying study was conducted in the tray dryer.

The flatness ratio was calculated by taking the ratio of the length to breadth of the kernel while the elongation ratio was calculated by taking the ratio of breadth to the thickness of the kernel. The surface area of the kernel was calculated by considering the shape as a where the mean diameter was taken as the diameter of the kernel. The importance of different physical properties helped to the design of various separating and handling, storing and dying systems.

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.

Engineering properties:

The following engineering properties were determined with the help of different formulae. Those are as follows:

Size or equivalent diameter or geometric mean 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.

$$\varphi = 3\sqrt{LBT}$$

where,

φ : Size or equivalent diameter

L : Length (Major diameter)

B : Breadth (intermediate diameter)|

T : Thickness (minor diameter)

Sphericity :

The shape of nutmeg kernel resembles like that of ellipsoid. The volume of the solid was assumed as equal to the volume of the triaxial ellipsoid with intercept L, B, T and that the diameter of the circumscribed sphere is the longest intercept (L) (Mohsenin, 1950), the degree of sphericity was determined with the help of following formula.

$$\theta = 3\sqrt{\frac{LBT}{L}}$$

where

φ : Sphericity

L : Length (Major diameter)

B : Breadth (intermediate diameter)|

T : Thickness (minor diameter

Also, Sphericity = Geometric mean diameter / Major Diameter

Unit volume:

Unit volume of individual seeds was determined from the values of L, B and T using the formula proposed by Miller. (1987)

$$V = \pi\frac{LBT}{6}$$

where,

V= Unit volume

Projected area:

Li *et al.*(1998) proposed an equation for calculating the projected area of the seeds. This was investigated by using unit volume above as,

$$A_p = kV^{2/3}$$

where,

A_p= Projected area

K= constant=1.21

V= Unit volume

Surface area:

The surface area of nutmeg seeds was calculated with the help of the formula,

$$As = (36\pi)^{1/3} V^{2/3}$$

where,

A_s= Surface area

Bulk density:

It was determined by filling a specific mass of sample in known volume of cylinder. The sample was weighed which required for filling the cylinder. The bulk density was determined with the help of 1000 ml cylinder. The bulk density of any material may be expressed as below

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

True density:

The procedure of determination of true density was done with the help of toluene solution. It was determined by pouring a specific mass or 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 calculated from bulk density and true density of kernels, which is expressed by following formula (Mohsenin, 1950).

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

Drying of nutmeg kernels:

A freshly harvested nutmeg at Lakhi Bag of Department of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli were taken for drying study. The initial moisture content of nutmeg kernel was 29.5 per cent, which is very harmful from microbial point of view. The safe storage moisture of the nutmeg kernel is 10 per cent. The Nutmeg fruit contain pericarp, kernel and mace. These three were separated from each other before putting the sample in the dryer for drying purpose. To measure initial moisture content of the kernel, there were kept in the air oven at 105^{0}C temperature for 24 hours. The nutmeg kernels were dried in the waste fired tray dryer by maintaining three different temperature *viz.,* 45, 50, 55^{0}C.

Initial moisture content:

The initial moisture content of sample was determined in gravity air oven at 105 ° C for 24 hours till constant weight was obtained. From above procedure final moisture content was obtained.

The formula used for the calculation of initial moisture content was,

$$M(\text{d.b.}) = \frac{W_1 - W_2}{W_2} \times 100$$

where,

W_1= weight of wet sample, g

W_2= weight of bone dry sample, g

The nutmegs were placed in the trays of the dryer for drying. The drying of nutmeg was carried out at 45°C, 50°C and 55^o C. The nutmeg was dried up to the final moisture content of 10% (d.b). The moisture removal from the nutmeg was determined by measuring loss in weight at an interval of one hour while drying.

Drying rate:

The drying rate of the nutmeg kernel was determined by using following formula.

$$R = \frac{Wm}{T}$$

where,

R= drying rate (g/hr/100 g of bone dry wt)

W_m = Wt loss in one hour interval (g/ 100 g of bone dry wt)

T = Time interval, hr

The rate of drying shows the loss in moisture per hour from the nutmeg.

Final moisture content:

The final moisture content of the nutmeg was calculated by measuring weight of the sample after every hour of drying. The drying was stopped after getting the constant weight of the sample in last 3 to 4 hours of drying.

$$M \quad (\text{d.b.}) = \frac{W_1 - W_2}{W_2} \times 100$$

where,

W_1= weight of wet sample, g

W_2= weight of bone dry sample, g

RESULTS AND ANALYSIS

The various engineering properties of nutmeg like physical and gravimetric properties were determined. And the drying was performed in the tray dryer.

Engineering properties:

The various engineering properties of local variety of nutmeg were determined and the results are discussed in as follows.

Physical properties:

The dimensions of the kernel such as length, breadth and thickness of nutmeg were measured with the help of digital vernier caliper and from that equivalent diameter, sphericity, flatness ratio, elongation ratio, unit volume, surface area, projected area were calculated. The average values of these physical properties of nutmeg are tabulated in Table 1.

Table 1 : Average value for physical properties of nutmeg

Sr. No.	Particular	Observations		Per cent change after drying
		Before drying	After drying	
1.	Length, mm	26.33	25.03	4.93733384
2.	Breadth, mm	21.49	20.84	3.02466263
3.	Thickness, mm	18.76	18.13	3.35820896
4.	Equivalent Diameter	22.37	21.24	5.05140814
5.	Sphericity	0.78	0.77	0.987179
6.	Flatness ratio	1.35	1.21	0.896296
7.	Elongation ratio	1.05	1.03	0.980952
8.	Unit volume	5237.56	5210.18	0.52276251
9.	Surface area	1419.65	1413.34	0.44447575
10.	Projected area	359.8	354.83	1.38132296
11.	Bulk density, kg/m^3	481.8	416.4	13.5740971
12.	True density, kg/m^3	1006.1	1017.05	-1.088361
13.	Porosity, %	52.11	59.05	-13.317981

Gravimetric properties:

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

Bulk density:

The bulk density of nutmeg at various moisture level were determined. The highest value of bulk density obtained before drying was 481.8 kg/m^3 and lowest value after drying was 416.4 kg/m^3

True density:

The true density of nutmeg at various moisture levels were determined.The lowest value of bulk density obtained before drying was 1006.1 kg/m^3 and highest value after drying was 1017.05 kg/m^3

Porosity:

The porosity of nutmeg was calculated from the values of bulk density and true density at corresponding moisture content. The lowest value of porosity obtained before drying was 52.11 % and highest value was 59.05% after drying.

The effect of drying on all the physical properties of nutmeg kernel was prominent. The average length was reduced by 4.93 per cent whereas the breadth and thickness was reduced by 3 to 3.5 per cent. The equivalent diameter was reduced by 5 per cent after drying. Where as the flatness ratio, sphericity, and elongation were varied by 0.89 to 0.98. The unit volume, surface area and projected area of the nutmeg were changed as 0.52, 0.44 and 1.38 per cent after drying. There was reduction in bulk density by 13.57 per cent where as the true density was increased by 1.08 per cent so as porosity by 13.31.

Drying characteristics of nutmeg:

A drying of nutmeg was performed in a tray dryer operated on electricity for heating of air and circulating it in the drying chamber. The drying was carried out for a period of 18 to 22 hrs *i.e.* for two days.

The loss of moisture content:

The average loss in moisture content of nutmeg dried at 45^{0}C, 50^{0}C , 55^{0}C in the tray dryer is plotted in the form of a graph which is shown in Fig. 1, Fig. 2 and Fig. 3, respectively.

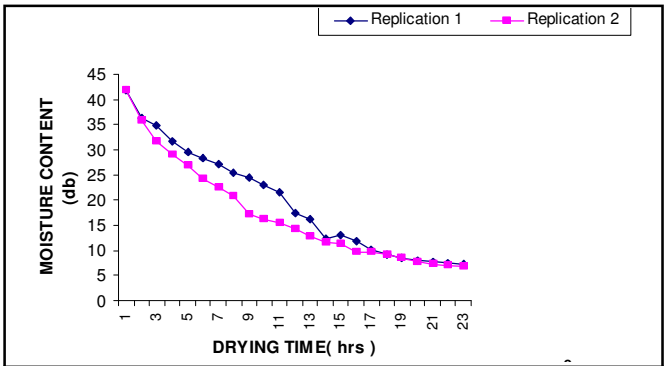

Fig. 1 : Moisture content verses drying time at 50 ^{0}C

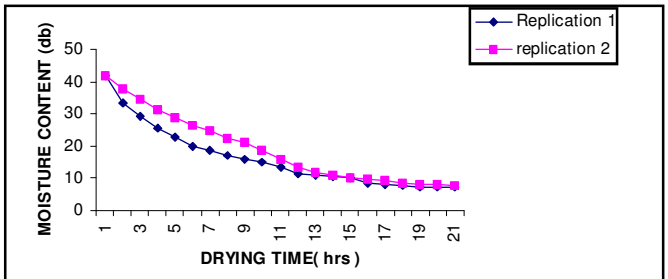

Fig. 2 : Moisture content verses drying time at 50 ^{0}C

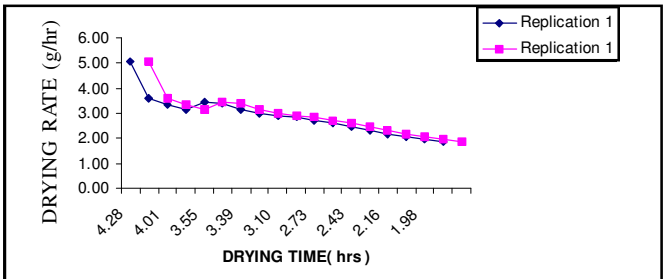

Fig. 6 : Drying rate verses drying time at 55 ^{0}C

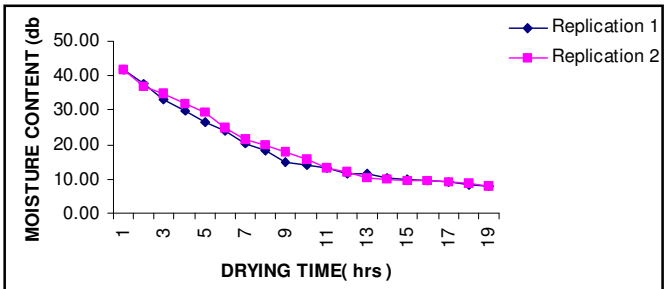

Fig. 3 : Moisture content verses drying time at 55^{0}C

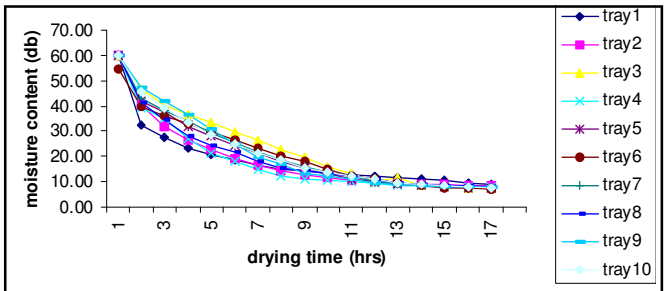

Fig. 7 : Moisture content of nutmeg at various trays

The graph indicates that the loss in moisture content of the nutmeg kernel in the beginning of drying was higher for all the three temperatures, which decreased as the experiment progressed. The nutmeg dried at temperature 45^{0}C showed that the loss in moisture content was slower compared to the other treatments whereas the loss of moisture content was higher in the initial period of drying with 55^{0}C.

The all treatments indicated that this loss of moisture content was quite constant towards the end of drying.

The time required for drying the nutmeg kernel was reduced as the temperature increased so that the time required for drying nutmeg at 55^{0}C was lesser than the other two temperature treatments. (Fig. 4, Fig. 5, Fig. 6 and Fig.7).

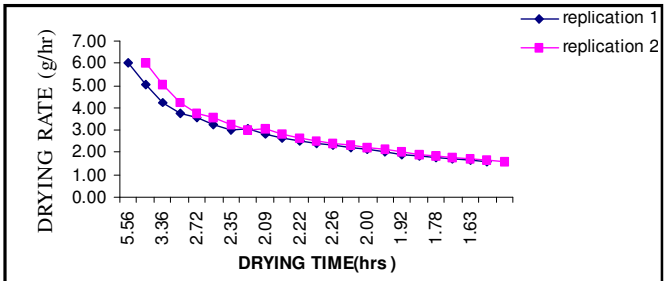

Fig. 4 : Drying rate verses drying time at 45 ^{0}C

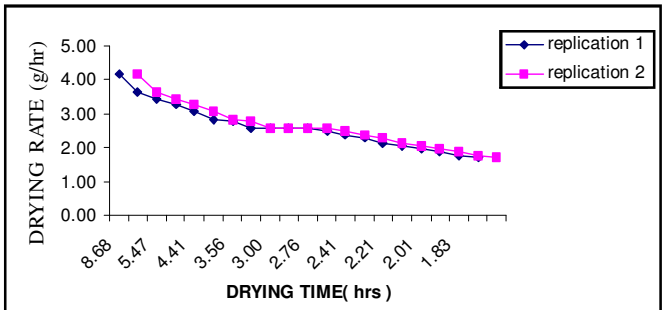

Fig. 5 : Drying rate verses drying time at 50 ^{0}C

REFERENCES

Balkrisshnan, M. and Sreenarayanan, V.V. (2002). drying of characteristics of cardamom in fluidized bed grier. *Madras Agric. J.* **89** (4-6): 2002: 257-259

Brooker, D.B.F.W., Bakker- Arkema C.W., Hall. (1992). *Drying and storage of granis and oilseeds*. CBS publication. 4596/ A New Delhi.

Chu, S. T. and A. Hustrulid (1968). General characteristics of variable diffusivity Process and dynamic equilibrium moisture content transactions of the *ASAE*. **11**(6): 709-710 & 715.

Gopalkrishnan, M. (1992). Chemical composition of nutmeg and mace. *J. Spices & Aromatic Crops*. **1**: 49-54,1992.

Gopalkrishnan, M. Thomas, P.P., Bhat, A. V., Vakey, A.G. Menon, N. and Mathew, A.G. (1980) . Post Harvest technology of Nutmeg Placrosym **111**: 189-200.

Joseph, J., Ramesh, M. N., Nanjundaiah, G., Raghavan, B. and P. N. Srinivas Rao (1997). Drying characteristics of large cardamom. *J. Agric. Eng.*, **34** (2) : 35-41

Li, M., Davies, D.C. and Barbosa-Cavovas G.B.(1998).

Engineering properties of foods and other Biological materials (A Laboratory Manual). ASAE press, St. Joseph, MI.

Millar, W.M. (1987). Physical properties data for post-harvest handling of flodida citrus, *Appl.Eng. Agric*., **3**(1):123-128

Mohesnin, N. N. (1950). *The physical properties of plant and animal materials.* Gordan and Breach, Science Publishers, Inc. New York,: 51-78

Pruthi, J.S., Satyavarti, K. Kutty (1985). A study of factors governing the recovery and quality of pectin from nutmeg waste, Indian Cocoa, *Arecanut and spices J.* **8**(3): 75-77, 89.

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