Development Drying of Cashew Kernel with Microwave by using a Continuous Belt

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Abstract

This research aims to develop microwave based dryer with continuous conveyor for cashew kernel. Stoves together with 8 magnetrons(100-1000w/unit) installed in zigzag pattern are employed in the experiments based on a variety of factors to be considered. The stove has dimension of 336x2000x350 mm.^{3}. The power of 1000 watts for 11 minutes gives cashew kernel containing 2.4194% dry basis and causes the seed color to be dark and not look appetizing. Moreover, the taste is quite bitter. However, the power of 1000 watts for 10 minutes can result in 4.5799 % dry basis, which is not far from that generally found in the market (3.7787 % dry basis), and lead to the maximum production of 14.400 kg/hr. The corresponding seed color is light brown and looks delicious. In addition, the other physical appearances look similar to those found in the market.

***Keywords**:* :, Microwave drying, cashew kernel, Anacardium Occidentale Of Fumigato

1. Introduction

Cashew (Anacardium occidentale L.) is one of the most important commercial crops in Thailand at 40,000 tons of raw nuts being produced from an area of 240 km^2 correspond to exporting value of 117 million baths [1]. The raw cashew nut is kidney shaped with 3.5 mm thick soft leathery outer skin (epicarp) and thin hard inner skin (endocarp). Between these two walls of the shell, there is a honeycomb structure, which contains the phenolic material, commercially known as cashew nut shell liquid (CNSL),[2]. The kernel is inside the shell wrapped in a thin brown skin known as the testa (*Fig. 1*). The major moisture-dependent physical properties of biological materials include shape, size, bulk density, porosity, mass of seeds and friction against various surfaces. These properties have been studied for various crops such as gram[3]; determining moisture-dependent physical properties of raw cashew nut in the moisture range of 3.14%-20.06%db.[4]

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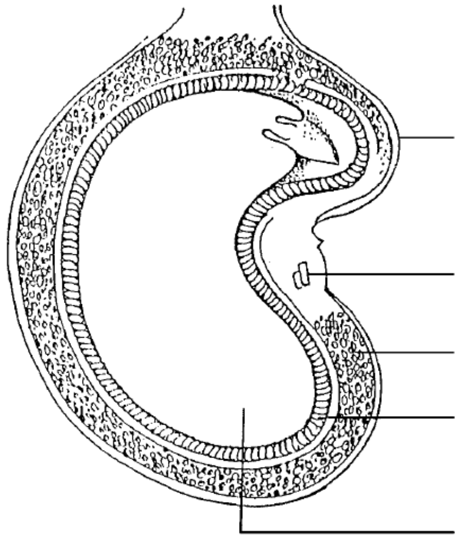

Fig.1Geometryof raw cashew nut (sectional view)[4]

Among tropical fruits, cashew nut fruit occupies an important posities. The fruit is valued not only for its high ascorbic acid content but also for the nut kernel which is the principal industrialized product. The kernels are rich in lipids (42.6%) and proteins (20.0%).[5]. Prior to the experiments, therefore, the exposure of fresh cashew nuts to the sun for about 7-8 days is needed. Despite an extensive search 2 machines, such as 1.The Design and development of Infrared roaster for cashew kernels. Infrared light a 700 watt power supply, 4 tubes of heat. Using a stainless steel cylinder forming a second layer of roasted cashew nuts at a time can be 1-2 kg. During the roasting temperature is controlled at 140 150 and 160 degrees Celsius, the speed appropriate to the cashews, roasted, not failure. And color uniformity is 6 cycles per minute.[6] 2.The roasted machine of cashew nuts. Food Technology Department TISTR. Development. The roasted cashew nuts up. The products have clean and safe. Consumption, which allows the roaster. Cashews of entrepreneurs. To follow the rules and procedures. Good food. And through. Certificate of office. The food and drug administration.[7] Because of the limited penetration depth of the microwave energy into green [8]. That is, if a high drying rate is possible to dry rapid dimensions but then the drying rate diminishes due to the limited penetration depth of the 2.45 GHz microwaves. Here, the idea is to drying the cashew kernel through open chamber with microwave directed from separate small magnetrons. The objective of this research is to design the device with microwave contribution to promote a rapid drying process for cashew kernels.

2. The response of cashew kernels to microwave energy

Water is a good absorber of microwave energy due to its physical properties, as shown in Fig. 2a. The electronic configuration concerns with the molecule forms a dipole which is directed along the bisector of the angle formed by the oxygen and hydrogen atoms [9]. When placed in an electric field, the dipole will be re-orientated with respect to the field (see Fig. 2b). The positive end of the dipole will experience a torque in the negative field direction whilst the negative pole would align itself with the positive direction of the field. If the field is made to alternate the molecule will oscillate as it endeavors to line up with the instantaneous field direction. The amount of lag between the axis of the dipole and the field direction will determine the amount of energy lost to the field in the form of friction. The tangent of the angle between the dipole and the electric field is called the loss tangent and is a measure of the dipole's ability to absorb microwave energy. It is both frequency and temperature dependent.

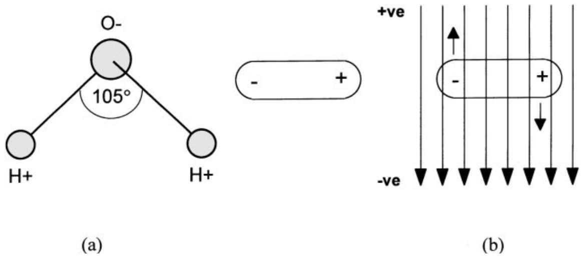

Fig. 2. (a) Electronic configuration of a water molecule and (b) dipole reorientation in an electric field.[10]

The loss tangent can be derived from a material's complex permittivity. The real component of the permittivity is called the dielectric constant whilst the imaginary component is referred to as the loss factor. The ratio of the loss factor to the dielectric constant is the loss tangent. The complex dielectric constant is given by [11]:

$$\varepsilon = \varepsilon' - j\varepsilon'' \qquad (1)$$

where ε is the complex permittivity; ε' is the real part of dielectric constant; ε'' is the loss factor; and $\varepsilon''/\varepsilon'$ = $\tan\delta$ is the loss tangent. Knowledge of a material's dielectric properties enables us to predict theirs ability to absorb energy when exposed to microwave radiation. The average power absorbed by a given volume of material when heated dielectrically is given by the equation [11]:

$$P_{av} = \varpi \varepsilon_0 \varepsilon_{eff}'' E_{rms}^2 V \qquad (2)$$

where P_{av} is the average power absorbed (W); ϖ is the angular frequency of the generator (rad/s); ε_0 is the permittivity of free space; ε_{eff}'' is the effective loss factor; E is the electric field strength (V/m); and V is the volume (m^3). The effective loss factor ε_{eff}'' includes the effects of conductivity in addition to the losses due to polarization. It provides an adequate measure of the total loss, since the mechanisms contributing to losses are usually difficult to isolate in most circumstances [11].

3. Experimental apparatus and procedure

3.1 The Design of microwave based stove for cashew kernels.

As with drying process in the conventional oven cashew kernel of sample were placed in a microwave oven and initial moisture content 80%db down to 4%db. The microwave oven used in this work was Samsung model MS103HCE 8 units. It has dimension of a 336 x 2000 x 350 mm.^{3}, by modify from microwave cooking and contains 8 magnetrons installed in zigzag pattern. The maximum output power of the oven was 8.0 kW. The wall of the stove is made from stainless steel with 1.5 mm. thickness. (Fig.3)

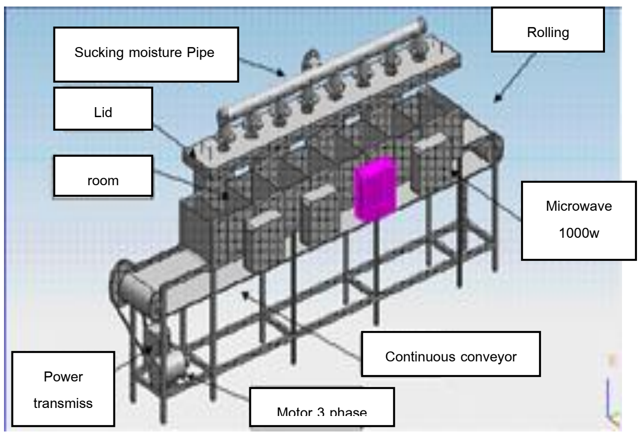

Fig.3 Structure of the microwave based stove for cashew kernels.

3.2 Materials preparation

Raw cashew kernels obtained from southern part of Thailand were collected at moisture content of 4.5-10.5%db. In order to determine the size and shape of the kernel, a sample of 200 nuts were individually weighed and then individually shelled to meet a site, i.e. 3 cm. long, 2.5 cm. width and 2-3 cm. thickness. A number of seeds per pound of meat 250 nuts. The process of samples preparation was preserved in water, leading to be easy to shell cashew kernels before drying process.(Fig.4,5)

Fig.4 Cashew kernels was preserved in water

Fig.5 Shelling of cashew kernels.

Fig.6 weighting of the cashew kernel.

3.3 The experimental procedure.

1. To weigh 200 g. (Fig.6,7)
2. Enable the motor to drive the conveyor belt system.
3. Set Time for stepping motor.
4. The microwave power level is adjusted to be 900-1000w .(Fig.8)
5. Cashew kernels are kept in a separate container.
6. Turn on the machine and run experiments. (Fig.9)
7. Weighting the sample again after drying.
8. Record the relevant data.
9. Measure the color.(Fig.11)
10. Record the corresponding data.

Fig.7 Cashew kernels before microwave application.

Fig.8 Process is running.

Fig.9 Cashew kernels after microwave application.

Fig.10 The cashew kernels value and compare.

Fig.11 Colorimeter spectrophotometer

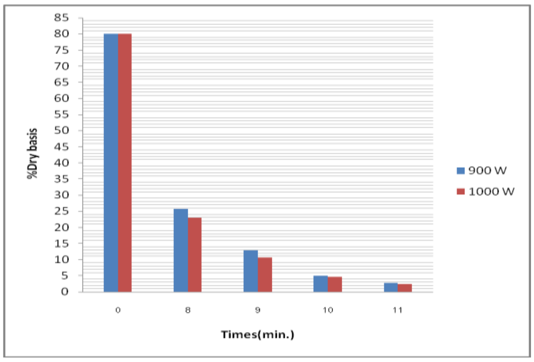

Fig.12 *Moisture content vs. time for conventional dried cashew* kernels

Fig.13 Microwave drying at 1000w in 11 min.

Table.1 The color value of cashew kernels at 900w 1000w compare with samples from market.

The color value	Samples from market		900W								1000W							
			8 min.		9 min.		10 min.		11 min.		8 min.		9 min.		10 min.		11 min.	
	over turn	turn face	over turn	turn face	over turn	turn face	over turn	turn face	over turn	turn face	over turn	turn face	over turn	turn face	over turn	turn face	over turn	turn face
L*	60.1	50.2	40.8	38.4	43.2	46.6	50.8	49.5	43	47	43.8	44.5	49.8	48.7	52.8	46.96	46	42.4
a*	0.15	2.33	2.49	2.68	2.66	1.65	1.49	2.44	3.1	2.22	2.01	2.46	2.14	2.64	1.53	1.68	4.52	4.36
b*	13.5	18	10	17.8	11	20.8	14.9	21.8	13.4	19.1	14.5	21.4	15.2	26.1	14.4	18.66	19.5	22.7

4.Results and Discussion

Samples were drying cashew kernels. To determine the initial moisture content of dried using hot air oven at 103 ºC for 72 hours until the moisture out of cashew kernels. An average of 80% db is obtained. The standard samples of dried cashew kernels were found in general market. An average of 3.7787%db was found. The optimal drying time was dependent on electrical power, i.e. 8, 9, 10 and 11 min. at the power of 900 and 1000w., Fig.12 show the results for the 900w in 11 minutes with 2.7839%db and 1000w is 10 minutes with 4.5799%db. The results obtained for 1000w in 11 minutes corresponded to 2.4194%db. Some samples were burned. The moisture content comparable with that found in the market place is obtained 1000w in 10 minutes.

Table. 1 Show color indicates by Colorimeter spectrophotometer machine. The results are acceptable at 900w in 11 minutes but drying faster than at 1000w 10 minutes.

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5. Conclusion

The experimental results for moisture content and color value presented examined here identify and illustrate relations of power and times influencing drying of a cashew kernel with continuous conveyor. Referring to Fig.12 and table.1, at power of 1000w for 11 minutes gives cashew kernel with 2.4194%db and causes the seed color to be dark and not look appetizing show in Fig.13. Moreover, the taste is quite bitter. However, the power of 1000w for 10 minutes can result in 4.5799%db, which is not far from that generally found in the market (3.7787%db), and lead to the maximum production of 14.400 kg/hr. The corresponding seed color is light brown and looks delicious. In addition, the other physical appearances look similar to those found in general market.

6. References

6.1 Article in Journals

[2] Ohler J G (1979). Cashew. Publication number 71. Department of Agricultural research, Royal Tropical Institute, Amsterdam,260

[3] Datta S K; Nema V K; Bharadwaj R K (1988). Physical properties of gram. Journal of Agricultural Engineering Research, 34(4), 259-268

[4] D. Balasubramanian (2001). Physical Properties of Raw Cashew Nut. Journal of Agricultural Engineering Research. 78(3), 291-297

[5] Trevas Filho, V., Tecnologia dos Produtos de pendunculo de caj(1988).: A cultura de cajueiro em Nordeste do Brasil, p. 486. BNB/ETENE, Fortaleza, Brazil (in Portuguese).

[6]Wanlapa A., Sayasoonthorn S., Sawaedsuk P. and Wanlapa, S.(2010). The Design and Development of Infrared Roaster for Cashew Kernels. Journal of Agricultural Science. 41(3/1)(Suppl.): 465-468

[8] Antti AL (1993) Microwave Drying of Hardwood: Potentials for Moisture Flux.,ISSN 0280-8242, Lulea University of Technology

[9] J. Thuery(1992)., Microwaves: Industrial Scientific and Medical Applications, Artech House, Norwood, MA, USA,

[10] A. Oloyede*, P. Groombridge(2000), The in influence of microwave heating on the mechanical properties of wood, Journal of Materials Processing Technology 100 67-73

[11] A.C. Metaxas, R.J. Meredith(1983),Industrial Microwave Heating, Peter Peregrinus Ltd., London, England,.

6.2 Web-Based Articles

[1] Propagation of cashew cultivation and processing, Thailand (2011). *Statistic Data*, URL:http://pirun.ku.ac.th/~eatpnk/wRITING/mango.htm, access on 18/04/2011

[7] Somphon S (1999), The roasted machine of cashew nuts., Thailand , URL: http://opac.tistr.or.th/Multimedia/STJN/4802/4802-2.pdf, access on 18/04/2011