

Utilization of Solar Dryer for Drying of Cashew Kernels

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Abstract Cashew (*Anacardium occidentale* L.) is one of the important tropical crops. It is called as the “poor man’s crop, rich man’s food”. Processing of cashewnut is the recovery of the kernel (edible meat portion) from raw nuts by mechanical or manual means. It consists of moisture conditioning, roasting, shelling, drying, peeling, grading and packing. The drying process removes moisture and helps in the preservation of the product. In open sun drying the disadvantages associated are that process is slow and insects, dusts may get mixed with the product. The use of solar dryer helps to eliminate these disadvantages. Drying is done faster and in controlled fashion by keeping quality of products. Shelled kernels were dried in direct solar dryer using solar energy for a single day for five hours. The experiment

was carried out to study the utilization of solar energy for cashew kernel drying. The cashew kernels treated at 110°C for 20 minutes gives best organoleptic properties when it is dried in solar dryer for five hours gives best results. Solar drying can be successfully used for cashew kernel drying by using solar dryer. It is less expensive and helps in increasing the quality enrichment of the cashew kernels.

Keywords Solar dryer, Cashew, Drying curves, Sensory evaluation.

Introduction

Cashew (*Anacardium occidentale* L.) is one of the important tropical crops. It is called as the “poor man’s crop, rich man’s food”. The cashewnut is native of Brazil from where the tree spread to other parts of tropical South and Central America, Mexico, India and West Indies. The genetic name, *Anacardium* was bestowed upon it because it is described as the heart like shape of the nut [1].

Cashew has major importance as export oriented cash crop. The area, production and productivity of cashew in India was 10,11,000 hectares, 7,53,000 MT and 0.7MT/ha, respectively during the year 2013-2014 [2].

Processing of cashewnut can be defined as the recovery of the kernel (edible meat portion) from raw nuts by mechanical or manual means. It consists moisture conditioning, roasting, shelling, drying, peeling, grading and packing [3].

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The processing of the cashewnuts may be done by primitive methods or through factory processing. The primitive way is the burning of raw nuts for a short time on an open fire or roasting in a pan, just enough to burn the outer shell and driving off the volatile shell liquid (CNSL) which is usually ignited. Roasting is to be designed to make the shell brittle and reduce the broken percentage which is a skillful work. Roasting is either open pan, drum, mild or oil both type. Decortication (shelling, peeling) connected with about 400 cashew-processing units in India, is being done by entirely manual labor [4].

The kernels after decortications from the shells are dried to reduce the moisture. The moisture content is thus reduced from 16 to 7%, so that the nuts can be safely stored [1, 3]. It is useful to loose the red skin adhering to kernel. A traditional use of solar energy has been for drying of agricultural products. The drying process removes moisture and helps in the preservation of the product. In open sun drying the disadvantages associated are that process is slow and insects, dusts get mixed with the product. The use of solar dryer helps to eliminate these disadvantages. Drying is done faster and in controlled fashion by maintaining the quality of products.

The kernels when taken out of the solar dryer are quite brittle and can be easily peeled of by hand. Peeling is the operation of removal of testa from the kernel. Those parts that still adhere to the kernel are removed with the help of sharp bamboo devices. One person can easily peel about 10 kg kernels/day. The testa is found to be an excellent source of tannin [5, 6].

The clean kernels are further subjected to a process of sweating to prevent breakage. They are placed in iron mesh trays and the water steam is passed through the tray to make the kernels tough.

The peeled nuts should be carefully handled and sorted out mechanically according to the size. However, final sorting based on size, color and whole kernels, splits and bits are till done manually. Graded and conditioned kernels are packed generally in 10 kg capacity tins in which the air is subsequently drawn only evacuated and replaced by carbon dioxide, after which they are hermetically sealed may be with the help of packaging machine.

Materials and Methods

Material

For the research work, Vengurla – 4 variety of cashewnut was selected. It was developed by regional fruit research center, Vengurla of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Vengurla – 4 is most commonly used variety for processing in Konkan region. One kg sample of Vengurla – 4 variety contains about 130 to 146 cashewnuts. The spatial dimension as length (l), breadth (b) and thickness (t) of Vengurla – 4 variety cashewnuts are 3.05 cm, 2.29 cm and 1.55 cm, respectively. Sphericity of same variety is 0.75 cm. For each treatment, 0.25 kg nuts i.e. approximately 30-35 nuts of Vengurla – 4 variety were taken.

Boiler

The boiler manufactured by the M/s Quality instruments and equipments Ltd. was used to make the steam from water. Then the steam is further use for softening of nuts. The diameter of boiler is 40 cm and height is 85 cm. The total capacity is 40 kg. The chamber is made up of thick gauge milk steel sheet duty painted with heat resistive paint. Totally leak proof chamber prevents temperature losses. It has single wall construction. The boiler is electrically as well as fire wood operated one. The three phase electric supply required for working of boiler. The water level controller is used to maintain the water level in boiler. The boiler is with temperature gauge for measuring the temperature of steam. The gauge can measure the temperature upto 120°C with least of 2°C.

Manually pedal operated cashewnut shelling machine

The manually pedal operated cashew shelling machine manufactured by M/s Quality instruments and equipments, Kudal was used for shelling of processed cashewnuts. The material of blade is special steel. The length of blade is 4.75 cm. The cashew cutter is with double heavy duty spring. The maximum capacity of the machine is 10 kg of kernels/day.

Solar dryer

The solar dryer manufactured by Eco-solar systems India Ltd. used for the drying of cashewnuts. It consists of toughened glass solar panel having solar transmissivity greater than 80%. The dryer consists of four trays having length, breadth and height equal to 100 cm, 10 cm and 5 cm, respectively. The temperature gauge used for measuring the temperature of drying chamber.

Steaming

Direct steaming method (i.e. exposure of steam right from its generation) was used in experiment. The process of steaming was carried out in direct boiler. The water in the water chamber was heated by 3 phase electrical supply. The generated steam was used for the steaming of cashewnuts. The temperature was measured by temperature gauge.

Various combinations of temperature and time selected were 90, 100 and 110 °C and 10, 15 and 20 minutes. Time element consists of two periods, time required to attain predetermined temperature and time required to reduce the same temperature to atmosphere. Time required to raise the pressure was solely dependent on rate of heating and temperature to be achieved. So it was considered as independent parameter the later time was controllable and hence was taken for consideration. During this time period temperature was reduced to atmosphere, first by condensing and then releasing the steam.

Steaming treatment helped to make shell softer. It also adds the moisture. Steaming brings easy separation of kernel from shells. The parameters involved in this process were deciding factor per cent whole kernel recovery as well as quality of kernels [7]. Combinations of temperature and time selected are given in Table 1.

Shelling

Steamed nuts were taken for shelling on manually pedal operated shelling machine by skilled labor. Shelling machine and labor was kept constant throughout the experiment. The number of whole kernels attained was noted for each treatment.

Table 1. Temperature and time for different treatments.

Treatments	Temperature (°C)	Time (min)
B ₁	90	10
B ₂	90	15
B ₃	90	20
B ₄	100	10
B ₅	100	15
B ₆	100	20
B ₇	110	10
B ₈	110	15
B ₉	110	20

Percent whole kernel recovery was calculated by following formula.

$$\text{Percent whole kernel recovery} = \frac{\text{No. of whole kernels obtained}}{\text{Total No. of kernels shelled}} \times 100$$

Drying

Shelled kernels were also dried in direct solar dryer using solar energy for a single day with time period from 9.20 am to 4.20 pm. After each one hour representative sample was weighed for calculation of moisture loss.

Sensory evaluation

Sensory evaluation of different organoleptic properties namely color, flavor and texture were carried out by panel of 11 judges of different edge group and food habits on the basis of nine point hedonic scale. The ranks were determined by to the scores given by the judges. The highest score was given as rank first and least score was given as lower rank. As the numbers of treatments were nine, all the ranks were in between one to twelve. If the score of two treatments was same, the mean of both ranks was given to those treatments.

On the basis of ranks Friedman's test was conducted and the value of F was calculated with the following formula [1, 3].

$$F = \frac{12}{nk(k+1)} \sum_{j=1}^k R_j^2 - 3n(k+1)$$

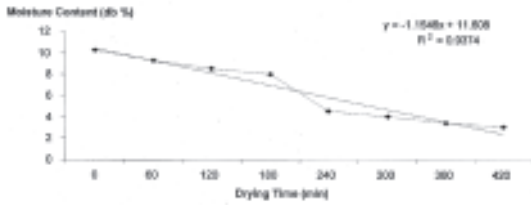


Fig. 1. Moisture content vs drying time.

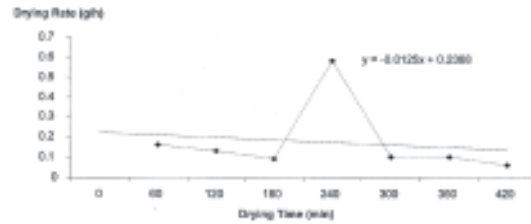


Fig. 2. Drying rate vs drying time
 $y = -0.1742x + 1.2271$

where, $j = 1+2+ \dots + k$ $k =$ Number of treatments
 $n =$ Number of judges $R =$ Rank of treatment

The calculated F values were compared with the standard value 15.51, to determine the significance of color, flavor and texture among the treatments.

Through ranks of the observations of treatments most and least accepted treatments were pointed out as per view of organoleptic properties.

Results and Discussion

Effect of steaming on drying curve of moisture content vs drying time

Fig. 1 represent variation of moisture content with drying time. It was observed that initial moisture content of about 9% decreased to about 3% during 5 h. These curves represent exponential relationship of form

$$Y = Ae^{-BX}$$

Where A and B are constants. Increase in exponent B value will represent reduction in drying time. R^2 values more than 0.95 represent good correlations between the attributes.

The value of exponent B increases with increase in steaming pressure. As value of B increases the curve become steeper. This indicates faster drying, however faster drying rates are high due to high initial moisture content. With an increase in time, firstly there is rise in value of exponent B, but thereafter it decreases showing a peak for time value of 15 minute

steaming time; which may be considered as optimal value of time on drying point of view. It should be noted that exponent B does not show much variation in all nine treatments. Thus steaming parameters in all treatments do not affect nature of drying curves prominently.

Effect of steaming on drying curve of drying rate vs drying time

Figure 2 shows the variation in drying rate with drying time. It was seen that drying rate varies initially from 1 gm/hr to zero. It was seen that drying rate decrease drastically in initial 30 to 50 minutes. The curve has steep slope in this region. Later on drying rate shows variation with wavy profile.

It may be proposed that, there was faster drying of cashew kernels with peels within first 30 to 50 minutes and then drying of kermels in internal layers. Wavy nature of drying rate is initially faster due to layer exposes to drying and approaches to zero at equilibrium moisture content.

In case of timing, 15 minutes steaming time treat-

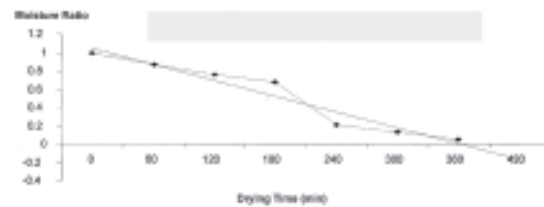


Fig. 3. Moisture ratio vs drying time.
 $y = -0.1742x + 1.2271$

Table 2. ‘H’ test evaluation on rank basis for organoleptic properties.

Treatments	Average rank scores				Average score
	Color	Flavor	Texture	Not etching to throat	
B ₁	4.68	6.18	6.36	5.09	5.57
B ₂	5.05	6.05	5.27	6.73	5.78
B ₃	5.32	5.09	5.23	5.68	5.33
B ₄	6.32	4.82	5.55	5.56	5.56
B ₅	5.59	4.82	5.13	3.59	4.78
B ₆	5.09	4.59	3.09	5.00	4.44
B ₇	4.81	3.91	4.64	4.05	4.35
B ₈	5.14	5.18	4.68	4.28	4.82
B ₉	2.82	4.36	4.59	3.59	3.84
Results (at 5% level)	Significant	Non significant	Significant	Non significant	

ments give lower in equilibrium moisture content values, which shows better drying.

Effect of steaming on drying curve of moisture ratio vs drying time

Moisture ratio versus drying time is plotted and shown in Fig. 3. Variation in moisture ratio with time is better correlated by linear relationship. Moisture ratio in initial stage was equal to 1. As time passes it approaches to zero.

Effect of solar drying on organoleptic properties

The results of are Friedman’s test revealed in Table 2.

The treatments were differing significantly for color and texture, as ‘F’ values were higher than standard value 15.51. The treatments non significant for flavor and not etching to throat properties as ‘H’ val-

ues were lower than standard values 15.51.

Treatment B₉ was liked by judges most for color and etching quality. Treatments B₇ and B₆ was most by judges for flavor and texture. Considering average rank B₉ treatment was selected as best.

Conclusion

Solar drying can be successfully used for cashew kernel drying by using solar dryer. It is less expensive and helps in increasing the quality enrichment of the cashew kernels. The cashew kernels treated at 110°C for 20 minutes gives best organoleptic properties when it is dried in solar dryer for five hours gives best results.

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