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Performance evaluation of LPG fired small cardamom drier in cardamom plantation

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■ **ABSTRACT :** Freshly harvested small cardamom capsules were dried in a LPG fired dryer in a cardamom estate, Idukki district of Kerala. The temperature of the drying air during the initial period of drying was 40°C ad thereby raised to 50°C towards the end. The drying characteristics of cardamom in the developed dryer were studied. It took about 23 hours of drying to reach a moisture content of 8 per cent (w.b) from an initial moisture content of 86 per cent (w.b). The quality parameters of the dried cardamom were analysed based on BIS specification. The cost of drying one kilogram of cardamom was worked out to be Rs. 2.10.

■ **KEY WORDS :** Cardamom, Liquefied petroleum gas, Drier, Drying characteristics, Quality

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Small Cardamom, (*Elettaria cardamomum*) popularly known as queen of spices, enjoys a premium preference in the international market and is relished for its distinct enriching properties. According to the statistics of Spices Board, Kerala, the area under cardamom cultivation was 55221 ha and the production in the year 2003-2004 was 11530 tonnes. There is a decline in the export of cardamom being produced in the country due to severe competition offered by Gautemala to India in the global market (Singhal, 1999). Hence, to raise the export potential of quality cardamom and to meet the growth in domestic demand the base of cardamom production need to be strengthened by better processing and post harvest techniques that could be easily adopted even by small planters is essential.

Cardamom capsules should be subjected to drying within 24 to 36 hours of harvest to avoid deterioration. Drying is one of the important unit operations as it determines the colour of the end product, which is the attractive and most important quality character. The retention of green colour is very important in cardamom drying as green colored cardamom fetches premium price in the export market. Fully matured capsules, which are not ripe yet, retain good colour after drying. Apart from retention of green colour, the capsules should not have excessive shrinkage and splitting of the capsules. Conventionally, cardamom is dried by flue curing in a special chamber known as the kiln. These kilns have many disadvantages such as high capital investment on buildings and also shortage of firewood as fuel, due to deforestation. Also the smoke coming out of these driers leads to environmental pollution.

Earlier field studies in the mechanical drying of cardamom was done with lesser capacity batch type mechanical dryers (George Varkey *et al.*, 1981) and in the case of tray dryers, the drying period was found to be considerably long. Moreover, these dryers were operated with electrical heaters where the consumption of electricity was found to be higher. The trays also occupy more space inside the dryer and the labour required for loading and unloading of trays is more. The trays need to be interchanged quite frequently to avoid overheating at the bottom.

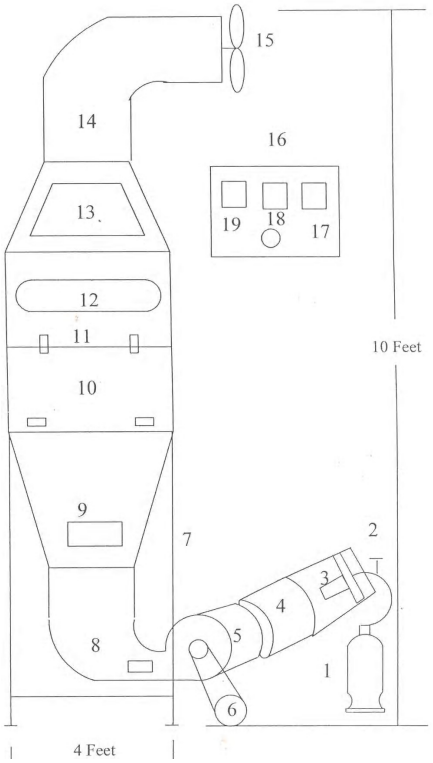
Better colour, flavour and aroma could be best retained at higher airflow and low temperature. This could be easily met using a forced flow type of cardamom drier using liquefied petroleum gas (LPG) as fuel. This type of drier requires less space and could be easily transported by vehicle to small plantations. The dryer could be used even in small plantations having limited power supply, since the availability of electricity is limited in such plantations. The dryer could handle 400-kg/ batch of fresh cardamom capsules and the retention of green colour were found to be maximum with better flavour and aroma.

■ METHODOLOGY

Description and operation of the LPG fired cardamom drier:

The drier has the following components: Drying chamber

where the fresh cardamom capsules are kept for drying, Plenum chamber to distribute the air uniformly to the cardamom kept inside the drying chamber, Burning unit which consists of LPG cylinder with a gas control valve where the flame could be regulated by adjusting the valve and the nozzle for injecting the flame, flame chamber which guides the air heated by the fuel into the blower, blower operated by a 3 HP electric motor for sending the heated air at a high velocity to the plenum chamber through the air inlet duct, exhaust air outlet where the moisture laden air coming out of the drier is carried by means of an exhaust fan and control panel consisting of temperature meter, voltmeter and ammeter. (Fig. A)



1. LPG cylinder, 2. Gas control valve, 3. Nozzle, 4. Flame chamber, 5. Blower, 6. Motor, 7. Outer frame, 8. Hot air inlet, 9. Plenum chamber, 10. Feed outlet, 11. Drying chamber, 12. Glass window, 13. Feed inlet, 14. Air outlet, 15. Exhaust fain, 16. Control panel, 17. Temperature indicator, 18. Voltmeter and 19. Ammeter

Fig A: LPG fired cardamom dryer

The LP gas cylinder was ignited and the flame was injected through a nozzle to the flame chamber. The temperature of the flame entering the drier was 40°C and this temperature could be regulated by means of flame control valve. The flame heats the ambient air entering the flame chamber and a blower draws inside this heated air. The blower sends the heated air through an air inlet duct to the plenum chamber. The hot air from the plenum chamber then moves to the wet produce kept inside the drying chamber and the moisture-laden air from the top of the drying chamber escapes outside by means of an exhaust fan.

Performance of the dryer :

The performance of the dryer was evaluated in terms of drying efficiency and heat utilization factor of the dryer according to Bhattacharya *et al*. (1971).

Heat utilization factor = Heat utilized/Heat supplied

$$= TD_1 - TD_2 / TD_1 - TD$$

where,

TD = Dry bulb temperature of ambient air, °C

$$\text{Thermal efficiency} = \frac{Q\lambda (M_0 - M_f)}{WC(100 - M_0)}$$

where,

Q = Quantity of final dried product

M_o = Initial moisture content, % (w.b)

M_f = Final moisture content, % (w.b)

λ = Latent heat of vaporization, KCal/kg

W = Quantity of fuel used, kg

C = Calorific value of fuel, kCal/kg

Process of drying cardamom

About 400 kg of freshly harvested cardamom of the variety Green Gold was first washed in per cent sodium carbonate solution to remove the extraneous matter. The water was then drained off. The cardamom was then loaded into the drier. The initial temperature was maintained at 40°C and hot air was blown at an airflow rate of 12m^3/min. The temperature and the relative humidity of the air inside and outside the drier was monitored at regular intervals using LT Lutron HT- 3003 model digital humidity/temperature meter. The temperature was then increased to 45° C, by adjusting the flame from the burner. After 19 hours of drying, the exhaust fan was switched off so that the hot air coming out could be recycled which aids in further drying. It took 23 hours for complete drying of the capsules. After drying, the drier was switched off and the capsules were kept inside the dryer for equilibration of moisture. The capsules were then unloaded from the drier and then cleaned to remove the stalk bits and packed in gunny bags.

Quality analysis of dried cardamom capsules :

Samples were drawn at regular intervals to estimate its moisture by toluene distillation method (ASTA, 1972). The retention of green colour before and after drying was monitored using a colour chart (Rayner, 1970). About one hundred dried cardamom capsules were taken and analysed to find the empty and malformed capsules, immature and shriveled capsules and blacks and splits according to BIS specifications of dried cardamom (IS: 1907-1984) and the

volatile oil of fresh and dried cardamom was estimated by hydro distillation method.

Statistical analysis :

All the results were statistically analysed to estimate significant difference among the treatments using AgRes Software. The experiments were carried out in triplicate.

Cost economics :

The cost of drying one kg of cardamom in the developed LP Gas fired dryer and the conventional kiln was worked out.

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussions have been presented under following sub heads:

Effect of moisture on drying cardamom :

The initial moisture content of fresh cardamom capsules was found to be 86 per cent (w.b). About 400 kg of freshly harvested cardamom was loaded into the dryer. The time required for attaining a final moisture content of 8 per cent (w.b) was 23 hours. The relationship between the drying time and moisture content of the sample at the bottom, middle and top layer can be seen in Fig. 1. It could be seen from the figure that the bottom layer encountered faster rate of drying than the next two layers below, since the heated air first reaches the bottom layer. The moisture coming out from the capsules at the bottom layer escapes out and the moisture laden air as it passes through the subsequent layers slows the drying process in the middle and top layers.

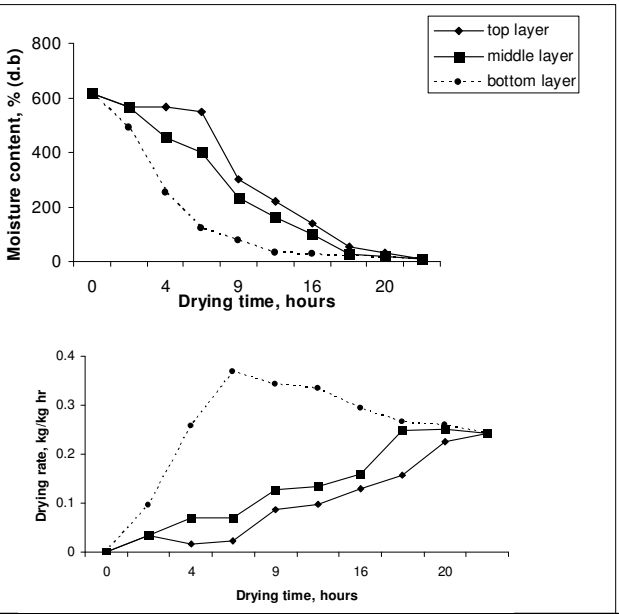


Fig 1: Effect of drying on moisture content and drying rate of cardamom (n=3)

The drying characteristics of cardamom was further analysed by studying the rate of drying at different intervals. The rate of drying at different intervals can be seen in Fig.1. The rate of drying was faster for the first two hours and thereby started decreasing at a rapid rate till the 16th hour and thereafter it was slow towards the end for the bottom layer. In the middle layer, drying rate gradually increased till 13th hour and then onwards decreased towards the end, whereas in the top layer, the rate of drying was found to be slower than the other two layers. The decrease in drying rate in all the three layers after sometime was due to the fact that as the drying continues, the surface moisture of the capsules diminished and moisture has to come out from the interior of the capsules by liquid/vapour diffusion. However, as the surface layer dries, the interior moisture must cross many layers to reach the surface resulting in decreasing of the drying rate.

Performance of the dryer :

The performance data of the dryer was evaluated in terms of thermal efficiency and heat utilization factor. The thermal efficiency of the dryer was found to be 75.74 per cent. The heat utilization factor was 0.789 at the beginning, 0.65 during the middle of the drying period and 0.33 towards the end. This may be due to the fact that maximum part of heat supplied by hot air is utilized during the initial period of drying. As the drying proceeds, moisture in the cardamom reduces thereby the temperature of the cardamom capsule increases causing an increase in the exit air temperature resulting in less heat utilization at the end of drying.

Quality of dried cardamom capsules :

The various quality parameters of the dried cardamom capsules as per Bureau of Indian Standards are presented in Table 1. Since the colour of the cardamom is an important quality attribute which adds value to the product, the changes in colour at every 6 hour interval was studied. The sample lot contained a mixture of citrine green and yellow green whose colour values according to the Munsell equivalent to the colour values 67 (citrine green/dark greenish yellow) and 71

Table 1: Quality of cardamom dried in LPG fired dryer

Quality parameters	Values
Empty and malformed capsules, per cent by count	Nil
Immature and shriveled capsules, per cent by weight	5±1.41
Black and split, per cent by count	Nil
Size (Dia. of holes in mm of sieve on which retained)	7 ±2.82
Volatile oil (v/w) per cent	8.5 ±1.41
Weight, g/litre	333±33.94
S.E.±	1.6330
C.D.(0.05)	3.767
C.V. %	2.24

(yellow green) are 10Y/6.8/6 and 6.2GY/6.3/4.7, respectively. It could be seen from the Fig.2 that the colour of cardamom capsules was found to be more or less retained during the drying process. It was found that drying in this type of dryer did not lead to much discolouration. The samples retained their colour during drying as seen with a colour chart. Dark greenish yellow and yellow green capsules were obtained at the end of drying.

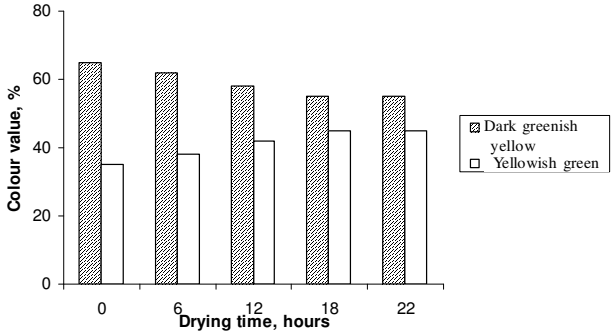


Fig.2: Effect of drying on colour of small cardamom (n=3)

The quality characteristics of cardamom capsules dried in the LPG fired dryer is presented in Table 1. The percentage of empty and malformed capsules was found to be nil. There were also no blacks and splits. This may be due to the maintenance of appropriate temperature for drying. The flavour of the cardamom capsules were measured in terms of volatile oil content of the samples. The volatile oil content per cent (v/w) was found to be 8.5 per cent and the weight in g/l was 333. The above quality parameters confined to BIS specification for dried cardamom. Statistical analysis revealed that the quality parameters were significantly different at 5 per cent probability.

Cost economics of the drying process :

The cost economics of drying in LPG fired cardamom drier and drying in conventional drier was worked out separately. The cost of drying one kg of cardamom in LPG fired drier was found to be Rs.2.10/kg whereas the cost of drying in a smoke house was found to be Rs.5.36/kg. It is seen that green colored good quality cardamom fetches a premium price of Rs.50/kg and thereby an additional income could be got in this type of drying.

Conclusion :

The LP gas fired cardamom drier was found to perform well during it's evaluation at the cardamom estate. The dried capsules were found to be better in quality retaining the green colour according to the BI standard. The cost involved in drying was also comparatively lesser than the conventional method of drying.

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