Curing of large cardamom (*Amomum subulatum* Roxb.) : Fabrication of a new dryer and a comparative study of its performance with existing dryers

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ABSTRACT

A simple natural convection dryer that could be easily dismantled and transported was designed, fabricated and field tested in a large cardamom (*Amomum subulatum)* plantation in Sikkim, India. The thermal efficiency of the dryer (5.2%) was much higher compared to the traditional curing house dryer (1.8%) thus saving substantial fuel. The dryer had a capacity of 300 kg of fresh cardamom capsules which was adequate for most of the plantations in the region. The time taken for drying the fresh capsules to a moisture content of about 10% was 24 h which was much less compared to conventional *bhatti* drying (55 h) and curing house drying (42 h). The quality of the dried product with respect to flavour and colour was also superior to that obtained from the other two methods of drying.

Key words : *Amomum subulatum,* curing, dryer, large cardamom, thermal efficiency.

Introduction

Large cardamom (*Amomum subulatum* Roxb.) (Zingiberaceae) is grown in sub-Himalayan regions in India and is the main cash crop of Sikkim. Drying of fresh capsules is the main post harvest process involved to obtain dried fruits of commercial trade. The moisture content of freshly harvested capsules is about 80%. This is dried to 10-20% moisture level before marketing. Drying, at present, is carried out in a *bhatti* dryer or in a curing house dryer. Unlike curing house dryer which is a humid chamber, *bhatti* is more like a through-flow dryer wherein the fresh capsules are heated directly by passing smoke and flue gases through a bed of capsules spread over a wire mesh. These are energy intensive, requiring 8 to 20 MJ of thermal energy to dry 1 kg of the produce. Comparatively high investment and unreliable electric power supply in large cardamom plantations

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are discourageing factors to employ modern electric dryers at the farm level (Annamalai, Patil & John 1988; Gurumurthy, Nataraj & Pattamashetty 1985; Kachru, Srivastava & Patil 1988; Karibasappa 1987; Roy 1988). These factors necessitated the development of a thermally efficient dryer which can be operated using firewood as fuel, and compare its performance with existing dryers.

Materials and methods

CFTRI-fabricated Natural Convection Dryer

A natural convection dryer was designed (Fig.1) based on a study of existing dryers for large cardamom in Sikkim. The dryer was fabricated at CFTRI and the components transported to a large cardamom plantation in Sikkim and assembled. The essential components of the dryer were: (i) furnace (ii) flue ducts (iii) wire mesh tray for charging fresh capsules and (iv) supporting structures. The flue ducts were arranged in two tiers, one over the other with sufficient space between ducts and two wire mesh trays were fitted one above each duct. The flue ducts were connected to the furnace in parallel. The hot flue gases passing through the ducts sets up convection currents in the air between the duct wall and wire mesh trays. The convection currents pass upward through the mesh and the bed of cardamom capsules on the mesh are subjected to drying as in a through flow dryer.

Furnace: Fabrication of the furnace was carried out using 8 mm thick MS plates. Lagging was done around the

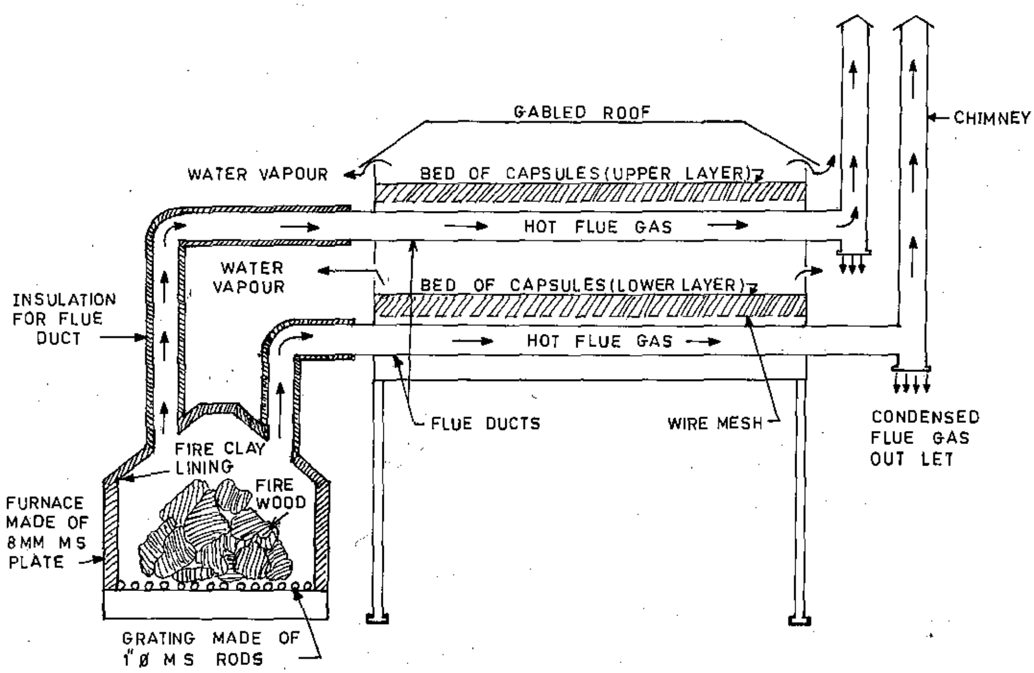

Fig.1. CFTRI - fabricated natural convection dryer

furnace to prevent dissipation of heat and to withstand a temperature of 800-1000°C. A brick lining inside the furnace on three sides provided sufficient insulation to minimize heat loss. The furnace front was provided with a double door. The brick wall was plastered with fire clay available locally in Sikkim. The hood of the furnace was tapered slightly and left flat at the top providing for the flue ducts to be connected. On the bottom of the furnace a grating made of 2.5 cm dia MS rods was fixed.

Flue ducts and chimney : The ducts and chimney were made of 1.6 mm thick GI sheets and connected with necessary flanges. The orientation of the ducts was made elliptical so as to dissipate heat uniformly over a wider area.

Wire mesh tray: Two crimped steel wire mesh (1.6 mm thick) trays with border reinforcements made of MS sheets were placed one over each duct leaving a sufficient gap and spread over the length and width of the dryer with necessary fastening.

Structural support: The structural support was fabricated using MS angle iron of different sizes and flats with suitable bolting arrangements to take the load of ducts, mesh and material to be dried. The sides of the structural frame were covered around with 6 mm thick asbestos sheets and the borders were reinforced with MS sheets to provide better insulation. Suitable provisions were made in the front and hind sides of the dryer to connect the ducts with the furnace and the chimney and also to load and unload the raw material through the left and right sides of the dryer. The ceiling of the dryer was covered with a gabled roof made of asbestos sheet to the required height. An opening was also provided to drain off the condensed water at the bottom elbow of the chimeny.

Drying trials

In a typical experiment, 300 kg of a raw capsules were washed under running water to release the adhering soil and extraneous matter and the water drained. The material was charged at the rate of 150 kg per deck and evenly spread over the entire area of the wire mesh tray. Firewood was weighed and charged to the furnace and the temperature maintained at 70-80°C. The capsules were raked once every hour to enable uniform drying. After 14-16 h of drying, the amount of firewood charged was reduced so that there was a drop in temperature (50-55°C) in both the decks. This was found essential to prevent charring of capsules. The rate of drying was determined by weighing a known number of capsules periodically. The initial moisture content in the raw capsules immediately after harvest, was 80% as determined by standard procedures (ASTA 1985). The moisture content in the sample during the course of drying was also determined at periodic intervals until the same reached 18%. When the moisture content dropped below 18%, a digital moisture meter (Farmex Meter, M/s. Lunkad Enterprises, Bombay) was used to read the moisture in the drying sample. This moisture meter was pre-calibrated for large cardamom by deterimning the moisture content by the oven method and obtaining the meter-reading for samples of different moisture contents. These values were plotted and a graph obtained (Fig. 2a). The drying capsules were randomly collected from both the trays, mixed thoroughly, filled into the sample holder of the meter and the value recorded. This operation was

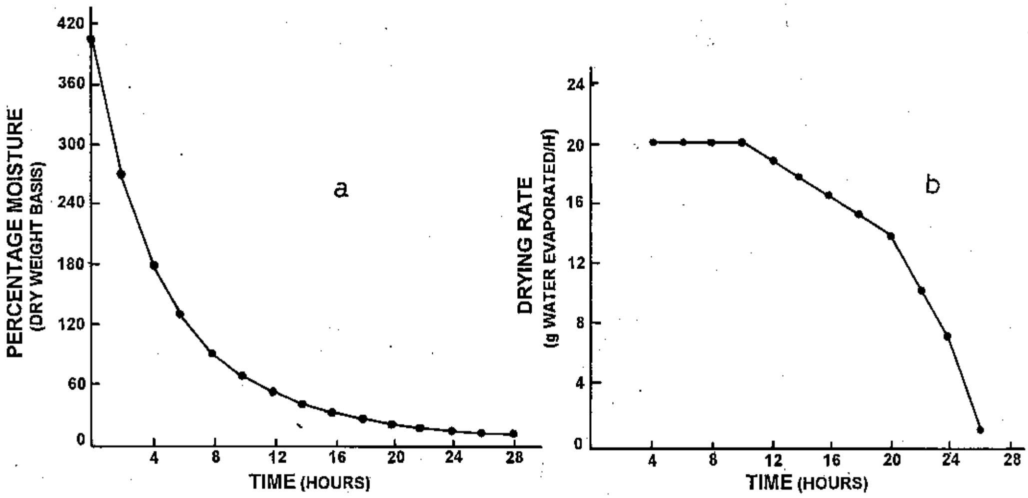

Fig.2. Curing of large cardamom using CFTRI - fabricated dryer
a. Percentage moisture *vs* time b. Drying rate *vs* time

repeated periodically and the values obtained each time were plotted (Fig. 2b) and the moisture content extrapolated. Drying was discontinued when the moisture content of the capsules dropped below 10%. The dried material was discharged from the trays and weighed. Two more drying trials of fresh capsules (300 and 282 kg) were carried out as described above. The average of the meter readings from replicate samples was taken into consideration for extrapolation in the graph to obtain the moisture content.

Curing house dryer

This is essentially a permanent structure like a room with inner dimensions of 2.95 x 2.62 x 3.00 m (l,b,h) consisting of three decks (wooden) and a furnace. About 42 wire mesh trays (70 x 40 x 10 cm) can be accommodated at the rate of 14 trays per deck and the capacity of the dryer is 200 kg. When the furnace is charged with a known quantity of firewood and heated, the hot flue gases pass through the cylindrical duct (23 cm) connected to the furnace, running horizontally through the curing chamber on three sides except the front one. The exit of flue gases is through the vertical duct connected on the third side of the horizontal duct and leading to the chimney out of the chamber. The curing house gets heated and the rate of drying depends on the temperature inside the room and moisture content of the capsules.

Drying trials

The wet capsules (200 kg) were washed with running water and loaded on to the wire mesh trays at the rate of 4.76 kg per tray. The trays were then placed in three decks and the furnace heated with a known quantity of firewood. The rate of drying and the moisture content in the drying capsules were determined as described earlier. The drying was discontinued when the moisture content in the sample dropped below 10%. The dried capsules were collected and weighed. The experiment was replicated.

Bhatti *dryer*

The *bhatti* dryer is made of brick and

clay walls on all the four sides with an opening in the front for charging the fuel. The dimension of the dryer is 170 x 270 cm. The entire area is covered by a wire mesh tray which rests on the walls supported by MS flats to withstand the weight of raw capsules.

Drying trials

The material (1200 kg) was weighed and spread evenly on the tray and heated using the fuel to dry the capsules. The drying capsules were raked periodically. When the moisture content was brought down to 10%, the furnace was put out and the dried capsules removed and weighed. The experiment was replicated.

The volatile oil and sensory characteristics of the dried capsules were also determined in all the trials.

Results and discussion

The data obtained in the drying trials using various dryers are given in Table 1. The performance of the CFTRI-fabricated dryer was economical with regard to the quantity of fuel used and time taken for drying the capsules. The thermal efficiency of the dryer was also high mainly because there was uniform distribution of heat in both the decks resulting in better product quality as judged by volatile oil content and sensory quality (Table 2).

The curing house dryer which produced a product comparable in quality to that of CFTRI - fabricated dryer was uneconomical since its thermal efficiency was less. This is mainly due to poor temperature distribution owing to dissipation of heat over a larger drying area. The temperature gradient (15°C) was also more between the upper and lower decks.

Although the drying area in *bhatti* dryer was half that of CFTRI dryer, the space occupied by both the dryers was almost equal. However, the quantity of capsules spread per unit area was extremely high in *bhatti* dryer. The high thermal efficiency was obvious

Table 1. Comparative performance of dryers for large cardamom

Parameter	CFTRI-fabricated dryer		Curing house dryer		*Bhatti* dryer	
	Mean	SD	Mean	SD	Mean	SD
Drying area (m^2)	9.00	-	16.20	-	4.60	-
Batch capacity (raw capsules) (kg)	294.00	8.40	201.67	6.24	1200.00	40.82
Tray load (kg/m^2)	32.66	0.94	12.45	0.38	260.87	8.88
Drying time (h)	24.33	0.47	42.33	0.47	55.00	0.81
Firewood (kg)	806.70	9.40	1620.00	16.32	3006.67	49.21
Fuel consumed/kg of raw capsules	2.74	0.07	8.04	0.20	2.51	0.05
Thermal efficiency* (%)	5.20	0.13	1.75	0.05	5.60	0.10

$$\text{*Thermal efficiency (\%)} = \frac{\text{Water evaporated(kg) x Latent heat}}{\text{Heat supplied (KCal)}} \times 100$$

SD = Standard deviation

Table 2. Quality of large cardamom capsules dried in various dryers

Dryer	Product quality	
	Volatile oil (%)	Sensory characteristics
CFTRI	3.5	Camphory, eucalyptus-like, sweet-spicy, maroon colour
Curing house	3.1	Eucalyptus-like, herbal, pink/maroon colour
Bhatti	2.3	Smoky, woody, brown/black colour

*Moisture free basis

since the dryer provided for direct heating of capsules; as a result, there was no control of temperature and the product temperature invariably exceeded 100°C, thus affecting the sensitive anthocyanin pigments present in the skin of the capsule. This resulted in darkening of capsules with brown/black colour. Further, the dried capsules possessed a strong smoky flavour with a heavy loss of volatiles.

The CFTRI - fabricated dryer is thus superior in many respects compared to curing house and *bhatti* dryers. Besides fuel economy and better thermal efficiency, the quality of the dried capsules is highly acceptable in terms of higher volatile oil content and very good sensory characteristics. Above all, the dryer is dismountable which enables its easy transportation to large cardamom plantations where the harvested capsules can be dried.

Acknowledgements

The authors express their sincere thanks to the sponsors, Spices Board, Kochi and Sikkim Industrial Development and Investment Corporation, Gangtok for funding this work. The authors are also grateful for helpful discussions with Dr. C K George, Executive Director, Spices Board during the course of the study. They are also thankful to Dr. Anand Kumar, Deputy Director (R&D) and Mr. I R Noolvi, Scientist, Regional Station, Spices Board, Gangtok for their kind co-operation in carrying out this study.

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