KINETICS DRYING OF CARDAMOM (*Elettaria Cardamomum*)

Lilia Méndez Lagunas and Juan Rodríguez Ramírez

Centro Interdiciplinario de Investigación para el Desarrollo Integral Regional IPN U. Oaxaca
Hornos 1003 Sta. Cruz Xoxocotlán Oax. México
Tel.(9)51-7-06-10, (9)51-7-04-00 ext. 2712, e-mail jrodrigr@redipn.ipn.mx

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ABSTRACT

Cardamom (*elettaria cardamomum*) drying is crucial in order to attain the storable stage and marketable color quality. The main objective of this work was to find proper drying conditions without deterioration product quality. Drying kinetics curves were obtained in a pilot thorough air dryer at different temperatures (40°C to 50°C) and air flow rates (1.272 to 1.728 m/s). Air flow affect significantly the percentage of unclipped capsules and the temperature affects significantly the drying-rate. The better conditions of drying were a temperature of 50°C and an airflow of 1.272 m/s in a convenient time of 10 hr.

INTRODUCTION

Cardamom is the seed capsule of a herbaceous plant "Elettaria cardamomum". Cardamom aroma is strongly fragrant and its taste is bitter. The dried capsule seed contains 7 to 8 (Babu et. al., 1981) volatile oils being 1,8 cineole and terpenyl acetate the principal constituents. The main use of this spice is to flavor meat dishes, beverages, baked products, etc. Generally the raw cardamom is subjected to sun dryer. The sundry cardamom with single layer thickness would take 3 days or 8 effective drying hours per day. If capsules are spread in more than one layer it takes more drying days. By sun drying could increase the splitting of capsules. The shiny shell capsulation the dry seed, contains about 80 % water (w.b.). When the moisture is removed, the thick shell is reduced to thin hygroscopic skin. Drying is crucial and laborious in cardamom post-harvest technology in order to attain the storable stage and marketable color quality. The losses that occur are due to mainly mechanical handle, color damage or mould grown. In

bad weather the sun drying take a week or more, resulting in successive pickings more problematic. Once the raw capsules are not dried immediately they turn moulds, white and gray are substandard in quality.
Above considerations, are necessary to study a method of capsules artificial drying. The main objective of this work was to find proper drying conditions without the deterioration of product quality.
Krishnamurthy (1964), studied the effect of the drying temperature and final moisture on the color and quality of cardamom. Blanching prior to drying was deleterious, increasing the percentage of split seeds, affecting color and volatile oil. Drying temperature of 37 °C to 42 °C gave a satisfactory product, equal to the best market grade, in a convenient time of 16 to 24 hr. In this work the drying characteristics of cardamom have been studied under wide conditions that Krishnamurthy (1964) ones in order to reduce the drying time without the deterioration of product quality.

PROCEDURE

Fresh sample was obtained in the Tehuantepec region located in the State of Oaxaca, Mexico, and immediately they were cleaning deleting the trash and unclipped capsules. Moisture was determined using AOAC 7.003 (1984).
Fresh samples were measured wide and long across and were sets on tray of 0.9 x 055 m^2. A monolayer was used. The air flowed is perpendicular to the bed.
A convective flow through pilot-size air dryer (figure 1) was used. It was equipped with an automatic temperature controller (±0.1 °C). The temperature sensor is fixed in the drying chamber above the sample tray. It possible to using a frequency converter of a fan motor to regulate the air velocity.
Area of drier was divided into 36 sections and the airflow was measured at each point and it was averaged. Digital anemometer was used for measuring the speed of air flow.
Water losses were measured weighing the tray and its content automatically used a load cell. Data acquisition system was used to store and record experimental data.
Mass reduction in samples was recorded every five minutes. During the measuring the airflow was deviated across alternate duct to avoid pressure over the bed.
To determinate the influence of temperature and flow velocity on the drying of cardamom was chosen a 2^2 experimental design, at random and with two replicates. It was selected the air temperatures of 40 °C and 50 °C and velocities of 1.272 and 1.728 m/s of airflow. The quality of the dried product was evaluated using the International Standard ISO 882.

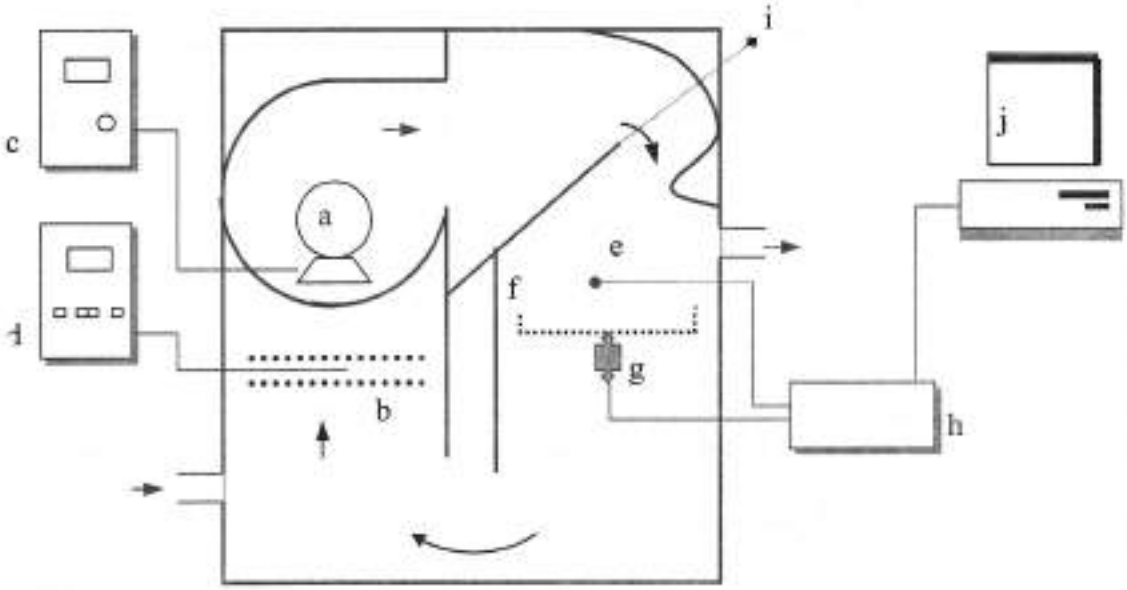

Figure 1. Convective flow through pilot-size air dryer. a) Fan b) Heater c) Motor speed control d) Temperature controller e) Sensor of temperature f) Sample tray g) Load cell h) Data acquisition system i) Air flow deviator, j) Computer.

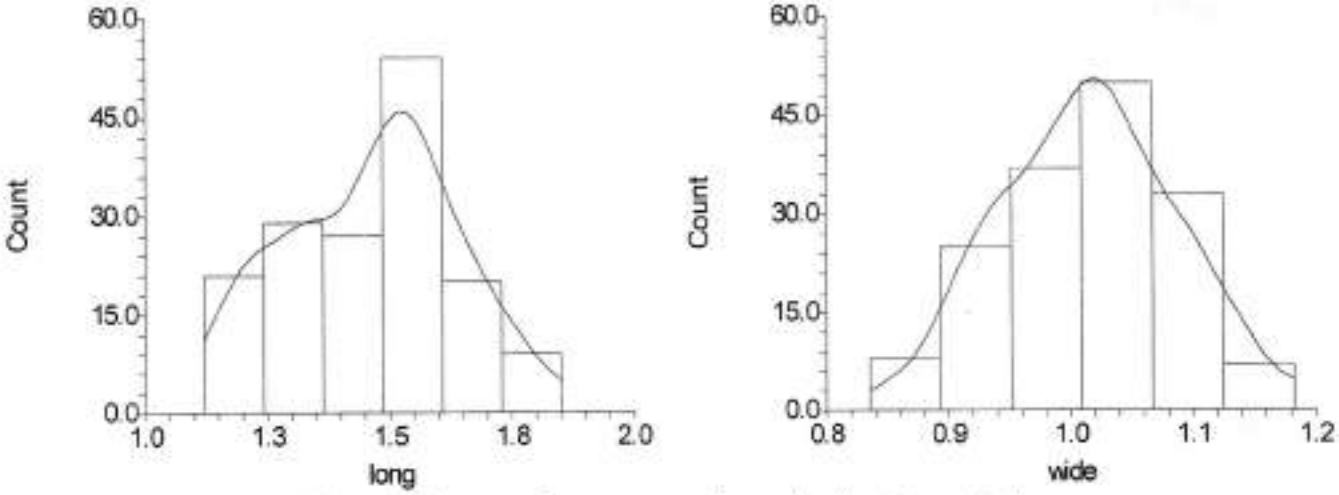

Figure 2 Histogram of measurement of capsules of cardamom fresh.

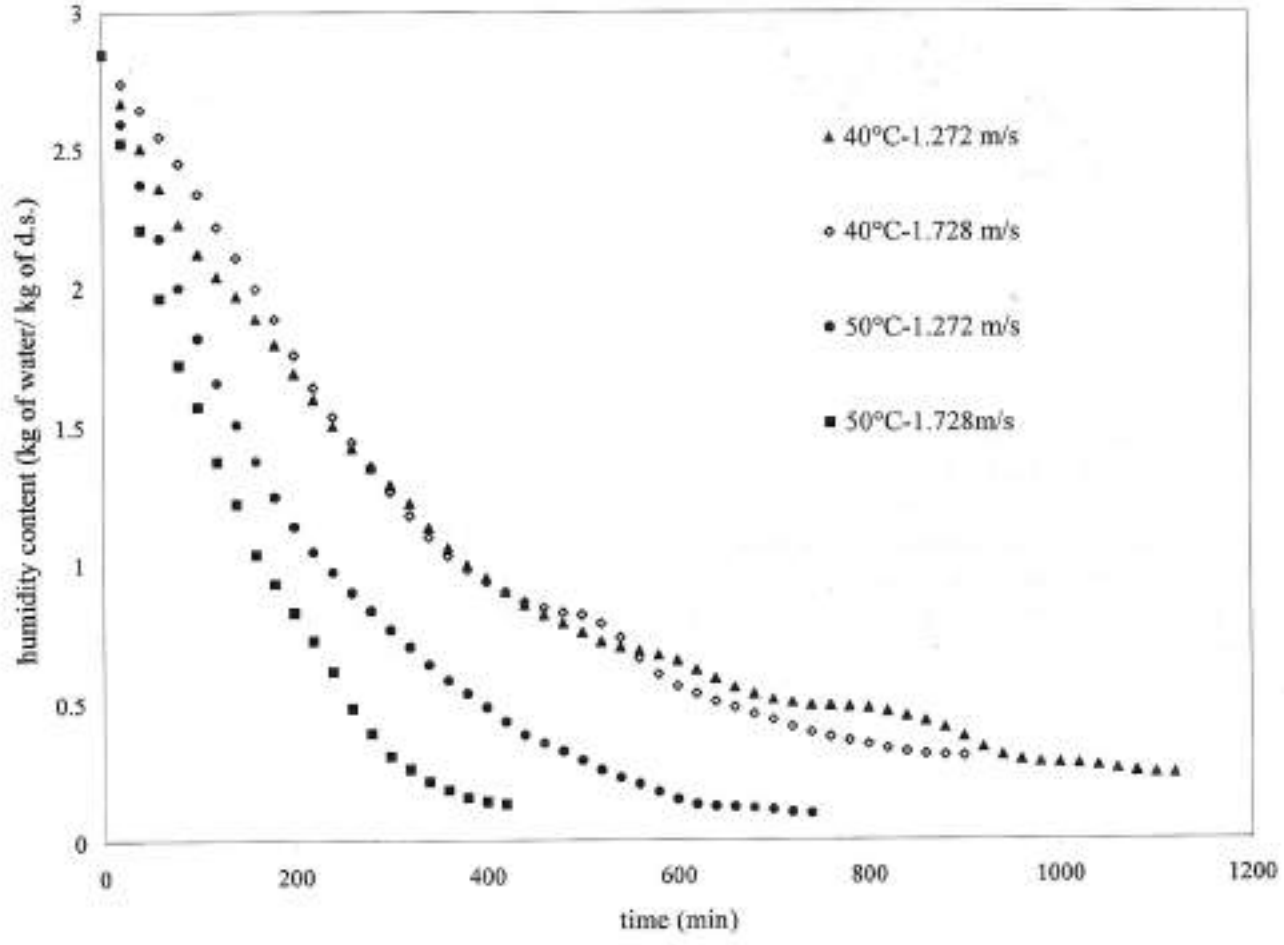

Figure 3. Drying curves of cardamom

RESULTS AND DISCUSSION

Histogram of measurements of capsules of cardamom fresh (figure 2) show its wide and long across in centimeters. Average wide was 0.9904 cm and long was 1.462 cm.

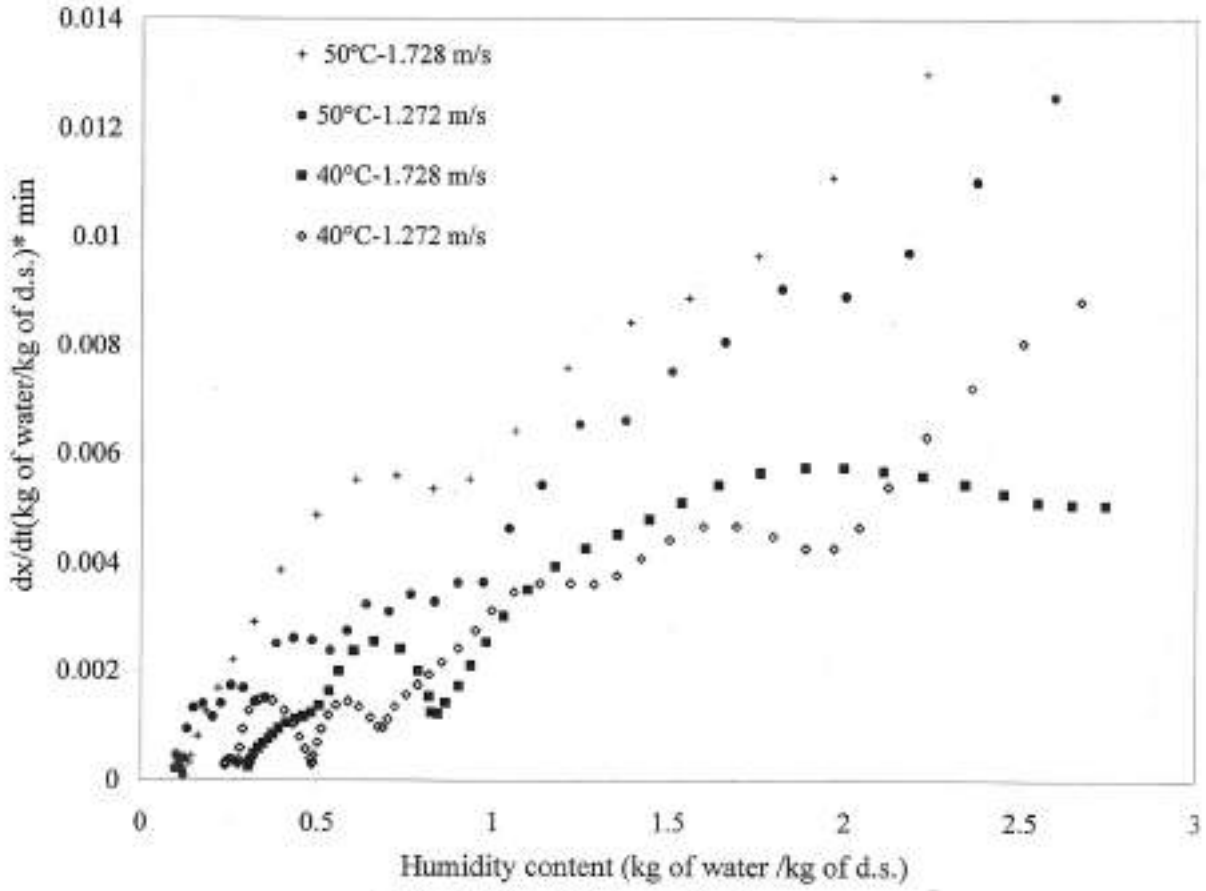

Figure 4 Drying-rate curves of cardamom

The drying curves (figure 3) show the effect of temperature and flow in the drying of cardamom. The air flow is not important at low temperature.

The drying-rate curves (figure 4) shows no the constant-rate period. Variations during the falling period were observed. That occurs when the internal resistance control the moisture movement.

Two response variables were chosen for the analysis of variance, one was the first moment and other was the percentage of unclipped capsules.

Analysis of variance shows that the temperature affects significantly the drying-rate (table 1), but also the airflow affect significantly the percentage of unclipped capsules. Krishnamurthy (1964) studied the drying process without considering the effect of airflow on quality products, but it is important the quality maintaining.

Table 1 Analysis of variance using first moment as response variable

Source Term	DF	Sum of Squares	Mean Square	F-Ratio	Prob Level	Power (Alpha=0.05)
A (temperature)	1	263538	263538	9.38	0.03756*	0.521320
B (flow)	1	242.00	242.00	0.01	0.93018	0.050459
AB	1	12.500	12.500	0.00	0.984182	0.050024
S	4	112383	28095.75			
Total (adjusted)	7	39.03168				
Total	8	376157.5				

* Term significant at alpha =0.05

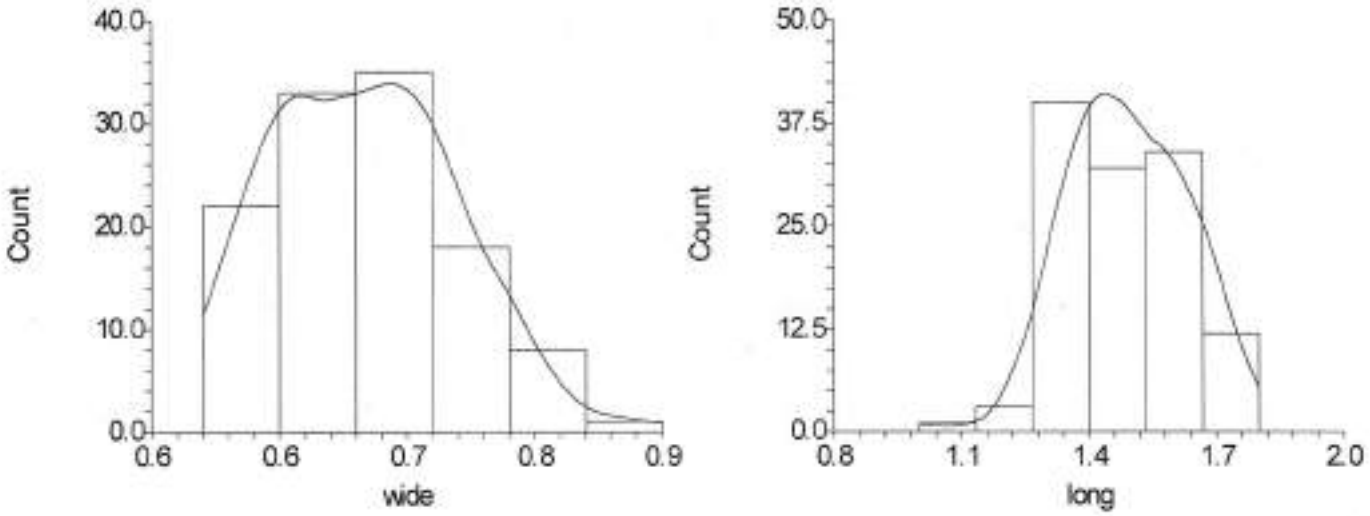

Figure 5 Histogram of measurement of capsules of cardamom dry.

A contraction of 31% in the wide across measurement was observed between the fresh and dried cardamom. That should explain the behavior during the falling period.
Quality was determined according to the International Standard ISO 882-1 (table 2).
Percentage of extraneous matter, immature and shivelled capsules exceeded the standard. That is because the material wasn't a suitable harvesting, then every operation previous to dry should be to take care over.
Conditions of operation the drier 50°C, 1.272 m/s was the better and the material obtained was Embarque classification according to the ISO 882-1 in a convenient time of 10 hr.

Table 2 Classified of cardamom drying in base of ISO 882-1

Conditions	Extraneous matter % (m/m)	Unclipped capsules % by count	Immature and shrivelled capsules % (m/m)	Blacks and slipts % by count	Empty and malformed capsules % by count	Mass g/l	Color
40°C-1.272 m/s	0.50	4.85	34.27	12.73	8.12	305	Dull white-brownish
40°C-1.728 m/s	0.33	0.00	44.63	9.84	0.33	338	Creamy-dull white
50°C-1.728 m/s	0.46	3.40	25.58	7.25	5.29	383	Light green
50°C-1.278 m/s	0.41	6.32	19.63	2.88	1.37	361	Deep green

CONCLUSIONS

The airflow should be considered in order to reduce the percentage of unclipped capsules.
Contraction should be considered in the phenomenological models in order to describe appropriately the cardamom drying.
Main factor that affected the drying rate was temperature of drying and the unclipped capsules was the airflow.

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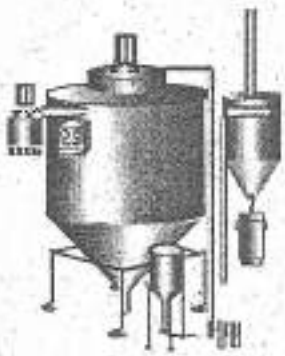

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