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MICROWAVE DRYING OF GARLIC

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Abstract- Microwave drying, application of microwaves, are relatively new addition in the existing drying techniques. Whole garlic cloves were subjected to microwave drying as well as convective drying. The drying parameters for microwave drying were 1 W, 2 W, 2.5 W and 50^{0}C, 60^0, 70^{0}C for convective drying. For quality assessment garlic samples were dried to safe moisture content. The quality of the products evaluated by the flavour strength and color test. In both the test, microwave drying found better in terms of uniformity, time and quality of the products. The economics of microwave drying were evaluated and found viable as cost benefit ratio is 3.77 for 3 years.

Index Terms- microwave drying, convective drying, garlic, flavor strength

I. INTRODUCTION

Garlic (*Allium sativum* Linn.) is a bulbous perennial vegetable spice. The world production of garlic in 2002 was 12.23 MT from an area of 1.13 Mha, out of which 500,000 tones from an area of 120,200 ha was produced by India [1]. Due to lack of suitable storage and transportation facilities, about 30% of fresh crop is wasted by respiration and microbial spoilage [2]. More recently, it has found uses in its dried form, as an ingredient in precooked foods and instant convenience foods including sauces, gravies and soups which has led to sharp increase in the demand of dried garlic.

Drying of foods is aimed at producing high density product, which when adequately packaged has long shelf life and after which the food can be rapidly and simply reconstituted without substantional loss of flavor, taste, color and aroma. Most of the cost of final product is dependent on the drying process. So it is necessary to dry the product in minimum cost, energy and time for techno-econo-socio compatibility.

Garlic is a high-moisture commodity and microwave drying technique has attempted rarely. Microwave drying is relatively a new addition in the existing drying techniques, viz. convective air drying (cabinet, fluidized bed, tunnel), spray, vacuum, foam mat and freeze drying [3]. Published work in the microwave drying domain have pointed out that this technique leads to a greater reduction in drying time, increasing the production capacity. This is due to high thermal efficiency of the process increase quality attributes equivalent to or better than those dehydrated by convective drying [4, 5, 6].

II. MATERIALS AND METHODS

The microwave drying of garlic cloves were investigated in microwave dryer installed in the Department of Processing and Food Engineering, College of Technology and Engineering, MPUAT, Udaipur. A microwave dryer, having a capacity of about 15 kg of garlic cloves /day is shown in Figure 1 and its specifications given in Table 1.

Fig.1. Peeled garlic cloves being dried in microwave dryer

Table:1 Specification of microwave dryer.

Microwave Cavity	
Dimention	700 X 700 X 550 mm
Thickness of the cavity	16 gauges
Material of the cavity	S S 304 with mirror finish
Microwave generator	
Magnetron	1 no.
Type no	2M121A Hitachi Make
Power	2.5 kW

Pulsed operation	Duty cycle 10 to 100%
Freqency	2450 MHz
Efficiency	60-70%
Cooling of Magnetron	Air (Air blower be provided)
Mode of operation	Continuous & stepwise 0.25 kW variation.
Product Holder	Circular type having diameter 600 mm, height of rim 120 mm, made of Teflon & rotating product at 360 degree.
Control and Interlocks	An electronic control system, comprising of relays, contractors and switches be provided on the control console.

A. *Principle of microwave dryer*

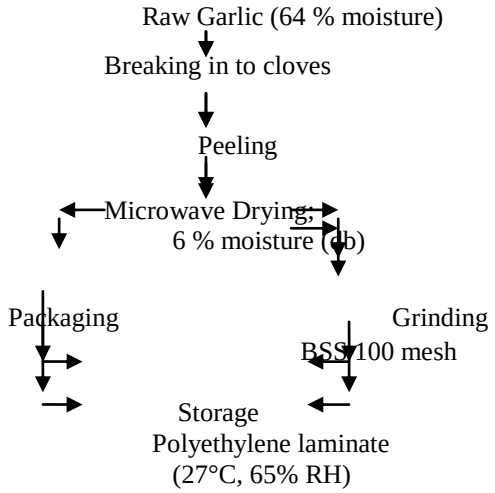
Microwaves are electromagnetic waves in the frequency range of 300 MHz – 30000 MHz. It is the combination of electrical and magnetic fields, with only the farmer being engaged in the conversion process when waves interact with the non-magnetic materials. The conversion of Microwave Energy in to heat in the food is because of the presence of water. As the water molecules are bipolar and rotate in the rapidly changing electromagnetic field (billion times a second), heat is evolved within the food stuff due to friction between the water molecules. As waves can penetrate directly in to material, heating is volumetric (from inside out) and provide fast and uniform heating through the product. The quick absorption of energy by water molecules causes rapid evaporation of water, resulting into high drying rates of the food.

B. *Specification of the raw material*

According to Indian standard for Garlic, IS: 3240 – 1965, the bulbs of garlic shall be mature, well cured, compact, that is, the cloves shall not be spreading out but shall fit closely together practical the entire length of individual of cloves and enclosed in an outer sheath. Mature and well cured means fully develop, fair, sufficiently dry and not soft and spongy. The cloves shall be well filled and fairly plump.
Fresh garlic (Allium sativum) bulbs were used in the investigation, which were procured in bulk from the local market. The Garlic had moisture contents ranging between 60 – 65 % (w.b.) and moisture content reduce up to safe moisture content of 6 % (w.b.). The vacuum oven method was used to determine the initial moisture content of the garlic cloves. Initial moisture content was determined with the help of vacuum oven with 70 °C with a gauge pressure of 85 kPa for about 24 h [7].

C. *Process Parameters*

Conventionally peeled garlic cloves are dried immediately in Microwave dryer applying 1 W, 2 W and 2.5 W through experiment. For convective heating, tray dryer was used with operating temperature of 50oc to 70 c with air velocity 2 m/s [8, 9]. A process flow chart of garlic cloves are furnish hereunder.

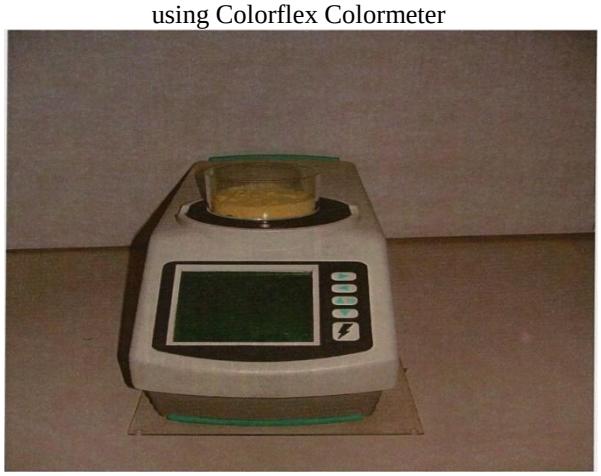


D. Quality Assessment

Color measurement

Color of fresh garlic and dried samples was evaluated by a Minolta Chroma Meter CR-200 Reflectance System shown in fig. 2. The results were expressed as L^* (whiteness–darkness), a^* (red–green), and b^* (yellow–blue) values. The measurements of color were repeated three times.

Fig. 2 Pictorial view of colour measurement of Garlic Powder using Colorflex Colormeter



Flavour strength

The flavor strength in the dried cloves was determined by Chloramine T method, a titration method. Garlic has charactorstic pungent flavor because of interaction of S – substitutes, L- cystein sulfoxide derivatives and the enzyme allinase. These sulfoxides are collectively called allins. Flavour strength can be determined by measuring the amount of Chloromine – T solution consumed for allin oxidation. The excess of Chloromine – T can be assessed by adding potassium thiosulphate using starch as indicator.

III RESULTS AND DISCUSSION

A amount of about 7.5 kg of peeled garlic cloves was loaded in the microwave cavity and it took about 6 hours for 2.5 W,

6.3 h for 2 W and 7 h for 1 W to dry to the product of final moisture content of 6.0 % (w.b.). The drying time can be greatly reduced by applying the microwave energy to the dried material [10, 11]. However, when the same load was kept in a tray dryer, drying took place in about 12 – 13 hours at 60^0C, in 16 h at 50^0C and 18 h at 40^0C. Increased drying temperature entails higher costs and may cause biochemical changes that degrade the dried product quality; whereas subdividing the material is an additional process that results, especially under industrial conditions, in mass losses and lowering of the product quality [12]**.** Garlic cloves dried in microwave dryer as shown in figure 3. respectively.

Fig. 3. Garlic cloves dried in microwave dryer

E. *Quality of Dried Products*

The dried garlic cloves were analyzed for quality with respect to flavor strength and color, because these two parameters become the basis of choice for acceptability by the consumers as far as garlic powder is concerned.

Color assessment

It was found that microwave drying made the color brighter (L = 73.42). Whereas drying slices with the convective method lessened the color brightness (L = 64.31), shifting it markedly towards red and yellow. Comparing the results presented with color assessment of garlic dried with the microwave method only [11, 13].

Flavour strength

Flavour strength for for microwave dried powder was found to be. 4.86 and for convective drying was 3.28. L value and favor strength are shown in Table 2 and Figure 4 (a), (b). This showed that favor strength was more in Microwave drying powder as compared to convective drying powder because uniformity and less time period increase the quality of the products. Same results were also be found, [11, 13].

Table: 2 Color Values and Favor Strength of Dried Garlic cloves

Drying Method	Flavour Strength (mg/g DM)	L-Value
Microwave Dried	4.86	73.42
Convective Dried 60^oC, 1 m/s	3.28	64.31

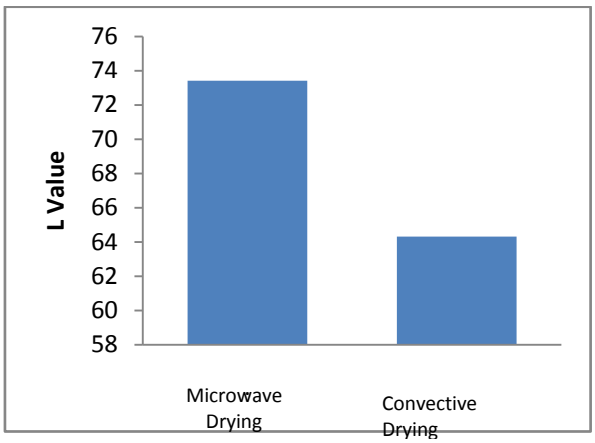


Fig. 4 (a) Color (L - value) of garlic powder dried by two methods.

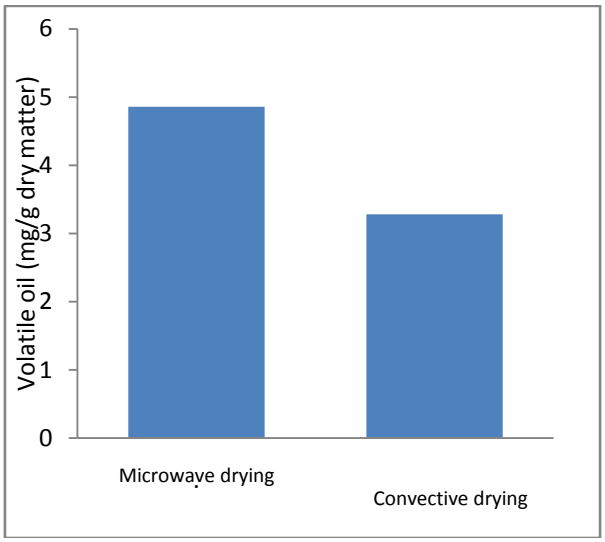


Fig. 4 (b) Flavor strength of garlic powder dried by two methods.

F. *Economics of the Microwave drying techniques*

When garlic processing and dehydration plant considered from a gross benefit steam the capital investment and operating costs i.e. cost of microwave dryer, packaging machine, labour input, electricity charges are deducted.

Financial Aspects

The following parameters have been considered for carrying out the economic analysis of the microwave dryer.

a) Life of the MW dryer 20 years
b) Life of packaging machine 10 years
c) Discount rate 8%
d) Capacity of the dryer 15 kg of raw material and processed product will be 6 kg per batch of 5 hours and two batches per day.
e) Number of days working for dryer = 300

The details of the fixed and operating cost shown in Table 3 and results of economic analysis shown in Table 4.

Table 3. The details of the fixed and operating cost.

Fixed capital	
Land and Building	***Amount (Rs Lakh)***
Land, 50 sq.m.	0.50
Built up area, 25 sq. m.	1.50
Total cost of land and building	2.0
Machinery and equipment Description Microwave dryer Packaging unit Total cost involved	 2.50 0.40 2.90
Total fixed cost (1.1.1 + 1.1.2)	**4.90**
Recurring expenses per annum Labour, 2 salary 10,000 per month	1.20
Raw material including packaging material Peeled garlic cloves, 30 kg per day for 300 days @ Rs. 40 per kg Packaging material	3.60 0.50
Utilities Power, 2.5 kWh for 10 hour per day @ Rs. 5 per kWh for 365 days per year water.	0.45 0.15
Other contingency Expenses Repair & maintainance charges	0.30
Total recurring expenditure (1.2.1 + 1.2.2+1.23+1.2.4)	**6.20**
Total Capital investment (Fixed capital + Recurring expenditure)	**11.10**
Sale proceeds per year Dehydrated cloves, 12 kg per day for 300 days @ Rs. 700 per kg	25.20

Table 4: Results of Economic Analysis

Economic indicators	
B/C ratio	3.7752
Pay back period	Less than 3 years

The Table shows the economic indicators determined for the garlic dehydration unit. It can be seen that benefit-cost ratio of the project is 3.77 and the payback period is less than 3 years. This indicates that project is economically viable.

IV. CONCLUSION

i. The drying time increased with increase microwave output power level.
ii. Microwave drying found better in terms of uniformity and reduce in time as compared to convective drying.
iii. Qualities of the microwave garlic cloves are found to be better.
iv. Microwave drying are economically viable.
v. The microwave drying could be employed in the drying of garlic cloves to produce dried cloves and garlic powder.

G. Future extension

Combination of microwave drying with other mode of heating, may give better results.
It is necessary to designed microwave dryer for more fruits and vegetables drying.

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