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COMPARATIVE STUDY OF DRYING CHARACTERISTICS IN PEARL MILLET STICKS

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ABSTRACT

The moisture content obtained after dough sticks attaining the safe moisture content in open sun drying, tray drying, only microwave drying, sun cum microwave drying and convective cum microwave drying was found to be 8.42, 5.53, 6.23, 5.43 and 4.6% (db). The time required to achieve the above levels of moisture content were 14, 12 h, 24 min, (2.5h+17 min), 20+17 min for pearl millet sticks in respective dryers. The rate of drying was highest in only microwave drying but gives less quality product, followed by convective cum microwave drying, sun cum microwave drying, tray drying and open sun drying.

Key Words: open sun drying, tray drying, convective drying, microwave drying, pearl millet sticks

INTRODUCTION

Pearl millet stick (*Kharodi*) is the product prepared in the Maharashtrian recipe which is a dehydrated traditional RTE food that may be eaten with onion slices straight away or after frying. Traditionally *Kharodi* is prepared manually in the form of chunks and dried in sunshine or in hot air dryer (Solanke *et al*., 2018) which is time consuming and unhygienic in nature. Also Giram (2019) dried *Kharodi* using sun drying for few hours and then with microwave drying but sun drying assisted microwave drying still required open sun shine for few hours which is unhygienic. Murtadak (2022) dried *Kharodi* sticks with convective drying assisted by

microwave drying in the form of triangular cross-sectional *Kharodi* sticks. But due to triangular geometry of sticks it gives high hardness value though it had high crispness. Therefore, to confirm the effect of food product geometry on textural properties of the sticks and to reduce its hardness, it was attempted to prepare circular cross-sectional sticks from pearl millet and dried using convective cum microwave drying process.

MATERIALS AND METHODS

Raw material preparation

The pearl millet grains of Dhanshakti variety were purchased from local market in parbhani (Maharashtra), and then manually cleaned and graded. A vertical plate attrition mill was used to grind the cleaned pearl millet grains. The grinded flour was sieved using a sieve analyzer and the flour fractions passing through the sieve with size 0.166 mm was used for preparation of pearl millet sticks.

Dough preparation

In cooking process first two teaspoon oil was taken in pan and heated for 10 s and then mustard seed, turmeric powder, garlic paste was added, stirred and fried till the mixture turn brownish in colour. A measured quantity of water (1800 ml) was added to the fried mixture (Solanke *et al*., 2018). After five minutes of heating when water starts boiling, the pearl millet grits were added slowly in boiling water and stirred continuously. The cooking was continued for predetermined time of 20 min. When the cooked dough attains a semisolid stage, heating was stopped and the dough was kept for colling for 10 min. After the cooling the dough obtains thick consistency.

Open sun drying

Aluminium trays were completely cleaned and the dough sticks were spread uniformly on the aluminium mesh placed in the trays. The loss of moisture was recorded at every hour of interval, by means of an electronic balance (accuracy 0.001 g, capacity 500 g). Ambient temperature also measured periodically with the help of thermometer. Also relative humidity was noted by means of hygrometer. Drying was continued till the sample attained a safe moisture content. The drying time and drying rate depended on the ambient temperature.

Tray drying

The extruded dough sticks were spread uniformly on the aluminium trays and the loss of moisture was recorded at every hour of interval. The drying was performed continuously for 12 h. The weight of sample was taken on a precise electronic balance having least count 0.001 g. The dried samples collected from trays and measures its quality attributes. The initial and final moisture content of sticks were measured in a hot air oven at 105^0C for 24 h. The moisture content values were calculated on dry matter basis and expressed in per cent.

Microwave drying

In this drying the cold extruded sticks were spread on carbon steel non-stick pan and the pan was kept on turntable fitted inside the microwave oven and the oven was turn on microwave mode at 180-900 W for 20 to 26 min drying time under consideration (Murtadak 2022).

Sun cum microwave drying

In this method the dough sticks extruded on aluminum mesh were kept on aluminum trays and dried in sunshine at temperature about 40-42 ºC for (2.0-3.5 h) in order to impart case hardening to dough sticks and then transferred to carbon steel non-stick pan and further dried in microwave oven at 540 W for 17min (Murtadak, 2022).

Convective cum microwave drying

In this method the case hardening of dough sticks was obtained by drying the dough sticks on mesh in microwave oven on hot air convective mode at 120 ºC for 20 min (Murtadak, 2022). Then the case hardened sticks were dried in microwave oven on microwave mode by varying the microwave power (180-900 W) and drying time (8-22 min). The values of microwave power and drying time were decided on the basis of moisture content of end product and quality parameters of dried product (Murtadak, 2022).

Drying time and curves

The drying curves were drawn for all five drying methods of drying. The values of moisture content (%db) were plotted against time of drying. The total time required for complete drying was also recorded in each case. The curves between drying rate and average moisture content (%db) and between drying rate (%dbh-1) and drying time (h) were also plotted.

Methods of analysis

Determination of moisture content

$$\text{M.C (d.b.)} = \frac{M_w}{M_d} X\ 100$$

Where,

M.C (db) = Moisture content, % dry basis

M_w = Mass of water, g

M_d = Initial mass of sample, g

Dehydration ratio

Drying ratio was calculated by taking the ratio of weight of sticks loaded for drying in order and that the dried sticks immediately after drying.

$$D_r = \frac{W_1}{W_2}$$

Where,

D_r =Drying ratio

W_1= Initial weight of sticks before drying (g)

W_2= final weight of dried product (g)

Drying rate

Drying rate of the sticks at any time was calculated by the following formula

$$R = \frac{W_r}{T\ X W_d} X\ 100$$

Where,

R= Drying rate (g/min)

W_r= Amount of moisture removed (g)

T= Time taken (h)

W_d= Total bone dry weight of sample (g)

RESULTS AND DISCUSSION

Drying characteristics of pearl millet sticks

The extruded dough sticks from the hand operated extruder were dried using five different drying methods *viz.,* open sun drying, tray drying, only microwave drying, sun cum microwave drying and convective cum microwave drying. The initial average moisture content of extruded sticks was found to be 84.17% (db). The drying characteristics of sticks under different drying methods are summarized below.

Variation in moisture content of pearl millet sticks with respect to drying time

The drying behaviour of extruded pearl millet sticks in different drying methods is presented in fig 1 as a plot of moisture content verses time of exposure. It can be seen that a typical drying curves have been obtained for sticks. The maximum drying temperature was achieved during the period of 12 to 2.00 PM for the open sun drying whereas as the tray dryer was set at 65^0C throughout the drying period an during microwave drying microwave was set at 540W (Murtadak,2022). The drying characteristics are varied for different drying methods.

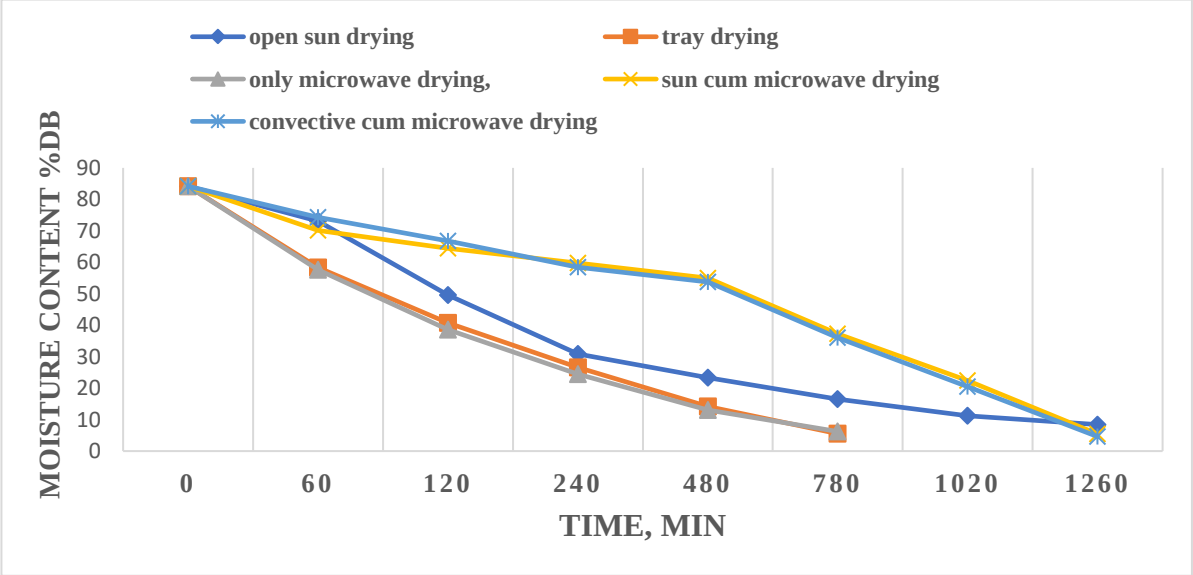


Fig 1: Variation of time with moisture content of pearl millet sticks under different drying methods

It was possible to dry the sticks to the final moisture content of 8.42, 5.53, 6.23, 5.43 and 4.6 %(db) in open sun drying, tray drying, only microwave drying, sun cum microwave drying and convective cum microwave drying, respectively. The time required to achieve the above levels of moisture content were 14, 10 h, 24 min, 2.5h+17 min, 20+17 min for sticks in respective dryers. The only microwave drying takes less time to remove the moisture content followed by convective cum microwave drying, sun cum microwave drying, tray drying and open sun drying.

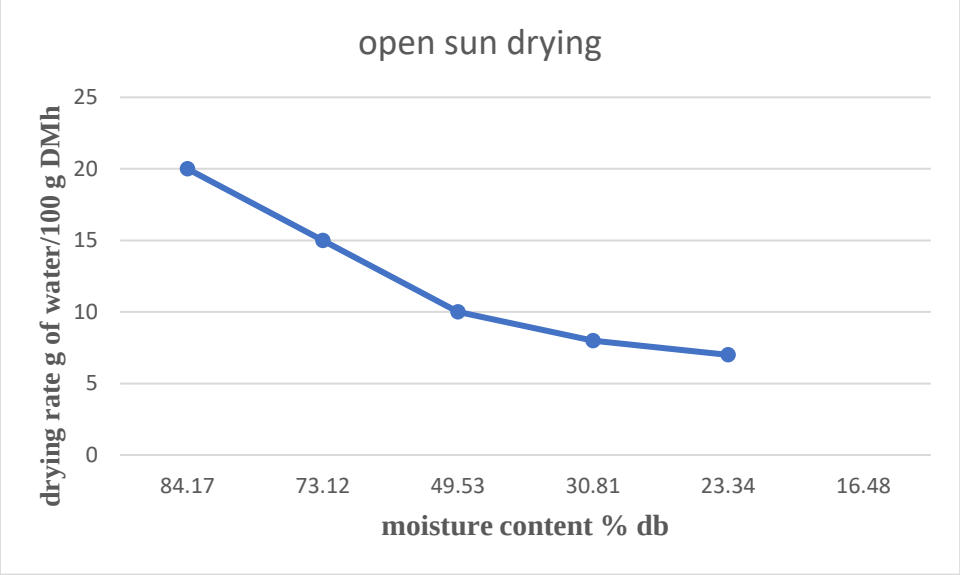
Variation of drying rate of sticks with respect to time

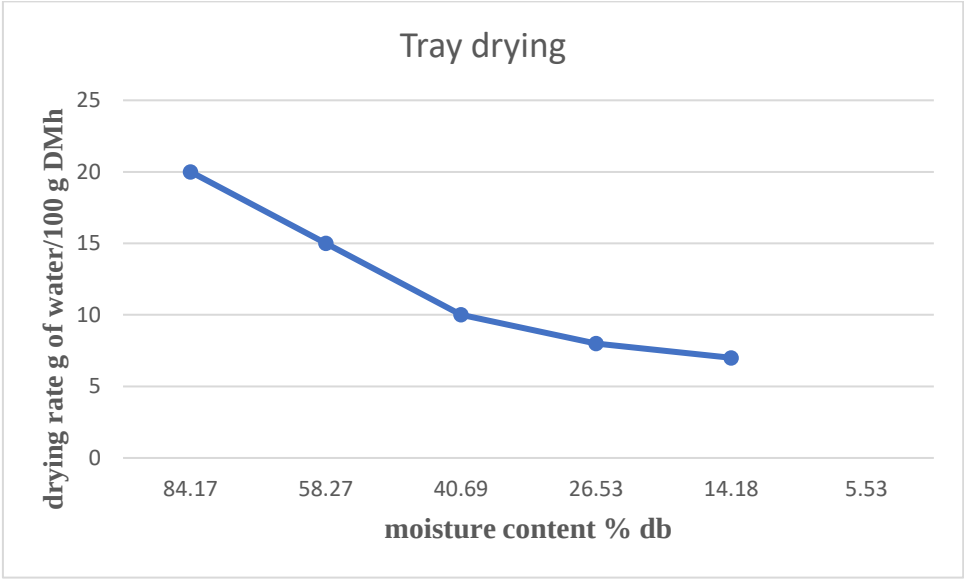
On examination of the plots between drying rate and drying time, it is clear that the entire drying process was accomplished in the falling rate period of drying and the constant rate period was absent like many other biological materials. This indicates that there was no free water on the product surface. Further, it can be seen that as the drying time increased the drying rate decreased. The rate was higher at the beginning of

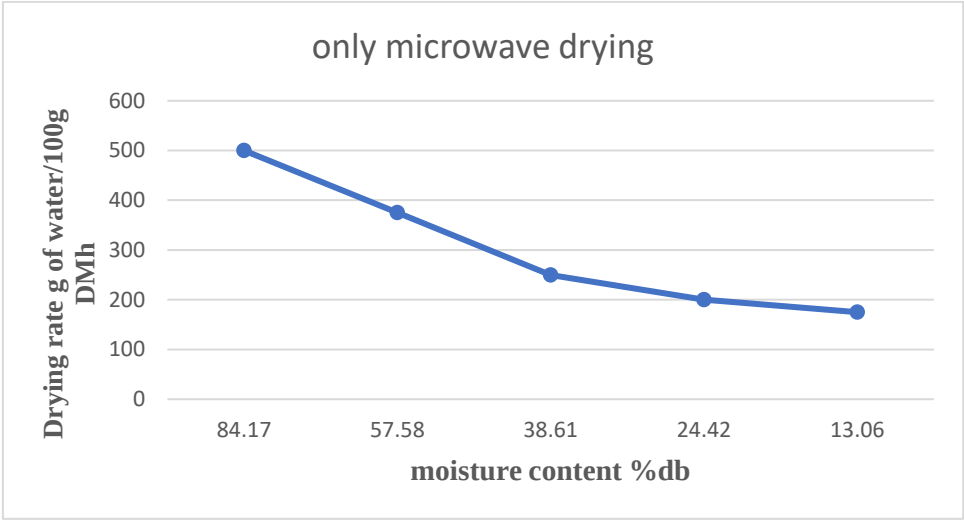
the process, which gradually reduced as the drying process progressed and the availability of moisture was reduced. On comparing the method of drying, it can be visualized that the highest drying rate with best quality parameters was achieved with convective cum microwave drying. The drying rate was found to 15-1, 220-7, 500-2, 500-175, 500-175 for sun drying, tray drying, sun cum microwave dying, only microwave drying and convective cum microwave drying, respectively.

Variation of drying rate of pearl millet sticks with respect to moisture content

The variation of drying rate with moisture content under different drying methods is shown in table 1. it can be seen that the drying rate decreases as the moisture content of the sticks decreases. This was fact because the availability of moisture for the drying reduced with the time of drying which eventually reduced the rate of drying. As already said the highest drying rate was observed in case of only microwave drying and was minimum for the open sun drying. Efforts have been made to correlate the drying rate with the moisture content of the sticks. Table 1 show the relationship between drying rate and moisture content for the different drying methods. The values of coefficient of determination r^2 showed that there exists good relationship between dependent and independent variables for pearl millet sticks.







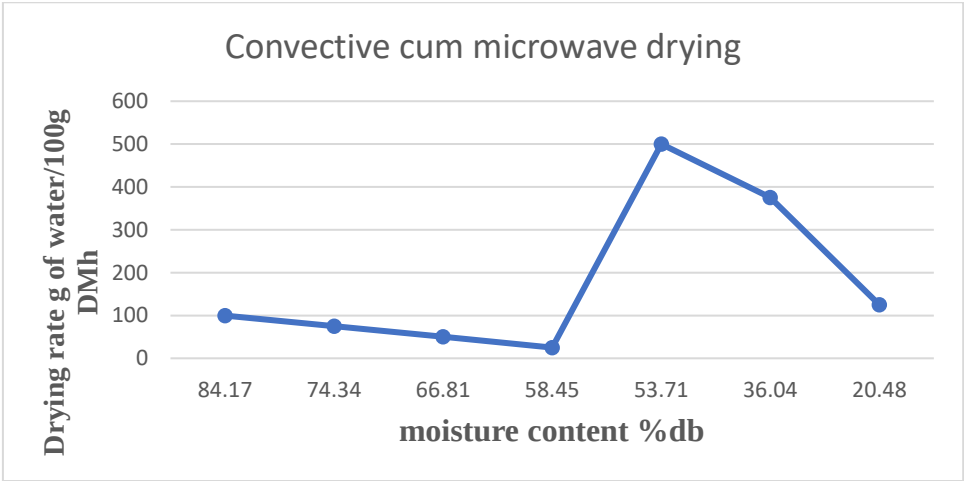


Fig 2: variation in moisture content of pearl millet sticks with time of drying in different drying methods

Table 1: Variation of moisture content and drying rate during drying of pearl millet sticks under different drying methods

Time h	Open sun drying		Tray drying		Time min	Only microwave drying	
	Mc% db	DR	Mc% db	DR		Mc% db	DR
0	84.17	….	84.17	….	0	84.17	….
2	73.12	5	58.27	20	5	57.58	500
4	49.53	15	40.69	15	10	38.61	375
6	30.81	10	26.53	10	15	24.42	250
8	23.34	8	14.18	8	20	13.06	200
10	16.48	7	5.53	7	24	6.23	175
12	11.21	3					
14	8.42	1					

Time	Sun cum microwave drying		Time min	convective cum microwave drying	
	Mc% db	DR		Mc% db	DR
0 h	84.17	….	0	84.17	….
1 h	70.16	24	5	74.34	100
1.5 h	64.38	16	10	66.81	75
2 h	59.74	12	15	58.45	50
2.5 h	54.98	4	20	53.71	25
5 min	37.27	500	5	36.04	500
10 min	22.39	250	10	20.48	375
17 min	5.43	125	17	4.6	125

From the above studies the following results were obtained:

- Open sun drying took nearly 14 h to dry the extruded dough sticks from an initial moisture content of 84.17 to 8.42 % db.
- The time taken under tray drying was about 10 h from an initial moisture content of 84.17 to 5.53 % db.

- Only microwave drying took 24 min to dry the extruded dough sticks. The moisture content of final dried product was 6.23 % db.
- The time taken under sun cum microwave drying was about 2.5h+17 min from an initial moisture content of 84.17 to 5.45 % db.
- Convective cum microwave drying took 37 min to dry the extruded dough sticks. The moisture content of final dried product was 4.6 % db.
- Pearl millet sticks dried in open sun found to have maximum moisture content i.e 8.42 per cent (db).
- In all drying methods, there was rapid moisture removal at the initial stage of drying.

CONCLUSION

It can be stated that the drying of pearl millet sticks is possible by all the five methods employed. The rate of drying was highest in the only microwave drying method but it gives less quality product than the other drying methods. After that rate of drying was highest in convective cum microwave drying also it took less time than sun cum microwave drying, tray drying and open sun drying.

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