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COMPARATIVE STUDIES OF SOLAR DEHYDRATORS

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Efficiency of various solar dehydrators for preservation of vegetables was studied. PCSIR model II, cot and UNICEF models produced better results than PCSIR model I and open sun drying.

INTRODUCTION

Pakistan produces a great variety of fruit and vegetables almost all the year round. It has been estimated that about 25 – 30% of this valuable food commodity is lost every year in the country on account of lack of technical skill, poor storage and transport facilities. These losses can be considerably reduced with the help of proper preservation techniques.

Several methods are being practised for the preservation of various food stuffs. These range from open sun drying to sophisticated high frequency electronic dehydrators [1].

Sun drying of vegetables and fruits like mangoes, papaya etc., is being practised in rural areas of Pakistan from ages, but the technique is extremely rudimentary and unhygienic. The end product contains lot of dust, insects, microorganisms and wastes of birds.

Solar dehydration as a scientific technique is of recent origin and is considered to be cheapest in countries with plenty of sunshine. Solar dehydrators have been designed, fabricated and tested with regard to their efficiency by various workers [2]. The present communication is an attempt to describe the design of solar dehydrators developed by PCSIR and compare their efficiency with that of UNICEF model and cot.

MATERIALS AND METHODS

Fresh vegetables were purchased from the local market and prepared for dehydration according to methods described by Cruess [3].

The prepared vegetables were loaded on to trays (70 x 30 cm size) made of "sarkanda" *(Saccharum arundinaceum)* at the rate of 8 kg/m^2.

A. *Dehydrators*

Besides open sun drying following four types of dehydrators were used:

1. *PCSIR Model I.* It is a portable type dehydrator, made of conduet pipes which could hold two trays (70 x 30 cm). The dehydrator was covered with polythene sheet, provided with holes for the inlet of dry air and outlet of saturated air (Fig. Ia).
2. *PCSIR Model II.* Same model as described above but is covered from three sides with black cotton cloth leaving the front side exposed to sun.

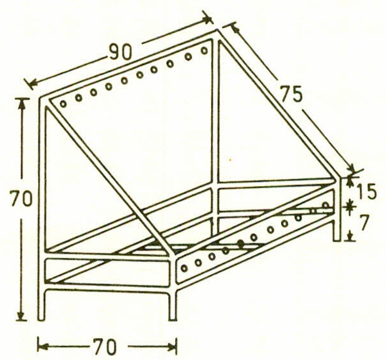

Fig.1(a)

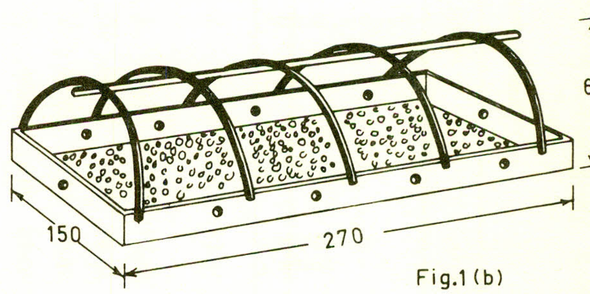

Fig.1(b)

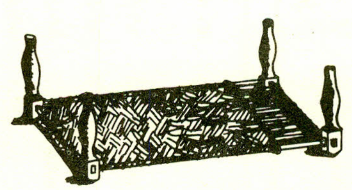

Fig.1(c)

Fig. 1. Solar dehydrators

Table 1. Dehydration of vegetables in different type of solar dehydrators.

Vegetables	Moisture before dehydration %	Open sun drying				PCSIR model				PCSIR model with black lining				UNICEF model				Cot			
		Drying temp. °C	Drying time (hr)	Relative humidity %	Moisture %	Drying temp. °C	Drying time (hr)	Relative humidity %	Moisture %	Drying temp. °C	Drying time (hr)	Relative humidity %	Moisture %	Drying temp. °C	Drying time (hr)	Relative humidity %	Moisture %	Drying temp. °C	Drying time (hr)	Relative humidity %	Moisture %
Bitter gourd	91.8	45-48	5	56-53	15.0	50-59	5	49.35	6.5	60-70	5	38-28	5.7	60-70	5	·38-28	5.8	57-69	5	42-29	5.7
Cabbage	90.0	45-50	5	56-49	17.9	55-61	5	47-38	6.8	60-69	5	38-29	5.6	60-70	5	38-28	5.8	58-68	5	40-30	5.8
Capsicum	85.0	45-50	10	56-49	16.4	50-60	10	49-40	10.4	59-73	10	39-25	7.8	60-73	10	38-25	7.6	58-72	10	40-25	7.7
Coriander	87.8	45-50	2	56-49	12.0	50-55	2	49.46	5.5	58.68	2	40-30	4.7	60-70	2	38-28	5.0	58-68	2	40-30	4.9
Mint	84.4	40-48	3	67-53	10.0	50-55·	3	49.46	6.0	55-61	3	46-39	5.0	55-61	3	46-39	4.5	55-60	3	46-39	5.2
Okra	86.8	45-48	10	56-53	16.3	50-58	10	49-36	7.8	60-75	10	40-23	7.4	62-75	10	36-23	7.0	58-72	10	40-25	7.7
Spinach	88.5	45-55	6	56-49	11.9	55-60	6	49-40	5.5	60-58	6	40-30	5.4	60-70	6	38-28	5.0	58-68	6	40-30	5.3

Table 2. Microbial load of fresh and dehydrated vegetables.

Vegetables	Microbial load before dehydration		Microbial load after dehydration									
			Open sun drying		PCSIR model		PCSIR model with black lining		UNICEF model		Cot	
	Total count	Viable count	Total count	Viable count	Total count	Viable count	Total count	Viable count	Total count	Viable count	Total count	Viable count
Bitter Gourd	$1.2x10^5$	$2.0x10^4$	$1.2x10^5$	$1.0x10^4$	$1.1x10^5$	$1.8x10^3$	$1.1x10^5$	$2.0x10^2$	$1.1x10^5$	$2.0x10^2$	$1.2x10^5$	$1.9x10^2$
Cabbage	$2.4x10^5$	$1.0x10^4$	$2.4x10^5$	$1.8x10^2$	$2.4x10^5$	$1.9x10^2$	$2.4x10^5$	$1.5x10^2$	$2.4x10^5$	$1.3x10^2$	$2.4x10^5$	$1.5x10^2$
Capsicum	$3.0x10^5$	$1.6x10^4$	$3.1x10^5$	$2.4x10^3$	$3.0x10^5$	$1.8x10^2$	$3.0x10^5$	$1.6x10^2$	$3.0x10^5$	$1.5x10^2$	$3.0x10^5$	$1.6x10^2$
Coriander	$2.5x10^5$	$5.5x10^3$	$2.6x10^5$	$1.4x10^3$	$2.5x10^5$	$1.5x10^2$	$2.5x10^5$	$1.3x10^2$	$2.5x10^5$	$1.2x10^2$	$2.6x10^5$	$1.4x10^2$
Mint	$2.0x10^5$	$6.0x10^3$	$2.1x10^5$	$2.5x10^3$	$2.0x10^5$	$2.0x10^3$	$2.0x10^5$	$1.5x10^2$	$2.0x10^5$	$1.5x10^2$	$2.0x10^5$	$1.4x10^2$
Okra	$3.0x10^6$	$3.1x10^4$	$3.0x10^6$	$2.0x10^3$	$3.0x10^6$	$1.4x10^2$	$3.0x10^6$	$1.1x10^2$	$3.0x10^6$	$1.2x10^2$	$3.0x10^6$	$1.2x10^2$
Spinach	$3.2x10^5$	$1.5x10^4$	$3.2x10^5$	$1.5x10^3$	$3.1x10^5$	$1.7x10^2$	$3.1x10^5$	$1.5x10^2$	$3.2x10^5$	$1.4x10^2$	$3.2x10^5$	$1.6x10^2$

3. *UNICEF Model.* It is a non-portable dome shaped model made of bricks and bamboo sticks. The rectangular base is made with bricks, and bamboo sticks in the curved form are fixed to the base. The rectangular base was partially filled with pebbles and the whole construction was covered with polythene sheet (Fig. Ib) Trays, loaded with prepared vegetables, were placed inside the rectangular base on pebbles.
4. *Cot.* The cot is made of wood and wound fibre strings and was placed upside down (Fig. Ic). The bottom was covered with black cotton cloth on which the vegetables were spread after pretreatment. The black cloth was also warpped along three sides leaving the front side exposed to sun. The whole cot was covered with polythene sheet.

All the dehydration experiments were started at 8'O clock in the forenoon. Temperatures, relative humidity and moisture contents were recorded at an interval of 2 h. uptil the termination of the experiments.

B. *Microbial Load*

Total and viable counts of the fresh and dehydrated vegetables were determined according to the method described by Baker [4].

C. *Rehydration*

Leafy dehydrated vegetables were rehydrated by boiling in water for 5 min; okra, bitter gourd and capsicum took 8 min to rehydrate. Rehydration ratios were calculated from the following relation [5].

$$\text{Rehydration Ratio} = \frac{\text{Rehydrated wt.} - \text{Dry wt.}}{\text{Dry wt.}}$$

RESULTS AND DISCUSSION

1. *Effect of Type of Solar Dehydrator on Dehydration of Various Vegetables.* Moisture content of fresh as well as dehydrated vegetables; temperature, relative humidity and dehydration time for various vegetables are reported in Table 1. Efficiency of various types of dehydators is evident from the dehydration rate of vegetables included in these experiments. Dehydration time for each vegetable was determined by conducting preliminary experiments on individual vegetable. Therefore, each vegetable exposed to solar dehydration for such period of time as could dehydrate it to a desired moisture level. This time varied with weather conditions and the type of vegetable used. For example, in open sun drying 10 h were required to achieve 16.3% moisture content of okra, while it took only 2 h to dehydrate coriander to 12% (Table 1). Therefore, individual vegetable was dehydrated for a fixed predetermined period of time and then efficiency of dehydrators was determined.

It can be observed from the results presented in Table 1. that PCSIR model II UNICEF Model and cot were comparable in efficiency. In some cases PCSIR model II showed better results in terms of dehydrating vegetables to lower final moisture content, while in other cases cot and UNICEF model were more efficient.

2. *Effect of Different Type of Solar Dehydrators on Microbial Load of Dehydrated Vegetables.* Vegetables dehydrated in PCSIR model II UNICEF model and cot showed lower microbial load on dehydration as compared with PCSIR model I (Table 2). This is seemingly

Table 3. Effect of type of dehydrator on rehydration characteristics of vegetables.

Vegetables	Dehydrators.				
	Open sun drying	PCSIR model	PCSIR model with black lining	UNICEF model	'Cot'
Bitter gourd	4.2	4.1	4.0	4.0	4.1
Cabbage	4.3	4.1	4.0	4.0	4.1
Capsicum	–	2.5	2.5	2.4	2.5
Coriander	4.4	4.0	3.8	3.8	3.8
Mint	4.1	4.0	3.8	3.6	3.8
Okra	3.8	3.5	3.4	3.4	3.6
Spinach	4.2	4.0	3.8	3.6	3.8

due to the difference in temperature attained during dehydration. PCSIR model I attained lower temperature compared to other models of solar dehydrators, and also exposure of the vegetables to dust particles and microbes present in the air.

3. *Rehydration Characteristics.* Rehydration studies were carried out immediately after the dehydrated vegetables were reserved from the dehydrators. Results (Table 3) showed that water absorbing capacity of open sun dried products was better as compared with the samples dehydrated in solar driers. Amongst the dehydrators PCSIR model I showed higher rehydration values as compared with the other three, while samples dehydrated in UNICEF model showed the lowest rehydration values. These variations might be due to differences in dehydration temperatures of the solar dehydrators. Higher dehydration temperatures seem to have adversely affected cells/tissues of the vegetables, resulting in their lesser water absorption capacity.

REFERENCES

1. S.G. Saunders, Ind. Heat Engg., **9**, 136 (1947). Vide Food Sci. Abstt., **23**, 1435 (1951).
2. K.M.Q. Rahman and S.F. Rubbi, The Adab News, **6**, 2 (1979).
3. V.W. Cruess, *Commercial Fruits and Vegetables Products.* (McGraw-Hill Book Co., N.Y., London, 1958).
4. F.J. Baker, *Hand Book of Bacteriological Techniques* Butterworks and Company Ltd. London, Kingsway WC-2).
5. J.C. Moyer, D.B. Hand, W.B. Robinson, R.S. Shallenberger and H.R. Palleson, Quartermaster Food and Container Institute for the Armed Forces. Chicago. Project No. 7-84-06-032 (1959).