

Solar Drying of Pea: Comparison of Various Methods Considering Its Dehydration and Rehydration Characteristics

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Abstract: *The drying behaviour of peas was studied by four solar drying methods viz. open sun drying, direct and indirect solar cabinet drying and solar cooker drying. In all drying methods, the entire drying took place at falling rate period only. The dried out peas obtained were evaluated for drying time, rate of drying, rehydration characteristics and changes in colour, flavour and appearance. The drying of peas by direct solar cabinet dryers was faster but the dried peas obtained was of poor quality, dull or yellowish in colour with poor moisture absorption capacity. On the other hand, indirect solar cabinet drying was found to be slow but the peas had better moisture absorption, appearance, colour (greenish) and flavour in comparison to other drying methods. Among all four drying methods, the indirect solar cabinet drying was found most suitable for drying of peas.*

Keywords: *Pre-treatment, solar drying, drying rate, drying time, average moisture, dehydration ratio, rehydration ratio*

1. INTRODUCTION

Pea (*Pisum sativum* L.) is one of the most important vegetable crops cultivated in most parts of the world. It is considered as one of the oldest known vegetables, which belongs to family leguminosae. In India, it is grown as winter vegetable, in the plains of north and as summer vegetables in the hills of northeast. It occupies a prominent position in the world with 33.3 per cent of total world's production with productivity of 9.6 tonnes per hectare [1]. Fresh peas are mainly dried for further cooking as a whole or for mixing with other vegetables after rehydration. It is also used as pulse in daily diet [2]. Drying is one of the most important primary operations for increasing shelf life of vegetables. Utilization of solar energy for drying foods has been in practice since ancient times. Solar dryers have great potential for replacement of mechanical drying of agro products where hot air temperature is normally less than 70°C. In India, the vegetables are grown in villages but due to lack of processing facilities at production catchment areas, the farmers are forced to sell peas in fresh form. This yields lower remunerative prices to them. The low cost, small capacity solar dryers that do not require costly electricity/fossil fuels shall prove to be the most promising alternative for drying of peas. This study was carried out with the objectives to determine the changes in pea during dehydration and rehydration processes and to pinpoint the best available solar dryer.

2. MATERIALS AND METHODS

2.1. Raw Material and Sample Preparation

The fresh local varieties of peas were purchased from the market and used in experiments. The green peas were removed from the pods and then washed in running water thoroughly.

2.2. Pre-Treatment of Peas

With the view to get the good quality final dried product, the pretreatment was given to peas. Its samples were blanched in boiling water solution containing 0.5% sodium meta-bi-sulphite, 0.1% magnesium oxide, 0.1% sodium-bi-carbonate for 4 minutes [3].

2.3. Drying of Peas

The drying experiments on sun drying and various dryers were quantitatively restricted (150 g per batch) to suit the laboratory conditions with the thought that the capacity of dryers can be easily scaled up as per the need. The pre-treated pea samples were dried in open sun, by direct and indirect solar cabinet dryers and also in solar cooker with 3 replications for each method. In sun drying experiment, a circular steel plate of diameter 24 cm was used. The steel plate was completely cleaned and 150 g of pre-treated samples of pre-treated peas were uniformly spread on steel plate giving spread density of 0.33 g/cm². The steel plate was kept 1 m above the ground level in open space in order to facilitate proper flow of ambient air. The samples were weighed at every one-hour of interval, by means of an electronic balance.

2.4. Dryers Used

2.4.1. Direct Solar Cabinet Dryer

In the present study, experiments were conducted using direct solar cabinet dryer [3], as shown in Fig 1 (a). The direct solar cabinet dryer consisted of a drying chamber that could accommodate 3 wire mesh trays. The dryer was made of hard cardboard frame occupying a floor area of 43 × 43 cm. The top of dryer was covered with polyethylene cover of thickness 150 gauge. An exhaust pipe was provided at the backside of the direct solar cabinet dryer to facilitate air circulation.

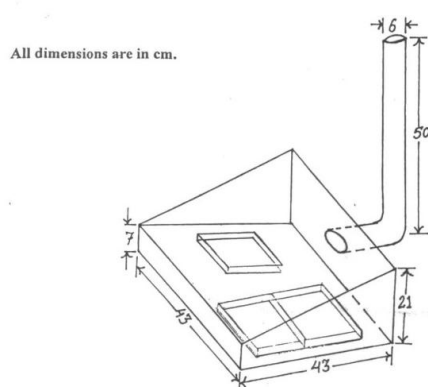


Fig1(a). Direct Solar Cabinet Dryer

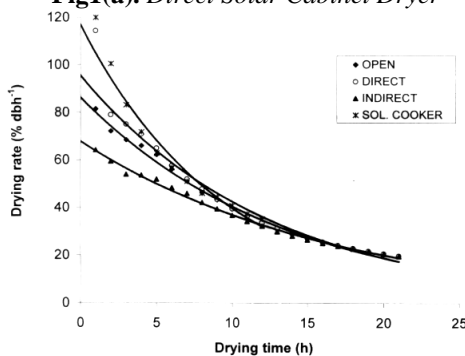


Fig2. Variation of drying rate of peas with respect to drying time

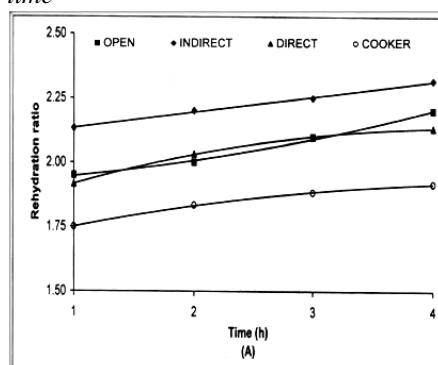


Fig4. Variation of rehydration ratio of dried peas by various drying methods with respect to time in (a) Cold water

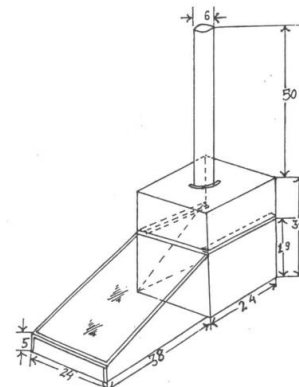


Fig1(b). Indirect Solar Cabinet Dryer

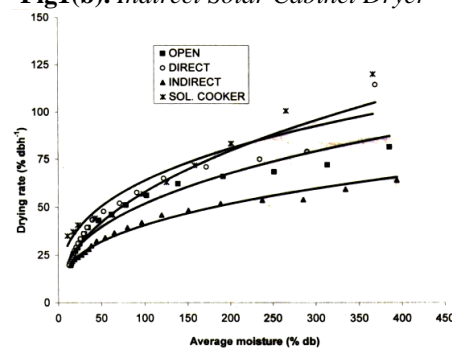
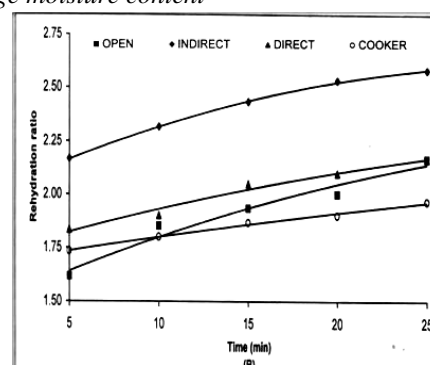


Fig3. Variation of drying rate of peas with respect to average moisture content



(b) Boiling water

2.4.2. Indirect Solar Cabinet Dryer

As shown in Fig. 1 (b), it was a natural convection cabinet type solar dryer [4]. It was mainly consisted of air heating unit and drying cabinet. Air heating unit was actually a mild steel box which was covered by transparent glass from the top, fixed with an angle of 20°. The heating unit was coupled with the drying cabinet. The drying cabinet was provided with a wire mesh tray at the base for entering of hot air coming from the heating unit. A chimney was provided at the top of indirect solar cabinet dryer to improve convection effect.

2.4.3. Solar Cooker

The solar cooker has proved successfully its ability to cook some of the products particularly at home level. It is available at subsidized rate throughout India. It was thought necessary to explore its potential in drying of peas also. Therefore, solar cooker was also included in present experimentation for drying of pea. In solar cooker drying, the solar cooker (make: Samata) having dimension (50 × 50 × 10 cm) was used for the experiment. The peas samples were spread uniformly in single layer on a cleaned steel plate having diameter of 18 cm. The temperature of drying chamber was recorded hourly with thermometer. The dryer was rotated to have its orientation towards the sun throughout the day to attain the maximum sun radiation.

2.5. Parameters Evaluated

For studying dehydration and rehydration processes, various parameters were used. Drying rate was defined as the ratio of amount of moisture removed per hour to weight of total bone dried sample. Average moisture was taken as average of two consecutive values of moisture content. Dehydration ratio was calculated by taking the ratio of weight of peas loaded for drying and the dried peas immediately after drying while rehydration ratio was calculated as ratio of the weight of the peas after rehydration to the initial weight of the dried peas. In all drying methods, the drying was continued until substantial reduction in weight of samples was achieved and thereby the weight of dried vegetables turned out to be nearly constant. The dried vegetable samples were filled in polyethylene pouches and kept again in larger polyethylene pouches and then heat-sealed. The samples were stored at ambient condition in clean place for further quality analysis.

2.6. Analyses of Drying Behaviour of Peas

The analyses of dried peas were done to deduce valuable information on changes in pea during dehydration. During drying of peas, samples were weighed at intervals of 1 h for determining moisture contents. The drying curves were drawn for all the four modes of drying. The curves between drying rate (% dbh⁻¹) and drying time (h) and again between drying rate (% dbh⁻¹) and average moisture content (% db) were also plotted. The data obtained from the experiment were statistically analyzed (Split-plot in Randomized Complete Block Design) to know the relative effect of different independent variables on the dehydration and rehydration characteristics [5].

2.7. Rehydration Time and Curve

The stored peas were rehydrated in tap water for 4 h and in boiling water for 25 min. During rehydration of dried peas, rehydrated samples of peas were drawn at (i) every hour when dried samples dipped in tap water and (ii) every 5 min when dried samples dipped in boiling water. Rehydration curves were drawn for dried peas obtained from all the four modes of drying by plotting rehydration ratio against time.

3. RESULTS AND DISCUSSION

3.1. Moisture Content of Fresh and Dried Peas

The initial moisture content of fresh peas was determined by oven drying method. The mean value of the moisture contents of fresh peas was found to be 81% (wb) or 426.2% (db) respectively. For dried peas moisture percent (db) was ranged from 5.3 to 15.4 %.

3.2. Dehydration Characteristics of Peas

3.2.1. Variation of Drying Rate of Peas with respect to Drying Time

For the peas, the variations of drying rate in relation to drying time are shown in Fig.2. It is evident that the maximum drying rate was observed during initial stage of drying. As the drying time

increased the drying rate decreased showing an inverse relationship between drying rate and drying time.

3.2.2. Variation of Drying Rate of Peas with respect to Average Moisture Content

The changes of drying rate (% dbh⁻¹) with average moisture content (%db) under different drying methods for peas are shown in Fig. 3. From the figure, it is evident that during the process of drying, the peas did not show any constant rate drying period and therefore complete drying took place only in the falling rate period only.

3.2.3. Effect of Drying Methods and Durations on Drying of Peas

The drying phenomenon is always affected greatly by the method and duration of drying. The Table 1 shows the analysis of variance for the effect of methods and duration on drying of peas. It is evident that both drying methods (48.44) and duration (506.88) had highly significant effect at 5% level. The effect of interaction of drying methods and duration of drying (3.16) is also found to be significant. From the F-ratio it is clear that the duration of drying (506.88) is more significant than method of drying (48.44) and interaction among them (3.16). The effect of replication (0.53) is found to be non-significant.

Table1. Analysis of Variance (ANOVA) of various solar drying methods for dehydration of peas

Source of variation	DF	SS	MSS	F _{ratio}	F _{tab.}	Significance
Main-plot						
Replication, (R)	3-1 = 2	0.54	0.27	0.53	5.14	NS
Drying Method, (M)	4-1 = 3	73.93	24.64	48.44	4.76	S
Error I	2 × 3 = 6	3.06	0.51	--	--	--
Sub-plot						
Duration, (D)	3-1 = 2	34508.41	17254.2	506.88	3.63	S
D × M	2 × 3 = 6	644.56	107.43	3.16	2.74	S
Error II	16	544.64	34.04	--	--	--

Where, S = Significant, NS = Non-significant

3.3. Rehydration Characteristics of Dried Peas

3.3.1. Effect of Dehydration and Rehydration Methods on Absorption of Water by Dried Peas

From the Table 2, it is evident that effect of drying methods (19.47), type of rehydrating water (10.07) and duration of rehydration (33.79) had significant effect on water absorption at 5% level. The effect of interaction of drying method with the rehydration water type (28.89) was also found to be significant. From the F-ratio, it is clear that the duration within water (33.79) is more significant than drying method (19.47) and type of rehydrating water (10.07). The effect of interaction between drying methods and type of rehydrating water (28.89) was significant however the effect of interaction of the drying methods and duration of rehydration within water (1.0) was found to have non-significant effect.

Table2. Analysis of Variance (ANOVA) for rehydration of dried peas obtained from various solar drying methods

Source of variation	DF	SS	MSS	F _{ratio}	F _{tab.}	Significance
Main-plot						
Replication, (R)	3-1 = 2	0.04	0.0179	0.38	5.14	NS
Drying Methods, (M)	4-1 = 3	2.72	0.9053	19.47	4.76	S
Error I	2 × 3 = 6	0.28	0.0465	--	--	--
Sub-plot						
Rehydrating water, (W)	2-1 = 1	0.04	0.0438	10.07	4.01	S
M × W	3	0.38	0.1257	28.89	2.77	S
Duration within water, (D)	6	0.88	0.1469	33.79	2.27	S
M × D within water,	18	0.08	0.0043	1.00	1.79	NS
Error II	56	0.24	0.0043	--	--	--

3.3.2. Variation of Rehydration Ratio with respect to Time

The rehydration ratios of the dried peas were determined as a function of rehydration time [6]. From Fig. 5 (a) and (b) it is clear that rehydration ratio of dried peas increased with time. However, with boiling water rehydration has higher increase of moisture content with respect to time. The dried peas

obtained from indirect solar cabinet dryer have shown maximum rehydration ratio in both tap and boiling water.

3.3.3. Performance Evaluation of Various Drying Methods

The performance of all drying methods was also determined to ascertain the best possible drying method. Various parameters were evaluated and their interpretations are discussed below.

3.3.4. Drying Time

The drying of peas necessarily had to be carried out over a period of four days to achieve the stage where reduction in moisture content was almost nil. Solar cooker took 12 h for drying of peas while direct and indirect solar cabinet dryers took maximum time i.e. 21 h. However, the open sun drying took 19 h to dry peas completely.

3.3.5. Total Moisture Reduction

Initially the moisture content of peas was 426.3% (db) while at the end of drying it was reduced to 15.4, 14, 12.6 and 5.3 % (db) for direct sun, indirect solar cabinet, direct solar cabinet and solar cooker drying respectively. The total moisture reductions were 410.8, 412.3, 413.7 and 421 per cent (db) by open sun, indirect cabinet, direct cabinet and solar cooker drying respectively. Thus the total moisture reductions by all the 4 methods were almost same. This shows that irrespective of drying methods used, the peas will be dried up to a same moisture level if sufficient exposure is given.

3.3.6. Dehydration Ratio

The dehydration ratio under various drying methods, were varied from 4.6 to 5. The dehydration ratio was the maximum (5) for solar cooker. Open sun drying and indirect solar cabinet drying gave equal dehydration ratios (4.6). The solar cooker drying gave peas with minimum moisture (5.3% db) than drying by other methods. This is due to high temperature (maximum 108°C) inside the solar cooker. However, the dried pea obtained by solar cooker drying was found to loose its original colour, flavour and taste.

3.3.7. Drying Rate

The rate of drying was somewhat higher in open sun drying as compared to other methods of drying. This is due to higher rate of air circulation and lower relative humidity outside. The average drying rate was found to be the maximum for solar cooker as compared to other methods of drying. The indirect solar cabinet dryer gave minimum drying rate.

4. CONCLUSION

It is concluded from the above findings that the direct exposure to sun gave undesirable changes in colour and flavour of dried peas. Poor absorption of water took place when directly dried peas were subjected to rehydration. Although, indirect solar drying by indirect solar cabinet dryer took more time but the rehydration ratio, colour, flavour and appearance of the dried peas were much better than those obtained by other drying methods.

REFERENCES

- [1] Prakash B., *Bharat mein fal evam sabji prasanskaran. Udyamita*. 11 pp. 9-5(2003).
- [2] Chandraker A., Comparative study of organic and inorganic farming in pea (*Pisum stivum L.*). M.Sc. Thesis, Indira Gandhi Agricultural University, Raipur, (2000) .
- [3] Mandhyan B. L., Abroal C. M. and Tyagi H. R., Dehydration characteristics of winter vegetables, *J of Food Sci. Technol.* 25:1-20, (1988).
- [4] Malaviya M. K. and Gupta R. S. R., Cabinet type natural convection solar dryer with chimney. *Agricultural Engineering Today* 11:4-37, (1987).
- [5] Steel, R. G. D. and Torrie J. H., *Principles and procedures of statistics - A biometrical approach*. McGraw-Hill Publ., New Delhi, 2nd edition, 377-398 (1981).
- [6] S. Ranganna, *Handbook of analysis and quality control for fruits and vegetable products*. Tata McGraw- Hill Publ, New Delhi, 1995, pp 976-979.

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