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RESEARCH ARTICLE II

Study of Feasibility of Solar Tunnel Dryer for Preparing Onion Powder

Hrishikesh Patil

Dept. of Food Process Engineering, Tamil Nadu Agricultural University, Coimbatore-641 003, India

Abstract

Drying is one of the most conventional methods used for and before preservation and storage. It also improves the post-harvest quality and is used for the value addition of the product. This present evaluate the the feasibility of a solar tunnel dryer for preparing onion powder. The study aims to minimize the storage losses and provide a cheap alternative to open sun drying. Solar drying would create an income source in a rural area, especially for farmers, and can also be used for a startup or small-scale industry. Onion powder was prepared and a sensory evaluation was done. Market acceptance of prepared onion powder was determined by the data collected from the market survey.

Keywords: *Drying; Solar tunnel dryer; Onion powder; Small-scale industry.*

Introduction

Drying is one of the traditional methods used for the preservation of agricultural produce. The reduction in the moisture content results in the physical as well as chemical stability of the product. Drying allows the storage of products at ambient temperature for an extended period (Arjoo *et al.*, 2017). For drying and dehydration of any product, several techniques have been employed which are solar drying, vacuum drying, infrared drying, etc. The problem in the conventional open-air sun drying process is contamination, theft, or damage by birds, rats, or insects. It is slow drying and has no protection from rain, dew, or any storm (Patil, R. Gawande., 2016).

Sunshine hours in India are about an average of 3000- 3200 hours per year and deliver about 2000 kWh/m^2-yr of solar radiation on a horizontal surface (Mani, 1980). Solar drying could be the best and cheap alternative to open-air sun drying. Solar tunnel dryers, solar cabinet dryers, PCM assisted solar dryers are examples of solar drying units. A solar tunnel dryer is a low-cost large capacity drying unit that can be used in the rural region to dry various agricultural produce. The temperature below 65^{o}C is sufficient for drying agriculture produce. The solar tunnel dryer provides a temperature range of 26 to 64 ^{o}C (Rathore and Panwar, 2011).

India is one of the largest producers of onion in the world second only to China, accounting for 16 percent of the total area under cultivation in the world and 13 percent of total production (Anonymous, 2010). Onion has a large market in India and the cost of it varies throughout the year. The lack of knowledge of post-harvest handling and improper storage practices leads to the huge loss of onion every year in India. The total storage losses of onions are comprised of physiological loss in weight (PLW) i.e. moisture loss and shrinkage (30-40%), rotting (10-12%), and sprouting (8-10%) for 4-5 months of storage (Tripathi and Lawande, 2016).

Drying provides value addition to the produce. For drying of onion slices from the initial moisture content of about 86% (wb) to the final moisture content of about 7% (wb), the energy required per unit mass of water removed without using recirculation of air was found to be between 23.548 MJ/kg and 62.117 MJ/kg water (P.N. Sarsavadia, 2007).

The experiment was conducted by using a solar tunnel dryer for drying onion. Drying characteristics and cost economics were determined for onion powder. The main purpose of this study is to determine the feasibility of solar tunnel dryers to prepare dried onion powder, for Indian farmers and small-scale industries or startups.

Materials and Methods

The study was carried out under the meteorological conditions of Akola, Maharashtra state (20.7002° N, 77.0082° E) in India in February from 09.00 a.m. to 05.00 p.m. The average high temperature of the Akola is 34 ^{o}C in February month.

Solar Tunnel Dryer

A small unit of solar tunnel dryer installed at CAET, Dr. PDKV,Akola, India was taken for study. The

*Email: hrishipatil735@gmail.com

specifications of the solar tunnel dryer are given in Table 1. The solar tunnel dryer used for the study is shown in Plate 1.

Plate 1. Solar Tunnel Dryer

Instruments and equipment

A digital thermometer was fixed inside the dryer to measure the temperature, Weighing of material was done by using an electronic balance, a low capacity vegetable slicer, a low capacity grinder is used to prepare the powder and a hot air oven is used to determine the initial moisture content.

Experimental procedure

Raw material, onion was collected from the local market. Primary unit operations such as peeling, and cutting were done manually. A low-capacity vegetable cutter was used for slicing the onion. The material was weighed on an electronic balance and then kept in a solar tunnel dryer for drying. Then 10 g sample was kept separately in the solar tunnel dryer to take weight readings for calculating drying characteristics. Weight readings of the sample were recorded after every one-hour interval from 9.00 a.m. to 4.00 p.m. The onion powder was prepared by grinding the dried onion flakes. Following is the flowchart of the onion processing.

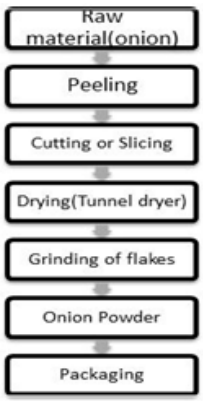

Figure 1. Flow of preparation of onion powder

Determinationof moisture content

To determine the initial moisture content, the oven-dry method suggested by (Ranganna S. 1986) is used. About 10 g of samples were taken in an oven and the moisture content on a wet basis (wb) was calculated using the Eq. (1)

$$M\ (\%\ wb) = ((mi - mf))/mi \times 100 \quad (1)$$

Where M is moisture content, mi and mf are initial and final moisture content.

The sample of onion was kept in the solar tunnel dryer, the dry basis moisture content is calculated by the following formula (Bala, 2016).

$$M.C.(\%db)=((W1-W2))/W2 \times 100 \quad (2)$$

Where, W1=Weight of the sample before drying, W2= Weight of bone dried sample.

Moisture Ratio-The Moisture ratio of the produce was computed by the following formula (Chakraverty, 1988).

$$MR=((M-Me))/((Mo-Me)) \quad (3)$$

Where, M is moisture content %(db), Me is EMC, %(db),Mo is IMC %(db)

Drying rate

The drying rate of the product sample during the drying period was determined as follows (Chakraverty, 1988).

$$DR=\square W/\ \tau \quad (4)$$

Where, DR is drying rate,g/min, □W is weight loss in 1 h interval,□tis difference in time reading, min

Market survey

A small survey was conducted in the local market of Akola, MS, India. The data on cost, packaging and overall quality of the existing brands of onion powder was collected for study. Packaged solar-dried onion powder is introduced to the local traders to determine its acceptability of the solar-dried onion powder in the market. The main objective of the market survey was to determine the quality assessment, packaging, cost, and the market available for onion powder.

Sensory evaluation

The descriptive numerical scoring system was used for the sensory evaluation of the organoleptic properties of dried onion powder. Properties are determined such as flavor, color, and texture. The test was carried out by a panel of nine judges of different ages, groups, and sex based on '9' point Hedonic scale which is defined as follows: Like extremely- 9, Like very much– 8, Like moderately– 7, Like slightly– 6, Neither like nor dislike– 5, Dislike slightly– 4, Dislike moderately– 3, Dislike very much– 2, Dislike extremely– 1 (Sukanya and Michael, 2014).

Results and Discussion

Initial Moisture Content (Oven drying method)

Theinitial moisture content determined by the oven drying method was 87% (wb).

Plate 2. Drying of onion slices in solar tunneldryerPlate 3. Dried onion flakes

Drying of OnionSlices (Solar tunnel dryer)

A total of 53 kg of onion was taken for processing. The weight of onion after peeling and cleaning was 46.6 kg and the weight of the final dried onion powder was 5.68 kg. The solar tunnel drying of onion slices is shown in Plate 2. The total moisture removed was 40.92 kg. Dried onion flakes are shown in Plate 3. The total drying time for solar drying of onion was 7 h. The data of moisture content, drying rate, and moisture ratio against time are given in Table 2. The initial and final weight of the solar tunnel dried onion sample was 10 g and 1.6 g respectively. The Moisture present in the final dried sample was 0.42 g. The total moisture removed from the sample was 8.4 g. Initial Moisture content was 747.45% (db) reduced to 35.59 % (db). The drying rate in the initial stage of drying was 0.0461 (g/min) and in the final stage of drying it was 0.0200 (g/min).

Drying Characteristics

Drying Characteristics are depicted by plotting the curve between the moisture content of onion and drying time. The variation of moisture content with drying time is shown in Figure 2. It is observed from the figure that moisture content at the initial drying stage decreased faster and later became slower. The relation between drying rate, drying time, and moisture ratio is shown in Figure 3. The drying rate is steadily decreasing with the drying time and the moisture ratio decreased faster in the initial stage of drying.

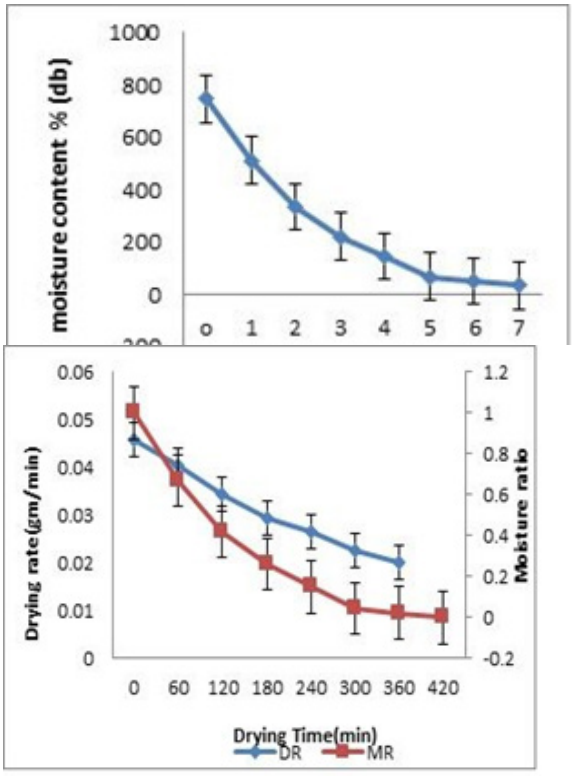

Figure 2. Moisture content v/s Time Figure 3.Drying rate v/s time v/s Moisture content

Analysis of Sensory Evaluation of Onion Powder

The organoleptic property was evaluated for different parameters such as color, flavor, taste, odor, appearance, and overall acceptability. The range of scores was 1(dislike extremely) to 9(like extremely). The mean score of sensory properties is given in Table 3. According to the Fig 4. the score of color, flavor, and taste belongs to the 'like very much' scale and the score of odor and appearance belongs to the 'like moderately' scale. The overall acceptability score is favorable.

COST ESTIMATION OF ONION POWDER (for 53 kg)

Total raw material= 53 kg

Cost of tunnel dryer, C = 48000

Salvage value, S= 4800

Annual use (expected operation), U= 300×12=3600h

Expected Life, L=10 yrs

Fixed cost

Depreciation cost= (C-S)/Uh (5)

=(48000-4800)/(10×300×12)

= Rs. 1.2 /hr

Interest on capital investment @12% per annum

Average price (I1)

=(C+S)/2U×0.12

=(48000+4800)/(2×3600)×0.12

=0.88 /hr

Insurance & housing cost @ 2% per annum an avg. price (I2)

=(C+S)/2U× 0.02

=(48000+4800)/(2×3600)×0.02

=Rs. 0.15 /hr

Repair/ Maintenance cost @ 10%

R=C/UL× 0.10

=48000/(3600×10)× 0.1

=Rs. 0.13/ hr

Total fixed cost = a + b + c + d

= 1.2 + 0.88 + 0.15 + 0.13

= Rs. 2.36 /hr

Variable cost

Raw Material cost Rs.8 /kg

= 8 ×53

=Rs. 424

Transportation cost= Rs. 20

Packaging cost = Rs. 10

Total variable cost= a + b + c

= Rs. 454

Fixed cost for 24 hrs (drying time)

=2.36× 24

=56.64 = Rs. 57

So, Total Cost = Fixed cost + Variable cost

= 454 + 57

= Rs. 511

Considering 12% profit

Profit = 511 × 0.12 = 61.32

= Rs. 60

So, Selling Cost = fixed cost + Variable cost + profit

= 511 + 60

= Rs. 571

The final dried onion powder is 5.68 kg, 571/5.68=100.52□ Rs.100 per kg.

This estimated cost is based on general local wholesale values and estimated for the processing of 53 kg of onion. Profit may vary depending upon assumed values. If the quantity of the product increases, the cost may get reduced.

Market Scope

Food processing industries need onion powder for several purposes. Farmers or FPO could approach these industries to make a supply contract. Moreover, after packaging and branding of onion powder, the local retail market is also open. The cost of onion powder available in the market ranges between Rs. 300 to Rs.700 per kg. The estimated cost of onion powder prepared by using a solar dryer was Rs.100 per kg.

Feasibility of the Solar Tunnel Dryer for Farmers and Startup

From the data above, the solar tunnel dryer is efficient for drying onion slices. The quality of dried onion powder was good, both in color and flavor. There is a reduction in drying time as compared to open-air sun drying.The maintenance of the solar tunnel dryer is less as compared to other electrical dryers.

Conclusion

The drying technique is the low-cost preservation method for agricultural produce. The solar dryer is a low-cost alternative to open sun drying with the best results in sensory qualities such as flavor and color of finally dried onion powder. It was free from impurities like dust, straws, etc. Farmers would not need to bear losses due to varying market prices and post-harvest storage losses. The produce can bedried after the sunshine and during cloudy weather conditions by integrating it with thermal energy storage (Lakshmi *et al*., 2021;Pankaew *et al*., 2020) or by using auxiliary heater(Murali *et al*., 2020; Moussaoui *et al.*, 2021)Thus solar dryers would reduce storage losses of onion and could provide a good income source for farmers. The produce can bedried after the sunshine and during cloudy weather conditions.

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Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Originality and plagiarism

Authors should ensure that they have written and submit only entirely original works, and if they have used the work and/or words of others, that this has been appropriately cited. Plagiarism in all its forms constitutes unethical publishing behavior and is unacceptable.

Consent for publication

Author agreed to publish the content.

Competing interests

There were no conflict of interest in the publication of this content.

Data availability

All the data of this manuscript are included in the MS. No separate external data source is required.

Author contributions

Idea conceptualization-S. kalbande, Experiments-Hrishikesh Patil, Writing original draft Hrishikesh Patil, Writing- reviewing &editing -Hrishikesh patil, P. Sudha.

Future Scope

This study was done by using a solar tunnel dryer that works only in sunshine hours. The auxiliary heater-assisted solar dryer would work at night and in hazy weather also. It will ensure all time operation.

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