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COMPARATIVE STUDY OF DRYING CHARACTERISTICS OF AMLA FRUIT USING OPEN SUN DRYING AND SOLAR DRYING METHOD

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A B S T R A C T

Amla fruits were utilised in this study to compare solar drying with open sun drying. For drying, open sun drying was used, and a lab-scale solar dryer was also constructed. Drying temperature, moisture content (MC), and drying rate were the comparison criteria used. In order to compare solar drying of amla with natural sun drying, three different air velocity flow rates are used: 5 m/s, 5.5 m/s, and 6 m/s. The ambient temperature is between 25ºC and 35ºC, while the drying chamber's temperature ranges from 50 to 85 degrees Celsius. The proposed dryer's efficiency ranges from 36.56 to 48.45 percent, whereas sun drying's efficiency ranges from 11.4 to 16.64 percent. It has been found that as air velocity flow rates rise, the dryer's efficiency rises as well. In identical environmental conditions, the solar dryer dried clothes more quickly than open-air drying. Compared to sun drying, which takes 12–16 hours, solar drying takes 4–8 hours to attain a safe moisture content. Additionally, the value of solar dried amla is superior to that of sun dried amla in terms of colour, flavour, odour, and look. The current work's observed results demonstrate that the suggested solar dryer works well for drying amla in this area.

Keywords*: Drying; Amla; Sun Drying Method; Solar Drying Method; Moisture Content; Drying rate.*

1. INTRODUCTION

The Indian gooseberry, or amla (Pyllanthus emblilica), has the highest concentration of vitamin C (ascorbic acid) of any fruit. Nearly 600-750 mg of vitamin C are present in every 100g of amla. Additionally, phosphorus, iron, calcium, carotene, and vitamin B complex are all abundant in amla [1]. The fibrous, pale yellowish, six-lobed, spherical amla fruit is sour, bitter, and astringent to taste. It has been discovered to have potent antioxidant qualities. It is very nutritious and has many healing qualities, which increased its popularity. Amla is a key ingredient in many Ayurvedic and Unani preparations because it revitalises the body's organ systems and fosters health and wellbeing [2]. Amla is effective in treating a wide range of illnesses, including fever, indigestion, constipation, piles, liver disorders, heart complaints, and urinary issues. It is most frequently used in the treatment of diabetes, hair loss, and skin conditions. Both antibacterial and anti-aging properties are present in it. It is accessible throughout the fall season. It is a native of India and is growing practically everywhere in the tropics and subtropics [3]. Due to its medicinal, dietary, and culinary benefits, it is estimated that 800 tonnes of amla are exported from India under the heading of Ayurvedic and Unani plants.

It is not readily eaten in fresh because to its acidic taste [4]. It requires processing in order to be readily palatable and accessible all year round. There have been reports of a number of amla value-added goods. According to comparison research on the effects of several drying techniques on amla, including sun drying, tunnel drying, spray drying, freeze drying, and vacuum drying, sun drying results in the lowest concentration of ascorbic acid [5]. Pragati et al. conducted research on the nutritional value of dried amla fruit [6]. The removal of the free water molecules during drying leaves only the vital bound water molecules. Because it is protected from microbial and fungal attack, this aids in the long-term preservation of amla.

Natural sun drying has been a traditional way of food preservation [7]. However, there are many drawbacks to natural sun drying, including uncontrollable drying, contamination from birds, insects, and dust, adverse weather conditions, etc. The product is discovered to be of inferior quality and cannot be exported [8]. Additionally, more labour is needed, and the procedure is reported to be slow. Amla can keep a significant amount of iron, vitamin C, and other original minerals when dried in the shade.

Dryers of several kinds have been reported by author[9]. According to the author, dryers using heat storing materials can keep their interior air at a constant temperature. Although mechanical driers have mostly eliminated the above drawbacks of natural sun drying, they still require energy and are significantly more expensive. Additionally, many rural locations do not have a consistent source of power. Farmers are increasingly using solar dryers. The majority of these solar dryers employ flat plate collectors to gather solar energy [10]. Thin layer solar drying of Cuminum Cyminum granules using a solar cabinet drying with a flat plate collector demonstrates that the optimal drying method for Cuminum is natural convection solar drying air flow rate in mixed mode. However, compared to flat plate collector efficiency, it has been shown that evacuated tube collector efficiency is much higher [11]. However, there are not many experimental research on solar evacuated tube dryers that have been published.

Therefore, a work has been conducted to build and maintain a novel solar dryer so that its effectiveness on amla can be studied. Sun dried amla and solar dried amla are contrasted. The features of the newly developed solar dryer include high efficiency, controlled pollution-free drying, speedy drying, and superior quality.

2. MATERIALS AND METHODS

2.1 Raw material and sample preparation

The trials used the indigenous variety of fresh amla that was acquired from the market. After weighing the cleaned product, 300 g samples of each drying technique were used, and the samples were then left in the open atmospheric air to let every surface moisture to evaporate [12]. By using the oven drying procedure at 70 ºC until consistent weight happened, the initial moisture content of the amla was ascertained.

2.2 Open sun drying

After thoroughly cleaning black polyethylene sheets, the samples were evenly distributed across the sheets. Using an electronic balance, the loss of moisture was tracked every 15 minutes for the first two hours, every 30 minutes for the following two hours, and every hour for the remaining drying time. A thermometer is used to periodically measure the surface temperatures. Additionally, a hygrometer was used to record the relative humidity. Drying was carried out until the sample's weight remained constant [13]. The ambient temperature affected both the drying time and the rate of drying.

2.3 Solar dryer

The drying chamber, the blower, and the chimney comprise the majority of this innovative solar dryer's construction. The drying chamber is created based on the amount of the product that needs to be dried, the air flow rate, and the temperature that is needed to complete the drying process [13]. A rock wool slab with a thickness of 40 mm that has been pressed to 30 mm insulates the entire 15' x 15' x 15' drying chamber, which is constructed of stainless steel sheets with a thickness of 20 mm [14]. It comprises of three perforated aluminium trays on which to insert the drying material.

2.4 Method of analysis

2.4.1 Determination of moisture content

$$Moisture\ Content\ (\%\ wb) = Mw/M\ x100 \quad (1)$$

Where,
M.C (wb.) = Moisture content, % wet basis
Mw = Mass of water, g
M = Initial mass of sample, g

2.4.2 Drying rate

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

$$Drying\ rate\ (g/hr) = Wr/TxWd\ x\ 100 \quad (2)$$

Where
R= Drying rate (g/min)
Wr = Amount of moisture removed (g)
T = Time taken (h)
Wd= Total bone dry weight of sample (g)Equations

3. RESULTS AND DISCUSSION

During the drying of amla fruits, it was found that the ambient air's temperature and relative humidity varied from 40°C to 50°C and 45 to 55%, respectively. With a rise in ambient air temperature, the RH of the surrounding atmosphere fell. The highest temperature was reached for all drying techniques between 12 and 2 PM at midday [15]. The solar tray drier measured a maximum temperature of 75 ºC and a low temperature of 40 ºC (Open sun drying).

Table 1. Effect of sun drying and solar drying on moisture content of amla fruit

Drying Time (hr)	Moisture Content %			
	Sun Drying	Air Velocity in Solar Drying		
		5 m/s	5.5 m/s	6 m/s

0	88	88	88	88
1	83	76.43	70.44	63.55
2	77	63.4	48.88	42.4
3	70	48.52	34.33	27.56
4	62.4	34.5	19.45	13.55
5	55.8	18.9	10.43	7.42
6	48.52	8.54	5.44	4.31
7	41	5	4.52	2.1
8	33.5	4.6	3.1	
9	26	3.88	2.3	
10	18.9	2.9		
11	13	2.1		
12	9.54			
13	6.57			
14	4.6			
15	2.9			
16	2.1			

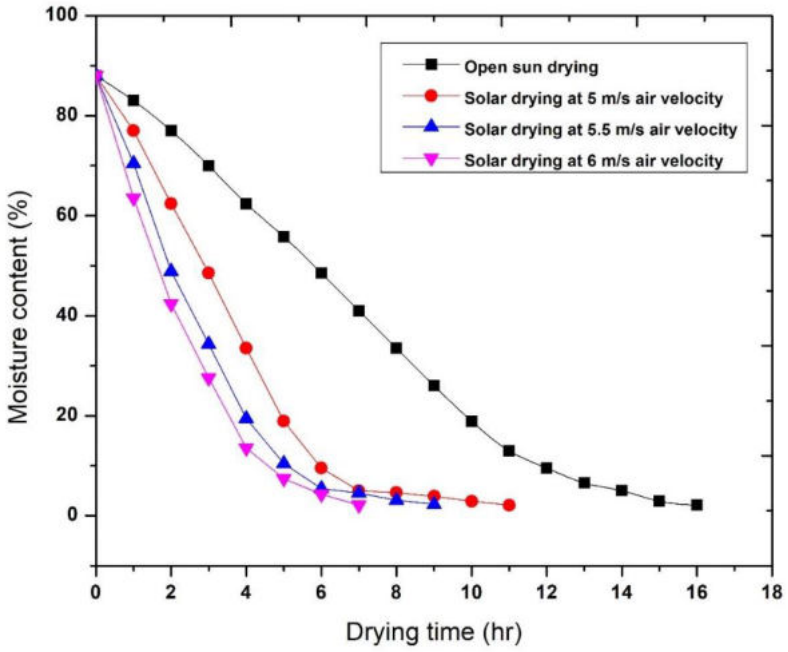

Fig 1. Effect of sun drying and solar drying on moisture content of amla fruit

3.1 Drying characteristics of amla fruit

Amla fruits were dried in two ways: solar drying at a temperature of 85 C. and open sun drying. It was discovered that amla had initial average moisture values of 87 and 89 percent (wb), respectively [16]. The section gives an overview of how amla dries using various drying techniques. Amla's moisture content varies depending on how long it takes to dry. In Fig. 1, a plot of moisture content vs exposure time depicts the drying behaviour of amla fruit using various drying techniques. It is evident that a typical drying curve for amla fruits has been achieved [17]. The solar dryer produced the maximum temperature (85°C), which was followed by open-air sun drying (35°C).

With solar dryer and open sun drying, the amla may be dried to a final moisture content of 2 to 4%, respectively [18]. For amla, it took between 7 and 16 hours to dry the fruit to the stated levels of moisture content.

3.2 Variation of drying rate of amla fruit with respect to time

According to the graphs of drying rate and drying time, the whole drying process was completed during the decreasing rate phase of drying; the constant rate period, which is present in the case of many other biomaterials, was not present [19]. This proves there was no free moisture present on the product's surface. Furthermore, it is obvious that the drying rate reduced as the drying time rose. As the drying process advanced and the amount of moisture available decreased, the rate steadily decreased from its higher starting point. Comparing the two methods of drying reveals that the solar dryer achieved the maximum drying rate, followed by open-air sun drying [20]. In the afore mentioned drying procedures, the drying rate was discovered to be 24.45 to 0.32, 17.56 to 0.09, 11 to 0.07, and 7 to 0.05, respectively.

Table 2. Drying Rate Curve – Drying Rate vs. Drying Time plot for amla fruit

Drying Period (hr)	Drying Rate (g/hr)			
	Sun Dryer	Air Velocity in Solar Dryer		
		5 m/s	5.5 m/s	6 m/s
1	6.00	11.00	17.56	24.45
2	3.50	6.80	10.78	10.58
3	2.53	4.96	4.85	4.95
4	1.65	3.76	3.72	3.50
5	1.46	2.92	1.80	1.23
6	1.25	1.56	0.83	0.52
7	1.07	0.65	0.23	0.32
8	0.94	0.05	0.18	
9	0.79	0.08	0.09	
10	0.59	0.07		
11	0.31	0.07		
12	0.25			
13	0.12			
14	0.10			
15	0.05			

3.3 Variation of drying rate of amla with respect to moisture content

Figures 2 depict that the drying rate fluctuates with moisture content while using various drying techniques. It is evident that the drying rate reduces as the fruit's moisture content rises [21]. This was true because the amount of moisture available for drying decreased with time, which finally delayed the drying process. As previously stated, the solar dryer produced the highest drying rates, but open-air sun drying produced the lowest rates. The drying rate and the amla fruits' moisture content have been tried to be correlated [22,23]. The link between drying rate and moisture content for the various drying techniques is shown in Table 1. Since the natural colour and appearance are preserved better in solar dried amla than in sun dried amla, its quality is higher [24]. Additionally, solar dried amla has a better flavour and aroma than sun dried amla [25]. Solar drying is more efficient and requires less labour overall. The link between drying rate and drying time is seen in Figure 2. Amla that has been solar-dried is well-protected from the elements, pests, and animals. Additionally, it is devoid of pollution and dust [26]. Above all, it can produce amla to strict specifications for export.

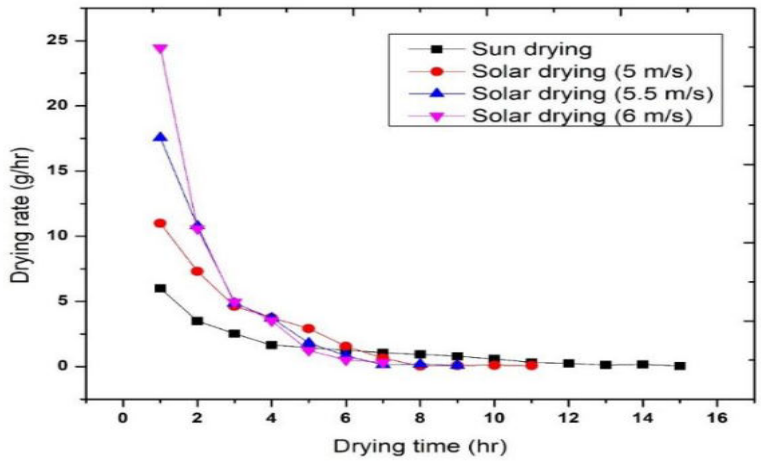

Fig 2. Relation between drying rate and drying time

4. CONCLUSION

Two techniques may be used to dry amla fruits, it can be said. At identical climatic circumstances, the solar tray drier produced the highest rate of drying (24.45 to 0.32), which was followed by open-air drying (6 to 0.05). The newly created solar dryer increases the temperature within the chamber and encourages faster drying, shortening the drying time. Less than half as long as natural sun drying would take for the solar dryer to attain a safe moisture content. The solar dryer performs well even on gloomy days and throughout the winter since it uses an evacuated tube collector. In contrast to natural sun drying, the drying process may be regulated in the specialised dryer. Additionally, as the air velocity flow rate is raised, the drying time decreases. When compared to sun-dried amla, solar-dried amla has higher quality in terms of colour, flavour, and appearance. Due to its high-quality standard, amla dried in the developed dryer suited better for export. The dryer does not produce any pollutants. You may dry any agricultural produce using this dryer. Therefore, it is obvious that evacuated tube collector solar dryers are superior to all other dryers.

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