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Effect of Tray Drying Conditions on the Bioactive Compound of the Papaya Leave

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Papaya is most popular annual plant. Immediately after its harvesting, the highly perishable raw material, i.e. leaves, have to be preserved against deterioration and spoilage. More often, during peak period, most of the crop is lost/wasted due to lack of proper post-harvest processing techniques. Drying is by far the most widely used treatment, which needs to be performed very carefully and preciously so as to preserve the bioactive compound of the leaves. Drying treatment and experimental tray drying method was carried out at the temperatures of 50°C, 60°C and 70°C to find and suggest the optimum drying condition for acquiring quality dried papaya leaves powder and bioactive compound like phenol, flavanoid and antioxidant activity of papaya leaves. Results have revealed that 'total drying time' is considerably reduced with the increase in drying air temperatures from 50°C to 70°C. It could be recommended that the best drying temperature is 50°C of papaya leaves to retain the various bioactive compounds. Tray dryer at 50 ^{0}C for unblanched sample ensures the best results in quality and bioactive compound of papaya leaves Powder.

Keywords: Drying; drying characteristics; papaya leaves powder; tray drying; bioactive compound.

1. INTRODUCTION

It is well known, modern scientific method came into existence after the traditional herbal medicine for the healthcare purpose and it has less side effect as compared to the modern medicines, The world health assembly adopted a new resolution that herbal medicine is of great

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importance to the health of individuals and community [1].

"Carica papaya, belongs to the family of Caricaceae, and many species from Caricaceae have been used as remedy for different diseases .The plant can grow up to 5 to 10 metres high. The leaves are large, 50-70 cm in diameter, deeply palmate with 7 lobes. It is herbaceous succulent plant with self-supporting stems. The leaves increases appetite, improves digestion and can used as an additive to tenderize meat as well" [2]. "*Carica papaya* L. leaf was compared to few other plants for its efficiency on malaria treatment. In the comparison to other medicinal plants, *Carica papaya* L. leaves have comparatively higher composition of tannins, terpenoids and phenolic acids .Other than malaria, papaya leaves are used for the curing of dengue. The papaya leaves extract is also found to be effective on glycemic status by reducing the blood glucose level" [3].

"The leaves are used for colic, fever, beriberi, abortion, asthma in India, and cancer in Australia papaya leaves are used traditionally in treatments like jaundice, malaria, dengue immunomodulatory and antiviral activity" [4].

"Young leaves are rich in flavonoids (kaempferol and myricetin), alkaloids (carpaine, pseudocarpaine, dehydrocarpaine I and II), phenolic compounds (ferulic acid, caffeic acid, chlorogenic acid), the cynogenetic compounds (benzylglucosinolate). They have medicinal properties like anti-inflammatory hypoglycaemic, anti-fertility, abortifacient, and hepatoprotective, wound healing, antihypertensive and antitumor activities" [5]. "Dried leaves are known as blood purifiers and taken as tonic. Papaya leaf tea is used to treat obesity and helps in losing weight and it acts against chronic indigestion, high blood pressure and arteriosclerosis weakening of heart" [6].

"Many active ingredients are present in the papaya leaves which are useful for the increment of total antioxidant power. The leaves of papaya have been total antioxidant power in the blood to reduce lipid peroxidation level" [7]." The papaya leaves are generally used for fever, colic, beriberi, abortion,asthma throughout India, papaya leaves are used traditionally in treatments like jaundice,malaria, dengue immunomodulatory and antiviral activityand for cancer in Australia" [4].

"Phenolic compounds are having biological properties like antidiabetic, antioxidant, gastroprotective, anti-inflammatory, spasmolytic, antimicrobial, anticarcinogenic" [8], (Veggi, et al. 2014). Antiseptic, disinfectant [9], hepato-protective, hypotensive and cardio protective [10]. It has influence on chronical and degenerative diseases and different types of cancer [11,12]. The plant materials of the papaya are having the phenol contents, due to this compound in the plant material which determines their use in the pharmaceutical industries, in various areas of cosmetic and food. Different groups of polyphenols are present in the different sources of plant material [13].

"For achieving the better quality of the dried product, there are lots of advancement in the drying" [14]. "Recently, development of drying method had led to a renewed interest in different drying methods to enhance drying process, such as extraction process. The papaya leaves contain the many bioactive compounds and those can deteriorates fast if they remains in their original from and hence bioactive compound loss occurs. Greater reduction in size and volume can be achieved by the adopting proper drying methods for making the powder products of the papaya leaves. Powdered products possesses the longer shelf life and are easier to handle" (Ankita, et al. 2015). "Processing methods can easily effects the bioactive compounds, therefore, there is a need for the minimization of processing loss. The specific drying method effect on the preservation of raw quality cannot be predicted, because that is dependent on the type of chemical compounds present and the different types of plants" [15].

2. MATERIALS AND METHODS

Fresh papaya leaves were taken from the plants (fifty plants) grown in the Horticulture Farm of College of the Horticulture, Anand Agricultural University, Anand. Papaya leaves were washed and thoroughly cleaned with tap water to remove soil and dust particles if any attached to it after hand picking. The soft stems were removed of papaya leaves and cut into pieces for further drying process.

The physical properties viz. length, width measured by standard scale, thickness by digital vernier scale and weight by electronic weighing balance were measured.

The chemical characteristics of the papaya leaves viz. Moisture (%), ash (%), crude fibre(%), fat(%), protein(%), carbohydrate (%) values were analysed as per standard analytical methods Mineral contents of sample were determined by using Inductive Couple Plasma-Optical Emission spectrometry, ICP-OES (Model Optima 7000DV) at the Micronutrient Research centre, Anand Agricultural University, Anand.

Total phenol, Total flavanoid content and antioxidant activity were estimated by the method as described by Sadasivam and Manickam, 1992. In preliminary experiment hot water blanching was carried out using the method described by Ranganna (1986) with some modification for catalase and peroxidase analysis.

Drying experiments were performed in a cabinet type laboratory hot air tray dryer (Plate. 1) manufactured by Navrang Scientific Works Pvt. Ltd., New Delhi and fitted with manually controlled digital thermostat, PT-100 thermocouple, a blower driven by 0.4 hp motor. The dryer was adjusted to the selected temperature (50, 60, 70 °C) for about half an hour before the start of experiment to achieve the steady state condition. Air velocity was set at 1.0 m/s and maintained by adjustable flap throughout drying time and measured by digital anemometer. Then 100 g of pretreated and untreated samples of papaya leaves were uniformly spread in the tray.

The moisture loss from the papaya leaves was recorded at every 15 minute interval at 50, 60 and 70 °C temperature during drying using top pan digital weighing balance. The drying process was stopped when the final moisture content reached to about 4-6 % (db). The product was then cooled for 10 minutes after drying and packed in Aluminium laminated pouch bags. All the experiments were conducted in triplicate for each air temperature and pre-treatment. The average values are reported.

2.1 Methodology of the Observation

The Dry basis moisture content and overall drying rate were calculated for drying characteristics.

2.2 Dry Basis Moisture Content

The Dry basis moisture contents were calculated using following equation.

$$MC\ (db\%) = \frac{MC}{DW} X100 \quad (1)$$

Where,

MC (db%) =Moisture content % on dry basis of the sample (% d.b.)
MC = Moisture content, gram
DW = Dry weight, gram,

Plate 1. Tray dryer

2.3 Overall Drying Rate

The effect of temperature and air velocity on the overall drying rate was also studied. The overall rate of drying was calculated as ratio of difference of initial and final moisture content and total drying time.

The overall drying rate was calculated as follows:

$$\frac{dM}{dt} = \frac{M_o - M_F}{t_T} \quad (2)$$

Where,

$\frac{dM}{dt}$ = Overall drying rate, % d.b. /minute
M_o = Initial moisture content, % d.b.
M_F = Final moisture content, % d.b.
t_T = Total drying time, minute

3. RESULTS AND DISCUSSION

3.1 Physical Properties of Fresh Papaya Leaves

Physical attributes of fresh mature papaya leaves such as length, breadth, thickness, weight and colour were estimated. Mature leaves were taken for measurement.

Physical characteristics of papaya leaves such as Length, breadth, thickness and weight of papaya leaves ranged between 49 – 60.20 cm (54.17 ± 4.08), 57-67 cm (61.85± 3.35) and thickness 0.25-0.30 mm (0.28 ±0.01) respectively with a mean weight of 61.8.- 83.70 (72.01 ±6.70) gm. All leaves used in the study were greenish to dark green in colour. The values for the dimensions of the leaves are listed below in Table 1.

Table 1. Physical characteristics of fresh papaya leaves

Parameters	Range value	Mean value± S.D.
Length, cm	49 – 60.20	54.17 ± 4.08
Breadth, cm	57- 67	61.85± 3.35
Thickness, mm	0.25-0.30	0.28 ±0.01
Weight, g	61.8-83.7	72.01 ±6.70
Visual color	Greenish to dark green	

Table 2. Biochemical parameters of fresh papaya leaves

Parameters	Mean Value ± S.D.	
Biochemical		
	Wet basis	**Dry basis**
Moisture,%	74.56 ± 0.61	293.08
Ash,%	4.73 ± 0.03	4.96
Crude fat, %	2.6 ± 0.1	2.67
Crude fiber, %	2.8 ± 0.1	2.88
Protein, %	0.2 ± 0.03	0.20
Carbohydrate, %	15.17 ± 0.09	17.88
Flavanoid, mg/100 g	118.94 ± 1.98	-
Phenol, mg/100 g	355.50 ± 5.00	-
Antioxidant mg/100 g	420.95 ± 1.98	-
Micronutrient, (mg/100 g)		
Fe	4.57	-
Mn,	0.96	-
Zn,	0.71	-
Cu	0.13	-
Ca	660.20	-
P	480.50	-
K	306.80	-
Na	55.00	-

3.2 Biochemical Characteristics of Freshly Harvested Papaya Leaves

Chemical characteristics of fresh papaya leaves were carried out as per the standard methods. The data obtained on the chemical composition of fresh papaya leaves i.e. moisture, total ash, crude fat, crude fiber, protein, carbohydrate, flavanoid, phenol, antioxidant activity, and mineral content like iron, manganese, zinc, copper, potash, phosphorus and sodium are presented in Table 2. The moisture 74.56 ± 0.61, ash 4.73 ± 0.03, fat 2.6 ± 0.1, crude fiber 2.8 ± 0.1, protein 0.2 ± 0.03, carbohydrate 15.17 ± 0.09, flavanoid 118.94 ± 1.98 mg/ 100 g, phenol 355.50 ± 5.00 mg/100 g, antioxidant activity 420.95 ± 1.98 %, mineral content like iron 4.57 mg/100 g, manganese 0.96 mg/100 g, zinc 0.71 mg/100 g, copper 0.13 mg/100 g, calcium, 660.20 mg/100 g, phosphorus 480.50 mg/100 g, potash 306.80 mg/100 g and sodium 55.00 mg/100 g respectively.

These results of chemical composition of fresh papaya leaves observed during the study are in good accordance with the results reported by Nwamarah, et al. [16] for crude fiber, fat, Na. Ash was good as investigated by Raja et al. [17] & Nobel [18]. The Protein was 0.82 % was less as compared to Nwamarah, et al. [16]. Ca, Mn, K were good as reported by Ayoola, et al. [19], Phenols was in harmony with Hossain, et al. [14]. However, some major and minor differences in the some composition of fresh papaya leaves may be due to environmental stress, climatic conditions, geographical, cultivation and harvesting practices.

3.3 Blanching Treatment

For leafy horticulture crops, the pre-treatments are necessary before processing in order to retain colour, inactivation enzymes and / or enhance drying rate process. The ultimate aim of pre-treatments is to improve quality of final product and reduce processing cost. The pre-treatments differ from product to product.

Blanching treatments with hot water at 50 to 80 ^{o}C for 1, 2, 3 and 4 minutes were carried out for the enzymatic inactivation for catalyst and peroxidase. Catalyst was inactivated in 75 ^{o}C for 3 and 4 minute. Peroxidase (enzyme) was inactivated in the temperature of 80 ^{o}C at the time of 1, 2, 3, and 4 minute. Therefore, time for blanching was kept 80 ^{o}C and 1 minute. This result was similarly studied by Ahmed, J. [20] in coriander leaves.

3.4 Initial Moisture Content

The papaya leaves were collected from the plants grown in the farm of the College of Horticulture, Anand Agricultural University, Anand. Average moisture content of 6 samples of the fresh papaya leaves was 74.56 % (w. b.) at the time of harvest. The range of moisture content varied from 73.00 – 76.00 % (w. b.), which shows that the papaya leaves can be considered under highly perishable group.

3.5 Drying Characteristics of Papaya Leaves

The drying characteristics of papaya leaves were analyzed using the experimental data on moisture of product at various time intervals for tray drying conditions. The experimental data of the drying behaviour of papaya leaves in relation to moisture content, was recorded and summarized. The blanched and unblanched samples were dried up to the safe moisture content level of 4 to 6 % (% d.b.).

Relation of time, temperature, moisture content (% d. b.) was attempted to characterize the drying behaviour of papaya leaves. The moisture content was compared for the blanched and unblanched samples with different time, temperature.

3.6 Hot Air Tray Drying of Papaya Leaves

The papaya leaves were dried in the drying chamber of hot air tray dryer that had set to pre decided temperature. The drying in hot air dryer was done at 50, 60 and 70 ^{o}C till the final weight reached to predecided level, according to the final moisture content of dried product. Fig. 1 through 3 illustrate variation in the moisture content with respect to drying time for blanched and unblanched samples of papaya leaves at 50, 60, and 70 °C temperatures respectively in the hot air tray dryer. From figures, it can be seen that the total drying time decreased with increased in drying temperature. The effect on drying time was found more prominent with blanched than unblanched samples for the temperature 50 and 60 °C. However, at air temperature of 70 °C, the effect of blanching on drying time was comparatively less. It was also observed that moisture reduced rapidly at initial level, which decreased with time in both

blanched and unblanched samples for all three temperatures.

The effect of temperature on drying time was found more prominent for blanched papaya leaves. The initial moisture content of blanched sample 281.68, 309.84 and 306.50 (% d.b.) were reduced to final moisture content of 5.60, 4.28 and 5.15 (% d.b.) in 105, 90, and 60 minutes for 50, 60 and 70 °C temperatures, respectively. In case of unblanched samples, the initial moisture 275.94, 303.23 and 287.60 (% d.b.) were reduced to final moisture content 4.60, 4.93 and 4.38 (% d.b.) in 180, 120 and 90 minutes for 50, 60 and 70 °C temperatures, respectively.

The papaya leaves dried at 50 °C took considerably long time to reduce the moisture content from about 275.94 % to 4.60 (% d.b.), while at higher temperature 70 ^{o}C took less time in unblanched samples. Obliviously, at higher temperature the movement of drying front was fast as compared to lower temperature that resulted into rapid evaporation of water from the vegetative parts of leaves, resulted into higher moisture loss and lesser time required for drying. The similar types of results were obtained in blanched samples.

It was observed that the constant drying rate period was absent and the drying took place in the falling rate period only. Same trend was observed by Amgoth, et al. [21], Kelaiya, et al. [22] and Kadam, et al. [23]. Time taken for drying of papaya leaves were somewhat more as compared to curry leaves as described by Jain et al. [24]. This might be due to some sticky nature of papaya plant leaves.

3.7 Overall Drying Rate

Overall drying rate in the tray drying for unblanched samples of papaya leaves varied from 1.51 to 3.15 % d.b./min and for blanched sample was 3.40 to 5.02 % d.b./min. Normally, it can be expected that the overall drying rate should be higher at higher temperature, which is reflected in the results represented in Table3. Overall drying rate increases with increase in temperature from 50 to 70 °C in all the cases in the blanched and unblanched papaya leaves samples. It is also seen that the overall drying rate slightly lower for unblanched samples than the blanched papaya leaves samples at almost all experimental temperatures 50,60 and 70°C for tray dryer.

3.8 Effect of Phenolic Content in Hot Air Drying

The Phenol content of fresh and dried papaya leaves was determined by spectrophotometric analysis. Using a laboratory dryers, it was found

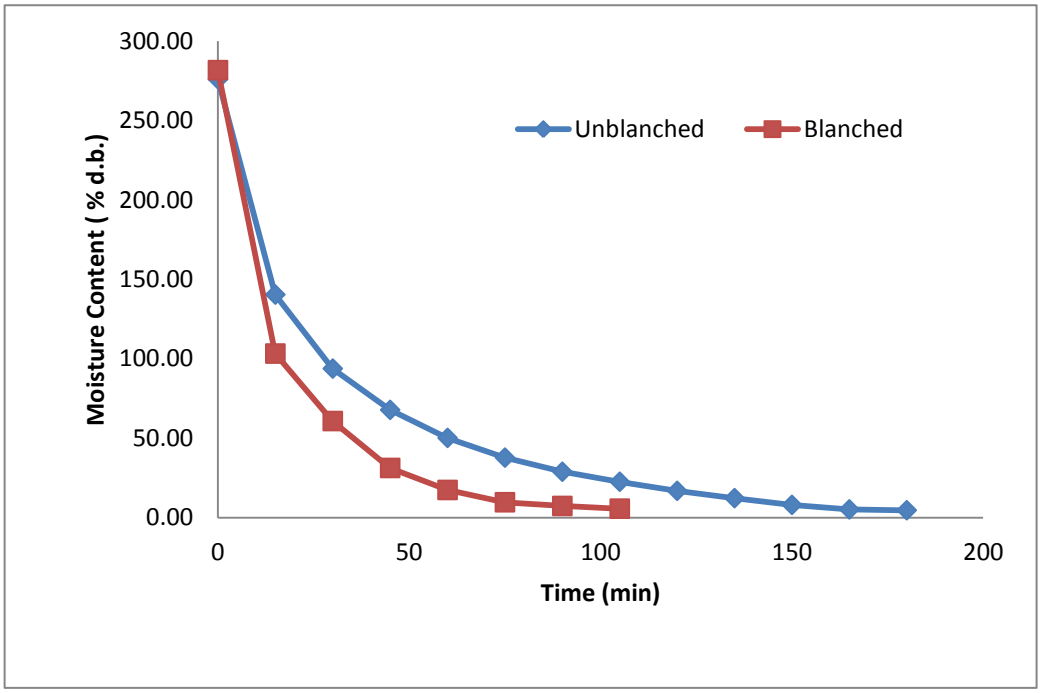

Fig. 1. Moisture content vs drying time for hot air tray drying at 50 °C

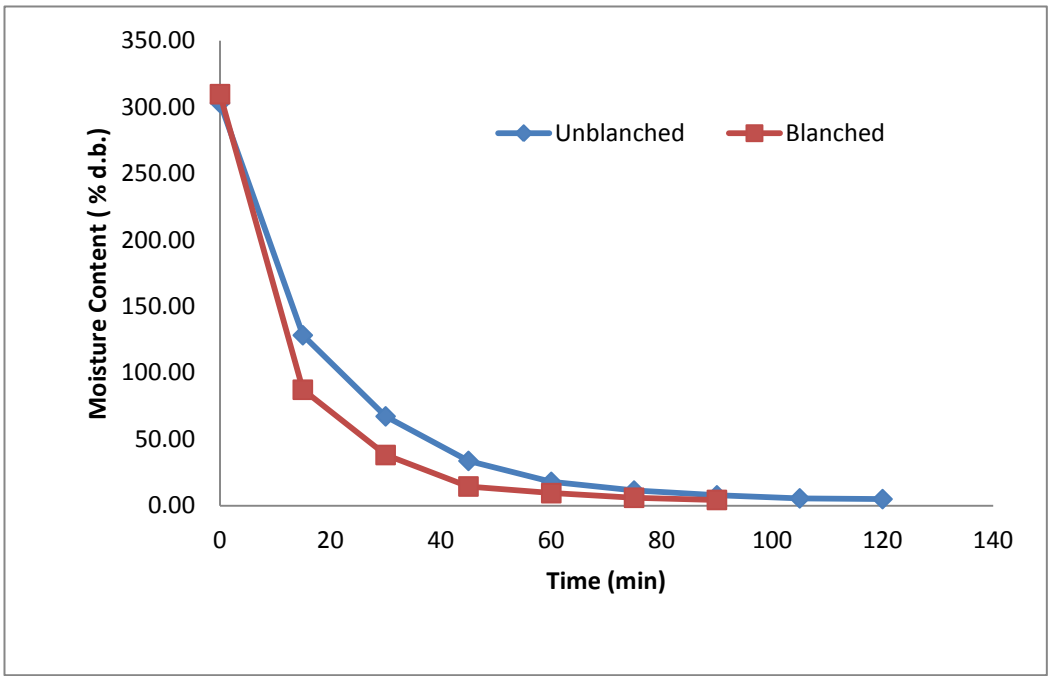

Fig. 2. Moisture content vs drying time for hot air tray drying at 60°C

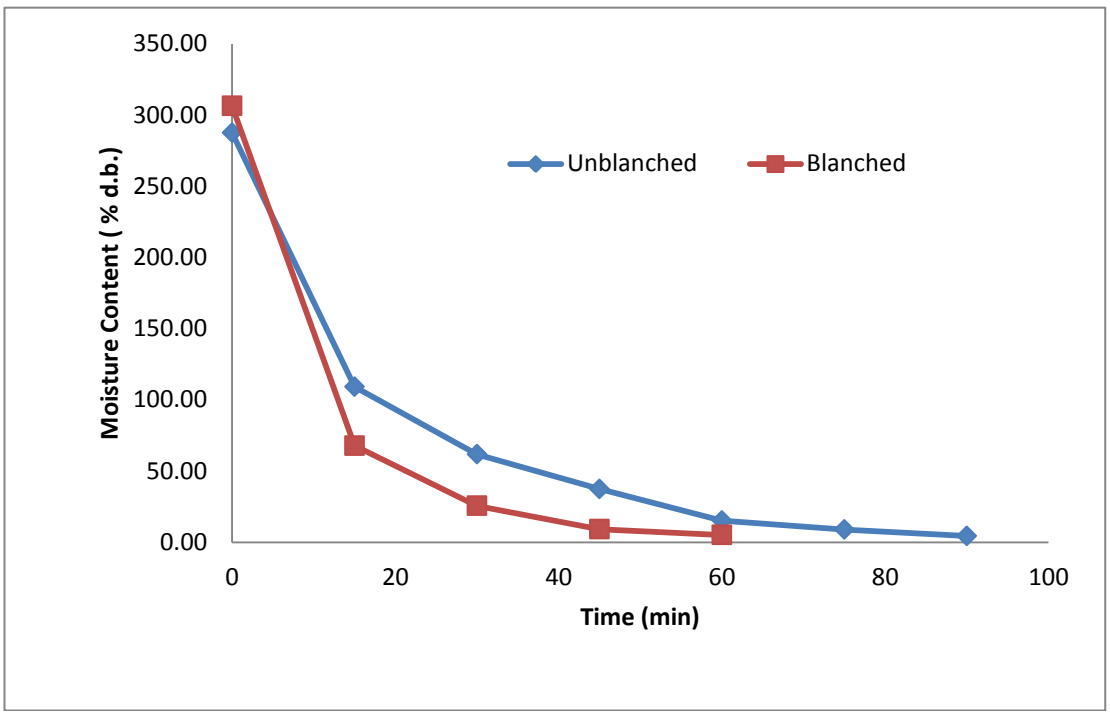

Fig. 3. Moisture content vs drying time for hot air tray drying at 70 °C

that the total phenols of papaya leaves were significantly influenced by drying air conditions (temperatures: 50, 60, and 70 °C, and blanching treatment). The phenol content of fresh papaya leaves was found to be 355 mg/100g (d.b.). The experimental results for phenol content of dried papaya leaves are presented in Table 4. It reveals that phenol content of dried papaya leaves ranged from 307.64 to 277.30 mg/100g powder for hot air dryer for unblanched sample while 303.28 to 275.83 mg/100g powder for hot air dryer for blanched sample. The unblanched

Table 3. Overall drying rate

Type of dryer	Temperature (°C)	Treatment unblanched (UB) / blanched (B)	Initial M.C. (%d.b.)	Final M. C. (% d.b.)	Total drying time (min)	Overall drying rate (%d.b./min)
Hot air dryer	50	UB	275.94	4.60	180	1.51
		B	281.68	5.60	105	2.63
	60	UB	303.23	4.93	120	2.49
		B	309.84	4.28	90	3.40
	70	UB	287.60	4.38	90	3.15
		B	306.50	5.15	60	5.02

Table 4. Experimental results on phenol content of papaya leaves powder

Treatment no.	Type of dryer	Temperature (°C)	Treatment unblanched (UB) / blanched (B)	Phenol content of dried leaves powder (mg/100g)	Loss in phenol (%)
1	Tray dryer	50	UB	307.64	15.56
2	,,	50	B	275.83	28.89
3	,,	60	UB	277.30	28.20
4	,,	60	B	303.28	17.22
5	,,	70	UB	299.26	18.79
6	,,	70	B	300.54	18.29

Table 5. Experimental results on flavanoid content of papaya leaves powder

Treatment No.	Type of dryer	Temperature (°C)	Treatment unblanched (UB) / blanched (B)	Flavanoid content of dried leaves powder (mg/100g)	Loss in flavanoid (%)
1	Tray dryer	50	UB	98.40	17.27
2	,,	50	B	95.05	20.08
3	,,	60	UB	93.80	21.14
4	,,	60	B	94.59	20.47
5	,,	70	UB	93.72	21.21
6	,,	70	B	92.20	22.48

Table 6. Experimental data on antioxidant activity (%) on dried papaya leaves powder

Treatment No.	Type of dryer	Temperature (°C)	Treatment unblanched (UB) / blanched (B)	Antioxidant of dried papaya leaves powder (mg/100 g)	Loss in antioxidant (%)
1	Tray Dryer	50	UB	409.32	2.76
2	,,	50	B	354.50	15.79
3	,,	60	UB	347.88	17.36
4	,,	60	B	375.08	10.90
5	,,	70	UB	380.32	9.65
6	,,	70	B	335.29	20.35

samples dried at the 50 ℃ had the loss of phenol wad 15.56 % while loss of phenol content at the 60 and 70 °C in the drying were 28.20 % and 18.79 % respectively. That shows that the lower the temperature, higher the retention of the phenol content and that loss increased at more

temperature i.e 60 °C (28.20 %). But at the 70 °C temperature, the loss of phenol content (18.79 %) was less as compare to the 60 °C. Harbourne et al. [25] said that increase in the drying temperature to 70 ℃ resulted in an increase in the drying rate of the herbs which also led to the loss of some phenolic compounds in unblanched sample. But in this case loss did not increased as compare to 60 °C. While in the case of blanched samples trends was not observed as said by Harbourne et al. [25].

3.9 Effect of Flavanoid Content Content in Hot Air Drying

Flvanoid content of dried papaya leaves is presented in Table 5. It showed that flavanoid content of samples varied from to 98.40 mg/100g to 92.20 mg/100g in the unblanched and blanched samples of the all drying temperatures. The highest flavanoid content (98.40 mg/100g) was found in the tray dryer at the 50 °C in the unblanched sample. Flavanoid content was higher in the unblanched samples and loss was less as as compare to blanches samples except the tray drying at 60 °C. This might be due to the flavanoid loss occurred during the blanching treatments. In the case of drying at 60 °C, the loss was 21.14 %, while loss of flavanoid at the 70 °C was 21.21 % in the unblanched samples. Less degradation of bioactive compound was also found in a product dried at higher temperature in the unblanched and blanched samples, which might be due to some glycosylated flavanoid contents are more resistant to heat treatment than aglycon flavonoids. This was observed by Chabaan et al. [26].

4. EFFECT OF DRYING CONDITIONS ON ANTIOXIDANT ACTIVITY

“The antioxidant activity was significantly affected by different drying temperatures (Table 6). Maximum antioxidant activity (409.32b mg/100g powder) was found in the unblanched sample dried at 50 °C in the tray dryer followed by 380.32 mg/100g in the tray dryer at 70 °C in the unblanched sample and minimum (347.88 mg/100g powder) was found in unblanched sample dried at 60 °C in the tray dryer. Hot air tray dryer method showed the significant effect on the concentration of antioxidant activity especially in tray dryer in the 50 °C. Drying at 50 °C in the tray dryer for unblanched sample was considered as the best processing condition on the basis of antioxidant retention. It was seen that the product which was dried at lower temperature retained the highest levels of bioactive components and antioxidant activity as studied by” Stepien, et al. [27]. This may be due to the fact that degradation of bioactive compound in papaya leaves is temperature dependent.

5. CONCLUSION

On the basis of experimental results and data analysis the following conclusions are drawn given as under.

The following conclusions could be drawn from the present investigation.

1. The length width, thickness, weight and colour of fresh leaves were observed to be 54.17 ± 4.08 cm, 61.85 ± 3.35 cm, (0.28 ± 0.01) and 72.01 ± 6.70 gm respectively .
2. The percent moisture, ash, protein, crude fat, crude fibre, carbohydrate, phenol content, flavanoid, and antioxidant activity in fresh papaya leaves were observed to be 74.56 ± 0.61 %, 4.73 ± 0.03 %, 0.2 ± 0.03 %, 2.6 ± 0.1 %, 2.8 ± 0.1 %, 15.17 ± 0.09 %, 355.50 ± 5.00 mg/100g, 118.94 ± 1.98 mg/100g, and 420.95 ± 1.98 % mg/100g respectively.
2. Total drying time considerably reduced with the increase in drying air temperature from 50 °C to 70 ° C temperatures.
3. The whole drying took place in falling rate period only.
4. Blanched sample took less time for drying compared to most of unblanched samples in tray dryer at every temperature from 50, 60 and 70 °C temperature
5. Phenol content was found higher in case of unblanched samples then blanched samples of papaya leaves.
6. The product quality in terms of antioxidants activity was found to be most acceptable when papaya leaves unblanched dried at 50 °C temperature in the tray dryer.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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