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Short Research Article

Comparative Studies on Quality Attributes of Open Sun and Solar Poly-tunnel Dried Wild Pomegranate Arils

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Abstract

Studies were conducted during the months of September-December in 2011 and January month in 2012 at the Department of Food Science and Technology, Dr. Yashwant Singh Parmar, University of Horticulture and Forestry, Nauni, Solan (HP), to compare the quality attributes of open sun and solar poly-tunnel dried wild pomegranate arils. Quality of open sunand solar poly-tunnel dried wild pomegranate arils was evaluated on the basis of various physico-chemical and sensory quality characteristics. The arils dried in solar poly-tunnel drier possessed higher amount of desirable chemical attributes viz., total solids (90.40%), total soluble solids (39.40 °B), titratable acidity (10.60%), reducing sugars (19.60%), total sugars (23.75%), ascorbic acid (12.70 mg 100 g^{-1}), anthocyanins (28.12 mg 100 g^{-1}) and phenols (108.60 mg 100 g^{-1}). Arils dried in solar poly-tunnel drier had lower amount of undesirable characteristics viz., moisture (9.60%), NEB (0.09 OD), HMF (1.07 ppm) and furfurals (14.40 ppb) as compare to open sun dried arils. The sensory characteristics viz., better colour, taste, texture and overall acceptability scores of arils dried in solar poly-tunnel drier reflected its superiority over open sun. Thus, drying of pre-treated wild pomegranate arils in solar poly-tunnel drier could be a better alternative method to prepare quality dried wild pomegranate arils (*anardana*) for the upliftment of small industry in the rural areas of developing countries.

1. Introduction

Wild fruits are consumed worldwide and contribute to the highest percentage of wild food plants. These fruits always have an elite status among the health foods because of great potential to reduce the risk of cancer, heart disease, premature ageing, stress and fatigue primarily due to the integrated action of oxygen radical scavengers, vitamins and minerals (Deshmukh and Waghmode, 2011). Among various wild fruits, one of the important fruit plant is wild pomegranate which has received considerable attention in recent years because of its lower requirement of inputs, higher yield, nutritional and medicinal properties. Wild pomegranate belongs to the family Punicaceae, genus *Prunus* and resembles with cultivated pomegranate for various morphological traits (Sharma and Sharma, 1990). It is believed that pomegranate originated in South West Asia probably in Iran, however, its wild form is mainly distributed in Transcaucasia, Central Asia and Western Himalayas (Chandra et al., 2014). In India, wild pomegranate plants are found in forest areas of mid hills of Himachal Pradesh (HP), Jammu-Kashmir and Uttarakhand states. This fruit is popular due to its commercial value. Wild pomegranate fruit is rich source of anthocyanins, vitamin C (ascorbic acid), polyphenols and organic acids such as citric acid, malic acid, succinic acid and tartaric acid (Thakur et al., 2011; Chandra et al., 2014). Despite of these nutritional components, it also contains fruit sugars, pectin, starch and minerals like potassium, calcium, phosphorous and iron. These nutritional components have great antioxidative, anticarcinogenic, antihypertension, antiatherogenic and anti-inflammatory activities in the human body (Zarfeshany et al., 2014). Arils are also used to treat sore eye, vomiting, spleen troubles, bronchitis, brain, liver and kidney disorders (Jalikop et al., 2002). Due to very sour taste, fresh arils are not preferred by people for consumption. Traditional use of wild pomegranate fruitis found in the form of dried arils which is commonly known as '*anardana*' in India (Pruthi and Saxena, 2005). Because of its higher acidic nature, the dried arils are used as a souring condiment in many Asian cuisines, chutney and curry preparations. Its arilscan be utilized in various culinary preparations like topping for yoghurt, ice-cream and salads.

Acidic taste of dried arils has ability to suppress the bitterness and enhance the flavour and appearance of many food items. Drying of horticultural products is considered as one of the cost effective and attractive use of solar energy. Traditional methods are followed by farmers of developing countries for the drying of arils of wild pomegranate fruits as fleshy seeds are dried in open sun without giving any pre-treatments and stored as such in gunny bags (Thakur et al., 2010). All these practices cause remarkable reduction of quality attributes of dried arils due to photo-oxidation reactions, contamination and spoilage of the product in open sun. It ultimately leads to lower cash money in returns to the concerned farmers. Thus, in the view of increasing demand of dried arils as a souring condiment in market, efforts have been made in present studies to compare quality of *anardana* prepared by using traditional i.e., open sun as well as non-conventional i.e., solar poly-tunnel methods of drying to uplift small scale industry for the welfare of rural farmers of developing countries.

2. Materials and Methods

Wild pomegranate fruits harvested at optimum maturity were purchased from farmers of district Mandi of HP and brought to the laboratory of the Department of Food Science and Technology, Dr. Yashwant Singh Parmar, University of Horticulture and Forestry, Nauni, Solan (HP) in the year 2011. Studies were conducted during the months of September to December in 2011 and January month in 2012.

2.1. Preparation of dried wild pomegranate arils

Fruits were thoroughly washed in water and used for aril extraction. Extracted arils were steam blanched for 30 seconds followed by sulphuring with 0.30% sulphur powder for 60 minutes in sulphur fumigation chamber before carrying out the drying (Thakur et al., 2010). The pre-treated arils were then dried by two different methods viz., open sun (D_1) and solar poly-tunnel drying (D_2). For open sun drying, the pre-treated arils (12 kg) were spread on the perforated aluminium trays (12 in number) and kept in the open sun in an inclined position for drying. The material was kept till the sunset before shifting it back in the laboratory for night. The mean temperature (°C), relative humidity (%) and wind speed (Km h^{-1}) recorded during the studies are given in Table 1. Similarly, for solar poly-tunnel drying (D_2), the pre-treated arils (12 kg) were spread on the perforated aluminium trays (12 in number) and put on the stand for drying inside a solar poly-tunnel drier of dimensions 297×204×207 cm. This drier was made up of polyethylene sheet of thickness 0.31 mm. The temperature recorded inside the solar poly-tunnel during drying was in the range of 34-39 °C, respectively. The pre-treated arils were dried in drying modes till they attain a constant weight.

2.2. Physical analysis

Yield of dried arils was calculated by dividing the weight of dried arils by the weight of fresh arils. Weighing of samples was done on top pan balance. The time taken to dry a given tray load was calculated by recording the time of sunshine hours (h) required by the material in the tray to attain a constant weight after drying in respective drying mode. The colour of dried arils was observed visually by comparing with colour cards of Royal Horticulture Society, London.

2.3. Chemical analysis

The moisture and total solids (TS) of dried arils were estimated by drying the weighed samples to a constant weight in a hot air oven at 70±1 °C. The oven dried samples were then cooled to room temperature in desiccator. Moisture and TS in terms of percentage were calculated. Water activity of the dried arils was recorded by computer based digital water activity meter (HW_3 model, Rotronic International, Switzerland), where direct measurements were taken at room temperature. Standard cuvette was used in which dried arils were filled upto the rim and placed below the sensor of the water activity meter, which gave direct reading of water activity. Hand refractometer was used to measure total soluble solids (TSS) and the results were expressed as degree Brix (°B) or per cent (Ranganna, 2009). For the preparation of sample, dried arils were crushed and mixed with distilled water to make an extract for further estimations. The readings were corrected by adding or subtracting the appropriate correction factor for temperature variation. The dried sample was diluted with distilled water and the reading was later multiplied by dilution factor. Reducing, total sugars and starch were estimated as per the standard procedures given by Ranganna (2009). Titratable acidity of dried samples was determined by titrating a known volume of crushed arils against standard 0.1 N NaOH solution by using phenolphthalein as an indicator upto light pink colour (end

Table 1: Meteorological data during the study period (2011-2012)

Month and Year	Temperature (°C)			Relative humidity (%)	Wind speed (km h^{-1})
	Maximum	Minimum	Mean		
September, 2011	28.4	16.4	22.4	74.4	2.3
October, 2011	27.0	9.8	18.4	67.3	3.1
November, 2011	24.5	5.6	15.1	49.9	3.2
December, 2011	20.5	0.9	10.7	48.5	3.1
January, 2012	14.9	0.7	7.8	62.0	3.4

Source: Meteorological observatory, Dr. Yashwant Singh Parmar, University of Horticulture and Forestry, Nauni 173 230, Solan (HP), India point). The titratable acidity was expressed as per cent citric acid (AOAC, 2004). The pH of dried arils was estimated by using a digital pH meter (CRISON Instrument, Ltd, Spain). The dried arils were crushed and mixed with distilled water to make an extract for pH determination. Before estimating the pH of the sample, pH meter was calibrated with standard buffers of 4, 7 and 9. Ascorbic acid content was determined as per AOAC (2004) method using 2, 6-dichlorophenol-indophonol dye. The total anthocyanins present in dried arils were determined by the method given by Ranganna (2009). The procedure involves extraction of the anthocyanins with ethanolic-HCl and measurement of colour at the wavelength of 535 nm against blank of ethanolic-HCl using a UV-Vis spectrophotometer (Model Shimadzu, Japan). The total phenolic content was determined by the Folic-Ciocalteu procedure given by Singleton and Rossi (1965). Optical density (OD) of prepared sample solutions as per the method explained by Singleton and Rossi (1965) was recorded at 765 nm with the help of UV-Vis spectrophotometer (Model Shimadzu, Japan). Pectin content of arils was determined by modified Carre and Haynes (1922) method. The pectin content in the samples was calculated and expressed as per cent calcium pectate. Total ash was determined by placing samples in a muffle furnace for ashing at a very high temperature of 550 °C to obtain a carbon free white ash with a constant weight. Ash content was expressed as per cent (Ranganna, 2009). For estimation of non-enzymatic browning (NEB), the dried arils were kept for 12 h in 20 ml of 60% ethyl alcohol and then were macerated and filtered. OD of filtered extract of centrifuged sample was measured by UV-Vis spectrophotometer (Model Shimadzu, Japan) against a blank of 60% alcohol (Ranganna, 2009). The absorbance of a sample extract at 440 nm was taken as a measure of NEB. Furfural was determined by a colorimetric method based upon its reaction with aniline and acetic acid in the presence of acidified $SnCl_2$ (Dinsmore and Nagy, 1974). Standard curve of freshly distilled furfuraldehyde of known concentration was plotted against absorbance at 520 nm wavelength. Furfural concentration in the samples was calculated by comparing their absorbance with standard curve and expressed as ppb of furfural. The hydroxy methyl furfural (HMF) content of different samples was determined by their reaction with resorcinol in an acidic media and measuring the reddish pink colour by using UV-Vis spectrophotometer (Model Shimadzu, Japan) at 540 nm after setting the instrument to zero absorbance with a water blank (Ranganna, 2009). The values of HMF were expressed in ppm after comparing the absorbance of sample with that of standard curve.

2.4. Sensory analysis

The sensory evaluation of prepared dried aril samples was carried out by hedonic rating test as given by Amerine et al. (1965). Sensory evaluation of dried wild pomegranate arils was conducted to assess the consumer acceptance. The prepared samples were evaluated for sensory quality on the basis of colour, texture, taste and overall acceptability on a 9 point hedonic scale by a panel of semi trained judges.

2.5. Statistical data analysis

The data pertaining to the sensory evaluation and physic-chemical analysis of *anardana* was analyzed by randomized block design (RBD) and completely randomized design (CRD). The experiments conducted in these studies were replicated three times.

3. Results and Discussion

3.1. Physical attributes of dried arils

Data in Table 2 indicate that the time taken to dry a given tray load (12 kg) in solar poly-tunnel drier (D_2) was lesser than open sun (D_1). Open sun drying took 220 h, while, solar poly-tunnel drying of wild pomegranate arils was completed within 140 h. However, the yield of D_1 dried arils was higher (25.50%) than D_2 dried arils (23.10%). Data pertaining to the effect of drying modes on the visual colour of arils indicate different colour shades of red to greyish purple. Arils dried in D_2 had red purple (RP-59B) colour which was found more attractive than greyish purple (GP-187-B) colour of D_1 dried arils. Relatively lesser time for drying of the arils in D_2 might be due to the faster drying rate, moisture removal and the partially modified temperature conditions inside solar poly-tunnel. Due to modification of environmental conditions inside the solar poly-tunnel and lesser exposure of wild pomegranate arils to photo-oxidation degradation reactions might have attributed to better colour retention of the arils dried in $D_{2,}$ while, direct sun light exposure, contamination and spoilage of arils by biological as well as non-biological factors during drying in open sun lead to lesser appealing colour in comparison of D_2 dried arils. Higher yield of D_1 arils might be due to poor moisture removal which gave higher bulk mass to arils in

Table 2: Physical characteristics of wild pomegranate arils dried in different drying modes

Characteristic	Drying Mode (D)		
	Open Sun (D_1)	Solar Poly-tunnel (D_2)	CD (p=0.05)
Yield (%)	25.50	23.10	2.00
Drying time (h)	220.00	140.00	6.00
Visual colour of arils	RP (59B)*	GP (187B)*	-

RP: red purple; GP: greyish purple; *: Card number of Royal Horticulture Society, London comparison of D_2 dried arils. Similar trend of results have also been reported by Wankhade et al. (2012) in dried okra slices, Kumar (2013) in Indian horse chestnut flour, Bhat (2014) in dried arilsand Pritika (2015) in dried pumpkin cubes and slices.

3.2. Chemical attributes of dried arils

The data in Table 3 reveal lower (9.60%) moisture and water activity (0.3952) in the D_2 dried wild pomegranate arils in comparison of D_1. However, higher TS (90.40%) and TSS content (39.40 °B) were found in the arils dried in D_2 and lower in D_1. Low water activity and moisture, high TS and TSS observed in D_2 might be due to the higher temperature conditions recorded inside the poly-tunnel which lead to relatively faster drying rate and removal of free available water from the arils than D_1. Poor moisture removal in open sun due to very fluctuating drying outside might be the reason for the higher moisture and water activity, lower TSS and TS of D_1 dried arils. Similar trend of results has also been reported by various workers (Thakur et al., 2012; Arun et al., 2014; Muhammad et al., 2015; Navale et al., 2015) in dried pine nuts (*chilgoza*), dried tomato cubes, dried carrot slices and dried fenugreek leaves, respectively. Data in the same table also show that higher reducing sugars (19.60%), total sugars (23.75%), starch (4.25%) and pectin (2.97%) were found in the arils dried in D_2, while, lower values of these components were recorded in the arils dried in D_1, respectively. Titratable acidity (10.60%), ascorbic acid (12.70 mg 100 g^{-1}), anthocyanins (28.12 mg 100 g^{-1}) and phenols (108.60 mg 100 g^{-1}) were also found to be higher in D_2 driedin comparison of D_1. The higher retention of these components in the D_2 dried arils, might be due to the reduced exposure time of arils for oxidation and other chemical reactions. Other reason for better retention of these nutritional components could be due to efficient removal of free water from wild pomegranate arils inside the solar poly-tunnel drier and lower water activity of D_2 dried arils. The above results are in conformity with the findings of Bhardwaj and Lal (1990) in dried apple rings and Bhat et al. (2014) indried arils. No significant difference was observed among different drying modes with respect to the ash, starch and pH content of dried arils (Table 2). Similar trend of observations were also seen by Kumar (2013) in Indian horsechest nut flour.

Table 3: Chemical characteristics of wild pomegranate arils dried in different drying modes

Characteristic	Open Sun (D_1)	Solar Poly-tunnel (D_2)	CD (p=0.05)
Moisture (%)	10.90	9.60	0.60
TS (%)	89.10	90.40	0.60
Water activity	0.4991	0.3952	0.0708
TSS (°B)	36.00	39.40	1.60
Reducing sugars (%)	19.00	19.60	0.30
Total sugars (%)	23.07	23.75	0.15
Starch (%)	4.09	4.25	NS
Titratable acidity (%)	10.00	10.60	0.50
pH#	3.83	3.75	0.08
Ascorbic acid (mg 100 g^{-1})	11.20	12.70	0.30
Anthocyanins (mg100 g^{-1})	21.20	28.12	3.70
Phenols (mg 100 g^{-1})	96.90	108.60	4.20
Pectin (%)	2.89	2.97	NS
Ash (%)	4.16	4.20	NS

#Sample was diluted 1:2 times with distilled water; NS: non significant

3.3. Undesirable chemical attributes which formed during drying

Data in the Table 4 show that D_2 dried arils were found with lower NEB (0.09 OD), HMF (1.07 ppm) and furfurals (14.40 ppb) as compare to D_1. This might be attributed to the inhibition in polymerization of ascorbic acid to form furfural and hindering the degradation of hexose sugars under acidic media to give rise to NEB and HMF because of lowering the moisture of arils through faster moisture removal and drying of arils under higher temperature conditions. Also bisulphite ions might have blocked the carbonyl group of sugar rendering it unavailable for interaction with acids in maillard reaction, therefore, preventing HMF, furfural and brown pigment formation in the dried arils. Lesser drying hours taken by wild pomegranate arils to attain a constant weight inside the solar poly-tunnel drier might have lead to reduction in oxidation reactions which cause lesser ascorbic acid degradation into brown pigments. Trend of results for these components is similar to the findings of Kumar (2013) in Indian horse chestnut flour, Bhat et al. (2014) in dried arils and Pritika (2015) in dried pumpkin cubes and slices.

3.4. Sensory attributes of dried arils

Data pertaining to various sensory attributes of dried arils

Table 4: Undesirable chemical characteristics of wild pomegranate arils formed during drying in different drying modes

Characteristic	Drying Mode (D)		
	Open Sun (D_1)	Solar Poly-tunnel (D_2)	CD (p=0.05)
NEB (OD)	0.18	0.09	0.03
HMF (ppm)	2.03	1.07	0.25
Furfural (ppb)	18.97	14.40	2.10

in two different drying modes viz., open sun (D_1) and solar poly-tunnel (D_2) are presented in Figures 1 and 2. It is evident from these Figures that relatively higher scores for colour (7.70), texture (7.95), taste (8.00) and overall acceptability (OA) (7.88) were awarded by panel of semi-trained judges to the arils dried in D_2, whereas, lower scores for all the above characteristics were given to the arils dried in D_1. The reason of best score for colour of D_2 might be due to lesser browning and photo-oxidation reactions experienced by the wild pomegranate arils inside the poly-tunnel, while the good texture of dried arils in D_2 might be due to lower moisture content and faster drying of arils than D_1. Faster drying rate and partially controlled conditions inside the poly-tunnel might also have reduced the risk of spoilage and contamination by dust, insect-pests, micro-organisms, birds and animals. Thus, provided better quality to the arils, therefore, improving the taste and overall acceptability by retaining higher quantity of desirable chemical constituents like TSS, ascorbic acid, titratable acidity, anthocyanins and phenols. Similar trend of sensory scores have also been recorded by Kiremier et al. (2010) in some dried vegetables, Ahmed et al. (2014) in dried peach halves, Sharma et al. (2014) in dried cabbage leaves and Sharma et al. (2014) in dried sweet bell pepper.

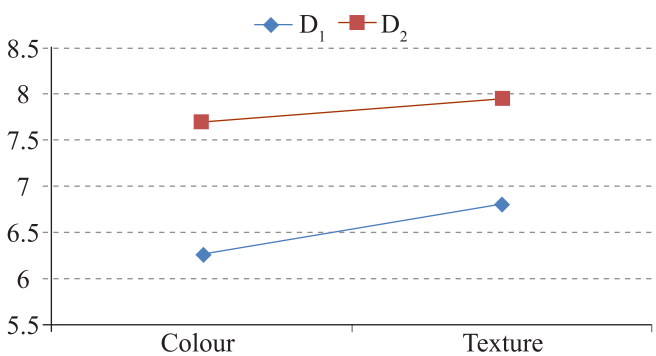

Figure 1: Colour and texture (sensory) scores of wild pomegranate arils dried in different drying modes on 9 point hedonic scale

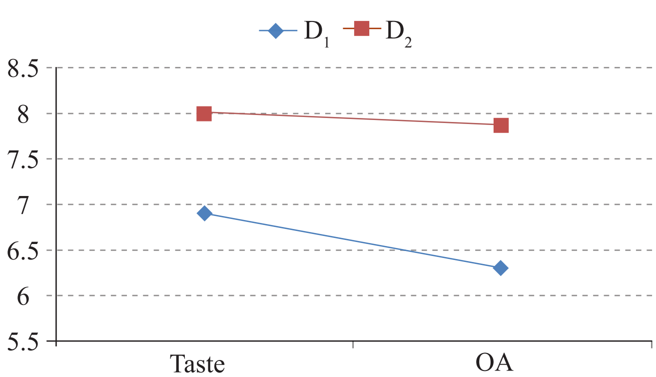

Figure 2: Taste and overall acceptability (OA) (sensory) scores of wild pomegranate arils dried in different drying modes on 9 point hedonic scale

4. Conclusion

Solar poly-tunnel (D_2) drying was an efficient drying mode in comparison of open sun (D_1) on the basis of physico-chemical characteristics viz., lesser drying time, moisture, NEB, HMF, furfurals and higher ascorbic acid, titratable acidity, anthocyanins and phenols of dried arils. Better sensory attribute scores of D_2 dried arils reflectedits superiority over D_1. Thus, solar poly-tunnel drying could be a cheap and efficient processing method for the preparation of quality *anardana*.

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