Research Article

Comparison of effect of storage on physico-chemical and sensory characteristics of dried wild pomegranate arils (*anardana*) prepared in mechanical cabinet and solar tunnel drier

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Abstract

Wild pomegranate (*Punica granatum* L.) fruit belongs to family Punicaceae is widely found in hilly slopes of HP, Uttarakhand and Jammu & Kashmir and contain higher amount of acid content which is processed into a popular dried product known as *anardana. Anardana* was prepared under mechanical cabinet and solar tunnel drier and comparative effect of 12 months storage period on physico-chemical and sensory characteristics were studied. The quality of *anardana* prepared in mechanical cabinet drier and solar tunnel drier was comparable in terms of various quality characteristics. After 12 months of storage period better quality attributes were observed in mechanically cabinet dried arils as compared to solar tunnel dried arils. However, comparatively minimum changes in *anardana* stored under refrigerated storage conditions were observed as compared to ambient temperature conditions.

Keywords: Anti-oxidants, Arils, Cabinet drier, Drying, Solar tunnel drier, Wild pomegranate

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Introduction

Wild pomegranate (*Punica granatum* L.) belonging to family punicaceae is one of the important wild fruits which resemble the cultivated pomegranate for various morphological characters [1]. The pomegranate fruit probably originated from South-West Asia and spread to other regions of the world like Mediterranean countries, India, China, Pakistan and Afghanistan [2]. Wild pomegranate is widely distributed in sub tropical tracts of north India particularly in Himachal Pradesh (HP), Uttarakhand and extending up to Jammu and Kashmir [3]. In Himachal Pradesh, it is distributed in some pockets of Solan, Sirmour, Mandi, Shimla, Kullu and Chamba districts [4-5]. The edible part of the pomegranate fruit is aril, which is rich in various nutritive and medicinal compounds like organic acids, vitamins, sugars, fibre, bioactive compounds and minerals like phosphorus, calcium, potassium and iron [6]. The cultivated and wild pomegranate fruit is one of the important sources of anti-oxidants like flavonoids, anthocyanins, ellagic acid derivatives and hydrolysable tannins which are responsible for the anti-oxidant activity of pomegranate fruit and a very high antioxidant activity in the fruit extracts (peel, juice and seeds) have been reported in the literature [5,7-9]. The unique anti-oxidant activity of this fruit contributes towards its medicinal value along with anti-microbial properties and used for curing vomiting, sore throat, brain diseases, spleen complaints, chest troubles, scabies, bronchitis, liver and kidney disorders [10-13]. The fruit being highly acidic in nature is being processed into its dried product known as *anardana* which has been used in formulations of various ayurvedic medicines used in curing a number of ailments like dysentery, diarrhoea, inflammations, stomach ache, hymenoletidosis, dyspepsia, bronchitis and cardiac problems [14]. This product has a great potential in the market and every year it is collected and sold in tonnes at various markets of country and abroad [15]. Traditionally, for the preparation of *anardana*, the arils are dried under solar radiation and recently solar tunnel and mechanical cabinet driers are widely in use for its preparation. Keeping this in view, present studies were carried out to evaluate the comparative effect of storage on physico-chemical and sensory characteristics of *anardana* prepared in mechanical cabinet and solar tunnel drier.

Materials and methods

Collection of fruit and chemicals

The raw material (wild pomegranate fruits) was procured from Karsog area of Mandi district of Himachal Pradesh,

India (1265 m above mean sea level). The fruits were further used for the preparation of *anardana* and the chemicals used during the entire study were procured from local market.

Preparation of dried arils (anardana)

Anardana was prepared as per the method suggested by Thakur *et al.* [16]. The pre-treated arils were spread on the perforated steel trays and dried in mechanical cabinet (60 ± 2 ^{o}C) and solar tunnel drier (30-45 ^{o}C).

Packaging and storage

The *anardana* was packed in the packaging materials like aluminium pouches (ALP), aluminium laminated pouches with vacuum (ALPV) and gunny bags. All the packages were stored under ambient temperature (9.8-24 °C) and refrigerated temperature (4-7 °C) for a period of 12 months and overall effect of storage was analyzed for changes in various physico-chemical and sensory quality attributes.

Physico-chemical analysis

Moisture content, total solids, TSS (total soluble solids), sugars, titratable acidity, ascorbic acid, anthocyanins, starch, NEB (non enzymatic browning), HMF (hydroxyl methyl furfural), furfural and residual SO_2 content of dried arils was determined according to Ranganna [17]. Water activity of the dried product (*anardana*) was estimated by computer based digital water activity meter (HW_3 model, Rotronic International, Switzerland). The pH of dried arils was determined by using a digital pH meter (CRISON Instrument, Ltd, Spain). Total fibres content was estimated by the method given by Gould [18]. Total phenol content was determined by Folin-Ciocalteu procedure given by Singleton and Rossi [19] and expressed as mg/100 g of GAE (Gallic Acid Equivalent). The total flavonoid content of fruit samples was estimated according to the method of Ilahy *et al*. [20] and expressed as mg/100 g of QuE (Quercetin Equivalent).

Antioxidant properties

One ml of sample was dissolved in 10 ml of methanol and 0.1 ml of methanolic (1 ml/g sample in 10 ml methanol) extract was taken for the estimation of various antioxidant properties. Free radical scavenging activity was measured as per the method of Brand-Williams *et al*. [21]. DPPH was used as a source of free radical and antioxidant activity was expressed as per cent. Metal chelating activity was determined according to method of Dinis *et al.* [22] and expressed as per chelation. Antioxidant activity as per FRAP assay was estimated according to the method of Benzie and Strain [23] and expressed as µM Fe^{2+}/100 g. Reducing power was determined as per the method of Oktay *et al*. [24] absorbance of the sample extract at 700 nm was taken as a measure of reducing power.

Sensory Evaluation

The sensory evaluation of prepared dried aril samples was carried out by hedonic rating test. Sensory evaluation of dried wild pomegranate arils was conducted to assess the consumer acceptance. The samples were evaluated for sensory qualities on the basis of colour, texture, flavour and overall acceptability on a 9 point hedonic scale.

Results and Discussion

Quality characteristics of anardana prepared in mechanical cabinet and solar tunnel drier

The physico-chemical and sensory characteristics of *anardana* prepared in mechanical cabinet drier and solar tunnel drier has been presented in **Table 1**.

Effect of storage on quality characteristics of anardana prepared in mechanical cabinet and solar tunnel drier

The comparison of quality characteristics of *anardana* prepared in mechanical cabinet and solar tunnel drier after 12 months storage has been presented in **Tables 2-5**.

Ambient storage

Physico-chemical characteristics

Data in Table 2 reveals that after 12 months of ambient storage the higher amount of total solids (89.89 %), TSS

(40.08 ^{o}B), reducing sugars (25.41 %), total sugars (26.17 %), titratable acidity (10.63 %), starch (2.68 %), total fibres (3.26 %) and residual SO_2 (190.86 ppm) was recorded in *anardana* prepared under mechanical cabinet drier and lower content of total solids (87.98 %), TSS (38.22 ^{o}B), reducing sugars (23.80 %), total sugars (24.54 %), titratable acidity (9.91 %), starch (2.49 %), total fibres (3.05 %) and residual SO_2 (123.22 ppm) was recorded in *anardana* prepared under solar tunnel drier. The lower amount of moisture (10.02 %), water activity (0.297) and pH (2.70) was recorded in *anardana* prepared in mechanical cabinet drier and higher amount of moisture (12.02 %), water activity (0.421) and pH (2.95) was recorded in *anardana* prepared in solar tunnel drier.

Table 1 Quality characteristics of *anardana* prepared in mechanical cabinet and solar tunnel drier

Characteristics	Mechanical cabinet drier	Solar tunnel drier
Physico-chemical Characteristics		
Moisture (%)	8.51	10.55
Total solids (%)	91.49	89.45
Water activity	0.211	0.348
TSS (^{o}B)	41.40	39.50
Reducing sugars (%)	24.80	23.15
Total sugars (%)	26.90	25.40
Titratable acidity (%)	11.55	10.90
pH	2.52	2.72
Ascorbic acid (mg/100 g)	15.20	12.75
Anthocyanins (mg/100 g)	40.40	35.70
Total phenols (mg GAE/100 g)	180.95	171.55
Total flavonoids (mg QuE/100 g)	40.60	38.30
DPPH anti-oxidant activity (%)	61.23	57.75
Metal chelating activity (%)	22.25	21.12
FRAP (μM Fe^{2+}/100 g)	34.60	32.85
Reducing power (Absorbance at 700nm)	0.610	0.576
Starch (%)	2.95	2.76
Total fibres (%)	3.52	3.40
NEB (OD)	0.042	0.090
HMF (ppm)	0.91	1.05
Furfural (ppb)	13.06	15.40
Residual SO_2 (ppm)	240.19	162.00
Sensory characteristics		
Colour	8.60	8.00
Texture	8.50	8.30
Flavour	8.60	7.90
Overall acceptability	8.57	8.07

The higher amount of ascorbic acid (12.65 %), anthocyanins (35.47 mg/100 g), total phenols (168.71 mg GAE/100 g) and total flavonoids (35.79 mg QuE/100 g) was retained in *anardana* prepared in mechanical cabinet drier whereas, lower amount of ascorbic acid (10.14 %), anthocyanins (31.17 mg/100 g), total phenols (159.17 mg GAE/100 g) and total flavonoids (34.71 mg QuE/100 g) was retained in *anardana* prepared in solar tunnel drier. After 12 months of storage the higher antioxidant activity in terms of DDPH antioxidant activity (57.60 %), metal chelating activity (20.02 %), FRAP (32.14 μM Fe^{2+}/100 g) and reducing power [0.540 (OD at 700 nm)] was recorded in *anardana* prepared in mechanical cabinet drier whereas lower DDPH antioxidant activity (53.97 %), metal chelating activity (18.90 %), FRAP (29.41 μM Fe^{2+}/100 g) and reducing power [0.500 (OD at 700 nm)] was recorded in *anardana* prepared in solar tunnel drier. After storage the less decrease or increase in chemical characteristics were recorded in *anardana* prepared in mechanical cabinet drier might be due to lower initial moisture content as compared to *anardana* prepared in solar tunnel drier. Due to the low initial moisture content the rate of various chemical reactions were slower in *anardana* prepared in mechanical cabinet drier leading to better stability of the product during storage.

The lower NEB browning (0.102), HMF (5.34 ppm) and furfural (36.78 ppm) content was recorded in *anardana* prepared under mechanical cabinet drier and higher NEB browning (0.150), HMF (5.65 ppm) and furfural (41.98 ppm) content was recorded in *anardana* prepared under solar tunnel drier. After storage the lower NEB browning, HMF and furfural formation in *anardana* prepared in mechanical cabinet drier might be due to the slower rates of

degradation of sugars and other reactions as it was having low initial moisture content as compared to *anardana* prepared in solar tunnel drier.

Table 2 Effect of storage on chemical characteristics of *anardana* under ambient temperature conditions

Characteristics	Mechanical cabinet drier	Solar tunnel drier
Moisture (%)	10.02	12.02
Total solids (%)	89.98	87.98
Water activity	0.297	0.421
TSS (^{o}B)	40.08	38.22
Reducing sugars (%)	25.41	23.80
Total sugars (%)	26.17	24.54
Titratable acidity (%)	10.63	9.91
pH	2.70	2.95
Ascorbic acid (mg/100 g)	12.65	10.14
Anthocyanins (mg/100 g)	35.47	31.17
Total phenols (mg GAE/100 g)	168.71	159.17
Total flavonoids (mg QuE/100 g)	35.79	34.71
DPPH anti-oxidant activity (%)	57.60	53.97
Metal chelating activity (%)	20.02	18.90
FRAP (μM Fe^{2+}/100 g)	32.14	29.41
Reducing power (Absorbance at 700nm)	0.540	0.500
Starch (%)	2.68	2.49
Total fibres (%)	3.26	3.05
NEB (OD)	0.102	0.150
HMF (ppm)	5.34	5.65
Furfural (ppb)	36.78	41.98
Residual SO_2 (ppm)	190.86	123.22

Sensory characteristics

After 12 months of ambient storage (Table 3) the higher colour (7.70), texture (7.89), taste (7.81) and overall acceptability scores (7.80) were obtained in *anardana* prepared under mechanical cabinet drier and lower colour (7.06), texture (7.73), taste (7.07) and overall acceptability scores (7.29) were obtained in *anardana* prepared under solar tunnel drier. After storage the higher sensory scores were obtained in *anardana* prepared in mechanical cabinet drier might be due to the higher initial sensory scores as compared to *anardana* prepared in solar tunnel drier.

Table 3 Effect of storage on sensory characteristics of *anardana* under ambient temperature conditions

Characteristics	Mechanical cabinet drier	Solar tunnel drier
Colour	7.70	7.06
Texture	7.89	7.73
Flavour	7.81	7.07
Overall acceptability	7.80	7.29

Refrigerated storage

Physico-chemical characteristics

Data on chemical characteristics of *anardana* presented in Table 4 shows that after 12 months of refrigerated storage the higher amount of total solids (90.83 %), TSS (40.90 ^{o}B), reducing sugars (25.02 %), total sugars (26.67 %), titratable acidity (10.97 %), starch (2.83 %), total fibres (3.40 %) and residual SO_2 (200.62 ppm) was recorded in *anardana* prepared under mechanical cabinet drier and lower content of total solids (88.62 %), TSS (38.94 ^{o}B), reducing sugars (23.37 %), total sugars (25.10 %), titratable acidity (10.29 %), starch (2.63 %), total fibres (2.21 %) and residual SO_2 (132.19 ppm) was recorded in *anardana* prepared under solar tunnel drier. The lower amount of moisture (9.17 %), water activity (0.248) and pH (2.62) were recorded in *anardana* prepared in mechanical cabinet drier as higher amount of moisture (11.38 %), water activity (0.391) and pH (2.84) was recorded in *anardana* prepared in solar tunnel drier.

The higher amount of ascorbic acid (13.77 %), anthocyanins (38.18 mg/100 g), total phenols (173.74 mg

GAE/100 g) and total flavonoids (37.89 mg QuE/100 g) was retained in *anardana* prepared in mechanical cabinet drier whereas, lower amount of ascorbic acid (11.27 %), anthocyanins (33.64 mg/100 g), total phenols (164.54 mg GAE/100 g) and total flavonoids (36.19 mg QuE/100 g) was retained in *anardana* prepared in solar tunnel drier. After 12 months of storage the higher antioxidant activity in terms of DDPH antioxidant activity (59.63 %), metal chelating activity (21.27 %), FRAP (34.06 μM Fe^{2+}/100 g) and reducing power [0.581 (OD at 700 nm)] was recorded in *anardana* prepared in mechanical cabinet drier whereas lower DDPH antioxidant activity (57.67 %), metal chelating activity (20.15 %), FRAP (31.31 μM Fe^{2+}/100 g) and reducing power [0.543 (OD at 700 nm)] was recorded in *anardana* prepared in solar tunnel drier. After storage the less decrease or increase in chemical characteristics were recorded in *anardana* prepared in mechanical cabinet drier might be due to lower initial moisture content as compared to *anardana* prepared in solar tunnel drier. Due to the low initial moisture content the rate of various chemical reactions were slower in *anardana* prepared in mechanical cabinet drier leading to better stability of the product during storage.

The lower NEB browning (0.062), HMF (2.61 ppm) and furfural (20.06 ppm) content was recorded in *anardana* prepared under mechanical cabinet drier and higher NEB browning (0.113), HMF (2.85 ppm) and furfural (28.30 ppm) content was recorded in *anardana* prepared under solar tunnel drier. After storage the lower NEB browning, HMF and furfural formation in *anardana* prepared in mechanical cabinet drier might be due to the slower rates of degradation of sugars and other reactions as it was having low initial moisture content as compared to *anardana* prepared in solar tunnel drier.

Table 4 Effect of storage on chemical characteristics of *anardana* under refrigerated temperature conditions

Characteristics	Mechanical cabinet drier	Solar tunnel drier
Moisture (%)	9.17	11.38
Total solids (%)	90.83	88.62
Water activity	0.248	0.391
TSS (^oB)	40.90	38.94
Reducing sugars (%)	25.02	23.37
Total sugars (%)	26.67	25.10
Titratable acidity (%)	10.97	10.29
pH	2.62	2.84
Ascorbic acid (mg/100 g)	13.77	11.27
Anthocyanins (mg/100 g)	38.18	33.64
Total phenols (mg GAE/100 g)	173.74	164.54
Total flavonoids (mg QuE/100 g)	37.89	36.19
DPPH anti-oxidant activity (%)	59.63	57.67
Metal chelating activity (%)	21.27	20.15
FRAP (μM Fe^{2+}/100 g)	34.06	31.31
Reducing power (Absorbance at 700nm)	0.581	0.543
Starch (%)	2.83	2.63
Total fibres (%)	3.40	2.21
NEB	0.062	0.113
HMF (ppm)	2.61	2.85
Furfural (ppb)	20.06	28.30
Residual SO_2 (ppm)	200.62	132.19

Table 5 Effect of storage on sensory characteristics of *anardana* under refrigerated temperature conditions

Characteristics	Mechanical cabinet drier	Solar tunnel drier
Colour	8.34	7.64
Texture	8.25	7.99
Flavour	8.34	7.58
Overall acceptability	8.31	7.79

Sensory characteristics

After 12 months of refrigerated storage the higher colour (8.34), texture (8.25), taste (8.34) and overall acceptability scores (8.31) were obtained in *anardana* prepared under mechanical cabinet drier and lower colour (7.64), texture (7.99), taste (7.58) and overall acceptability scores (7.79) were obtained in *anardana* prepared under solar tunnel drier

(Table 5). After storage the higher sensory scores were retained in *anardana* prepared in mechanical cabinet drier might be due to the higher initial sensory scores as compared to *anardana* prepared in solar tunnel drier.

Conclusion

Both the dying modes viz. mechanical cabinet and solar tunnel drier were found suitable for the preparation of *anardana*, with slightly better quality characteristics of arils dried in mechanical cabinet drier. The dried arils prepared under both drying modes could be stored safely for a period of twelve months under both storage conditions. However, *anardana* prepared in mechanical cabinet drier stored under refrigerated conditions retained higher quality characteristics after twelve months of storage period.

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