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ORIGINAL ARTICLE

Standardization of pre-treatments for the preparation of dried arils from wild pomegranate

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Abstract Pre-treatments for drying of wild pomegranate arils were standardized to check discolouration of dried arils. Steam blanching of arils for 30 s followed by sulphur fumigation at 0.3% for 60 min was found suitable as they took minimum time to dry a given tray load, and had minimum non-enzymatic browning, furfural, hydroxyl methyl furfural and moisture contents. The dried arils of the standardized pre-treatment recorded maximum scores for sensory characteristics like colour, texture, taste, aroma and overall acceptability.

Keywords Wild pomegranate · Dried arils · Sulphuring · Sulphiting · Cabinet drier

Introduction

Wild pomegranate (*Punica granatum* L.) is the only important wild fruit with great economic significance because of its high acidic nature. It is widely distributed in drier and sub marginal land of mid hill region of outer Himalaya at an elevation of 900 to 1800 MSL. The fruit contains citric acid as the major acid besides malic acid, oxalic acid, succinic acid and tartaric acid (Saxena et al. 1987). But wild pomegranate is highly acidic and hence cannot be used for table purpose but can be a good souring agent for use in curries, *chutneys* and other culinary preparations in dried form (Phadnis 1974; Chauhan at al. 1994). Lot of work on the preparation of dried arils has been reported from the commercial cultivars of pomegranate (Pruthi and Saxena 1984; Patil et al. 2003; Singh and Sethi 2003) but information on the drying of wild pomegranate arils particularly with pre-treatments is scanty. In India, nearly 1000 tonnes of dried arils are produced annually traditionally from wild pomegranate fruits, valued at Rs 150 crores (Yadav et al. 2006). Arils are dried traditionally without any pre-treatment, as a result poor quality product is produced, which fetches low price in the market. The poor quality of dried arils is due to the discolouration of arils caused by browning during drying and handling. Keeping these in view the present study was undertaken to standardize the pre-treatments for the preparation of good quality dried arils.

Material and methods

Wild pomegranate (*Punica granatum* L.) fruits harvested at optimum maturity were procured from Narag area of district Sirmour of Himachal Pradesh. Chemicals and other materials used were procured from local market.

Standardization of pre-treatments The arils were extracted from the selected fruits manually. One kg freshly extracted arils in each treatment was subjected to pre-treatments as given in Table 1.

In some of the pre-treatments blanching time of arils was standardized by estimating the activity of peroxidase enzyme. Its activity was determined as per the method given by Putter (1974). The enzyme activity per litre of extract was calculated using the formula:

$$\text{Enzyme activity/litre} = \frac{3.18 \times 0.1 \times 1000}{6.39 \times 1 \times t \times 0.1t} = \frac{500}{\Delta t}$$

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Table 1 Pre-treatments of freshly extracted arils

T_1	Unblanched/Control
T_2	SB
T_3	SB+1000 ppm KMS, 10 min
T_4	SB+1000 ppm KMS, 20 min
T_5	SB+1000 ppm KMS, 30 min
T_6	SB+2000 ppm KMS, 10 min
T_7	SB+2000 ppm KMS, 20 min
T_8	SB+2000 ppm KMS, 30 min
T_9	SB+0.3% S fumigation, 40 min
T_{10}	SB+0.3% S fumigation, 50 min
T_{11}	SB+0.3% S fumigation, 60 min
T_{12}	1000 ppm KMS, 10 min
T_{13}	1000 ppm KMS, 20 min
T_{14}	1000 ppm KMS, 30 min
T_{15}	2000 ppm KMS, 10 min
T_{16}	2000 ppm KMS, 20 min
T_{17}	2000 ppm KMS, 30 min
T_{18}	0.3% S fumigation, 40 min
T_{19}	0.3% S fumigation, 50 min
T_{20}	0.3% S fumigation, 60 min

SB Steam blanching for 30 s, *KMS* Sulphiting with Potassium metabisulphite, *S* Sulphuring with sulphur powder

where, Δt: Time to increase the absorbance by 0.1, min; 6.39: Extinction coefficient of guaiacol dehydrogenation product at 436 nm.

After blanching, arils were fumigated in a chamber by burning sulphur. In sulphiting, blanched arils were dipped in potassium metabisulphite (KMS) solution for varying time at ambient temperature (25 °C). In control, extracted aril samples were directly dried without any pre-treatment.

Drying of arils The arils of all pre-treatments were dried at 60±2 °C till constant weight in a mechanical cabinet drier (Windson Scientific Works, New Delhi) having 90×60×90 cm dimensions.

Quality characteristics of fruits and arils Random sample of 15 fruits were selected. The size of selected fruits was determined with the help of vernier calliper by measuring the length and diameter, and the average size was expressed in millimeter. The average weight of fruits, arils and rind was measured on a top pan balance of Metler Toledo (PB 153-S, Zurich, Switzerland) make. The arils from 15 randomly selected fruits were counted individually and average number of arils per fruit was calculated. The aril: pomace ratio was calculated by dividing weight of aril by the rind. The colour of fruits was observed visually but the colour of arils was compared visually with colour cards of Royal Horticulture Society, London and the card numbers were mentioned along with the colour. Time taken to dry a given tray load was calculated by recording the time required by the material in the tray to attain a constant weight after drying. Yield of dried arils was also calculated by taking into consideration the weight of fresh arils.

Total soluble solids (TSS) were measured by hand refractometer of Erma, Japan make applying correction factor for temperature variation. Dried samples were diluted 2 times with distilled water and the reading was later multiplied by 2. The pH was determined by using a digital pH meter Elico (G163, Hyderabad, India) make after calibration of the meter with buffers of pH 4 and 9. In case of fresh fruit, its pH was determined by taking its juice, whereas, in dried arils sample was prepared by crushing arils and diluting it with sufficient distilled water. Sugars, moisture, total solids, titratable acidity (citric acid), ascorbic acid, anthocyanins, ash content, non-enzymic browning (NEB) and hydroxy methyl furfural (HMF) and pectin were estimated as per Ranganna (1986). The total phenols were determined by the Folin-Ciocalteu procedure (Singleton and Rossi 1965). 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).

Pre-treated and dried arils were evaluated for sensory quality by 10 semi-trained panelists on the basis of colour, texture, taste and overall acceptability, on a 9-point Hedonic scale (Ranganna 1986). The experiments were replicated as per replications (n) mentioned in the respective tables. Statistical analysis of data of various atributes including physico-chemical characteristics was carried out by completely randomised design (Mahony 1985) and sensory analysis by randomised block design (Cochran and Cox 1967).

Results and discussion

All the physico-chemical characteristics of fruit and aril presented in Table 2 were within the ranges described by various workers (Parmar and Kaushal 1982; Sharma and Sharma 1990; Chauhan et al. 1994; Kher 1999). The slight differences recorded might be due to the age of the plant, soil moisture conditions of the area from where the samples were procured.

Standardization of blanching time With the increase in the blanching time the peroxidase activity decreased in the arils from the initial 375.9 to 187.9/l in 150 s in the blanched sample (Table 3). Minute leaching losses in colour and soluble solids were observed in the arils blanched for 30 s. But blanching beyond 30 s led to quite high losses in these attributes. So blanching time of 30 s was found suitable for

Table 2 Physico-chemical characteristics of wild pomegranate fruit and arils

Length[a], mm	58.9±1.58
Diameter[a] mm	46.4±1.00
Weight[a]g	64.0±3.20
Fruit colour	Yellowish green
Arils colour	Red Purple (61 B)[b]
Number of arils[a]/fruit	225.20±14.18
Weight of arils[a]/fruit, g	33.2±2.50
Arils : pomace ratio	1.0±0.08
Moisture,%	72.3±0.20
Total solids,%	27.7±0.20
TSS, °Brix	20.1±0.08
Reducing sugars,%	7.1±0.17
Total sugars,%	7.3±0.16
Titratable acidity,% citric acid	4.0±0.04
pH	2.5±0.01
Ascorbic acid, mg/100 g	21.1±0.38
Anthocyanins, mg/100 g	7.4±0.10
Pectin,%	0.7±0.02
Phenols, mg/100 g	89.8±3.26
Ash,%	0.9±0.12

TSS Total soluble solids

[a] n=15

[b] Colour card number of Royal Horticulture Society, London

arils although the enzyme activity was not inhibited completely. Melnick et al. (1944) have reported that steam blanching is preferable to water blanching because of less leaching losses of soluble nutrients in the fruits.

Physico-chemical characteristics Results in Table 4 indicate that blanched arils were dried faster compared to others and the time taken to dry the treated arils ranged from 10 to 11.5 h. However, minimum time of 10 h was taken to dry the arils of T_3 to T_{11}, whereas, T_1, T_{18}, to T_{20} took maximum time of 11.5 h to dry a given tray load, which was found at par with T_{12} to T_{17}. Further, the yield of dried arils ranged from 31.4 to 32.6% and was maximum in T_{20}, which was found at par with T_1, T_9 to T_{14}, T_{18} and T_{19}, while minimum was in T_8.

Table 3 Peroxidase enzyme activity per litre of extract

Blanching time, sec	Time required in min to increase absorbance by 0.1, Δt	Enzyme activity=500 Δt	Colour and soluble solids loss
0	1.3	375.9	No loss
30	1.5	333.3	Very less
60	1.7	289.0	Less
90	2.0	250.0	More
120	2.3	214.0	High
150	2.7	187.9	Very high

Less time taken to dry the arils in all the blanched arils might be due to the rupturing of their membrane during blanching, thus facilitating faster removal of moisture because of plasmolysis. Higher yield observed in T_{20} might be due to no leaching losses as blanching was not done in this pre-treatment.

Better colour of arils was retained in all the treatments as compared to the control (Table 4). The red colour (R-46A) was recorded in T_2 to T_6, T_9 to T_{15}, T_{18} to T_{20}. However, greyish red (dull) colour (GR-181A) of arils was observed in control (T_1). The moisture content in the dried arils ranged from 9.0 to 10.5%. It was minimum in T_3 to T_{11} and maximum in T_1, T_{18} to T_{20}. The total solids in the dried arils ranged from 89.5 to 91.0% whereas, the maximum total solids in the dried arils were in T_3 to T_{11} and minimum in T_1, $T_{18,}$ T_{19} and T_{20}. The red colour, minimum moisture and correspondingly high total solids in the above treatments might be due to the combined effect of blanching and sulphuring, which reduced the moisture content by means of exposing the cells by rupturing their membrane, thus facilitating their plasmolysis due to heat and thereby retaining higher total solids. Best colour preservation in the above treatments might be due to SO_2 reaction with polyphenols, which prevented development of brown colour in sugar amino system as has been reported by Burton et al. (1963). The retention of best colour might also be due to reduced non-enzymatic reactions as SO_2 inhibits brown colour formation at the beginning of the reaction as reported by McWeeny (1984). Moisture content in the dried arils was in the same range as reported by various workers for different cultivars of pomegranate (Patil et al. 2003; Singh and Sethi 2003). The TSS of dried arils ranged from 36.0 to 41.5° B; maximum being in T_1 which was significantly higher than other pre-treatments, while minimum was in T_8 (Table 4). Moisture and total solids values were in the narrow range of 9.0–10.5% and 89.5–91.0%, respectively in all the treatments.

Chemical characteristics Maximum values of reducing and total sugars were recorded in T_{20} (24.1%) and T_1 (25.6%), respectively (Table 5). These sugars (21.6% and 22.5%) were minimum in T_8. The maximum TSS, and sugars found in T_1 and T_{20} might be due to the low moisture retention as well as absence of leaching losses in the arils. The titratable acidity of dried arils ranged from 13.01 (T_2) to 14.6 (T_1)%, while pH values, however, were 3.6 in all treatments (Table 5). The highest titratable acidity in the arils found in T_1 might be due to lack of leaching losses as a result of no blanching as compared to other pre-treatments.

Ascorbic acid content of dried arils ranged between 13.02 (T_8) and 14.06 (T_{20}) mg/100 g. Anthocyanins were highest in T_{18} (33.45 mg/100 g) and lowest in T_8 (30.2 mg/100 g) (Table 5). Higher retention of ascorbic

Table 4 Effect of pre-treatments on the physico-chemical characteristics of wild pomegranate arils

Treatment	Drying time, h	Yield%	Visual colour[a]	TSS °B
T_1	11.5	32.5	GR (181A)	41.5
T_2	10.5	31.5	R (46A)	37.0
T_3	10.0	31.5	R (46A)	37.0
T_4	10.0	31.5	R (46A)	36.8
T_5	10.0	31.5	R (46A)	36.6
T_6	10.0	31.5	R (46A)	36.8
T_7	10.0	31.4	R (46B)	36.2
T_8	10.0	31.4	R (46C)	36.0
T_9	10.0	32.0	R (46A)	38.6
T_{10}	10.0	32.0	R (46A)	38.8
T_{11}	10.0	32.0	R (46A)	39.2
T_{12}	11.0	32.0	R (46A)	39.6
T_{13}	11.0	32.0	R (46A)	39.6
T_{14}	11.0	32.0	R (46A)	39.4
T_{15}	11.0	31.5	R (46A)	39.4
T_{16}	11.0	31.5	R (46B)	39.2
T_{17}	11.0	31.5	R (46B)	38.9
T_{18}	11.5	32.5	R (46A)	40.0
T_{19}	11.5	32.5	R (46A)	40.2
T_{20}	11.5	32.6	R (46A)	40.4
CD $_{0.05}$ (n=3)	0.9	0.6	–	0.5

Figures in parentheses are square root transformed values

T_1-T_{20}: As in Table 1

Moisture content was in the narrow range of 9.0–10.5% (3.0–3.2) and total solids 89.5–91.0% (9.46–9.54) in all samples

GR Greyish Red, *R* Red, *TSS* Total soluble solids

[a] Colour card number of Royal Horticulture Society, London

Table 5 Effect of pre-treatments on the chemical characteristics of wild pomegranate arils

Treatment	Phenols mg/100 g	NEB, OD	Furfural, ppb	HMF, ppm	Reducing sugars%	Total sugars%	Anthocyanins mg/100 g
T_1	105.7	0.064	18.42	1.82	23.96 (4.85)	25.64 (5.06)	33.56
T_2	109.7	0.056	16.97	1.26	21.70 (4.65)	22.98 (4.79)	32.01
T_3	112.5	0.039	16.25	1.21	22.79 (4.66)	22.80 (4.77)	30.79
T_4	117.2	0.036	16.21	1.15	21.76 (4.66)	22.74 (4.77)	30.54
T_5	119.1	0.032	16.18	1.09	21.69 (4.65)	22.65 (4.76)	30.49
T_6	120.1	0.031	16.16	1.11	21.75 (4.66)	22.82 (4.78)	30.45
T_7	121.9	0.029	16.12	1.03	21.65 (4.65)	22.60 (4.75)	30.34
T_8	123.7	0.026	16.06	0.96	21.58 (4.64)	22.52 (4.75)	30.20
T_9	122.4	0.027	15.88	0.98	22.78 (4.77)	24.13 (4.91)	32.84
T_{10}	125.4	0.022	15.42	0.95	22.82 (4.77)	24.25 (4.92)	32.25
T_{11}	133.9	0.020	14.85	0.83	22.96 (4.79)	24.61 (4.96)	32.12
T_{12}	110.4	0.043	16.90	1.22	23.15 (4.81)	25.12 (5.01)	33.32
T_{13}	112.5	0.041	16.87	1.20	23.07 (4.80)	25.01 (5.00)	33.15
T_{14}	115.5	0.040	16.80	1.17	23.00 (4.79)	24.92 (4.99)	33.05
T_{15}	118.1	0.039	16.83	1.17	23.00 (4.79)	25.07 (5.00)	33.05
T_{16}	118.9	0.036	16.70	1.13	22.92 (4.78)	24.82 (4.98)	31.56
T_{17}	121.3	0.035	16.59	1.05	22.81 (4.77)	24.72 (4.97)	30.61
T_{18}	116.2	0.036	16.42	1.17	23.65 (4.86)	25.40 (5.04)	33.95
T_{19}	119.5	0.034	16.38	1.12	23.86 (4.88)	25.26 (5.03)	33.69
T_{20}	121.2	0.032	16.33	1.07	24.06 (4.90)	25.10 (5.01)	33.46
CD $_{0.05}$ (n=3)	1.7	0.002	0.03	0.03	0.01	0.03	0.02

Figures in parentheses are square root transformed values; *NEB* Non enzymatic browning; *HMF* Hydroxymethyl furfural; T_1-T_{20}: As in Table 1

pH was 3.6 and the values were in the narrow range of 13.01–14.60% (3.60–3.82) for titratable acidity, 13.02–14–06 mg/100 g for ascorbic, 2.79–2.83% (1.67–1.68) for pectin and 4.15–4.61% (2.04–2.15) for ash for all treatments

acid and anthocyanins in the arils of T_{20} and T_{18}, respectively might be due to lack of leaching losses as no blanching was done.

T_{11} had maximum (133.9 mg/100 g) phenols, while T_1 minimum (105.7 mg/100 g). There was no significant effect of pre-treatments on the pectin content of dried arils. T_{11} had highest (4.6%) and T_{20} lowest (4.1%) ash content. Minimum NEB (0.020), furfural (14.8 ppb) and HMF (0.83 ppm) in the dried arils were observed in T_{11}, while maximum NEB (0.064), furfural (18.4 ppb) and HMF (1.82 ppm) were in T_1. Pectin values were in the narrow range of 2.79–2.83% in all the treatments. Maximum retention of phenols in the arils of T_{11} might be due to slower enzymatic reactions in arils as well as the inhibitory effect of SO_2 against the enzymes (Frank 1975). Maximum retention of ash in arils of T_{11} might be due to the fact that less amount of these constituents would have participated in browning reactions. The minimum NEB, furfural, and HMF observed in T_{11} might be due to the effect of sulphuring, which to some extent prevented formation of NEB products, polymerization of ascorbic acid with sugars to form furfural and degradation of hexose sugars in presence of acids to form HMF by lowering the drying time and moisture of arils. SO_2 might have blocked carbonyl group of sugar to render it unavailable for interaction with amino acids in Maillard reaction (Frank 1975; Andrews and Godshall 2002).

Sensory characteristics of dried arils Maximum scores for colour, texture, taste, aroma and overall acceptability were observed T_{11}, however, it was at par with T_8 and T_9 with respect to colour, T_1, T_9, T_{10}, T_{12}, to T_{14}, T_{18}, to T_{20} with respect to texture and taste and T_{20} with respect to aroma, whereas T_2 had minimum scores for all the sensory characteristics tested (Table 6). The maximum sensory characteristics scores of pre-treated arils for colour, texture, taste, aroma and overall acceptability were obtained for T_{11} (blanching+sulphuring at 0.3% for 60 min). The reason for the best colour score might be due to less browning observed in arils, while the good texture of arils might be due to low moisture content in arils and quick drying of arils would have retained the taste and aroma of the arils thereby, improving the overall acceptability. Retention of colour and flavour during drying of arils might also be due to the pre-treatment effect of SO_2 as has been explained by Joslyn and Braverman (1954).

Conclusion

After extraction of arils from the wild pomegranate fruits, they can be pre-treated with steam for 30 s followed by sulphuring @ 0.3% for 60 min and dried in a cabinet drier at 60±2 °C for the preparation of best quality dried arils.

Table 6 Effect of pre-treatments on the sensory[a] characteristics of dried wild pomegranate arils

Treatment	Colour	Texture	Taste	Aroma	Overall acceptability
T_1	7.0	8.0	8.0	7.6	7.5
T_2	7.0	7.0	7.0	7.0	7.0
T_3	7.5	7.5	7.5	7.5	7.5
T_4	7.5	7.5	7.5	7.5	7.5
T_5	7.5	7.5	7.5	7.5	7.5
T_6	7.5	7.0	7.2	7.2	7.2
T_7	7.5	7.0	7.2	7.2	7.2
T_8	7.5	7.0	7.2	7.2	7.2
T_9	8.5	8.0	8.0	8.2	8.2
T_{10}	8.5	8.0	8.0	8.2	8.2
T_{11}	8.9	8.5	8.5	8.7	8.7
T_{12}	8.0	8.0	8.0	8.0	8.0
T_{13}	8.0	8.0	8.0	8.0	8.0
T_{14}	8.0	8.0	8.0	8.0	8.0
T_{15}	8.0	7.5	7.5	7.7	7.7
T_{16}	8.0	7.5	7.5	7.7	7.7
T_{17}	8.0	7.2	7.5	7.6	7.6
T_{18}	8.0	8.0	8.2	8.1	8.1
T_{19}	8.0	8.0	8.2	8.1	8.1
T_{20}	8.0	8.0	8.2	8.2	8.1
$CD_{0.05}$	0.7	0.8	0.7	0.4	0.4

[a] Based on 9- point Hedonic scale (n=10 panelists)

References

Andrews LS, Godshall MA (2002) Comparing the effects of sulphur dioxide on model sucrose and cane juice systems. J Am Soc Sugarcane Technol 22:90–100

Burton HS, Mc Weeny DJ, Pandhi PN (1963) Non enzymatic browning of apple phenols and its inhibitors by sulphur dioxide. Nature 199:659–666

Chauhan SK, Lal BB, Sharma R (1994) Development of instant dehydrated wild pomegranate *chutney*. J Food Sci Technol 31:58–59

Cochran WG, Cox CW (1967) Experimental designs. Wiley, New York, pp 171–217

Dinsmore HL, Nagy S (1974) Improved colorimetric determination of furfural in citrus juices. J Assoc Off Agric Chem 57:332–335

Frank AL (1975) Browning reactions. In: Basic food chemistry. AVI, Westport Connecticut, pp 173–195

Joslyn MA, Braverman JBS (1954) Chemistry and technology of pre-treatment and preservation of fruit and vegetable products with sulphur dioxide and sulphite. Adv Food Res 5:97–160

Kher R (1999) Note on the physico-chemical characters of wild pomegranate (*Punica protopunica* L.). Ann Biol 15:231–232

Mahony MO (1985) Sensory evaluation of food: Statistical methods and procedures. Marcel Dekker, New York, pp 168–169

McWeeny DJ (1984) Sulphur dioxide and the Maillard's reactions in food. Progr Food Nutr Sci 5:395–404

Melnick D, Hockberg M, Oser BL (1944) Comparative study of steam and water blanching. Food Res 9:148–153

Parmar C, Kaushal MK (1982) Wild fruits of sub-Himalayan region. Kalyani Publ, New Delhi, p 74

Patil JN, Satnadhar PN, Machewad GM, Pawar VD, Sarkale BK (2003) Studies on process standardization for preparation of anardana. J Food Sci Technol 40:429–431

Phadnis NA (1974) Pomegranate for dessert and juice. Indian Hortic 19:9–13

Pruthi JS, Saxena AK (1984) Studies on anardana (dried pomegranate seeds). J Food Sci Technol 21:296–299

Putter J (1974) Methods of enzymatic analysis. In: Bergmeyer A (ed). Academic Press, New York, p 685

Ranganna S (1986) Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw Hill Publ Co Ltd, New Delhi, p 1112

Saxena AK, Manan JK, Berry SK (1987) Pomegranates: post-harvest technology, chemistry and processing. Indian Food Pack 41 (4):43–60

Sharma SD, Sharma VK (1990) Variation of chemical characters in some promising strains of wild pomegranate (*Punica granatum*). Euphytica 49:131–133

Singh D, Sethi V (2003) Screening of pomegranate genotypes for the preparation of quality grade anardana. J Food Sci Technol 40:236–238

Singleton VL, Rossi JA (1965) Colorimetry of total phenolics with phosphomolybedic phosphotungstic acid reagents. Am J Enol Vitic 16:144–158

Yadav K, Sarkar BC, BC KP (2006) Pomegranate: recent developments in harvesting, processing and utilization. Indian Food Ind 25(2):56–62