EFFECT OF STORAGE CONDITIONS AND PACKAGING MATERIAL ON QUALITY OF ANARDANA

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ABSTRACT

Wild pomegranate arils were blanched in hot water at 85°C for one minute and then pretreated by soaking in 0.2% solution of potassium metabisulphite (KMS) for 2 minutes. The pretreated arils were dried in a mechanical drier at 60°C as well as in a solar drier. The time taken to bring the moisture content to 8% (db) during mechanical drying and solar drying was 5.5 hours and 13 hours respectively. The dried pomegranate arils (anardana) were packaged in HDPE, LDPE and PP film packages and stored under ambient (14-39°C) and refrigerated (7°C) conditions. The quality of anardana, during storage for 12 months, was determined based on moisture content, total sugars, acidity, ascorbic acid, tannins and colour (overall change in colour, hue angle and chroma). Packages and storage temperature were found to have a significant effect in controlling the quality parameters during its storage. Anardana packed in HDPE film packages can be best stored for 9 months under refrigerated conditions and 6 months under ambient condition without any major loss in quality.

KEYWORDS: *Anardana, Drying, Packaging, Pomegranate Arils, Quality & Storage.*

I. INTRODUCTION

Pomegranate (Punica granatum L.) is one of the favorite fruit of tropical and subtropical regions where it has enjoyed the consumer's patronage for its healthy dietelic and medicinal properties [1]. The pulp bearing seed (arils) is the edible portion of the fruit and is consumed fresh, or it can be processed into juice, syrup, jams or wine. One of the major problems in pomegranate fruit is cracking at maturity leading to huge economic loss to farmers. In addition to the desert purpose (sweet type), pomegranate is also found in wild form. The seeds of these wild fruits being acidic are usually dried to yield a value added product known as anardana which is used as acidulant in curries, chutneys and other culinary [2]. Anardana is also a good source of vitamins and minerals. It improves mouth feel and digestion [3].

Drying of arils of pomegranate for anardana is the most important process since it has a great effect on the quality of end product. In India, usually drying for preparation of anardana is done in sun, which faces a major problem of inferior quality due to contamination with dust and dirt under open environment. During open drying, due to exposure to atmosphere for a longer time, microbial contamination and spoilage of product occurs. Systematic dehydration ensures longer shelf life and can be used in off-season of particular fruit crop. Product can be dried in the mechanical driers where the quality is much better and drying time is drastically reduced.

A study on drying of pomegranate seeds (anardana) under different conditions was carried out by [4]. Pomegranate seeds blanched for 5 min in boiling water gave the best quality anardana having bright maroon colour under sun drying as well as under cabinet drying conditions. Mean values for moisture differed significantly in sun-dried (15.73%) and cabinet-dried (9.33%) samples. Anardana samples had 3.4% more acidity in the cabinet dried product than in the sun dried product irrespective of the pre-treatment used. Non-enzymatic browning was maximum in cabinet dried pre-treated samples (steam blanched along with sulphuring).

Pre-treatments for drying of wild pomegranate arils were standardized in [5] 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.

Drying temperature was optimized during convective drying of anardana in [6] for getting better end product with quality retention during storage. The arils were dehydrated at 50, 55, 60°C and packed in polyethylene bags. The change in quality parameters such as acidity, colour, microbial load and enzymatic browning were studied.

Packaging of dried product also plays an important role in enhancing the shelf life of product and act as barrier against air borne contamination or loss and gain in moisture thus ensuring the retention of all the desirable quality of product during storage [7]. Hence, selection of right type of packaging is pre-requisite to ensure the retention of desirable quality of the product associated with it during storage [8], since dried fruit products undergo tremendous quality changes due to improper storage. These deteriorative changes increase with increase in temperature, relative humidity and time of storage [9]. Chemical composition of dried product in terms of acidity, total sugars, ascorbic acid, moisture and organoleptic evaluation changes during storage [10].

Application of the best post-harvest technique to enhance the shelf life and to maintain the quality of anardana plays a vital role in commercialization. A scientific method of drying and storing will help in preserving anardana for a longer period. Hence, the present investigation was undertaken with the objective to find out the suitable packaging material and storage condition for anardana.

II. MATERIALS AND METHODS

Wild pomegranates of uniform maturity were received from Jammu, India. Good quality pomegranate fruits were selected from the produce, washed, hand peeled and juicy arils were separated. Arils were washed and blanched in hot water at 85°C for 1 minute [11]. The blanched arils were immersed in solution containing 0.2% (permissible level) of potassium metabisulphite (KMS) for 2 minutes under ambient conditions [12]. The pretreated pomegranate arils were then dried in a mechanical drier (at a temperature of 60°C and at a velocity of 1m/s) as well as in solar drier to bring the arils at a final moisture content of approximately 8% (db). After drying by both the methods, dried arils were then packaged in high density polyethylene (HDPE) film packages, low density polyethylene (LDPE) film packages and polypropylene (PP) film packages. The packaged samples were stored under ambient (14-39°C) as well as refrigerated (7°C) conditions for the period of 12 months and analysed for quality parameters in terms of moisture content, total sugars, acidity, ascorbic acid, tannins and colour (overall change in colour, hue angle and chroma) at an interval of 3 months. The moisture content was determined by standard method [13]. Total sugars were estimated by the methods of [14]. Acidity % (as citric acid) and ascorbic acid content were determined by the procedure in [15]. Tannins were determined by the procedure described in [16]. Samples were analysed for colour characteristics 'L', 'a' and 'b' values using Hunterlab miniscan XE plus colorimeter. The 'L' dimension measures the lightness band varying from 100 for perfect white to 0 for perfect black, the 'a' dimension refers to red-green hues, it is red when positive and green when negative, 'b' measures yellowness when positive and blue when negative. These data were converted to different functions of colour as total colour difference, hue value and chroma. These derived functions were calculated as follows:

Total colour difference (DE) = $[(L-L_o)^2 + (a-a_o)^2+(b-b_o)^2]^{1/2}$

Hue angle = $\tan^{-1} (b/a)$

Chroma= $(a^2+b^2)^{1/2}$

The data obtained were subjected to factorial CRD statistical analysis as suggested by [17]. The critical difference value at 5% level of probability was used for making comparison among treatments viz. drying methods (D), storage temperature (T), type of packaging (P) and storage period (S) to evaluate their effect on various quality parameters and to find out the significant difference, if any.

III. RESULTS AND DISCUSSION

Drying studies conducted on pomegranate arils after blanching in hot water at 85°C for 1 min and pre-treated by soaking in 0.2% solution of potassium metabisulphite (KMS) for 2 minutes showed that the

time required to reduce moisture content of pomegranate arils from 80% to 7.6% (wb) in mechanical drying at 60°C was 5.5 hours and to 7.9% (wb) in solar dryer was 13 sun- shine hours. Solar dried arils contained slightly higher moisture content as compared to mechanically dried arils before storage. A gradual increase in moisture content was found in anardana during 12 months storage under both environmental conditions and for all packaging materials (Table 1). However, this increase in moisture content was significantly lower when the product was packaged in HDPE film packages as compared to LDPE or PP packaged film packages. The less increase in moisture content in HDPE film packages can be attributed to the lower permeability in comparison to other packaging material. With regard to storage condition, at ambient conditions, anardana samples showed greater increase in moisture content when compared with refrigerated conditions.

Table 1: Effect of different treatments on moisture content (%) and total sugars (%) of anardana during storage

	Moisture Content					**Total Sugars (%)**				
	Storage period (Months)					**Storage Period (Months)**				
Treatment	**0**	**3**	**6**	**9**	**12**	**0**	**3**	**6**	**9**	**12**
T1	7.6	7.8	8.1	8.2	9.2	15.1	15.0	14.1	9.1	6.0
T2	7.6	7.7	7.9	7.9	8.9	15.1	15.0	14.2	9.5	6.7
T3	7.6	7.9	8.2	8.3	9.4	15.1	14.3	12.7	8.4	5.0
T4	7.6	7.7	7.8	7.9	8.1	15.1	15.0	14.3	13.9	13.6
T5	7.6	7.7	7.8	7.8	7.9	15.1	15.0	14.4	14.0	13.7
T6	7.6	7.8	7.9	8.0	8.1	15.1	14.4	13.9	12.2	11.4
T7	7.9	8.1	8.3	8.4	9.6	14.4	13.3	13.1	9.5	5.6
T8	7.9	8.0	8.2	8.3	9.3	14.4	14.3	14.0	10.0	6.0
T9	7.9	8.2	8.4	8.5	9.8	14.4	13.7	12.9	8.1	4.6
T10	7.9	8.0	8.1	8.2	8.3	14.4	14.3	14.1	13.0	12.6
T11	7.9	8.0	8.1	8.1	8.2	14.4	14.4	14.2	13.3	12.9
T12	7.9	8.1	8.2	8.4	8.5	14.4	14.1	13.9	12.9	11.4

CD @ 5%	Drying Methods (D)	0.014	0.026
	Storage Temperature (T)	0.014	0.026
	Type of Packaging (P)	0.017	0.032
	Storage Period (S)	0.221	0.041
	D x T x P x S	NS	0.1422

T1: Mechanically dried Ambient LDPE
T2: Mechanically dried Ambient HDPE
T3: Mechanically dried Ambient PP
T4: Mechanically dried Refrigerated LDPE
T5: Mechanically dried Refrigerated HDPE
T6: Mechanically dried Refrigerated PP
T7: Solar dried Ambient LDPE
T8: Solar dried Ambient HDPE
T9: Solar dried Ambient PP
T10: Solar dried Refrigerated LDPE
T11: Solar dried Refrigerated HDPE
T12: Solar dried Refrigerated PP

Initial total sugar content was 15.1% in anardana dried in mechanical drier and 14.4% in anardana dried in solar drier. Under ambient conditions of storage, these values reduced to 5.0-6.0% in mechanically dried samples and 4.6-6.0% in solar dried samples under different type of packaging. At ambient conditions decline in total sugar content was slow up to 6 month storage and then decreased rapidly from 6-12 months (Table 1).Under refrigerated conditions, slow but significant decrease in sugar content was observed during 12 months of storage. Regarding mode of packaging, anardana packaged in HDPE film packages maintained highest level of free sugars than anardana packaged in LDPE and PP film packages during entire period of storage. Decline in total sugar content was also observed in [18].

Irrespective of the storage condition and packaging material, mechanically dried anardana had more acidity (as citric acid) than solar dried samples may be due to shorter time of drying. During 12 month storage acidity of anardana decreased significantly under all the treatments. This decline in acidity was rapid after 6 month storage. Decrease in acidity of anardana during storage was also reported in [19] for anardana, and in [20] for mango. Samples at refrigerated conditions maintained more acidity than samples at ambient conditions Also, less decline was observed in anardana packaged in HDPE film packages than anardana packaged in LDPE and PP film packages under both storage conditions and drying methods (Table 2). Decrease in acidity might be attributed to utilization of acids for converting them to other compounds [21]. Besides, high density of HDPE film blocks this conversion of acid to other compounds and hence was able to retain maximum acidity.

Table 2: Effect of different treatments on acidity (%) and ascorbic acid content (mg/100g) of anardana during storage

	Acidity (%)					**Ascorbic acid (mg/100g)**				
	Storage period (Months)					**Storage Period (Months)**				
Treatment	**0**	**3**	**6**	**9**	**12**	**0**	**3**	**6**	**9**	**12**
T1	9.7	9.3	8.1	6.7	4.8	15.7	14.5	12.8	8.5	5.3
T2	9.7	9.4	8.6	7.1	5.7	15.7	14.9	13.5	9.8	6.9
T3	9.7	9.2	8.2	7.0	3.9	15.7	14.2	11.5	8.4	5.5
T4	9.7	9.3	8.3	6.9	5.5	15.7	15.0	13.5	11.5	9.5
T5	9.7	9.6	9.0	8.0	6.6	15.7	15.3	14.2	13.2	12.1
T6	9.7	9.4	8.4	7.7	5.7	15.7	15.0	13.9	10.8	9.0
T7	9.4	9.2	8.0	6.6	4.6	15.1	13.9	12.0	8.3	5.2
T8	9.4	9.3	8.5	7.6	5.5	15.1	14.4	13.1	9.5	6.5
T9	9.4	9.2	8.4	7.0	3.6	15.1	13.5	10.8	8.4	5.1
T10	9.4	9.2	8.6	7.3	5.3	15.1	14.6	13.0	11.0	9.1
T11	9.4	9.4	8.7	8.0	6.6	15.1	14.8	14.0	12.8	11.9
T12	9.4	9.3	8.4	7.4	5.7	15.1	14.0	12.5	10.3	9.0

CD @ 5%	Drying Methods (D)	0.017	0.345
	Storage Temperature (T)	0.017	0.345
	Type of Packaging (P)	0.021	0.423
	Storage Period (S)	0.027	0.546
	D x T x P x S	0.093	NS

T1-T12: As in Table 1

Ascorbic acid content of anardana was significantly affected with storage period. A decline in ascorbic acid content was found with increase in storage period. However, this decline was slow in all the samples up to 180 days of storage. After 180 days, decline in ascorbic acid content was rapid and significant (Table 2). These results are in line with the results of [18] in anardana. Decrease in ascorbic acid content might be due to degradation of ascorbic acid molecules forming dehydro ascorbic acid by oxidation [22]. Comparatively, HDPE film packages were found to exhibit maximum vitamin C during storage, whereas it was least in PP film packages. Samples stored under refrigerated conditions retained more ascorbic acid as compared to samples stored at ambient conditions. This might be due to higher oxidation of ascorbic acid during storage at room temperature as compared to low temperature storage, which is in line with the observations of [23] and [21] in dehydrated ripe mango and dehydrated aonla segments respectively.

The colour of anardana is one of the important appearance characteristics and it is usually red, bright red, dark red, light brown and dark brown. Bright red is most attractive colour of anardana which can increase the consumer appeal and sale ability. There was significant and visible change in colour of anardana during storage (Table 3). 'L' value indicating bright of lightness and 'a' value indicating

redness of anardana was highest in mechanical dried samples as compared to solar dried samples during the entire storage period. 'L' and 'a' value of anardana decreased during 12 month storage period, but this effect was more pronounced at ambient conditions. This could be due to prevailing low temperature under refrigerated conditions that might have prevented both enzymatic and non-enzymatic oxidation processes [21]. More formation of brown colour in products at room temperature has been reported by [24] in heat sensitive material. Among packaging materials, higher retention in colour was observed in HDPE film packaged samples as compared to anardana packaged in LDPE and PP film packages.

Table 3: Effect of different treatments on colour (L,a,b) of anardana during storage

	Colour														
	Storage Period (Months)														
	0			3			6			9			12		
Treatment	**L**	**a**	**b**	**L**	**a**	**b**	**L**	**a**	**b**	**L**	**a**	**b**	**L**	**a**	**b**
T1	33.5	15.8	5.8	31.8	11.8	7.2	27.7	8.4	7.5	25.1	6.1	7.9	23.5	4.8	8.2
T2	33.5	15.8	5.8	32.5	12.3	6.7	32.0	9.6	7.2	28.7	7.6	7.3	22.7	4.9	7.4
T3	33.5	15.8	5.8	30.2	12.0	6.8	29.0	9.4	7.5	25.3	6.4	8.1	22.1	4.7	8.4
T4	33.5	15.8	5.8	30.3	13.1	6.2	29.5	13.0	6.3	29.4	12.9	6.4	29.1	12.7	6.3
T5	33.5	15.8	5.8	32.6	15.7	6.4	32.4	15.6	6.5	31.7	15.5	6.6	30.0	15.5	6.6
T6	33.5	15.8	5.8	30.7	14.4	6.4	29.7	14.0	6.7	29.1	13.9	6.8	28.9	13.9	6.9
T7	26.4	10.6	4.2	24.2	7.0	6.4	23.2	6.2	6.9	19.2	4.2	7.7	14.7	2.8	9.0
T8	26.4	10.6	4.2	25.8	7.9	6.3	23.5	7.7	6.8	19.9	5.8	7.3	14.7	3.5	8.3
T9	26.4	10.6	4.2	24.5	7.5	6.4	23.2	6.6	8.1	19.1	4.8	8.6	14.9	3.3	9.4
T10	26.4	10.6	4.2	25.7	9.7	6.2	25.7	9.6	6.7	22.2	8.9	7.5	20.4	8.2	8.8
T11	26.4	10.6	4.2	26.3	10.5	6.1	26.2	10.3	6.5	24.6	10.2	7.0	20.9	10.1	7.6
T12	26.4	10.6	4.2	25.4	9.7	6.3	25.1	9.6	7.6	23.7	9.0	8.2	19.8	8.6	8.8

CD @ 5%	Drying Methods (D)	0.102	0.071	NS
	Storage Temperature (T)	0.101	0.071	0.730
	Type of Packaging (P)	0.124	0.087	0.090
	Storage Period (S)	0.249	0.112	0.120
	D x T x P x S	0.556	0.400	NS

T1-T12: As in Table 1

Tannin content of anardana increased significantly during storage (Table 4). However, changes in tannin content were lower when the samples were packaged in HDPE packages and stored at refrigerated conditions. The increase in tannins during storage may be due to interaction between sugar and acid [22].

Table 4: Effect of different treatments on tannins (mg/100g) and overall change in colour (DE) of anardana during storage

	Tannins (mg/100g)					Overall change in colour (DE)			
	Storage period (Months)					Storage Period (Months)			
Treatment	**0**	**3**	**6**	**9**	**12**	**0-3**	**0-6**	**0-9**	**0-12**
T1	4.1	4.4	5.1	5.6	7.0	4.5	9.5	13.0	15.1
T2	4.1	4.3	5.0	5.1	6.3	3.8	6.5	9.6	15.4
T3	4.1	4.6	5.3	6.0	7.0	5.2	8.0	12.7	16.1
T4	4.1	4.4	4.7	5.0	5.3	4.2	4.9	5.1	5.4
T5	4.1	4.1	4.4	4.7	5.1	1.1	1.3	2.0	3.7

T6	4.1	4.4	4.9	5.2	6.0	3.2	4.3	4.9	5.2
T7	4.4	5.0	5.3	6.1	7.6	4.8	6.1	10.3	14.8
T8	4.4	4.8	5.1	6.0	6.8	3.4	4.8	8.7	14.3
T9	4.4	4.8	5.6	6.2	7.3	4.2	6.4	10.3	14.6
T10	4.4	4.7	5.0	5.2	5.8	2.3	2.8	5.6	8.0
T11	4.4	4.5	4.6	5.1	5.6	1.9	2.3	3.3	6.5
T12	4.4	4.7	5.2	5.8	6.3	2.5	3.8	5.0	8.3

CD @ 5%	Drying Methods (D)	0.031
	Storage Temperature (T)	0.031
	Type of Packaging (P)	0.038
	Storage Period (S)	0.049
	D x T x P x S	0.169

Statistical analysis for Overall change in colour (DE) has not been done as this parameter has been calculated by using various colour parameters (L,a,b)

T1-T12: As in Table 1

Similarly, overall change in colour (DE) was more pronounced in PP and LDPE film packages as compared to HDPE film packages. The DE increased with storage time (Table 4). These colour changes may be associated to Maillard reactions.

Hue describes what the average person thinks of when one speaks of colour as red, yellow, green and blue. It is widely used as an analytical tool to describe colour. A hue angle of 90° represents a typical yellow colour. The fruits with angle less than 90° are redder than the fruits with 90°. The hue values of anardana with storage period have been given in Table 5. The perusal of this table shows that with storage period the hue values increased in all the packages and at all the temperatures. However, this increase was less in HDPE film packages. At refrigerated conditions, the rise in hue is negligible showing the maintenance of red colour. The same trend was observed in samples dried by solar drier.

Chroma or Saturation may be defined as the properties of chromatic content in the total colour perception. It is also the degree of difference from the grey of the same lightness value. The chroma results of mechanically dried samples (Table 5) showed a decreasing trend with storage period except in the case of refrigerated samples packaged in HDPE film packages. However, there was no uniform trend in the case of solar dried samples.

Table 5: Effect of different treatments on Hue angle (°) and chroma of anardana during storage

	Hue Angle (°)					**Chroma**				
	Storage period (Months)					**Storage Period (Months)**				
Treatment	**0**	**3**	**6**	**9**	**12**	**0**	**3**	**6**	**9**	**12**
T1	20.3	31.4	41.3	52.2	60.0	16.8	13.8	11.3	10.0	9.5
T2	20.3	28.4	36.9	43.8	56.1	16.8	14.0	12.0	10.5	8.9
T3	20.3	29.7	38.7	51.6	60.7	16.8	13.7	12.0	10.4	9.7
T4	20.3	25.2	25.6	26.6	26.6	16.8	14.5	14.5	14.4	14.2
T5	20.3	22.3	22.8	23.3	23.3	16.8	16.9	17.0	16.8	16.9
T6	20.3	23.7	25.2	26.1	26.6	16.8	15.7	15.5	15.5	15.5
T7	21.8	42.9	48.5	61.6	72.6	11.4	9.5	9.3	8.8	9.4
T8	21.8	38.3	41.3	51.8	67.3	11.4	10.1	10.2	9.3	9.0
T9	21.8	40.4	50.7	60.7	70.5	11.4	9.9	10.4	9.9	9.9
T10	21.8	32.6	35.0	40.0	47.2	11.4	11.5	11.7	11.7	12.1
T11	21.8	30.1	32.2	34.2	36.9	11.4	12.1	12.2	12.4	12.6
T12	21.8	33.0	38.3	42.0	45.8	11.4	11.5	12.3	12.2	12.3

Statistical analysis for Hue Angle values has not been done as this parameter has been calculated by using various colour parameters (a,b)

Statistical analysis for Chroma has not been done as this parameter has been calculated by using various colour parameters (a,b)

T1-T12: As in Table 1

IV. CONCLUSIONS

The keeping quality of anardana was found to be better in mechanically dried samples than the solar dried samples. HDPE film packages were found to be best among all packaging materials used and it was observed that anardana packed in HDPE packages can be stored for 9 months under refrigerated conditions and 6 months under ambient condition without any major loss in quality.

V. FUTURE SCOPE

Study can be carried out to observe the effect of different blanching and chemical treatments on pomegranate arils prior to drying by different methods and to evaluate the quality parameters during storage of anardana in different types of packaging materials.

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