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THE QUALITY CHARACTERISTICS OF DRIED ARILS (*ANARDANA*) PREPARED FROM WILD POMEGRANATE (*PUNICA GRANATUM* L.) STORED AT AMBIENT TEMPERATURE CONDITIONS

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Abstract

Wild pomegranate fruit (*Punica granatum* L.) widely distributed in northern India is processed into a value added dried product namely *anardana*. During fruiting season fruits are available in bulk and traditional sun drying process is completely weather dependent which might lead to holding period before drying. Studies were carried out for the preparation of *anardana* at different intervals *viz.* 10, 20, 30 days from stored fruits at ambient temperature conditions (18-24^{o}C). Physico-chemical, namely TSS, sugars and anthocyanins and sensory parameters of *anardana* increased significantly with the advancement of storage period. However, ascorbic acid and total phenols decreased with the storage period. After 20th day of storage of fruits, the various quality characteristics of *anardana* increased slightly, whereas, the acid content decreased slightly after 10th day of storage of fruits with faster decreasing rate after 20th day of storage. The best quality *anardana* in terms of quality characteristics can be prepared from the fruits stored up to 20 days period.

Introduction

Pomegranate (*Punica granatum* L.) fruit belonging to Punicaceae is native to Iran and wild pomegranate is a very popular and unique fruit of Northern hills of India because of its highly acidic nature of arils (Hamid *et al.* 2020a). Wild pomegranate belongs to same family and regarded as biotype of cultivated pomegranate as it resembles the cultivated pomegranate for various morphological characters. The wild forms of pomegranate are widely distributed in Transcaucasia and Central Asia from Iran and Turkmenistan towards northern India (Chandra *et al.* 2010). In India, it is distributed upto 1800 m above mean sea level in wild sub tropical tracts such as scrub forests and natural diversity is found particularly in Himachal Pradesh, Uttarakhand and extending up to Jammu and Kashmir (Rawat *et al.* 2012). The wild pomegranate arils are rich source of anti-oxidants like anthocyanins, phenols, ascorbic acid etc. (Thakur *et al.* 2018) and these compounds strengthen the immune function with lowering down the risk of infection, cardiovascular diseases and cancer (Thakur *et al.* 2018 and 2021) as its fruit have high antioxidant, antiviral, anticancer, antibacterial, antidiabetic, antimutagenic and anticarcinogenic activity (Bhatt *et al.* 2021). The major use of wild pomegranate fruit is for the preparation of *anardana* (dried arils) which is used as an acidulant or spice in culinary purposes (Hamid *et al.* 2020b, Thakur *et al.* 2020). This product has great demand in the market and every year it is collected from the production areas and sold in the popular markets of country and abroad (Bakshi *et al.* 2013). Traditionally, for the preparation of *anardana* the arils of this fruit are dried under solar radiation and the varying seasonal conditions like rains and high humidity obstruct the immediate preparation of *anardana* from the freshly harvested crop which ultimately led to the holding of

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crop till the rainy season is over. Also there are certain reports related with the increase in anthocyanins content of cultivated pomegranate during ambient storage conditions. Therefore, keeping in view the above mentioned problems, investigations were carried out on preparation of *anardana* from the stored fruits at different storage intervals and its various quality characteristics were compared.

Materials and Methods

Wild pomegranate fruits were procured from four locations (Table 1). *Anardana* was prepared from the fruits stored under ambient temperature conditions (0, 10, 20 and 30 days) and further analyzed for various physico-chemical and sensory characteristics. Wild pomegranate arils were extracted and pre-treated as per the method suggested by Thakur *et al.* (2010) and the pre treated arils were dried at a constant temperature of 60 ± 2°C in mechanical cabinet drier.

Table 1. Details of locations for procurement of wild pomegranate fruits.

Sl. No.	Location	District	Height above mean sea level (m)
1	Narag	Sirmour	1130
2	Karsog	Mandi	1265
3	Basantpur	Shimla	1325
4	Darlaghat	Solan	1390

The colour of arils was observed visually by comparing with colour charts of Royal Horticulture Society, London. Yield of dried arils was calculated on per cent basis. TSS, sugars, titratable acidity, ascorbic acid and anthocyanins content of dried arils was determined according to Ranganna (2009). Total phenol content was determined by Folin-Ciocalteu procedure given by Singleton and Rossi (1965). The sensory evaluation of dried arils carried out by hedonic rating test and evaluation of dried wild pomegranate arils was conducted to assess the consumer acceptance for various characteristics like colour, texture, flavour and overall acceptability.

Data on physico-chemical characteristics of dried arils were analyzed by CRD (factorial). The data pertaining to the sensory evaluation of dried wild pomegranate arils were analyzed by Randomized Block Design (RBD). Data on physico-chemical and sensory characteristics of dried arils during the study were replicated five times.

Results and Discussion

The data presented in Table 2 show the changes in visual colour of *anardana* prepared from stored fruits and in all the locations the visual colour of *anardana* was observed as Red. However, the intensity of red colour of *anardana* prepared from stored fruit increased slightly with the advancement of storage period. This increase in intensity of red colour might be due to the continuous biosynthesis and accumulation of anthocyanins pigments in pomegranate fruit during storage from which the *anardana* was prepared. In pomegranate fruit increase in anthocyanins content during ambient storage was previously reported by Fawole and Opara (2013), Arendse *et al*. (2014a), Mphahlele *et al.* (2014). Data presented in Fig. 1(a) reveal the changes in yield (on aril weight basis) of *anardana* prepared from stored fruits. The yield of *anardana* prepared from stored fruit increased with decreasing rate up to 30th day of storage. The highest yield of *anardana* was observed in the 30 days stored fruits. The increase in yield of *anardana* prepared from stored

fruits might be due to the physiological loss of weight of extracted arils. The decrease in initial moisture content of arils extracted from stored fruit led to the increase in yield of *anardana* on weight basis.

Table 2. Effect of ambient storage of wild pomegranate fruit on *visual colour of *anardana*

Locations	Storage interval in days			
	0	10	20	30
Narag	Red (45 D)	Red (45 D)	Red (45 C)	Red (45 C)
Karsog	Red (46 C)	Red (46 C)	Red (46 A)	Red (46 A)
Basantpur	Red (45 D)	Red (45 C)	Red (45 C)	Red (45 C)
Darlaghat	Red (48 A)	Red (48 A)	Red (47 B)	Red (47 B)

*Colour card number of Royal Horticulture Society, London.

The acid content was slightly higher in *anardana* prepared from the fruits stored up to 10 days, which later decreased slowly up to 20 days, but beyond this the decrease in acid content was observed at very fast rate (Fig. 1b). The highest acid content was observed in *anardana* prepared from 10 days stored fruits. It was observed maximum in Karsog location and minimum in Narag location. The initial increase in acid content of *anardana* might be due to the initial loss of moisture content in 10 days stored fruit which led to slight concentration of acids. The further decrease in acid of *anardana* with advancement of storage period of fruits might be due to ongoing metabolism in the fruit since the organic acids are used as the one of major respiratory substrates during postharvest storage (Sayyari *et al.* 2011). Maximum acid content in *anardana* prepared from the stored fruits of Karsog and Darlaghat locations was as a result of higher initial values of acid content in the fruits of these locations from which *anardana* was prepared. Similar trend of increase followed by gradual decrease in acid content of pomegranate fruits during ambient storage was reported by Fawole and Opara (2013) and Silva *et al.* (2015).

A perusal of data given in Fig. 1(c) indicates that total soluble solids (TSS) content of *anardana* prepared from stored fruit increased throughout the storage period. However, this increase was observed faster up to 20th day which later slowed down. Highest TSS content was observed in *anardana* prepared from the 30 days stored fruits. The highest TSS content was recorded in the *anardana* prepared from the stored fruits of Karsog location and minimum in Narag location. The increase in TSS content of *anardana* prepared from stored fruits might be due to the moisture loss in arils during storage leading to the concentration of total soluble solids. The other possible reason of increase in TSS of the product might be due to hydrolysis of starch into sugars in the fruit during storage from which *anardana* was prepared. After 20th day the rate of increase in TSS content of *anardana* was observed at slower rate which might be due to slower hydrolysis of the starch into sugars in the stored fruit. Higher TSS observed in *anardana* of Karsog location was as a result of higher initial value of TSS in fruits as compared to others. Similar trend of increase in TSS content of pomegranate fruits during ambient storage was reported by Al-Mughrabi *et al*. (1995), Arendse *et al.* (2014b), Rawan *et al.* (2017).

Data presented in Fig. 1(d) showed a general increasing trend in reducing sugars content of *anardana* prepared from the stored fruits. The rate of increase in reducing sugars content of *anardana* was observed faster in the 20 days stored fruits which later slowed down. The highest reducing sugars content was observed in *anardana* prepared from 30 days stored fruits. Among

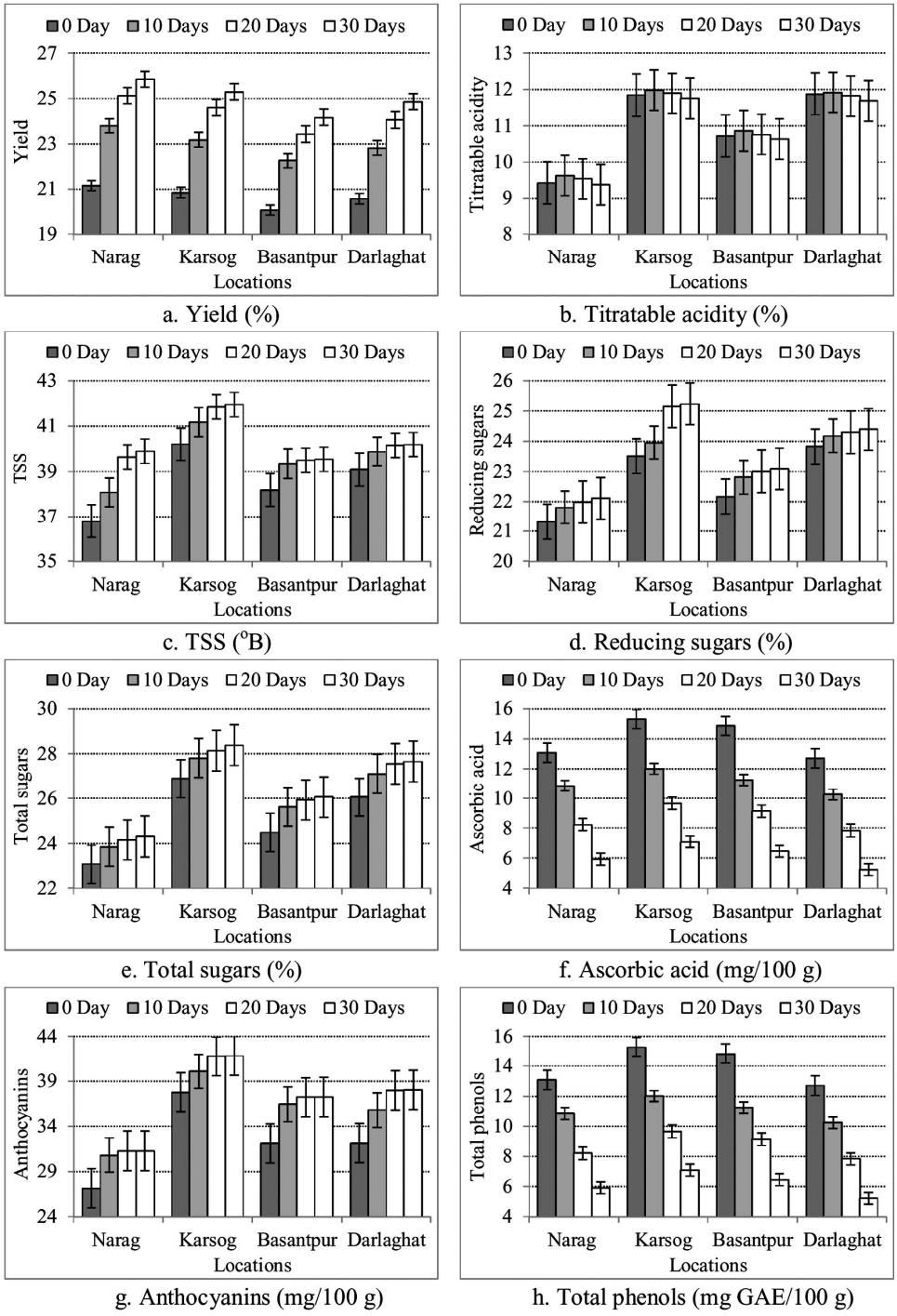

Fig. 1. (a-h) Effect of ambient storage of wild pomegranate fruit on physicochemical characteristics of *anardana* (error bars indicates standard deviations of the average).

various locations, highest and lowest reducing sugars contents were recorded in *anardana* prepared from the stored fruits of Karsog and Narag locations, respectively. The slight increase in reducing sugars content of *anardana* prepared from stored fruits might be due to the moisture loss in arils during storage which might have led to the concentration of reducing sugars. Increase in reducing sugars content throughout the storage period in *anardana* prepared from stored fruit might also be because of the hydrolysis of starch into sugars in the fruits during storage. After 20th day the rate of increase in reducing sugars content of *anardana* observed at slower rate might be due to slower hydrolysis of the starch into sugars in the stored fruit. The highest reducing sugars content observed in *anardana* of Karsog location might be due to higher initial value as compared to others. Rawan *et al.* (2017) have also reported a slight increase in reducing sugars content of pomegranate fruits during ambient storage.

The total sugars content of *anardana* prepared from stored fruit increased throughout the storage period and the rate of increase in total sugars content of *anardana* was observed faster in the 20 days stored fruits which later increased at very slow rate (Fig. 1e). The highest total sugars content was observed in *anardana* prepared from 30 days stored fruits. Among various locations the highest and lowest total sugars content was recorded in *anardana* prepared from the stored fruits of Karsog and Narag locations, respectively. The slight increase in total sugars content of *anardana* prepared from stored fruits might be due to the moisture loss in arils during storage leading to the concentration of total sugars. The other possible reason for increase in total sugars content of the product might be due to hydrolysis of starch into sugars in the fruit during storage from which *anardana* was prepared. After 20th day, the rate of increase in total sugars content of *anardana* was observed at slower rate which might be because of to slower hydrolysis of the starch into sugars in the stored fruit. The highest total sugars observed in *anardana* of Karsog location might be due to higher initial value as compared to others. Rawan *et al.* (2017) have also reported a slight increase in total sugars content of pomegranate fruits during ambient storage.

Data presented in Fig. (1f) showed that ascorbic acid content of *anardana* prepared from stored fruit decreased throughout the storage period of fruits and it was found maximum in Karsog location and minimum in Darlaghat location at the end of the storage. The decrease observed in ascorbic acid content of *anardana* prepared from stored fruit might be due to the loss of ascorbic acid during storage because of its oxidation to dehydro-ascorbic acid. The decrease in ascorbic acid content of *anardana* might also be because of its loss during preparation of *anardana* from stored fruits. The highest ascorbic acid content observed in *anardana* of Karsog location might be due to higher initial value as compared to others. Similar trend of decrease in ascorbic acid content of pomegranate fruits during ambient storage has been reported by Al-Mughrabi *et al.* (1995), Hellen *et al.* (2014), Arendse *et al.* (2014a).

The anthocyanins content of *anardana* prepared from stored fruit increased significantly throughout the storage period and the increase in anthocyanins content of *anardana* was observed at very fast rate in 20 days stored fruits after which the rate of increase was observed at slower rate (Fig. 1g). The highest anthocyanins content was observed in *anardana* prepared from 30 days stored fruits. Increase in anthocyanins content was found at faster rates in *anardana* prepared from 20 days stored fruits and after this period this parameter increased at slower rate. The maximum anthocyanins content was observed in Karsog location and minimum in Narag location at the end of the storage. The increase in anthocyanins content observed in *anardana* prepared from stored fruit might be due to the increase in anthocyanins content in the fruits which was as a result of activation of enzymes like phenylalanine ammonia lyase and uridine diphosphate glucose and flavonoid-3-O-glucosyltransferase responsible for the biosynthesis of anthocyanins (Miguel *et al.* 2004, Selcuk and Erkan 2014). After 20th day the rate of increase in anthocyanins content of *anardana* observed at slower rate might be due to the decrease in the concentration of enzymes

responsible for the biosynthesis of anthocyanins in the stored fruit. The higher anthocyanins content in *anardana* of Karsog location might be due to its higher initial value as compared to others. Similar trend of increase in anthocyanins content of pomegranate fruits during ambient storage has been reported by Fawole and Opara (2013), Arendse *et al.* (2014a) and Mphahlele *et al.* (2014).

Data of total phenols content of *anardana* prepared from stored fruits indicate that it decreased significantly throughout the storage period (Fig. 1h). However, the decrease was slower up to 10th day thereafter it decreased at faster rate. The maximum total phenols content was observed in the *anardana* prepared from the stored fruits of Karsog location and minimum in Darlaghat location followed by Narag location. The reduction in total phenols content of *anardana* prepared from stored fruits might be because of to their degradation as a result of enzymatic activities occurring in the fruit (Baltacioglu *et al.* 2011). The highest phenols content observed in *anardana* of Karsog location was as a result of its higher initial value as compared to others. Similar trend of decrease in total phenols content of pomegranate fruits during ambient storage was reported by Fawole and Opara (2013) and Mphahlele *et al.* (2014).

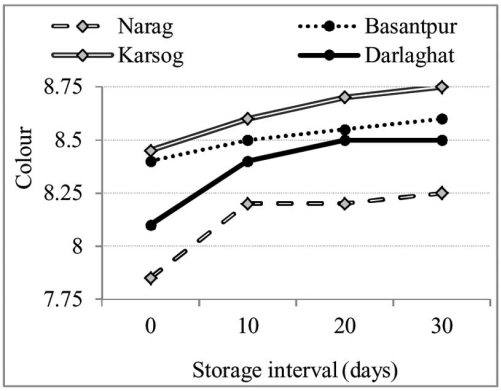

Fig. 2. Effect of ambient storage of wild pomegranate fruit on colour scores of *anardana*.

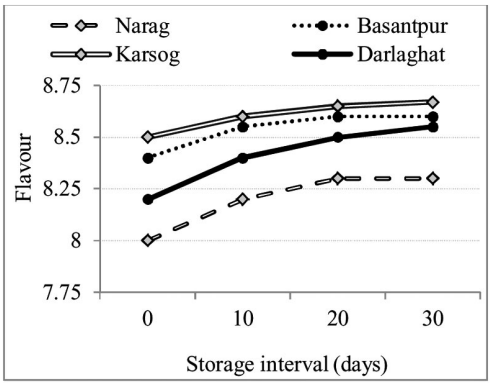

Fig. 3. Effect of ambient storage of wild pomegranate fruit on flavour scores of *anardana*.

The colour score of *anardana* prepared from stored fruits increased significantly throughout the storage (Fig. 2). However, this increase in colour score of *anardana* prepared from stored fruit increased at faster rate up to 20th day of storage of fruit which later slowed down. The highest colour score was obtained in *anardana* prepared from 30 days stored fruits. The maximum colour score was obtained in the *anardana* prepared from the stored fruits of Karsog location and minimum in Narag location. The increase in colour score of *anardana* prepared from stored fruits might be due to the increase in colour pigment of fruit during storage which led the judges to award the highest score of colour to the *anardana* prepared from 30 days stored fruits. After 20th day the rate of increase in colour score of *anardana* was observed at slower rate which might be due to slower increase in colour pigment of the fruit. The higher colour score of *anardana* in Karsog location might be due to the higher initial colour pigment (anthocyanins) in the fruit as compared to other locations, because of this highest colour score of the end product were observed in this location. An appraisal of data reflects that there was a general increasing trend in flavour score of *anardana* prepared from stored fruit (Fig. 3). However, the increase in flavour score of *anardana* was observed faster up to 20th day which later slowed down. However, the highest flavour score was observed in *anardana* prepared from 30 days stored fruits. The highest flavour

score was obtained in the *anardana* prepared from the stored fruits of Karsog location and lowest in Narag location. The increase in flavour score of *anardana* prepared from stored fruit might be due to the better sugar acid ratio of fruit during storage which might have contributed towards the better flavour of the end product. After 20th day, the rate of increase in flavour score of *anardana* was observed at slower rate which might be due to slight improvement in sugar acid ratio of the dried product. Among all the locations the highest score of flavour was observed in Karsog location which might be due to the higher initial sugar acid ratio as compared to other locations.

From the above study it was observed that there was a significant increase in various physico-chemical (TSS, sugars and anthocyanins) and sensory characteristics of *anardana* prepared from stored fruits whereas, the ascorbic acid and total phenols of *anardana* decreased with the storage of fruits. The *anardana* can be prepared up to 20 days after fruit harvest with significant increase in quality characteristics especially acidity, TSS, sugars, anthocyanins and sensory characteristics of end product. The study was also provided a base for intentional holding of fruits before industrial level processing (mechanical cabinet drying) which can result in better quality end product with better quality characteristics.

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