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Quality attributes of seabuckthorn squash during storage

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ABSTRACT

Seabuckthorn (*Hippophae rhamnoides* L, Elaegnaceae), berries were assessed for fruit weight, dimension and juice yield. Physico-chemical analysis of the seabuckthorn pulp yielded 11% TSS, 2.5% acidity, 1.13% reducing and 6.7% total sugars. Seabuckthorn squash was developed as per FPO specification 1955 (9) (25% pulp, 45% TSS, 1.0% acidity and 350 ppm SO_2). In order to develop a cloud stable squash, four hydrocolloids, viz. guar gum, gum acacia, gum tragacanth and gum *ghatti* were added at 0.0, 0.25, 0.50, and 0.75% each. Addition of 0.5% guar gum increases consumer acceptance of seabuckthorn squash. Protein content of seabuckthorn squash was 0.92% while ash content was 0.43%. Ascorbic acid content was found to be 120.5 mg/100 ml. Sodium and potassium content was 212.8 and 6.04 mg/kg respectively, while calcium and iron content was 457.4 and 24.7 mg/kg respectively. The squash were stored in glass bottle at ambient temperature for 120 days. Changes in total soluble solids, titratable acidity, ascorbic acid, reducing sugar and total sugars during storage were evaluated. The results revealed that there was gradual increase in total soluble solids, titrable acidity, reducing sugars and total sugars while ascorbic acid content and consumer acceptance decreased during 120 days of storage. No microbial growth occurred in the seabuckthorn squash during the study period.

Key words: Hippophae, seabuckthorn, squash, storage, quality.

INTRODUCTION

Seabuckthorn (*Hippophae rhamnoides* L., Elaegnaceae), a native of Himalayas and Siberia, is a lesser known thorny shrub that grows in the Temperate region. In India, it is naturally distributed over 11,500 ha in Ladakh region (Dwivedi *et al*., 8). The shrub has the distinction of bearing a highly nutritious berry rich in antioxidant vitamins, minerals and phytochemicals. Seabuckthorn is now valued as an emerging storehouse for researchers in the field of biotechnology, neutraceutical, pharmaceutical, cosmetic and environmental sciences (Stobdan *et al*., 13). Growing interest on seabuckthorn in India can be judged from the fact that the price of the berries has increased from Rs. 8/kg in 2001 to Rs. 22/kg in 2010. A litre of seabuckthorn pulp fetches Rs. 75 in Ladakh. Due to highly acidic nature, seabuckthorn berries are not commonly consumed as whole fruit. Despite its highly acidic nature and exotic flavour, seabuckthorn berries have good potential for producing various products like ready-to-serve (RTS) beverages, squash, syrup, jam and jelly. Judicious blending of seabuckthorn juice/ pulp with other fruits such as papaya, apple and oranges in different ratios could be a promising way for the processing of seabuckthorn and for minimization of juice astringency.

In view of the rich nutrient content in seabuckthorn, juice prepared from seabuckthorn serves as a convenient means for individual to significantly increase their nutrient intake without the use of dietary supplement. However, fruit juices undergo a number of deteriorative reactions during storage at room temperature. Such reactions results in the development of off-flavour and browning. Nutritive value of juice also undergoes changes during storage. Ascorbic acid is highly sensitive to changes in the environment such as, pH, oxygen and environment. The present work was therefore carried out to assess the quality attributes of seabuckthorn squash during storage.

MATERIALS AND METHODS

Ripe seabuckthorn berries were collected from forest area of Leh district of Ladakh region (Jammu & Kashmir) 3,193 to 3,206 m amsl. For preparation of squash, berries were sorted, cleaned and washed with running water and the juice was extracted by using a pulper (DK Barry, India). Seabuckthorn squash was prepared as per FPO 1955 specification containing 25% pulp, 45% total soluble solids (TSS) and 1% acidity. Acidity was maintained by adding citric acid. The squash was strained through a cheese cloth separated into thirteen parts. Variable concentration ranging from 0 to 0.75% of four hydrocolloids, *viz*. gum acacia, guar gum, gum tragacanth and gum *ghatti* were added for cloud stabilization of the squash. Sulphurdioxide (350 ppm) was used as preservative. Seabuckthorn squash was stored in glass bottles at room temperature for storage studies. The storage was

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monitored by evaluating parameters like TSS, titratable acidity, ascorbic acid, reducing sugar and total sugars at 0, 60 and 120 days storage period. The samples were analyzed for microbiological evaluation by the standard plate count method. Mould and yeast counts were conducted using potato dextrose agar (PDA). The stored products were subjected to sensory evaluation by semi-trained penal of 20 members. The panelists were asked to rank the samples using a 5 points scale regarding colour, flavour and overall acceptability.

Total soluble solids were measured with refractometer (ATAGO, Toyko) and values were corrected at 20°C (Ranganna, 12). Titrable acidity, ascorbic acid and sugars were determined as outlined by Ranganna (12). Crude protein (N×6.25) was determined by the semi-micro Kjeldahl method. Ash was determined by igniting a weighed sample in a muffle furnace at 550°C to a constant weight. Sodium and potassium were determined by flame photometer while calcium and iron were determined by atomic absorption. The pH-value was measured using a microprocessor based pH-meter (1012, ESICO, India). Data were subjected to General Linear Model (GLM) two-way ANOVA for means of comparison, and significant differences were calculated according to 2-tailed Duncan's multiple range test. Data are reported as means ± standard deviation of the means. Differences at $p \leq 0.05$ were considered statistically significant. SPSS (version 17) was used to perform the statistical analysis.

RESULTS AND DISCUSSION

Physico-chemical analysis of the seabuckthorn pulp yielded 11% TSS, 2.5% acidity, 1.13% reducing and total sugars of 6.7%. Squash prepared using the pulp has protein content of 0.92%, while ash content was 0.43%. Sodium and potassium content was 212.8 and 6.04 mg/kg respectively, while calcium and iron content was 457.4 and 24.7 mg/kg respectively. Ascorbic acid content was 120.5 mg/100 ml, which is many fold richer than that of juices made from other fruits.

The TSS contents of the sample maintained at 45% increased significantly during 120 days of storage (Table 1). The percentage increase ranged from 0.77 to 1.8%. Increase in TSS with the passage of time has been reported by Barwal *et al*. (3) in apricot squash. Hydrocolloids and their concentrations had significant effect on TSS of the product during storage. Guar acacia recorded increase in TSS value from 45 to 45.62, 45.74 and 45.75% during 120 days storage at concentration of 0.25, 0.5 and 0.75%, respectively. Gum tragacanth, gum ghatti and gaur gum added at 0.75% concentration increases the TSS to 45.63, 45.39 and 45.75%, respectively while the control sample without any hydrocolloid showed increase in TSS from

Table 1. Effect of hydrocolloids and storage on total soluble solids and acidity in seabuckthorn squash.

Hydrocolloid	Conc. (%)	Total soluble solids (%)			Acidity (%)		
		Days after storage					
		0	60	120	0	60	120
Control	-	$45.0 \pm 0.04^{a}_{x}$	$45.2 \pm 0.01^{a}_{y}$	$45.4 \pm 0.01^{a}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.1 \pm 0.02^{a}_{B}$	$1.3 \pm 0.01^{a}_{C}$
Gum acacia	0.25	$45.0 \pm 0.03^{a}_{x}$	$45.3 \pm 0.01^{b}_{y}$	$45.6 \pm 0.01^{c}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.1 \pm 0.01^{a}_{B}$	$1.3 \pm 0.01^{a}_{C}$
	0.50	$45.0 \pm 0.03^{a}_{x}$	$45.4 \pm 0.01^{c}_{y}$	$45.6 \pm 0.01^{c}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.1 \pm 0.01^{a}_{B}$	$1.3 \pm 0.01^{a}_{C}$
	0.75	$45.0 \pm 0.03^{a}_{x}$	$45.6 \pm 0.02^{f}_{y}$	$45.8 \pm 0.01^{e}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.0 \pm 0.01^{a}_{A}$	$1.3 \pm 0.01^{a}_{C}$
Gum tragacanth	0.25	$45.0 \pm 0.01^{a}_{x}$	$45.3 \pm 0.02^{b}_{y}$	$45.5 \pm 0.02^{c}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.1 \pm 0.01^{a}_{B}$	$1.3 \pm 0.01^{a}_{C}$
	0.5	$45.0 \pm 0.01^{a}_{x}$	$45.4 \pm 0.02^{d}_{y}$	$45.6 \pm 0.01^{c}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.1 \pm 0.01^{a}_{B}$	$1.3 \pm 0.01^{a}_{C}$
	0.75	$45.0 \pm 0.01^{a}_{x}$	$45.5 \pm 0.01^{e}_{y}$	$45.6 \pm 0.01^{b}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.1 \pm 0.02^{a}_{B}$	$1.3 \pm 0.01^{a}_{C}$
Gum *ghatti*	0.25	$45.0 \pm 0.02^{a}_{x}$	$45.2 \pm 0.01^{a}_{y}$	$45.4 \pm 0.01^{a}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.1 \pm 0.01^{a}_{B}$	$1.3 \pm 0.01^{a}_{C}$
	0.50	$45.0 \pm 0.02^{a}_{x}$	$45.2 \pm 0.01^{a}_{y}$	$45.4 \pm 0.01^{a}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.1 \pm 0.02^{a}_{B}$	$1.3 \pm 0.01^{a}_{C}$
	0.75	$45.0 \pm 0.01^{a}_{x}$	$45.3 \pm 0.01^{b}_{y}$	$45.4 \pm 0.01^{a}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.1 \pm 0.01^{a}_{B}$	$1.3 \pm 0.01^{a}_{C}$
Guar gum	0.25	$45.0 \pm 0.02^{a}_{x}$	$45.3 \pm 0.01^{b}_{y}$	$45.6 \pm 0.02^{c}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.1 \pm 0.01^{a}_{B}$	$1.3 \pm 0.01^{a}_{C}$
	0.50	$45.0 \pm 0.02^{a}_{x}$	$45.4 \pm 0.02^{d}_{y}$	$45.7 \pm 0.01^{d}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.1 \pm 0.01^{a}_{B}$	$1.3 \pm 0.01^{a}_{C}$
	0.75	$45.0 \pm 0.02^{a}_{x}$	$45.5 \pm 0.02^{e}_{y}$	$45.8 \pm 0.02^{e}_{z}$	$1.0 \pm 0.01^{a}_{A}$	$1.1 \pm 0.01^{a}_{B}$	$1.3 \pm 0.01^{a}_{C}$

Values represented as mean ± SD; for each column, different superscript letters indicate statistically significant differences at $p \leq 0.05$; for row, different lowercase and uppercase subscript letters indicate statistically significant differences at $p \leq 0.05$ with respect to TSS and acidity, respectively.

Table 2. Effect of hydrocolloids and storage on reducing and total sugars in seabuckthorn squash.

Hydrocolloid	Conc. (%)	Reducing sugar (%)			Total sugars (%)		
		Days after storage					
		0	60	120	0	60	120
Control	-	31.5 ± 0.04 $^{ab}_{A}$	32.1 ± 0.03 $^{a}_{B}$	33.5 ± 0.05 $^{b}_{C}$	42.3 ± 0.03 $^{b}_{x}$	43.0 ± 0.02 $^{c}_{y}$	43.6 ± 0.05 $^{c}_{z}$
Gum acacia	0.25	31.5 ± 0.01 $^{ab}_{A}$	32.7 ± 0.03 $^{d}_{B}$	33.8 ± 0.04 $^{d}_{C}$	42.6 ± 0.03 $^{c}_{x}$	42.9 ± 0.04 $^{b}_{y}$	43.3 ± 0.02 $^{b}_{z}$
	0.50	32.2 ± 0.01 $^{cde}_{A}$	33.3 ± 0.02 $^{h}_{B}$	34.3 ± 0.02 $^{g}_{C}$	43.0 ± 0.06 $^{e}_{x}$	43.9 ± 0.02 $^{g}_{y}$	44.7 ± 0.02 $^{gh}_{z}$
	0.75	32.8 ± 0.10 $^{efg}_{A}$	33.9 ± 0.02 $^{j}_{B}$	34.5 ± 0.05 $^{h}_{C}$	43.3 ± 0.06 $^{g}_{x}$	44.3 ± 0.01 $^{j}_{y}$	44.7 ± 0.04 $^{gh}_{z}$
Gum tragacanth	0.25	31.3 ± 0.02 $^{a}_{A}$	32.5 ± 0.04 $^{c}_{B}$	33.6 ± 0.02 $^{c}_{C}$	42.2 ± 0.02 $^{a}_{x}$	42.7 ± 0.02 $^{a}_{y}$	43.2 ± 0.05 $^{a}_{z}$
	0.5	32.1 ± 0.03 $^{bcd}_{A}$	33.2 ± 0.05 $^{g}_{B}$	33.8 ± 0.04 $^{d}_{C}$	43.0 ± 0.01 $^{e}_{x}$	43.5 ± 0.01 $^{e}_{y}$	44.3 ± 0.02 $^{e}_{z}$
	0.75	32.6 ± 0.05 $^{def}_{A}$	33.3 ± 0.03 $^{h}_{B}$	34.8 ± 0.04 $^{i}_{C}$	44.1 ± 0.02 $^{i}_{y}$	43.3 ± 0.03 $^{d}_{x}$	44.2 ± 0.01 $^{d}_{y}$
Gum	0.25	31.7 ± 0.03 $^{abc}_{A}$	32.3 ± 0.04 $^{b}_{B}$	33.2 ± 0.04 $^{a}_{C}$	42.8 ± 0.03 $^{d}_{x}$	43.5 ± 0.02 $^{e}_{y}$	44.7 ± 0.03 $^{gh}_{z}$
	0.50	32.3 ± 0.02 $^{de}_{A}$	33.0 ± 0.04 $^{f}_{B}$	34.1 ± 0.01 $^{f}_{C}$	43.3 ± 0.01 $^{g}_{x}$	43.6 ±0.03 $^{f}_{y}$	44.8 ± 0.03 $^{i}_{z}$
	0.75	33.2 ± 0.02 $^{fg}_{A}$	33.9 ± 0.09 $^{j}_{B}$	34.1 ± 0.02 $^{f}_{B}$	43.2 ± 0.02 $^{f}_{x}$	44.2 ± 0.01 $^{i}_{y}$	44.3 ± 0.02 $^{e}_{z}$
Guar gum	0.25	32.4 ± 0.03 $^{g}_{A}$	32.9 ± 0.04 $^{e}_{B}$	34.0 ± 0.01 $^{e}_{C}$	42.8 ± 0.02 $^{d}_{x}$	43.5 ± 0.03 $^{e}_{y}$	44.4 ± 0.01 $^{f}_{z}$
	0.50	33.4 ± 0.03 $^{de}_{A}$	33.7 ± 0.01 $^{i}_{B}$	34.6 ± 0.10 $^{hi}_{C}$	43.3 ± 0.05 $^{g}_{x}$	44.0 ± 0.05 $^{h}_{y}$	44.9 ± 0.01 $^{j}_{z}$
	0.75	34.3 ± 1.18 $^{h}_{B}$	34.0 ± 0.01 $^{k}_{A}$	35.0 ± 0.04 $^{j}_{C}$	43.5 ± 0.04 $^{h}_{x}$	44.4 ± 0.02 $^{k}_{y}$	45.0 ± 0.01 $^{k}_{z}$

Values represented as mean ± SD; for each column, different superscript letters indicate statistically significant differences at $p \leq 0.05$; for row, different uppercase and lowercase subscript letters indicate statistically significant differences at $p \leq 0.05$ with respect to reducing sugar and total sugars, respectively.

45 to 45.35% during 120 days storage. Possible reason for the increase in TSS during storage may be due to conversion of polysaccharides into sugars (Pandey and Singh, 11).

Significant increase in the acidity was observed with increase in storage period. Squash without any added hydrocolloid showed increase in acidity from an initial value of 1 to 1.06 and 1.25% after 60 and 120 days storage period respectively. Similar changes were also observed in squashes with hydrocolloids (Table 1). This result is in agreement with those reported by Ziena (14) in lime juice and Das *et al.* (6) in *jamun* beverages. Attri *et al*. (2) reported increase in acidity during storage of blended pear, apricot and plum ready-to-serve beverages. Increase in acidity during storage may be due to formation of organic acids, vitamin C degradation or due to degradation of pectic substances present in the pulp.

Table 2 shows the effect of hydrocolloids and storage on the reducing sugar content of the seabuckthorn squash. Significant increase in the reducing sugars of the product from initial mean value of 31.45 to 32.05 and 33.44% was observed respectively during 60 and 120 days of storage in sample without any added stabilizer. Samples containing 0.5% guar gum recorded increase in reducing sugar from initial 32.24 to 33.68 and 34.95% during 60 and 120 days storage. Squash containing same quantity of gum acacia, gum tragacanth and gum *ghatti* also showed increase in reducing sugar content. The interaction effects were significant suggesting that the effect of storage and concentrations were different for different hydrocolloids. Aggarwal and Sandhu (1) reported similar results in Kinnow squash. Ghosai and Khurdiya (10) reported inversion of non-reducing sugars into reducing sugars in presence of acid upon prolonged storage. Similarly total sugars of the product also increased significantly during 120 days of storage (Table 2). This result is in agreement with those reported by Aggarwal and Sandhu (1) in Kinnow squash. Increase in total sugars during storage might be attributed to hydrolysis of starch into sugar (Barwal and Shrera, 4).

A gradual decrease was traced for ascorbic acid content of the squash with prolonged storage period. Ascorbic acid content recorded at 0 day was 120.5 mg/100 ml sample without any added stabilizer. Loss of ascorbic acid during storage has also been reported by Ziena (14) in citrus lime juice and Burdurlu *et al*. (5) in citrus juice concentrate. Presence of hydrocolloids in squash has no significant effect on rate of ascorbic acid degradation (Table 3). Ascorbic acid retention (%) in the entire samples during storage was similar and thus hydrocolloid has no significant effect on degradation of the antioxidant vitamin. Similar result was observed in Kinnow squash (Aggarwal and Sandhu, 1). Ascorbic

Table 3. Effect of hydrocolloids and storage on ascorbic acid content in seabuckthorn squash.

Hydrocolloid	Conc. (%)	Ascorbic acid (mg/100 ml)		
		Days after storage		
		0	60	120
Control	-	120.5 ± 0.05 $^{a}_{C}$	116.2 ± 0.02 $^{a}_{B}$	104.1 ± 0.02 $^{b}_{A}$
Gum acacia	0.25	120.5 ± 0.05 $^{a}_{C}$	116.2 ± 0.04 $^{a}_{B}$	104.3 ± 0.04 $^{d}_{A}$
	0.50	120.6 ± 0.17 $^{a}_{C}$	116.2 ± 0.04 $^{a}_{B}$	105.1 ± 0.01 $^{e}_{A}$
	0.75	120.5 ± 0.05 $^{a}_{C}$	117.2 ± 0.04 $^{b}_{B}$	104.3 ± 0.05 $^{d}_{A}$
Gum tragacanth	0.25	120.6 ± 0.17 $^{a}_{C}$	117.2 ± 0.03 $^{b}_{B}$	104.3 ± 0.05 $^{d}_{A}$
	0.5	120.6 ± 0.17 $^{a}_{C}$	116.2 ± 0.03 $^{a}_{B}$	105.3 ± 0.05 $^{f}_{A}$
	0.75	120.5 ± 0.17 $^{a}_{C}$	116.2 ± 0.03 $^{a}_{B}$	103.7 ± 0.05 $^{a}_{A}$
Gum *ghatti*	0.25	120.5 ± 0.05 $^{a}_{C}$	116.1 ± 0.04 $^{a}_{B}$	104.3 ± 0.00 $^{d}_{A}$
	0.50	120.6 ± 0.05 $^{a}_{C}$	117.2 ± 0.01 $^{b}_{B}$	106.2 ± 0.01 $^{g}_{A}$
	0.75	120.6 ± 0.05 $^{a}_{C}$	116.2 ± 0.03 $^{a}_{B}$	103.8 ± 0.05 $^{a}_{A}$
Guar gum	0.25	120.5 ± 0.05 $^{a}_{C}$	117.2 ± 0.04 $^{b}_{B}$	104.3 ± 0.03 $^{d}_{A}$
	0.50	120.6 ± 0.17 $^{a}_{C}$	116.2 ± 0.04 $^{a}_{B}$	106.2 ±0.05 $^{g}_{A}$
	0.75	120.5 ± 0.05 $^{a}_{C}$	116.2 ± 0.04 $^{a}_{B}$	104.2 ± 0.06 $^{c}_{A}$

Values represented as mean ± SD; for each column, different superscript letters indicate statistically significant differences at $p \leq 0.05$; for row, different uppercase subscript letters indicate statistically significant differences at $p \leq 0.05$.

acid is usually degraded by oxidative processes, which are stimulated in the presence of light, oxygen, heat, peroxides and enzymes. In addition, this bioactive compound may undergo anaerobic degradation (Burdurlu *et al*., 5). No microbial (bacteria, mould and yeast) growth occurred in the seabuckthorn squash during the study period of 120 days.

Consumer acceptance of the product containing 0.5% guar gum was highest in comparison to squash with other combination of the same and other hydrocolloids tested. Product without any added stabilizer had poor appearance due to pulp floatation. Consumer acceptance of squash containing 0.5% guar gum was high at the beginning of the experiment for the following parameters: colour (4.8), flavour (4.2) and overall acceptability (4.5). However, at the end of the experiment, slight decrease in score was observed: colour (4.6), flavour (4.1) and overall acceptability (4.3) (Table 4). Deka *et al*. (7) reported similar result during storage of mango-pineapple spiced beverage.

We conclude that addition of 0.5% guar gum increases consumer acceptance of seabuckthorn squash. During 120 days storage studies, it has been observed that there was gradual increase in total soluble solids, titrable acidity, reducing sugars and total sugars, while ascorbic acid content and consumer acceptance decreased slightly. However, no major change in the squash was observed during storage at room temperature that can render the product unacceptable for consumption.

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Table 4. Effect of storage on colour, flavour and overall acceptability of seabuckthorn squash.

Parameter	Hedonic Scale		
	Days after storage		
	0	60	120
Colour	4.8	4.7	4.6
Flavour	4.2	4.2	4.1
Overall acceptability	4.5	4.5	4.3

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