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Journal of Postharvest Technology
2017, 05(2): 79-88
http://www.jpht.info

RESEARCH ARTICLE

Changes in anthocyanin, total phenolic, antioxidant activity, texture and color of canned strawberry during storage

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Received: 23.01.2017 Accepted: 16.03.2017

ABSTRACT

In the present study, strawberry at three different stages (unripe, half ripe and full ripe) were canned.Physico-chemical, ascorbic acid, color; texture and phytochemical analysis were carried out for canned strawberry. Results showed decrease in moisture content 59.96-56.89%, 62.74-57.01%, 56.96-50.92% and titratable acidity 2.32-0.20%, 1.06-0.11%, 0.74-0.09% respectively. Significant ($p \leq 0.05$) decrease in anthocyanin, total phenolic content**,** antioxidant activity, texture and color *L** and *a** value were also observed. However significant ($p \leq 0.05$) increase in total soluble solids from 32.0-37.11,34.0-37.06, 39.0-40.13%,ascorbic acid content 1.57-4.11,1.43-2.82, 1.37-1.81% and color b* value 27.17-56.03, 27.96-57.58, 33.29-50.86 respectively was noticed during storage period.

Keywords: Canned strawberry, ascorbic acid, anthocyanin, total phenolic content, quality

Citation: Naseem. Z., Gull, A., Wani. S.A., Masoodi, F.A., Ganaie, T.A. 2017. Changes in anthocyanin, total phenolic, antioxidant activity, texture and color of canned strawberry during storage**.** *Journal of Postharvest Technology*, **5**(2): 79-88.

INTRODUCTION

Strawberries (*Fragaria* × *ananassa*) are well liked as having sweet taste, aroma, smooth texture. Strawberries are natural sources of micronutrient, ascorbic acid and phytonutrients (Mahmood et al., 2012). Nutrient compositions differ by, cultivation technique; cultivar, variety, as well as harvesting time and ripeness. Fruits are nutritious components of our diets and are often health-promoting. In addition, typically fruits contain over 90% water, once they are harvested; begin to undergo higher rates of respiration, resulting moisture loss, quality deterioration and microbial spoilage. Processing technologies have been utilized for centuries to transform these perishable fruits into safe, delicious and stable products. Strawberry being non-climacteric fruit, harvested at distinct stages of maturity, depending on the cultivar and market preference. However, maturity indices as well as harvesting time mostly varied with cultivars (Kafkas et al., 2007). Its perishability and susceptible to fungal decay is accelerated under subtropical humid climatic conditions. At purchasing time, firmness and appearance are quality parameters by which consumer's grade fruits. Fruit quality and shelf life depend on maturity stages. Its shelf life could be extended if harvested before optimum maturity, but quality and nutritive value become minimized. On the contrary, fully matured

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ISSN: 2348-4330

strawberry fruits enchant high nutritive value with limited shelf life. So, it is obligatory, to stabilize maturity stage and nutrient content of fruits.

Canning transforms perishable fruits into products that can be consumed throughout year and transported safely. But thermal processing treatment is especially detrimental to heat-sensitive nutrients (Fennema, 1982). When used prior to canning, blanching serves to expel air in the tissue and improve thermal conductivity and packing into the container.

Temperature administration during storage is most important factor in minimizing, quality deterioration and extending shelf life. Storing at ambient temperature makes postharvest management of strawberries very strenuous (Asrey et al., 2004) as higher temperature results in higher respiration rates, associated with fruit quality reduction (Ayala-Zavala et al., 2004). Keeping in consideration the above facts, the present work aimed at determining the effect of maturity and storage periods on physicochemical and antioxidant potential of canned strawberry.

MATERIALS AND METHODS

Raw material and chemicals

Strawberry at three different maturity stages (unripe, half ripe and full ripe) uniform in size, colour and weight were procured from local market Hazratbal Srinagar (J&K) in the month of May 2018. Unwanted particles were removed by washing thoroughly using potable water. Strawberry used was canned using 50^{o}B and 500 ppm calcium chloride as preservative. The canned strawberry was stored at ambient temperature until analysed.

Chemicals and reagents

Sodium nitrite, (+)-catechin, Folin-Ciocalteu reagent, hydrochloric acid, aluminium chloride, sodium hydroxide, methanol, ethanol, acetone, Gallic acid, 2,2diphenyl-1-picrylhydrazyle (DPPH), Dichloro indophenol (DCIP), metaphosphoric acid, sodium hydroxide, sodium carbonate, phenol, lead acetate, potassium oxalate, citric acid and ascorbic acid were purchased from HIMEDIA (Mombay India). All the chemicals used were of analytical grade.

Physico-chemical properties

Moisture content: Moisture content were estimated using oven drying method.

$$Moisture\ content\ (\%) = \frac{Loss\ in\ Weight\ (g)}{Weight\ of\ sample\ (g)} \times 100$$

Total soluble solids: The total soluble solids (TSS) were estimated by using hand refract meter (0 to 60 ^{o}B) and results were expressed as degree Brix (^{o}B). To estimate TSS, fruit pulp was crushed in a pestle and mortar and then squeezed through a muslin cloth for extraction of juice.

Titratable acidity: Titratable acidity was expressed in terms of percentage of citric acid and was recorded by titrating 10 ml of juice against N/10 sodium hydroxide using phenolphthalein as an indicator.

$$\%\ Acidity = \frac{Titre\ value\ \times\ normality\ of\ NaOH\ \times\ equivalent\ weight\ \times\ vol.made\ \times\ 100}{Wt.of\ sample\ \times\ vol.of\ aliquot\ \times 1000}$$

Ascorbic acid: Ascorbic acid was determined using the Dye method (Ranganna, 1977). About (10 g) sample was homogenized with 90 mL (3% metaphosphoric acid) and filtered mixture was titrated against a Dye solution 2,6-dichlorophenol-indophenol (1g) DCIP to 150 mL water containing 42 mg sodium carbonate) to an end point pink which should persist for 15s. Results were expressed as mg ascorbic acid per 100 g. Ascorbic acid content was calculated as;

$$mg\ ascorbic\ acid\ (\frac{mg}{100\ g}) = \frac{(TV \times Dye\ factor \times Volume\ made \times 100)}{Wt.of\ sample \times Volume\ of\ aliquot}$$

TV- titre value.

Color: Color was measured with a hand held tristimulus reflectance colorimeter. Color was recorded using the CIE L^* a^* b^* uniform color space (CIE Laboratories), where L^* indicates lightness, a^* indicates chromaticity on a green to red axis, and b^* indicates chromaticity on blue to yellow axis. Numerical values of a^* and b^* were converted to hue angle and chroma.

Texture: Texture was measured using texture analyzer (TA-XT2., Stable Micro systems, UK) fitted with cylindrical probe (p/2). The pretest, test and post-test speed were 1.00 mm/sec, 2.00 mm/sec and 2.00 mm/sec, respectively. The test distance was 5mm and weight of trigger force was 1g. Force time curve was recorded and peak compression and number of peaks were analyzed for firmness of samples. Each test was performed in triplicates.

Total phenols: Total phenolic compound (TPC) was assessed by using the Folin-Ciocalteu's assay (Spanos et al., 1990)**.** After crushing and homogenization, 100mg (0.1g) sample were taken and diluted to 10 ml then 0.3 ml sample was taken in test tube and 2.5 ml (2 N) Folin-Ciocalteu reagent and 2 ml (7.5% sodium carbonate solution) were added, and final volume made up to 10 ml. The contents were kept at dark for 8-10 min and absorbance was measured at 750 nm using spectrophotometer. TPC were quantified from a calibration curve using Gallic acid as standard expressed as (mg GAE/100g) on dry weight basis.

Total flavonoid: Modified colorimetric method was used for total flavonoid content determined. About 20mg extract was mixed with 200 ml distilled water and subsequently 0.3ml of 5% $NaNO_2$ solution. After 6 min, 0.3ml of 10% $AlCl_3$,6H2O solution was added and allowed to stand for 5 min before further addition of 2 ml of 1N NaOH. Water was added to bring the total volume to 10 ml and the samples were read immediately at 510 nm against a prepared blank using spectrophotometer (DYNEX Technologies, Inc.). All values were expressed as milligrams of catechin equivalents per 100 g of strawberry.

Anthocyanin: Estimation of total anthocyanin content were estimated according to the method (Fuleki and Francis, 1967b)**.** About 10ml of sample taken with 50 ml of ethanolic HCl were filtered through whatman No. 4 filter paper. The volume was raised to 250 ml with ethanolic HCl. Two milliliters of this aliquot were again diluted to 100 ml with ethanolic HCl and its absorbance was measured at 535 nm in UV-visible spectrophotometer.

$$Total\ AC\ of\ berry/100g\ = \frac{Absorbance\ (535) \times Vol.made\ of\ extracts\ for\ color\ measurement \times total\ vol}{ml\ of\ the\ extract\ used \times weight\ of\ sample\ taken} \times 100$$

Free radical scavenging activity: Antioxidant potential (%) was measured as described by Brand-(Williams et al., 1995). About (5g) homogenized sample were extracted with 10 ml methanol for 2 hr. About 0.1 ml methanolic extract was added in test tube having 3.9 ml of DPPH solution (6 × 10^{-5}mol/l), then incubated for 30 min. After incubation absorbance was measured at 517 nm. Radical scavenging activity was calculated as percent inhibition DPPH radical by the following formula:

$$\%\ inhibition = \frac{(Absorbance\ of\ blank - Absorbance\ of\ sample)}{Absorbance\ of\ blank} \times 100$$

Statistical analysis

The experiments were carried out in triplicates. The significant differences were obtained by one -way analysis of variance (ANOVA) followed by Duncan's multiple range test ($p \leq 0.05$) using Statistica V.7.

RESULTS AND DISCUSSION

Moisture

The moisture content of canned strawberry at different harvest stages are shown in Table 1. From the results it is evident that moisture content decreased slightly during the storage period. Moisture content of unripe strawberry at 0 month of storage was recorded to be 59.96%, which decreased to about 56.89% after 3 months. Similarly moisture content of half and full ripe strawberry obtained at 0 month storage period was 62.74 and 57.01%respectively, which declined to 56.96 and 50.92% respectively at the end of the storage. Decrease in moisture content after storage may be due to ex-osmosis of water into surrounding syrup. However no significant difference ($p \leq 0.05$) in moisture content among three strawberry samples evaluated were observed.

Total soluble solids (TSS)

The results obtained during storage study of canned strawberry for TSS is given in Table 2. The TSS of the unripe, half ripe and fully ripe strawberry at 0 month storage period recorded was 32^{o}B, 34 ^{o}B and 39^{o}B, respectively. The TSS value of 37 ^{o}B was found in unripe, 37 ^{o}B in half ripe and 41^{o}B in fully ripe strawberry after 3 months storage period. Significant ($p \leq 0.05$) increase in TSS was observed irrespective of the harvest period, may be due to degradation of complex macromolecules, like polysaccharides and starch into their monomers. Further implications reveal that with storage, there was an augmentation in TSS, which increased sweetness of product with storage.

Titratable acidity

The titratable acidity values in case of canned strawberry during the storage period of 3 months are mentioned in Table 3. From data it is evident that there was significant ($p \leq 0.05$) decrease in titratable acidity value in all canned strawberry irrespective of harvesting stage. Initial titratable acidity value for unripe strawberry obtained was 2.32%, which decrease to 0.20% at end of storage period. While as in case of the half ripe and full ripe strawberry, titratable acidity value at 0 month of storage period recorded to be 1.06 and 0.74%respectively, which reduced to about 0.11 and 0.09% after 3 month of storage respectively. Decrease in acidity with storage might be due to the release of H^{+} and formation of some organic acids and may also be due to copolymerization of organic acids and formation of brown pigments.

Ascorbic acid

Results for ascorbic acid content are presented in Table 4. Significant ($p \leq 0.05$) increase in ascorbic acid content was obtained throughout the storage. Unripe, half and full ripe strawberry showed ascorbic acid content of 1.57, 1.43 and 1.37% respectively during zero month of storage. However after 3 months storage, ascorbic acid content of 4.11, 3.00 and 3.81% respectively was obtained. This increase in ascorbic acid content during storage might be due to the conversion of certain glucose units like L-galactose (L-GAL) into ascorbic acid. Increase in ascorbic acid content was also reported by (Durst and Weaver, 2013) in canned peach.

Color

Color evaluation results are mentioned in Table 5. Results showed significant ($p \leq 0.05$) decrease in *L** value from 26.15-19.88 (unripe), 28.31-20.81 (half ripe) and 32.45-23.23 (full ripe) canned strawberry. Likewise significant ($p \leq 0.05$) decrease in a* value from 5.98-2.01 (unripe), 9.19-2.59 (full ripe) and 14.64-5.32 (full ripe) canned strawberry was observed during the entire

storage period (Table 6) .Decrease in *L** and *a** value may be due to respiratory activity and browning reaction (Hernández-Herrero and Frutos, 2014). However significant increase ($p \leq 0.05$) in b* value were observed during storage period of 3 months (Table 5).

Firmness

Results for texture analysis are given in Table 6. Significant ($p \leq 0.05$) decrease in texture during the entire storage period was observed. Unripe, half ripe and full ripe strawberry shows firmness value of 17.9 dyne/cm^2, 16.5 dyne/cm^2 and 12.0 dyne/cm^2 at zero month of storage which decreased to 9.7 dyne/cm^2, 7.6 dyne/cm^2 and 4.7 dyne/cm^2 at the end of the storage period. The decrease in texture may be due to breakdown of matrix during thermal processing. Softening results from changes in structure of the cell wall polysaccharides (cellulose, hemicelluloses and pectin). Pectin play a key role in fruit softening, as they are partially solubilized by (polygalactourinase and pectin methyl esterase) enzyme during ripening, leading to tissue softening (Fischer and Bennett, 1991).

Phenolic content

The values for phenolic content (mg GAE/100g) for the canned strawberry during storage period of 3 months are presented in Table 7. Results showed significant decrease ($p \leq 0.05$) in total phenolic content during the storage of the canned strawberry. Unripe, half and fully ripe canned strawberry showed total phenolic content of 0.43, 0.39 and 0.25(mg GAE/100 g) during zero month of storage. Highest decline in total phenolic content 0.05(mg GAE/100 g) was recorded in case of fully ripe, followed by half ripe and unripe canned strawberry which showed 0.090 (mg GAE/100 g) and 0.21(mg GAE/100 g) respectively after 3 months of storage period. This decrease in total phenolics of canned strawberry during storage may be attributed due to leaching of phenolic compounds into the syrup from strawberry solids and also due to processing (Sablani et al., 2010; Kunwar et al., 2010).

Anthocyanin

Effect of canning and harvest stage on retention of anthocyanin content is shown in Table 8. Results reflect significant ($p \leq 0.05$) decrease in anthocyanin content during the entire storage period (Table 8). Unripe, half ripe and fully ripe canned strawberry showed anthocyanin content of 15.66%, 17.85% and 11.42% respectively. But after storage period of 3 months anthocyanin content decreased from 15.66-4.25%, 17.85-7.12% and 11.42-6.23 % respectively. Decrease in anthocyanin content may be due to thermal degradation of phenolic compounds, (Abers and Wrolstad, 1979).

Antioxidant

The antioxidant activity as measures by DPPH assay is given the Table 9. Free radical scavenging ability by hydrogen donation is known mechanism for antioxidation. The radical scavenging activity based on DPPH assay was determined for methanolic extracts of strawberry (unripe, half ripe and full ripe) stored for a time period of 3 months. Results obtained reveal half ripe canned strawberry showed highest 92.36% scavenging activity followed by full ripe 91.98% and unripe strawberry 89.41%. However after storage period of 3 months unripe, half ripe and full ripe canned strawberry showed decrease in antioxidant activity (Table 9). Reduction in antioxidant activity may be attributed due to thermal degradation of naturally occurring antioxidants during canning and also due to the formation of early maillard reaction products with pro-oxidant properties (Nayak et al., 2013).

Table 1. Effect on moisture content (%)

Maturity stage	Storage (months)			
	0	1	2	3
Unripe	59.96^{a}±3.4	60.2^{b}±3.1	56.9^{c}±2.98	56.89^{cd}±3.2
Half ripe	62.74^{a}±5.0	60.6^{b}±4.0	56.97^{c}±3.1	56.96^{cd}±3.0
Full ripe	57.01^{a}±2.8	57.6^{ab}±2.5	56.97^{c}±2.2	50.92^{cd}±2.7

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

Table 2. Effect on Total soluble solids (%)

Maturity stage	Storage (months)			
Unripe	32.0^{cd}±1.4	32.12^{c}±1.2	36.11^{b}±1.9	37.11^{a}±1.9
Half ripe	34.0^{d}±1.5	35.07^{c}±1.8	36.05^{b}±2.0	37.06^{a}±2.0
Full ripe	39.0^{b}±2.1	37.12^{c}±1.2	34.12^{d}±1.0	41.13^{a}±2.2

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

Table 3. Effect on Titratable acidity (%)

Maturity stage	Storage (months)			
Unripe	2.32^{a}±1.0	0.61^{b}±0.2	0.23^{d}±0.0	0.20^{c}±0.0
Half ripe	1.06^{a}±0.11	0.76^{b}±0.5	0.19^{c}±0.0	0.11^{cd}±0.0
Full ripe	0.74^{a}±0.01	0.57^{b}±0.4	0.11^{c}±0.0	0.09^{d}±0.0

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

Table 4. Effect on ascorbic acid (%)

Maturity stage	Storage (months)			
	0	1	2	3
Unripe	1.57^{d}±0.1	1.81^{c}±0.2	3.87^{b}±1.0	4.11^{a}±1.1
Half ripe	1.43^{cd}±0.2	1.54^{c}±0.1	2.32^{ab}±1.1	3.00^{a}±1.0
Full ripe	1.37^{cd}±0.1	1.41^{c}±0.1	1.59^{ab}±0.9	3.81^{a}±0.5

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

Table 5. Effect of maturity and storage on "*L*" "a" and "b" value

Maturity stage	Storage (months)			
			"L" value	
	0	1	2	3
Unripe	26.15^{a}±2.06	25.16^{b}±3.40	20.09^{c}±1.32	19.88^{d}±1.11
Half ripe	28.31^{a}±2.08	24.91^{b}±2.71	22.84^{c}±2.92	20.81^{d}±1.52
Full ripe	32.45^{a}±3.00	27.34^{b}±2.28	25.23^{c}±2.80	23.23^{d}±1.80
			"a" value	
Unripe	5.98^{a}±1.86	3.67^{b}±1.16	2.99^{c}±0.66	2.01^{cd}±0.98
Half ripe	9.19^{a}±0.38	5.13^{b}±0.62	3.59^{c}±0.80	2.59^{cd}±0.80
Full ripe	14.64^{a}±0.84	9.79^{b}±0.50	7.03^{c}±3.69	5.32^{d}±0.50
			"b" value	
Unripe	27.17^{d}±2.17	40.14^{c}±13.76	54.29^{b}±10.75	56.03^{a}±2.06
Half ripe	27.96^{c}±0.77	29.30^{d}±1.84	55.58^{b}±5.09	57.58^{a}±5.09
Full ripe	33.29^{d}±1.69	40.42^{c}±2.34	48.6b^{8}±3.16	50.86^{a}±3.14

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

Table.6 Effect of maturity and storage on firmness (N)

Maturity stage	Storage (months)			
	0	1	2	3
Unripe	17.9^{a}±8.7	13.8^{b}±6.1	11.3^{c}±4.1	9.7^{d}±2.0
Half ripe	16.5^{a}±3.9	12.0^{b}±3.8	9.9^{c}±2.2	7.6^{d}±1.4
Full ripe	12.0^{a}±1.3	8.6^{b}±1.2	6.3^{c}±1.1	4.7^{d}±0.9

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

Table.7 Effect of maturity and storage on phenolic content (mg GAE/100 g)

Maturity stage	Storage (months)			
	0	1	2	3
Unripe	0.43^{b}±0.1	0.52^{a}±0.1	0.35^{c}±0.01	0.21^{d}±0.01
Half ripe	0.39^{a}±0.1	0.36^{b}±0.1	0.14^{c}±0.01	0.09^{d}±0.01
Full ripe	0.25^{b}±0.1	0.33^{a}±0.1	0.12^{c}±0.01	0.05^{d}±0.01

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

Table.8 Effect of maturity and storage on anthocyanin (%)

Maturity stage	Storage (months)			
	0	1	2	3
Unripe	15.66^{a}±2.2	11.23^{b}±1.0	8.31^{c}±1.0	4.25^{d}±1.0
Half ripe	17.85^{a}2.1	14.85^{b}±1.5	11.72^{c}±1.7	7.12^{d}±1.0
Full ripe	11.42^{a}±2.7	9.55^{b}±1.2	8.35^{c}±1.0	6.23^{d}±1.0

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

Table.9 Effect of maturity and storage on antioxidant content (%)

Harvesting	Storage(months)			
Stage	0	1	2	3
Unripe	89.41^{a}±3.1	36.87^{b}±2.0	27.96^{c}±1.0	17.96^{d}±1.0
Half ripe	92.36^{a}±4.0	43.82^{b}±3.1	37.85^{c}±1.7	23.75^{d}±1.2
Full ripe	91.98^{a}±5.0	47.17^{b}±2.5	38.67^{c}±3.1	27.57^{d}±1.6

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

CONCLUSION

This research was designed to determine the effect of maturity and storage on physicochemical properties and antioxidant potential of canned strawberry. The outcome of present research suggest that physicochemical properties soluble solids, ascorbic acid, color b* value increased. However decrease in anthocyanin, total phenolic content, antioxidant activity, texture

and color *L** and *a** value were observed during storage. Our findings suggest that functional quality attributes of canned strawberry remained unaltered up to one month of storage.

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