Antioxidant Activity and Quality of Spray Dried Aonla Powder as Affected by Storage Behavior of Juice

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Good quality powder can be prepared from aonla juice by spray drying. It may be consumed as health drink after reconstitution, because of its high vitamin C content and antioxidant capacity. An experiment was conducted to evaluate the antioxidant activity and other quality parameters of spray dried powder prepared from aonla juice stored up to one year. The juice, extracted from aonla cv. Chakaiya, was pasteurized at 90°C for 2 min and preserved with 500 ppm SO$_2$ in food grade carboys at room temperature (18 – 40°C). The powder was prepared from stored juice (0, 2, 4, 5, 6, 9 and 12 months) in a spray dryer at inlet temperature of 190°C and 16 rpm feeding speed with 2 per cent maltodextrin as stabilizing agent. The analytical data indicated that ascorbic acid in juice decreased gradually from 375.0 to 137.2 mg 100ml$^{-1}$ during 12 months of storage. The corresponding reduction of ascorbic acid in powder was from 3176 to 1632 mg 100g$^{-1}$. The content of polyphenols also decreased in juice (1.55 to 1.20%) during storage, but the changes in its content in powder were not significant. Gradual reduction in antioxidant activity (FRAP value) in juice (259.5 to 111.9 mmol ml$^{-1}$) during storage was noticed with a concomitant decrease in powder (995.1 to 578.7 mmol g$^{-1}$) prepared from stored juice. Non-enzymatic browning increased significantly in juice (0.033 to 0.262 OD) during 12 months of storage but increased marginally in powder (0.004 to 0.067 OD). The color of the powder also changed from creamy white to brownish white when prepared from fresh and 12 months stored juice. The significant decrease in ascorbic acid content (30%) and antioxidant activity (27%) was observed at 6 months of storage when room temperature increased drastically (25 to 40°C). It may be concluded that good quality spray dried powder could be prepared from aonla juice stored up to 5 months at room temperature without much deterioration in ascorbic acid content and antioxidant activity.

Keywords: Aonla juice; storage; spray-dried powder, antioxidant activity; ascorbic acid; polyphenols; non-enzymatic browning

Introduction

Indian gooseberry or aonla or amla (Emblica officinalis Gaertn.) belongs to the family Euphorbeaeac and is native of India, Sri Lanka, Malaysia, and China. The fruits are well-known natural source of powerful antioxidants like vitamin C and polyphenols and are extensively used in Ayurvedic system of medicine in India. Because of high astringency fruits can not be consumed fresh and, therefore, traditionally processed into various products like murabba, juice, candy, pickle, powder, segments-in-syrup, etc. Among these products, aonla juice is gaining commercial importance because it can easily be consumed as health drink due to its nutraceutical properties. Among 19 fruits in Indian diet, aonla was found to have the highest phenol content vis-à-vis antioxidant and super-oxide anion scavenging activity. Superior antioxidant activity of aonla extract could balance the toxic effects of metal salts in hepatic and renal toxins than equivalent amount of pure ascorbic acid. Free and bound phenolic compounds in aonla showed 4–10 fold higher levels of antioxidant activity than that of turmeric due to the presence of higher level of polyphenols in aonla. Aonla juice suffers from severe browning and loss of vitamin C during storage under ambient conditions. Spray drying of juice is a viable option for commercial preparation of good quality powder which can be used as ready-to-serve health drink as well as in encapsulated medicine with tremendous market potential and export value. Spray drying is a well-known industrial technology used extensively on a large scale for drying of heat sensitive materials including fruit and vegetable juices, viz. guava, watermelon, acai, and pitaya, worldwide.

However, the literature on preparation of spray dried aonla powder from juice is very scanty and no literature is available at present particularly regarding the effect of juice storage on the antioxidant activity and other quality parameters of spray dried...
powder. The aim of the present investigation is, therefore, to observe the changes in quality attributes and antioxidant activity of spray dried aonla powder prepared from juice stored under ambient conditions.

**Materials and methods**

**Materials**

Freshly harvested mature aonla fruits of cv. Chakaiya were procured from the experimental farm of the Institute. After sorting, healthy fruits were washed under running tap water for 10 min to remove adhered dust and microbial load from the surface. Juice was extracted by Hydraulic Press (Bajaj Machinen, New Delhi, India) at a pressure of 1500 lb sq. inch$^{-1}$ after crushing the fruits in a Fruit Mill. It was then filtered, pasteurized at 90°C for 2 min and preserved with 500 ppm SO$_2$ as potassium metabisulphite in food grade carboys (10L capacity) up to 12 months under ambient conditions (18 – 40°C, 50 – 90% R.H.). Powder was prepared at the time of juice extraction and thereby from 2, 4, 5, 6, 9 and 12 months stored juice using a laboratory model Spray Dryer (Advanced Drying Systems, Mumbai, India) at an inlet temperature of 190°C with 16 rpm feeding speed. Two per cent maltodextrin (obtained from Loba Chemie, India) was added as stabilizer to juice before spray drying. The amount of maltodextrin to be added to juice, without affecting the quality of powder, was earlier standardized in a laboratory trial. Various quality parameters like ascorbic acid content, polyphenols content and non-enzymatic browning along with antioxidant activity were analyzed in juice during storage and in freshly prepared powder from stored juice.

**Determination of quality parameters**

Ascorbic acid in juice and powder was estimated by titrimetric method using 2,6-dicholorophenol indophenol dye solution and polyphenols content was estimated by Folin and Ciocalteu’s phenol reagent method$^{12}$. Non-enzymatic browning (NEB) was determined by measuring optical density (OD) of methanol extracted juice and powder samples at 440 nm in UV-VIS Spectrophotometer (Labomed Inc., USA).

**Determination of antioxidant activity**

The antioxidant activity in juice and powder was determined as ferric reducing antioxidant potential (FRAP) values$^{13}$. The principle of this method is based on the reduction of a ferric-tripyridyltriazine complex to its ferrous blue coloured form in the presence of antioxidants. The FRAP reagent contained 2.5 ml of 10 mmol L$^{-1}$ TPTZ (2,4,6-tripyridyl-s-triazine) solution in 40 mmol L$^{-1}$ hydrochloric acid (HCl) plus 2.5 ml of 20 mmol L$^{-1}$ ferric chloride (FeCl$_3$) and 25 ml of 300 mmol L$^{-1}$ acetate buffer, pH 3.6 and was prepared freshly. Aliquots of 0.25 ml for juice or 250 mg for powder were mixed with 25 ml ethanol and 1.8 ml FRAP reagent. The absorbance of reaction mixture was measured spectrophotometrically at 593 nm after incubating at room temperature (around 35°C) for 40 min. The 1 mmol L$^{-1}$ ferrous sulfate (FeSO$_4$,7H$_2$O) was used as reference standard. The final result was expressed as the concentration of antioxidants having a ferric reducing ability equivalent to that of 1 mmol L$^{-1}$ FeSO$_4$.

**Results and discussion**

**Changes in quality parameters in juice during storage**

**Changes in ascorbic acid**

Ascorbic acid, one of the important quality parameters in aonla juice, decreased significantly throughout the storage period. From an initial value of 375.0 mg 100ml$^{-1}$, it declined to 291.4 mg 100ml$^{-1}$ after 2 months of storage, thereafter the decrease was slow up to 5 months. It again decreased rapidly after 6 months of storage, and the rate of decrease became slower when storage period prolonged up to 12 months (Fig. 1a). An amount of 137.2 mg 100ml$^{-1}$ of ascorbic acid was retained in juice after 12 months of storage. The loss of ascorbic acid was 63.4 per cent in juice during year long storage. The sharp decrease in ascorbic acid content during middle period of storage might be due to the rise in room temperature from 25°C to around 40°C at that time. The average room temperature varied between 35 to 40°C during summer months of April, May and June, 2010 in Lucknow. During the rainy and autumn season room temperature came down and hovered around 20–25°C causing the slower rate of decline of ascorbic acid at that time, which proved the influence of temperature on the decrease of ascorbic acid content in juice during storage. The higher rate of degradation of ascorbic acid in aonla juice at higher storage temperature and longer storage period is in agreement with the literature$^{14}$. It was observed that ascorbic acid concentration decreased under the influence of temperature and oxygen in orange juice$^{15}$. Similar observations regarding loss of ascorbic acid under the influence of ambient storage condition have recently
been reported in kinnow juice blended with aonla and ginger juice.

**Changes in polyphenols**

The content of polyphenols decreased gradually in juice (1.55 to 1.20%) throughout the storage period (Fig. 1b). The loss in polyphenols after 12 months of storage was 22.6 per cent. It might be suggested that storage period had a negative effect on the contents of polyphenols in juice. Similar observations have been reported in aonla juice during 9 months of storage under ambient conditions. They reported that the contents of some individual polyphenols like kaempferol and caffeic acid in aonla juice decreased continuously throughout the storage period irrespective of pasteurization temperature which resulted in the loss of total polyphenols. Similar decrease in the contents of phenolic acids (5-21%) and flavonoids (8-19 %) in apple juice stored up to 11 months under ambient conditions was noticed.

**Changes in non-enzymatic browning (NEB)**

Another significant change in juice during storage was observed in terms of NEB, which also affected the quality of juice. NEB increased continuously in juice (0.033 to 0.262 OD) throughout the storage period. The browning was less in juice up to 6 months of storage (0.071 OD), which increased rapidly thereafter (Fig. 1c). The presence of SO$_2$ as preservative in juice might have prevented the reactions leading to NEB during initial periods of storage apart from comparatively lower storage temperature (around 30°C). Maillard reaction, the reaction between sugars and amino acids, might be a contributing factor leading to browning in aonla juice as reported earlier in literature. The increase in room temperature after 6 months of storage might have aggravated the browning reactions by decreasing the SO$_2$ content in juice. Different fruit juices have different main reactions that lead to browning, e.g., reaction between dehydroascorbic acid and α–amino acids in orange drinks, accumulation of...
5-hydroxymethylfurfural (5-HMF) through Maillard reaction in apple juice, degradation of ascorbic acid in cashew apple juice, etc. Some researchers suggested that reactions involving ascorbic acid contributed more to overall browning than Maillard browning reactions in kiwifruit juice during storage. The increase of NEB with the increase of storage temperature and period has also been reported in apple and peach juices.

Changes in antioxidant activity
The antioxidant activities (in terms of FRAP value) of fresh aonla fruits and juice were estimated. FRAP value of juice (259.5 mmol ml⁻¹), just after extraction, was slightly lower than that of fresh fruits (275.0 mmol ml⁻¹). The antioxidant activity of juice decreased with the prolongation in storage period. From an initial FRAP value of 259.5 mmol ml⁻¹, it decreased to 180.0 mmol ml⁻¹ after 5 months and finally to 111.9 mmol ml⁻¹ after 12 months of storage (Fig. 1d). Only 43.2 per cent of antioxidant activity was retained in juice after year long storage, while almost 70.0 per cent of antioxidant activity could be retained in 5 months stored juice. The results indicated that the decrease in FRAP value of juice was slow during initial and later periods of storage, but fast in the middle stages (during hot summer season). The slower rate of decline in antioxidant activity during later period of storage could be attributed to the formation of browning reaction products. The similar pattern of decrease in antioxidant activity was also observed in orange juice stored for a longer period. It has been reported that the antioxidant effect of browning reaction products appeared to increase as browning of juice increased. The decrease in antioxidant activity during storage was also reported in reconstituted orange juice pasteurized by heat and in black chokeberry juice.

Changes in polyphenols
The changes in polyphenols content in spray dried powder followed almost similar pattern as that in stored juice. The changes in polyphenols content in spray dried powder during storage was not reflected in spray dried powder prepared from stored juice. NEB increased moderately in powder (0.004 to 0.067 OD) when prepared from fresh and 9 months stored juice. Browning was visible in powder when prepared from 9 months stored juice. Accordingly, the color of the powder changed from an attractive creamy white to slightly brownish white when prepared from fresh and 9 months stored juice.

Changes in non-enzymatic browning (NEB)
The increase in non-enzymatic browning in juice during storage was not reflected in spray dried powder prepared from stored juice. NEB increased moderately in powder (0.004 to 0.067 OD) when prepared from fresh and year long stored juice (Fig. 2c). Browning was visible in powder when prepared from 9 months stored juice. Accordingly, the color of the powder changed from an attractive creamy white to slightly brownish white when prepared from fresh and 9 months stored juice.

Changes in antioxidant activity
The changes in antioxidant activity in spray dried powder followed similar pattern as that in stored...
Initially its decline was very slow in powder prepared from juice stored up to 5 months (995.1 to 921.2 mmol g$^{-1}$), then it decreased sharply after 6 months of storage (675.4 mmol g$^{-1}$) followed by another slower rate of decline (623.1 and 578.7 mmol g$^{-1}$) when prepared from 9 and 12 months stored juice (Fig. 2d). The loss of antioxidant activity during one year storage of juice at room temperature was less in powder (41.9%) as compared to juice (56.9%). Here also the pattern of decline in antioxidant activity in powder was found to be directly proportional to the pattern of decline in ascorbic acid content, which proved the role of ascorbic acid as the most potent antioxidant in spray dried powder.

**Conclusion**

The results indicated that loss of ascorbic acid at high temperature caused a reduction in antioxidant activity in aonla juice during storage as well as in powder prepared from stored juice. It can be suggested from this study that good quality spray dried powder can be prepared from aonla juice stored up to 5 months at room temperature without much deterioration in ascorbic acid and antioxidant activity, but powder should be prepared from stored juice before the onset of hot summer season.

**References**