Effect of process parameters on quality of carbonated Kinnow juice

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Abstract

One of the new strategies for enhancing palatability and extending the shelf life of juice without incorporating any synthetic flavours and additives is carbonation. The experiment was designed to study the effect of salt addition in carbonation at different levels of temperature and pressure. Kinnow fruit juice was carbonated at 4 °C to 8 °C and pressure of 80 psi to 120 psi. TSS and pH followed inverse relation with carbonation conditions and acidity followed direct relation. Antioxidant activity, total phenols transposes as ascorbic acid and observed highest at 80 psi and 4 °C. Reducing sugar and colour of carbonated kinnow juice remains unaffected at different carbonation conditions. In a nutshell, higher degree of carbonation can be achieved at higher pressure and lower temperature increasing juice acceptability without affecting physical quality. Salt-addition does not have significant effect on its nutritional parameters. Though the nutritional parameters found to be decline, the deviation observed was minimum.

Keywords: Carbonation, kinnow, antioxidant activity, total phenol, ascorbic acid

1. Introduction

India is the 5th largest producer of citrus fruits. Considering Indian terrain, 10% of the total land under fruit cultivation is tenanted with citrus crops followed by mango and banana (Mahawar, Jalgaonkar et al. 2019) [7]. Kinnow comes under ‘Mandarin’ group of citrus which was breaded from cross between ‘King’ (Citrus nobilis) and ‘Willow leaf’ (Citrus deliciosa) mandarin which is considered to be high quality variety (Mahawar, Jalgaonkar et al. 2019) [7]. The mandarin has proved to be high yielding and disease tolerant compared to other citrus fruits grown in India when it was brought to Regional Fruit Research Station, Abbhor in 1959 by Punjab Agricultural University. It has been found that it can be cultivated well in Punjab, Himachal Pradesh, Rajasthan, Uttarakhand, Jammu and Kashmir, Uttar Pradesh and Maharashtra states. Unlike other citrus variety, harvesting of kinnow is done based on internal ripening which means dissolving the CO₂ into water under high pressure. Carbonated drink gives good taste because it shows tingling effect which is the main reason of popularity of carbonated drink along with this it has thrust quenching and refreshing properties.
2. Materials and Methods

2.1 Raw materials

Kinnow fruits used for the experiment were procured from orchard in Bhatinda, Punjab and medium size fully matured fruits were selected for the experiments. Remaining materials were purchased from Thanjavur Consumer Co-operative Warehouse (Thanjavur, Tamil Nadu, India) and food grade additives viz. acid regulators and preservative were purchased from Himedia (Himedia, Nashik, India).

2.2 Preparation of carbonated kinnow fruit drink

The kinnow fruits were sorted based on maturity. The selected fruits were washed using bubble washer and juice was extracted by using citrus-juice extractor (Accelor Food Tech., Coimbatore, India) from kinnow fruits. The extracted juice was filtered through plate and frame filter press. The fruit juice was maintained at, total soluble solid 15%, acidity 1.5% and preservative 60 ppm and further used for preparation of kinnow fruit nectar. The standardised dilution factor K50 (kinnow: water, 50:50) was considered for further experiment of carbonation. The kinnow fruit juice dilution factor of K50 was prepared and subjected to pasteurization at 115±0.5 °C for 2 sec seconds followed by instant cooling at 25±2 °C and stored at refrigeration condition at 4 °C (Eagerman and Rouse 1976) [6]. After cooling, the pasteurized kinnow fruit nectar subjected to carbonation and the detailed flow chart is given in figure 1. The experiment was performed to compare the effect of temperature and pressure on kinnow juice with salt and without salt. The developed formula was chilled and carbonation was done at 4 °C, 6 °C and 8 °C temperature in the pressure range of 80 psi, 90 psi, 100 psi, 110 psi and 120 psi by using carbonation unit (Spectra Plast India, Coimbatore, India). Carbonation was carried with addition of 0.5% salt and. The prepared carbonated kinnaw drinks were filled in 250ml bottles and sealed tightly by using capping machine and it was stored at refrigeration condition at 4 °C for further evaluation of physicochemical and phytochemical properties.

Fig 1: Flow Sheet for the Processing of Carbonated Kinnow Fruit Drink

2.3 Quality analysis

2.3.1 Total soluble solids

Total Soluble Solids (TSS) was measured using the digital refractometer (ATAGO PAL-LOOP, Fukaya, Japan). A one or two drops of carbonated kinnow drink was placed on digital refract meter. The TSS value was expressed as °Brix (Mohapatra, Yuvraj et al. 2016) [9].

2.3.2 pH

The pH of the fresh fruit juice was determined by using digital pH meter (pH Tutor, Eutech Instruments, Singapore). The pH meter was calibrated with commercial buffer solutions at pH 9.0, 7.0 and 4.0 before measurement. About 10 ml sample was taken in glass container and pH electrode was inserted the pH value was recorded after stabilization (Agarkar, Aggarwal et al. 2019) [1].

2.3.3 Titrable acidity

The 10 ml sample of kinnaw juice was diluted with water at ratio 1:10. From that 25 ml of solution was taken in beaker
and 2 to 3 drops of phenolphthalein indicator was added and titrated against 0.1N NaOH till color changed to pink. Then the values were noted and acidity was determined by the following formula (Ranganna 1986) \(^{11}\).

\[
\text{Titrable acidity} (\%) = \frac{\text{Titrate value} \times \text{acid factor} \times 100}{\text{volume of aliquot}} \quad \ldots 1
\]

### 2.3.4 Ascorbic acid

Ascorbic acid was determined by titrating the sample against 2,6-dichlorophenol indophenol with sodium carbonate in which sample preparation include 5 ml of sample with 100 ml 4% oxalic acid further centrifuged. 5 ml of supernatant was collected and mixed with 10 ml of 4% oxalic acid and the titrated against dye. Amount of vitamin C was calculated by following equation 3.

\[
\text{Amount of ascorbic acid mg/100ml sample} = \frac{6.25 \times V_T \times V_S}{5 \times 100 \times \text{Sample volume}} \quad \ldots 2
\]

#### 2.3.5 Antioxidants

Total antioxidant activity was determined by 2,2’-diphenyl-1-picrylhydrazyl (DPPH) assay reported by (Zubia and Dizon 2019) and (Darsana, Bhosale Yuvraj et al. 2016) with slight modification. 300 μl of sample was taken and added with 4 ml of methanolic solution of DPPH with 0.004% concentration. The mixed solution was kept in dark for half an hour and absorbance was recorded at 517 nm against the reagent blank. Results were expressed in terms of the percent inhibition of free radicals and it was calculated by following equation:

\[
\% \text{Inhibition} = \frac{(A_{\text{blank}} - A_{\text{sample}})}{A_{\text{blank}}} \times 100 \quad \ldots 3
\]

Where \(A_{\text{blank}}\) was absorbance of DPPH radical in methanol and \(A_{\text{sample}}\) was absorbance of DPPH radical mixed with sample.

#### 2.3.6 Total phenol content

By using Folin-Ciocalteu method, the total phenol content of sample was determined as reported by (Theagarajan, Malur Narayanaswamy et al. 2019) \(^{14}\) with slight changes on procedure. 300 μl of juice was mixed with 1 ml of Folin-Ciocalteu reagent prepared 1:10 with distilled water and it was mixed vigorously. 1 ml of 10% Na₂CO₃ was added and final volume was made up to 5 ml with distilled water. The dispersion was left for half an hour at room temperature and absorbance was measured at 765 nm using UV–Vis Spectrophotometer (UV-1800, Shimadzu, Japan). The total phenol content was expressed as mg gallic acid equivalents per ml of juice.

### 3. Result and Discussion

#### 3.1 Total soluble solids

Observational data shows very negligible changes in TSS after carbonation. There is a decrease in TSS with the rise in pressure at constant temperature, (Aggarwal, Bajaj et al. 1992) \(^{13}\) recorded that TSS remained the same with negligible changes in carbonated peach nectar. Kinnow juice carbonation has no major effect on the TSS of juice. Maximum TSS 8.15±0.07°Brix observed at 80 psi pressure and 4°C temperature in sample containing salt and without salt. Minimum value of TSS 7.65±0.07°Brix was observed for sample with salt at 120 psi and 8°C and found lowest for without salt sample 7.55±0.07°Brix at same processing conditions. TSS values for sample with salt and without salt found statistically non-significant. During thermal processing, complex polymeric carbohydrates break down into simple soluble sugars and this may be the explanation why total soluble solids in pasteurized juice kinnow juice increase (Margean, Lupu et al. 2020) \(^{8}\). Following graph shows the decrease in TSS-

![Graph showing TSS changes](http://www.chemijournal.com)

#### 3.2 pH and acidity

Increased pressure induces reduced pH at each carbonation temperature, which is not significant, although with the rise in pressure, acidity shows significant changes. Effective carbonation is caused by increased pressure and shows more acidity supported by (SILER, MORRIS et al. 1993) \(^{12}\) as they stated that carbonated juices produce higher titratable acidity and this rise in acidity was defined during titration with dissociation of carbonic acid. Maximum pH was observed at 80 psi pressure and 4°C temperature. Sample with salt had 4.015±0.02 and without salt sample had 4.01±0.01 which were non-significant. Minimum pH value for with salt sample was 3.95±0.01 and without salt sample contains 3.945±0.007 which was found non-significant at 120 psi pressure and 8°C temperature. Vice-versa Acidity found lowest at 80 psi pressure and 4°C temperature. For sample with salt, it was 0.485±0.007% and for without salt sample it was 0.475±0.007%. Highest acidity was found at 120 psi pressure and 8°C temperature. For sample with salt it was 0.56±0.007% and sample without salt had 0.57±0.01% which were non-significant. pH and acidity of drink was represented graphically below-

![Graph showing pH changes](http://www.chemijournal.com)
3.3 Ascorbic acid
As the carbonation pressure rises, the vitamin C content of kinnow juice was observed to decrease with minor variance. The headspace inside the bottle is packed with CO2, which inhibits ascorbic acid aerobic oxidation and maintains the stability of vitamin C (Zhao, Qin et al. 2018) [16]. Maximum retention of ascorbic acid was observed at 80 psi pressure and 4 °C temperature for sample with salt 34.63±1.16 mg/100ml and in sample without salt it was observed at 31.29±1.64 mg/100ml which are significantly different. Ascorbic acid found lowest during carbonation at 120 psi pressure and 8 °C temperature, for sample with salt it was 24.48±0.95 mg/100ml and sample without salt it was found to be at 24.44±1.79 mg/100ml. Change in ascorbic acid was represented graphically below-

![Graph 3: Effect of carbonation temperature and pressure on pH and Acidity](image)

3.4 Antioxidants
With the rise in pressure for carbonation, antioxidants appear to be decreased in the experiment. Oxidation of some bioactive ingredients such as vitamin C, carotenoids and phenolic compounds with the help of activation of certain enzymes, including peroxidase, polyphenol oxidase, may clarify this loss of antioxidant function after carbonation (De Ancos, Rodrigo et al. 2020) [5]. Maximum retention of total phenol was observed at 80 psi pressure and 4 °C temperature for sample with salt 1.675±0.07mg/100ml and in sample without salt it was observed at 1.67±0.01 mg/100ml which are not significantly different. Total phenol found lowest during carbonation at 120 psi pressure and 8 °C temperature, for sample with salt it was 1.47±0.01 mg/100ml and sample without salt it was found to be at 1.43±0.02 mg/100ml.

![Graph 5: Effect of carbonation temperature and pressure on Antioxidants](image)

3.5 Total Phenol
The dissolved CO2 can have an effect on enzymes because it helps to shift the ionic equilibrium and affect the activity under high pressure. Bubbling refers to enzyme inactivation during carbonation and de pressurization. These enzymes are responsible for reaction that cause the depletion of phenols (Zhao, Qin et al. 2018) [16]. Maximum retention of total phenol was observed at 80 psi pressure and 4 °C temperature for sample with salt 1.675±0.07mg/100ml and in sample without salt it was observed at 1.67±0.01 mg/100ml which are not significantly different. Total phenol found lowest during carbonation at 120 psi pressure and 8 °C temperature, for sample with salt it was 1.47±0.01 mg/100ml and sample without salt it was found to be at 1.43±0.02 mg/100ml.

![Graph 6: Effect of carbonation temperature and pressure on Total phenols](image)

4. Conclusion
Carbonation of kinnow juice enhances the organoleptic properties with its mouth feel, tingling effect, imposes
refreshing quality with healthy natural taste of fruit. The present study describes that the addition of salt into drink does not have significant effect on its palatability as well as its physicochemical and phytochemical parameters. After carbonation phytochemical properties showed good retention. Carbonation of fruits has further potential application and can be major part for replacing sugar based soft drink. Kinnow is the underutilized fruit, which has greater health benefits and nutrient-rich benefits. In this section, further scope is enriched carbonated kinnow drink with a variety of flavours to enhance consumer preference, which leads to increased demand for kinnow fruit to support farmers and processors 'economic status.

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