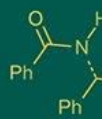


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Formulation of carbonated peach juice beverage and study of phytochemical properties

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Abstract

Carbonated beverages are popular for their ability to quench thirst and provide a refreshing experience, but they lack important nutritional components. An effort has been undertaken to create a carbonated drink based on fruit juice, utilizing peach juice concentrate at varying concentrations (5%, 7.5%, and 10%), in combination by addition of sugar syrup and chilled water containing carbon dioxide. The peach juice was obtained through a screw-type extractor and concentrated from 7.8 to 69.6 °B using a rotary vacuum evaporator. The assessment included determination of both the physicochemical and phytochemical characteristics of peach juice and concentrate. Peaches serve as a valuable source of important vitamins and minerals, such as vitamin C, vitamin A, potassium, and dietary fiber, along with flavonoids and phenolic compounds. Following preliminary sensory assessments, a 7.5% juice concentrate was selected as the benchmark for formulating the carbonated beverage. In conclusion, mixing peach juice concentrate into carbonated beverages brings a dual benefit: providing consumers with convenient and naturally flavored carbonated drinks while potentially stimulating growth in the fruit based carbonated beverage industry.

Keywords: Antioxidant activity, beta-carotene, total phenols, juice extraction

1. Introduction

The global beverage sector is an extensive and multipart market encompassing a diverse range of products and customer bases (Sharma *et al.*, 2023) [15]. It is projected to achieve a market value of \$3 trillion by 2028, by anticipated compound annual growth rate (CAGR) of 4.6% from 2023 to 2028. The non-alcoholic beverage category can be further categorized into carbonated soft drinks (CSDs), juices, nectars, water, and other non-alcoholic beverages. Among these, CSDs stand out as the dominant sector, representing more than 30% of the overall market share (Global Beverage Markets Research, 2023) [6]. The peach (*Prunus persica* (L.) Batsch) is acknowledged as a substantial special crop on a global scale and holds the position of being the sixth most vital tree fruit crop (Byrne *et al* 2012) [4]. China currently exerts significant control over worldwide peach production, primarily catering to its domestic market (according to FAOSTAT data from 2020). Peaches are a delicious and healthful fruit, offering a diverse range of vigorous nutrients. They are a nourishing fruit, with a medium-sized fresh peach being a source of carbohydrates and containing minimal fat (Byrne *et al* 2012) [4]. Peaches oblige as a valuable reservoir of essential micro nutrients, including vitamin A, vitamin C, potassium, and dietary fiber (Sánchez-Moreno *et al.*, 2006) [13]. Additionally, they deliver antioxidants such as flavonoids and phenolic compounds, which play a protecting role against harm caused by free radicals. Given their important water content and naturally sweet flavor, peaches make a healthful and stimulating inclusion in your diet, contributing to your overall health and vitality (Bento *et al.*, 2022) [3]. You can enjoy peaches in different forms, like fresh, cooked, or preserved in processed cans. Peach juice refers as a popular beverage, created from the extracted juice of ripe peaches. The extraction of peach juice involves the process of blending or pressing fresh peaches, and it is regularly available as a commercial and pasteurized product. Carbonating natural health beverages offers an innovative way for new products. The carbonation of natural fruit juices led to enhance the flavor, smell, and nutritional value of these drinks. Carbonation also acts as preservation method, integrating carbon dioxide (CO₂) into the fruit juice. Carbonation serves as a barrier against the growth of microorganisms inside the juice, to prolonging the product's shelf life.

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This preservation method includes subjecting the liquid to high pressure, resulting in the creation of smaller bubbles that generate a delightful tingling sensation upon opening. The carbonation process for peach juice comprises numerous steps, including juice extraction, pasteurization, mixing, and carbonation that create a valuable product. The main objective of this research to study how carbonation influences various aspects of peach juice, including sensory attributes, total acidity, titratable acidity, shelf life, color, pH levels, and phytochemical characteristics.

2. Materials and Methods

2.1 Raw Materials

Peaches were purchased from local fruits and vegetable markets in Ludhiana, India. These fruits gone through an inspection to identify any damage or infestation. Afterward, they were washed with distilled water to remove any dirt or pesticide residues. Following this, the extraction of juice was carried out.

2.2 Juice extraction

The peach fruit was diced into small pieces using a stainless-steel knife. A screw-type juice extractor was used to extract the juice, ensuring efficient extraction with minimal pulp residue. The juice extraction process was repeated three times using the extractor, and subsequently, the juice was filtered through a muslin cloth filter to enhance its quality.

2.3 Preparation method for carbonated peach juice beverage

Peach juice was homogenized and pasteurized by regulating the temperature to 85 °C and maintaining it for 2 minutes, after which it was quickly cooled. Careful attention was given to monitoring time and temperature to prevent overcooking. Then, the juice was concentrated using a rotary vacuum evaporator at a temperature of 40 °C until a total soluble solid content of 70 ± 0.5 °B was achieved. These carbonated peach juice beverage trials were prepared by, the post-mix carbonation technique was used, following the approach detailed by Arora and Aggarwal (2020) [12]. There are 3 distinct formulations were developed, each incorporating varying proportions of peach juice concentrate, specifically 5.0%, 7.5%, and 10%. The sugar syrup, maintained at 80 °B, remained constant at 5% in all formulations. The remaining mixture consisted of chilled carbonated water at 3-5 °C. Carbonation levels range from 2 to 5 grams of CO₂ per unit volume of beverage. This fizz enhances sensory experience, contributing to refreshing and fizzy qualities that consumers associate with carbonated beverages. Glass bottles with a pre-sterilized condition, each having a capacity of 200 ml, were loaded with a mixture of peach concentrate and sugar syrup. Afterward, the filled bottles were rapidly chilled to a temperature up to 0 °C. Bottles were then filled with chilled carbonated water, and they were sealed with corks. Afterward, these bottles underwent a processing step in boiling water, lasting for 20 minutes, followed by immediate cooling to complete the process.

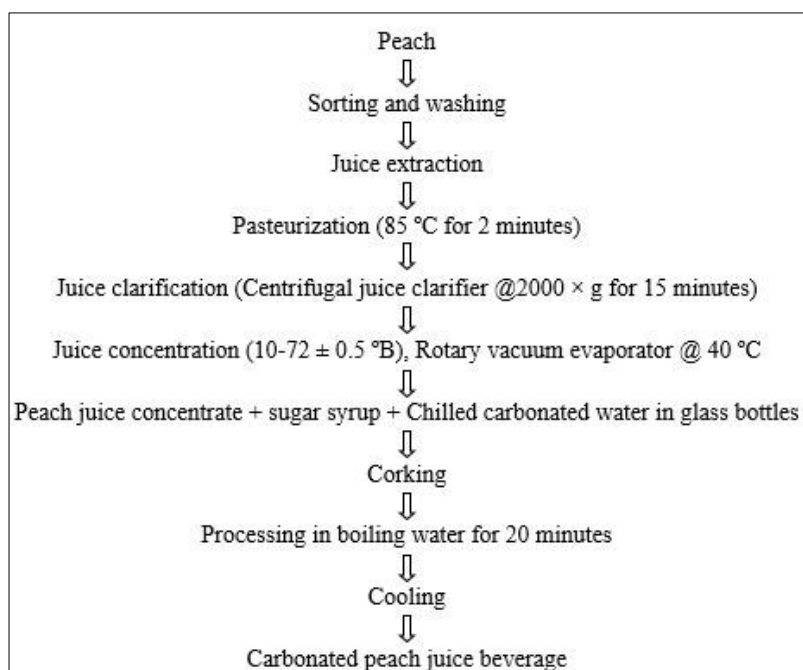


Fig 1: Flow diagram of carbonated peach juice beverage

2.4 Physicochemical parameters

The analysis of the peach juice samples included several significant measurements. Total Soluble Solids (TSS) content was measured by means of a hand refractometer from Erma, Japan. Titratable Acidity, measured in malic acid equivalents, was assessed following by standard titrimetric procedure as outlined by Ranganna's (2005) [12]. Additionally, the pH of the samples was measured using a pH meter manufactured by (Mettler Toledo, India). Several analyses were performed on the peach juice samples:

Carbon dioxide gas volume and total Solids were determined by Ranganna's (2005) [12]. AOAC (2019) [11] method was used to assess the carbon dioxide content (mg/100ml). The CO₂ gas volume was quantified as per Agarkar *et al.*, 2019. Color characteristics (L, a, b) were evaluated by Hunter Color Lab equipment (Ultra Scan, Hunter Lab, USA). The color values, including L* (lightness ranging from 0 to 100), a* (redness to greenness on a scale of + to -), and b* (yellowness to blueness on a scale of + to -), were assessed using Hunter Colour Lab.

2.5 Phytochemical analysis

Calculation of ascorbic acid done by standard titrimetric method, employing a 2,6-Dichlorophenol indophenol dye solution, this compound is changed into a colorless substance through the action of ascorbic acid, following methodology outlined by (Kaur *et al.* in 2022) ^[17]. The determination of β -carotene and total carotenoids measurements involved acetone and petroleum ether extraction, trailed by spectrophotometric measurement, with results expressed as $\mu\text{g}/100\text{ ml}$, according to the procedures described in (AOAC, 2019) ^[1] reference. Total phenols were calculated using the Folin-Ciocalteu reagent method, following the protocol outlined by Kaur *et al.*, (2022) ^[17], with results expressed as mg GAE (Gallic acid equivalent) per 100 g. Furthermore, the antioxidant activity, measured as DPPH free radical scavenging activity, was assessed using the method given by (Kaur *et al.*, 2022) ^[17].

2.6 Sensory evaluation

The sensory characteristics of the carbonated peach beverage were assessed via a 9-point hedonic scale, with ratings ranging from 9 (liked extremely) to 1 (disliked extremely). Panel consisting of 25 semi trained individuals, comprising students and staff members aged 21-50 years from the Department of Food Science and Technology at Punjab Agricultural University in Ludhiana, India, conducted organoleptic evaluation. The cooled beverage, served at a temperature of 4-6 °C, was evaluated based on measures appearance, mouthfeel, flavor, and overall acceptability, were taken into consideration as part of

evaluation.

2.7 Statistical analysis

All analysis for the study were performed in triplicates. The difference among the means were tested by one-way ANOVA, at 95% CI ($p < 0.05$), using statistical software SPSS version 25.

3. Results and discussion

Quality characteristics of peach juice and peach juice concentrate

The findings of physico and phytochemical parameters of peach juice and concentrate are presented in Table 1. The TSS, titratable acidity, and pH values of peach juice closely matched the research conducted by Shao *et al.* (2011) ^[14]. Remarkably, all the physico and phytochemical characteristics confirmed a prominent and statistically significant increase ($p < 0.05$) following concentration process, likely attributable to removal of water. In a similar manner, the juice concentration process led to the retention of all solid components, leading to a significant rise in the total solids content, which increased from 9.56% to 70.4% in the peach juice concentrate (as shown in Table 1). Vijayanand *et al.* (2010) ^[16] noted a comparable effect when vacuum concentration was applied to litchi juice, resulting in elevated TSS and titratable acidity levels, increasing range of 16.2 to 59.5 °B and from 0.17% to 0.73%, respectively. Table 1: Quality characteristics of fresh peach juice and peach concentrate.

Table 1: Quality attributes of fresh peach juice and concentrate

Parameters	Peach Juice	Peach Juice concentrate	$p < 0.05$
Physicochemical			
Total Soluble Solids (°B)	7.80 $\pm$ 0.36	69.6 $\pm$ 1.34	S
Total solids (%)	9.56 $\pm$ 0.51	70.4 $\pm$ 2.64	S
pH	4.02 $\pm$ 0.12	3.98 $\pm$ 0.16	S
Acidity (%)	0.50 $\pm$ 0.03	2.11 $\pm$ 0.21	S
Color coordinates			
L*	36.76 $\pm$ 0.13	33.72 $\pm$ 0.15	S
a*	1.43 $\pm$ 0.03	2.11 $\pm$ 0.05	S
b*	5.31 $\pm$ 0.12	4.27 $\pm$ 0.14	S
Phytochemical			
Ascorbic acid (mg/100 ml)	19.72 $\pm$ 0.43	65.22 $\pm$ 1.35	S
Beta carotene (mg/100 ml)	2.5 $\pm$ 0.06	9.52 $\pm$ 0.32	S
Carotenoids (mg/100 ml)	6.5 $\pm$ 0.02	30.12 $\pm$ 0.48	S
Total phenols (mg GAE/100 ml)	220.32 $\pm$ 8.02	1282.50 $\pm$ 28.48	S
Antioxidant activity ($\mu\text{mol TE}/100\text{ ml}$)	17.04 $\pm$ 0.84	115.12 $\pm$ 2.76	S

Results are expressed as mean $\pm$ standard deviation, n = 3

GAE: Gallic acid equivalent; TE: Trolox equivalent; S: Significant ($p < 0.05$) difference among columns

Color is a crucial feature that serves as significant quality parameter, influencing consumer acceptability and purchasing decisions (Kaur *et al.*, 2022) ^[17]. L* value, which means lightness or darkness, exhibited a significant decrease ($p < 0.05$), during the concentration process. (Table 1). During vacuum concentration, substantial increase in the a* value was observed, indicating shift to a more red or

orangish hue. Simultaneously, there was decrease in the b* value, reflecting reduction in the yellowness component, likely due to carotenoid pigments. Carbon dioxide (CO₂) concentration in carbonated drinks was determined at 530.46 milligrams per 100 milliliters, and the volume of CO₂ gas was determined to be 2.26 cubic meters. Table 2: Sensory evaluation of carbonated peach juice beverage.

Table 2: Sensory evaluation of carbonated peach juice beverage

Ingredients	Formulations		
	F ₁	F ₂	F ₃
Peach Juice concentrate	5	7.5	10
Sugar syrup	5	5	5
Chilled carbonated water (ml)	190	187.5	185
Sensory characteristics			
Color	7.52 ± 0.32 ^b	8.32 ± 0.62 ^a	7.62 ± 0.35 ^b
Mouthfeel	7.26 ± 0.28 ^b	8.24 ± 0.86 ^a	7.10 ± 0.56 ^b
Flavor	7.55 ± 0.42 ^b	8.17 ± 0.42 ^a	7.72 ± 0.45 ^{ab}
Overall Acceptability	6.52 ± 0.63 ^b	8.48 ± 0.21 ^a	7.25 ± 0.36 ^b

Results are expressed as mean ± standard deviation, n = 30

Different letters in superscript indicates significant ($p < 0.05$) difference between columns

Carotenoids, with beta-carotene as prominent example and precursor to vitamin A, assist as powerful antioxidants with the potential to offer several health advantages (Gul *et al.*, 2015) [7]. These components play vital role in protecting cells from oxidative damage, secondary eye health, and enhancing the body's immune system, amongst other benefits. In the current study, amount of beta carotene and total carotenoids in peach juice were measured at 1.51 µg/100 ml and 3.24 µg/100 ml, respectively, which were similar conclusions of Navarro *et al.*, (2011) [9] who reported 1.30-1.90 µg/100 ml Beta carotene in mandarin juice. Concentration process led to an increase in the amount of these compounds to 9.52 and 30.12 µg/100 ml, respectively corresponding to approximately 6.5 times of the original values, ensuing from evaporation of water (Table 1). Carotenoids, particularly B-carotene, a precursor of vitamin A, are known for their robust antioxidant properties and various health benefits, as noted by (Gul *et al.*, 2015) [7]. In the current study, the B-carotene and total carotenoid levels in peach juice were measured at 1.51 and 3.24 µg/100 ml, respectively, findings that closely matched those reported by Navarro *et al.* (2011) [9], who observed 1.3-1.9 µg/100 ml of B-carotene in mandarin juice. Notably, the concentration process resulted in a significant increase in these compounds, reaching 9.52 and 30.12 µg/100 ml, respectively, which corresponds to approximately 6.6 times the initial values, primarily due to moisture evaporation (as shown in Table 1). Ascorbic acid, identified as an antioxidant vitamin, serve critical role in the body by facilitating absorption of iron. This property makes it key component of a nutritious and balanced diet. Results shown that peach juice contained 19.3 mg/100 ml of ascorbic acid, quantity lower than what has been reported by several other researchers (Di Vaio *et al.*, 2015) [5]. The lower amount of ascorbic acid in the peach juice observed in this study could be linked to distinctions, possible loss during handling, variations in juice extraction, and temperature fluctuations. These factors together contribute to detect difference in ascorbic acid content (Oliveira *et al.*, 2012) [10]. Substantial ($p < 0.05$) rise corresponding to about 5.2 times original amount of ascorbic acid was detected subsequently concentration of juice (Table 1). While ascorbic acid is acknowledged to be sensitive to light and heat, it's important that the concentration process carried out under controlled conditions at 40 °C led to minimal loss of this vitamin. This highlights effectiveness of controlled environment in protecting ascorbic acid content in juice. Vijayanand *et al.*, (2010) [16] informed that concentration of litchi juice by vacuum processing resulted in a prominent increase in ascorbic acid content, rising from 17.6 mg/100 ml to 32.6 mg/100 ml. Also, total phenol content in concentrate was

found to be six times greater than original values. (Table 1). Low temperature concentration process probably contributed to the preservation and concentration of polyphenolic compounds within juice. Furthermore, mild heating during concentration process led to release of bound polyphenolic compounds, which was reflected in a significant rise in total phenol content of concentrate when compared to juice (Padayachee *et al.*, 2012) [11].

4. Conclusion

In recent years, carbonated beverages have lost popularity due to their lack of nutritional value. However, there is an opportunity to enhance their nutritional content by introducing fruit juices to provide natural flavor and color while still maintaining the fizziness. The carbonated beverage's nutritional characteristics were enhanced through the addition of a 7.5% peach juice concentrate. Based on our analysis, it is evident that the sample with a greater concentration of carbon dioxide was more effective in enhancing the shelf life of the juice. This led to a highly favorable consequence, as the beverage exhibited enhanced bioactive components. This enhancement was attributed to the natural flavor and color derivative from the peach juice concentrate. The incorporation of carbon dioxide well known anaerobic conditions. These conditions effectually prevented the oxidation of ascorbic acid, antioxidant activity, flavonoids, and total phenols. This preservation method allowed the retention of phytochemicals while keeping the organoleptic quality intact.

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