DEVELOPMENT OF PREBIOTICS ENRICHED CARROT READY-TO-SERVE DRINK

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The twenty-first century has seen a major increase in consumer awareness of healthy foods that promote healthy lifestyles. As a result, various health-promoting food products have gained significant demand in the food industry. Carrots (*Daucus carota* L) are an essential tuber crop rich in biochemical elements such as alpha and beta carotene; Arrowroot (*Maranta arundinaceae* L.) is an alternative carbohydrate crop which can be used to substitute commercial prebiotics such as inulin. This study aimed to evaluate the properties of arrowroot-enriched carrot juice, including its nutritional composition, and its physicochemical and microbiological attributes during storage. The control sample (T1) contained raw carrot juice, while T2 contained citric acid [0.1 g], T3 contained lime [2 ml], and T4 contained pineapple [5 ml] juice. Each sample received 25 ml of xanthan gum (0.2%) and 1% of arrowroot solution. The final product was subjected to proximate analysis, microbial quality testing, physicochemical analysis, and sensory analysis. The results of sensory evaluation among the selected four samples revealed significant differences ($P > 0.05$) in aroma, flavor, and overall acceptability, except in appearance, color, and texture. Considering overall acceptance, T4 (carrot with pineapple [5 ml] juice) was selected as the best sample. T4 was further tested for nutrition composition and found to have 86.45% moisture, 1.7% protein, 0.66% dietary fiber, 0% fat, and 11.19% carbohydrates. A significant increase ($p<0.05$) in acidity was observed on the 7th and 14th day compared to the initial sample (0.62±0.07, 0.80±0.06, and 0.34±0.04%, respectively). The ascorbic acid or vitamin C content significantly decreased over the 14 days storage period (4.65±0.98 mg /100 mL) compared to the initial sample (11.31 mg /100 mL). Ascorbic acid may have been degraded during manufacturing and storage, as ascorbic acid is susceptible to oxygen, heat, and light, causing fast oxidation. There was also a significant increase in total plate count (7.16±7.64 log CFU/mL) and yeast and mold (1.15±5.00 log CFU/mL) in the product after 14 days. Carrot juice enriched with pineapple and arrowroot can be used as a healthy, ready-to-serve drink.

Keywords: - Carrot, Arrowroot, Prebiotics, Inulin, Alpha carotene, Beta carotene

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INTRODUCTION

Functional beverages are one of the most active and popular categories within the functional food market among consumers. To provide health advantages beyond basic nutrition, these non-alcoholic beverages are fortified with nutraceuticals and bioactive components such as vitamins, phytonutrients like carotenoids, terpenes, and polyphenols, antioxidants, minerals, and probiotics. The ready-to-drink, fruit-based functional beverage sector is the fastest-growing segment in the functional food market, driven by new product development criteria such as convenience, "freshly prepared", "portion control", and "customization". According to studies, carrots have higher levels of alpha-carotene (2186 µg/ 100g fresh weight) and beta-carotene (7975 µg/ 100g fresh weight) than other fruits and vegetables **(**Anonymus, 2011)**.** Vitamin A deficiency is a global public health concern, affecting 190 million preschool-age children and 19.1 million pregnant women, leading to night blindness, impaired immune function, and increased risk of gastrointestinal disease and measles. Vitamin A status in women and children in disadvantaged regions has been significantly improved by providing β-carotene-rich vegetables and fruits. Consumers demand convenience, quality, and novelty in food products that balance health and flavour. (Haskell, 2012).

Prebiotics, which are non-digestible dietary ingredients, stimulate gastrointestinal microflora, thereby improving host health. Inulin-type fructans stimulate gut bacteria, with adults typically consuming 4-30g daily of resistant starch, dietary fiber, proteins, and lipids (Roberfroid, 2010). Arrowroot (*Maranta arundinaceae* L.) is a large perennial herb found in tropical woods. It belongs to the Marantaceae family. Although arrowroot contains Fructo Oligosaccharides [FOS], there has been limited research on its potential application as a prebiotic in the functional food business. Some studies have found that arrowroot extraction and inulin exhibit similar prebiotic activities. Thus, arrowroot extract presents an excellent opportunity to substitute commercial prebiotics such as inulin. With rising concerns about sugar-containing soft drinks being a major contributor to obesity and related health issues, there is a growing need to develop and introduce low-sugar, low-calorie and healthy soft drinks with enhanced prebiotic properties.

METHODOLOGY

Carrot juice preparation

Organic carrots (1kg) were washed, peeled, and cleaned with distilled water. The carrots were then grated using a grater and steam blanched at 100°C after being soaked in tap water to remove excess heat. [Tiwari 2018]. The steam-blanched carrots are blended in a laboratory blender (BL-T70PR2, Toshiba) for 3 minutes, blending with 2-minute intervals two times. The juice was extracted by filtration via four layers of cheesecloth. The extracted of juice 200 mL was transferred to four beakers, and each was treated with T1 as raw carrot juice (control), T2 as citric acid [0.1 g], T3 with lime (2 mL), and T4 pineapple (5 mL) juice. Each sample received 25 mL of xanthan gum (0.2%) and 1% of arrowroot solution. (Shakeel,2013). The samples were homogenized using a laboratory homogenizer (HG-15A, Daihan Scientific, Japan) at 150 Mpa for five minutes. White sugar (0.5 g) and sodium benzoate (0.024 g) were added, and the samples were pasteurized at 98 $\pm$ 2℃ for 120 seconds for Acidified Juices (T2, T3, and T4), according to Vasantha (2012). While T1 control was pasteurized at 80℃ for 7 minutes according to Livia, (2021). All samples were stored in the refrigerator at 8℃.

Sensory evaluation

The final product was selected through two sensory evaluations involving 30 untrained panelists who assessed coded samples for appearance, colour, texture, aroma, flavour, and overall acceptability.

Proximate analysis

The moisture, dietary fibre (ash content), protein content, fat, and carbohydrate content were determined according to the AOAC,2000 methods.

Shelf-life analysis

Microbial analysis was conducted using the Total Plate Count (TPC) and Yeast and Mold Count (YMC) tests. Titratable acidity was determined using the titration method (Uzma, 2022). A digital reflectometer (H196801, Hanna) was used to measure the Total Soluble Solid (TSS) contents.

Nutritional properties

The ascorbic acid or vitamin C content was determined using the iodine titration method, as per Alam(2019).

Data analysis

Three replicates were used for each treatment, and data were analyzed using the ANOVA general linear model, applying the MINITAB 21 software package. Means were compared using Tukey's multiple comparisons, and sensory data were analyzed using ONE-WAY ANOVA and the Friedman test.

RESULTS AND DISCUSSION

Table 01 shows the sensory evaluation results for selecting the best flavour combination. The evaluation revealed that T1 (Control), T3, and T4 exhibited significantly higher ranks aroma and overall acceptability, with no significant difference in appearance, color, or texture among treatments. The T4 sample ranked highest, possibly due to its unique flavour and aroma, while the T2 sample had a highly acidic flavor.

Table 1: Sensory Evaluation 01- Selection of the best flavor combination

*Means with similar superscript letters in a column are not significantly different (P> 0.05)

Table 2 shows the sensory data for the developed carrot juice with added arrowroot powder. There was no significant difference between treatments for appearance, colour, flavor or texture except aroma and overall acceptability. T4 and T3 showed significantly higher differences in aroma compared to control. The overall acceptability for Control T1 and T3, T4 showed significantly higher scores compared to T2. Therefore, we selected T4 for further studies as it showed the highest score, as in Figure 1, for both aroma and overall acceptability.

Table 2: Sensory Evaluation 02 after incorporating 1% of arrowroot addition

Treatment	Appearance	Colour	Flavour	Texture	Aroma	Overall acceptability
T1	6.13±1.17^{a}	5.80±0.83^{a}	**4.00±1.42^{a}**	4.25±1.22^{a}	4.27±1.20^{b}	**5.65±1.25^{a}**
T2	5.93±1.54^{a}	5.90±1.20^{a}	3.00±1.58^{b}	4.02±1.44^{a}	3.76±1.40^{c}	3.78±1.50^{b}
T3	6.00±1.17^{a}	5.86±0.56^{a}	**4.23±1.56^{a}**	4.50±1.45^{a}	**4.57±1.30^{ab}**	**5.95±1.26^{a}**
T4	6.23±1.08^{a}	5.93±0.87^{a}	**5.13±1.42^{a}**	4.95±1.13^{a}	**5.20±1.18^{a}**	**6.10±1.12^{a}**

*Means with similar superscript letters in a column are not significantly different (P> 0.05)

Treatment	Appearance	Colour	Flavour	Texture	Aroma	Overall acceptability
T1	5.93±1.12^{a}	6.17±0.65^{a}	**5.20±1.34^{a}**	4.60±1.05^{a}	5.23±1.30^{b}	**5.48±1.25^{a}**
T2	5.60±1.45^{a}	5.80±1.68^{a}	3.17±1.65^{c}	4.10±1.22^{a}	3.40±1.41^{c}	3.63±1.50^{b}
T3	6.07±1.05^{a}	6.27±0.75^{a}	**5.17±1.40^{a}**	4.57±1.45^{a}	**5.37±1.25^{a}**	**5.50±1.26^{a}**
T4	6.17±1.11^{a}	6.27±0.82^{a}	**5.70±1.28^{a}**	4.73±1.13^{a}	**6.10±1.05^{a}**	**6.10±1.09^{a}**

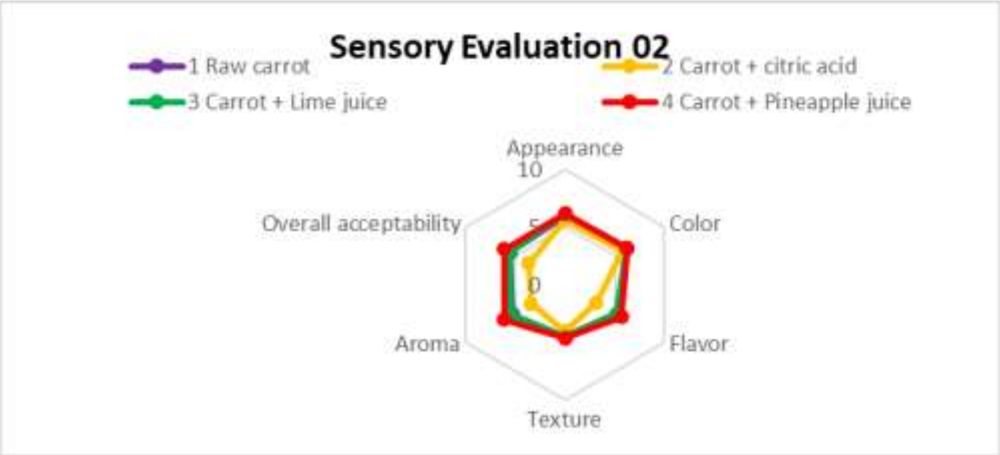

Figure 1: Sensory Evaluation 02

Proximate analyzed data are shown in Table 3. The dietary fibre content or ash content in T4, carrot-pineapple, and arrowroot-based drinks was found to be 0.66%. The fibre quantity was affected due to the addition of arrowroot powder as an ingredient. Researchers like Bhavsgar et al. (2010) and Barbar et al. (2008) found that adding fruits and vegetables increased ash content. However, microbes can utilize and break down fibre, which could reduce ash content during storage. The developed carrot juice had fat and protein content of 0.01% and 1.7%, respectively. The developed carrot juice contained 11.18% carbohydrates. Tanvir *et al.*, (2022) reported that during 25 days of storage, carbohydrate decreased by 12.87%. This decrease is due to microorganisms converting carbohydrates into alcohol, organic acids, and carbon dioxide, as well as the hydrolysis of saccharides, which releases reducing sugars like glucose and fructose.

Table 3: Proximate analysis of the final product

Component	Test values
Moisture	86.45%
Dietary fibre	0.66%
Protein	1.7%
Fat	0.01%
Carbohydrates	11.18%

*Carbohydrates value was calculated by difference [100- (Moisture% + Dietary fibre % + Protein% + Fat%]

Table 04 shows that the pH values of the prepared beverage somewhat decreased (5.42 ±0.03, 5.41±0.01, 5.35±0.03) during storage due to increased titratable acidity, which is inversely related to pH. This is consistent with Chavan et al.'s (2015) findings, which found a significant decrease in pH from 4.3 to 4.1 after 30 days of refrigerated storage. This decrease may be due to amino and organic acid formation during protein and lactose storage, or due to its antimicrobial properties. The acidity of whey-mango-based mixed drinks after 14 days of refrigerated storage was (0.34±0.04, 0.62±0.07, 0.80±0.06), influenced by ascorbic acid, which affects sugar and protein composition. According to Yadav *et al.*, (2010), the conversion of lactose and proteins into lactic acid and amino acids can increase acidity and lower pH. The sample showed a slight increase in Total Soluble Solid (TSS) as (10.48±0.26, 10.51±0.04, and 10.60±0.13) possibly due to the conversion of insoluble polysaccharides into reduced sugars. Acid hydrolysis of sugars can also cause a rise in decreasing sugar levels, possibly due to the breakdown of disaccharides into monosaccharides. Alane et al. (2017) observed a similar trend in a whey-based mango herbal beverage.

Table 4: Physiochemical parameters of the final product

Table 05, the developed carrot juice showed no colony counts in TPC and YMC within 0-7 days, but after 14 days, rapid growth was observed. Yonis et al. (2014) suggested beverages with extended storage periods may encourage microorganism growth.

Table 5: The microbiological parameters of the developed carrot juice

Time duration	Total Plate Count (log CFU / mL)	Yeast and Mold Count (log CFU / mL)
Initial	ND	ND
1st week	ND	ND
2nd week	7.16±7.64ª	1.15±5.00ª

Time duration	pH	Acidity%	Brix value
Initial	5.42±0.03ª	0.34±0.04ᶜ	10.48±0.26ª
1st week	5.41±0.01ª	0.62±0.07ᵇ	10.51±0.04ª
2nd week	5.35±0.03ª	0.80±0.06ª	10.60±0.13ª

Ascorbic acid content variations over storage are shown in table 6. The concentration of ascorbic acid significantly decreased during the 14 days of storage. Sakhale *et al.*, (2012) reported similar results in whey-based ready-to-serve mango beverages. However, ascorbic acid levels in all beverage samples could decline drastically during the storage as ascorbic acid is susceptible to oxygen, heat, and light, leading to rapid oxidation. This suggests ascorbic acid may have been degraded during manufacturing and storage.

Table 6: Ascorbic acid content of the final product

Time duration	Ascorbic acid (mg /100 mL)
Initial	11.31±0.40ª
1st week	7.46±0.99ᵇ
2nd week	4.65±0.98ᶜ

CONCLUSION

The study suggests that arrowroot extract could be used to create a prebiotic-enriched carrot juice having high content of fiber in the developed carrot RTS. T4 received the highest score for taste, containing 195 ml of carrot juice, 5 ml of pineapple, and 1% of arrowroot. The product has a one-week shelf life at refrigerated temperatures.

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