Whey-carrot based functional beverage: Development and storage study

by Vijay Kumar

Submission date: 27-May-2023 01:53PM (UTC+0530)
Submission ID: 2103014628
File name: Manuscript_without_author_details_R2.docx (153.39K)
Word count: 3829
Character count: 20193

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Abstract

The current study was designed to prepare whey-carrot-based functional beverages and to study the effect on physicochemical properties during the 28-day storage period. Different ratios of whey and carrot juice were selected for the preparation of the six formulations, out of which based on the sensory acceptance only three were selected for further storage studies (sample 1=45:55, sample 2=50:50, and sample 3=55:45 of carrot juice to whey ratio). During 28 days of storage, the developed beverage samples revealed a significant increase in reducing sugars, total phenolic content, and acidity. The pH, sweetness, and acceptance percentage of the beverage were found to be decreased with the storage period. It was also found that there is no change in the properties of the beverage storage with and without the preservative. It was revealed that beverage with less proportion of carrot juice is more acceptable quality. The results also suggest that whey can be used with fruit and vegetable to create the whey-based beverage.

Keywords: carrot, whey, functional beverage, shelf life, storage

1.Introduction

People today are more concerned with their health, which has led to an increase in awareness of functional foods (Kohli et al., 2019). In recent years, a variety of unique functional food products have been created; of them, over 40% are dairy products, and the main functional beverages are those made with milk whey. In addition to being delicious, fruit and milk-based beverages are gaining popularity these days because of their nutritious value (Ahmed et al., 2023). Whey, a valuable byproduct liquid from the cheese business, is made when milk proteins precipitate. Additionally, numerous techniques have been investigated over time to transform massive amounts of whey into food-grade goods. This is because only roughly 60% of the whey obtained globally is utilized to make products and the remaining is discarded as waste or fed to cattle (Arsić et al., 2018). Furthermore, due to the existing environmental restrictions, it is required to treat the whey before disposal, which is a challenging task for industries and a cost-consuming process. Alternatively, whey has a range of nutrients, such as protein (serum albumin, immunoglobulins, β-lactoglobulin, α-lactoalbumin), vitamins (thiamine, and riboflavin), phosphorus, magnesium, and calcium. Additionally, whey proteins are fast proteins because of their ability to quickly deliver nourishment to muscles. It also has protective and curative nature against different diseases such as liver complaints, anemia, jaundice, arthritis, and gonorrhea (Begum et al., 2019). This makes milk whey to be a good functional food, so its utilization in the food chain is a more reasonable and economical method than discarding.

The carrot (*Dauca carota*) is one of the widely used vegetables. It is a good source of nutrients like carbohydrates, minerals, and vitamins as well as therapeutic compounds such as carotenoids (potent antioxidants). It helps to fulfil vitamin A deficiency, diminish cholesterol, lower the risk of arteriosclerosis, purification of blood, and constipation, prevention of the appearance of colon cancer, and combat diarrhea (Sharma et al., 2012). Ginger (*Zingiber officinale* Rosc.) belongs to Family *Zingiberaceae*, whose rhizomes are used as a spice. It is a good source of minerals (iron, calcium, and phosphorous), and vitamins (thiamine, riboflavin, niacin, and vitamin C). Its pungency is due to gingerol. It has anticoagulant, anti-inflammatory, anti-fungal, antiseptic, and antioxidant properties. It helps to relieve cramps and tension, stimulate digestion, and absorption, relieve constipation and flatulence, and reduces nausea and vomiting. Some constituents of ginger inhibit the growth of some colon bacteria like *Proteus* species, *Escherichia coli*, *Streptococci*, *Staphylococci*, and *Salmonella* (Shukla and Singh, 2007). A few researchers investigated whey-fruit-based beverages such as probiotics (Dinkçi et al., 2023), ovine (Nedanovska et al., 2022), pineapple (Islam et al., 2021), grape (Barros et al., 2021), orange (Oliveira et al., 2022; Vieira et al., 2020), and strawberry (Souza et al., 2019).

The current study aims to formulate a whey-carrot-based functional beverage with various proportions of whey and carrot juice with a constant portion of ginger extract and sugar. The study also investigated the physicochemical properties and sensory attributes of formulated beverages for the storage life of 28 days at 7.0 ±1.0°C.

2. Materials and Methods

2.1 Material

Milk, carrot, ginger, and sugar were procured from the local market of Dehradun. The carrot and ginger were selected based on the visual inspection and these were then cleaned and washed to remove foreign matter and adhesive debris.

2.2 Method

2.2.1 Preparation of protein whey

Whey was produced by the procedure explained by Chavan et al. (2015) with few changes. The pasteurized double-toned milk (1.5% Fat, 9.0% SNF) was heated to 80°C for 10 min. with continuous stirring and coagulated at 72°C by adding 1% citric acid. It was then cooled and filtered using a muslin cloth to separate coagulated casein i.e., paneer and whey. The whey was then stored at 7.0 ± 1.0°C for further usage.

2.2.2 Preparation of carrot juice

The carrot juice was prepared by the extraction method. The peel was removed from the washed carrot and it was chopped into pieces to facilitate the extraction of juice by using the juicer. The juice was then filtered by using a muslin cloth to remove the suspended particles. It was then stored at 7.0 ± 1.0°C for further usage.

2.2.3 Preparation of ginger extract

The ginger was washed thoroughly, and the peel was removed using a knife. The ginger was then chopped into small pieces to extract the juice from the juicer. The juice was then filtered and stored at 7.0 ± 1.0°C for further usage.

2.2.4 Preparation of Whey Carrot Based RTS Beverage

The whey-carrot-based functional beverage was produced by the procedure explained by Baljeet et al. (2013) with few modifications. The whey, carrot juice, ginger extract, and sugar were properly mixed in the different ratios mentioned in Table 1. The obtained mixture was preheated at 45°C, which is then filled in the pre-sterilized bottles, sealed, and pasteurized at 90°C for 15 min. The bottles were then cooled at room temperature and stored at 7.0 ± 1.0 °C for further analysis.

Table 1 Different ratios of whey-carrot-based beverage

	Ingredients			
Samples	**Carrot juice (%)**	**Whey (%)**	**Sugar (%)**	**Ginger extract (%)**
S_1	25	75	3	0.75
S_2	35	65	3	0.75
S_3	45	55	3	0.75
S_4	50	50	3	0.75
S_5	55	45	3	0.75
S_6	60	40	3	0.75

2.2.5 Physico-chemical properties

The pH, total soluble solids, moisture content , and ash content was determined by the method explained by Ranganna (1986). The fat content and protein content was determined by method described by Ranganna, (1986). The titrable acidity , reducing sugar, total phenolic content, antioxidant and sedimentation for the beverage, was determined by the method explained by Gad et al. (2013) and Kumar et al., (2019) . The acceptance percentage of the beverage was also determined.

2.2.6 Sensory Evaluation

The sensory evaluation was done for all the prepared beverages by using the rating given by panel members.

2.2.7 Storage analysis

The beverage samples were stored with and without the addition of preservatives and analyzed for their physicochemical properties, and sensory properties such as pH, TSS, titrable acidity, sweetness, reducing sugar, total phenolic content, and % acceptance at intervals of 7 days for 28 days.

2.2.8 Statistical analysis

The statistical analysis was performed in Origin 6.0 (Origin Lab Corporation, USA). The values in the graphs are the mean of triplicates ± standard deviation. The bar indicates the standard deviation.

3. Result and Discussion

The whey-carrot-based functional beverages were prepared by using different concentrations of whey and carrot juice. After the sensory evaluation of the all mixtures the three blends were found to be acceptable, i.e., S_3 (45:55), S_4 (50:50), and S_5 (55:45), which will be further represented as T_1, T_2, and T_3, respectively and which are shown in Fig 1. Therefore, only these mentioned combinations were only analyzed further for physicochemical properties throughout the storage time.

(45:55) (50:50) (55:45)

T_1 T_2 T_3

Fig. 1 Selected blends for the analysis throughout the storage time

3.1 Physicochemical analysis of whey, carrot, and formulations

The physicochemical properties of the different formulations of whey and carrot juice are shown in Table 2. It was found that the carrot juice has high pH, TSS, ash content, reducing sugar, antioxidant content, TPC, and sedimentation rate compared to the whey. It can also be observed from Table 2, as the concentration of carrot juice increases in the functional beverage, all the above-mentioned parameters also significantly increase as the carrot juice contains more reducing sugar, total phenolic content, and antioxidant. Similar results were obtained by Zaman et al. (2023), in which by increasing the sugarcane juice concentration the value of these parameters was also found to be increased. The sedimentation rate was found to be highest for the sample with the lowest carrot juice concentration.

Table 2 Physicochemical parameters of whey, carrot, and formulations

Parameters	Whey	Carrot juice	T_1	T_2	T_3
Ph	5.64	6.73	5.51	6.09	6.54
TSS	5.63	7.7	12	12.5	13
Titrable Acidity (%)	0.39	0.128	0.036	0.018	0.018
Moisture (wb%)	94.9	92.7	88.2	90.1	89.4
Ash (%)	11.8	14.4	6.79	7.83	7.45
Fat (%)	0.32	0.1	0.42	0.37	0.32
Protein	0.0297	0.0293	0.02167	0.0353	0.0277
Reducing Sugar (mg/ml)	18.15	27.94	29.9	42.4	47.2
Antioxidant (mg/ml)	2.14	2.42	0.77	0.89	0.99
Total Phenol Content (mg/ml)	0.158	0.336	0.280	0.320	0.360
Sedimentation rate (%)	0.74%	2.08%	4.75%	4.32%	3.89%

3.2 Storage studies of functional beverage

3.2.1 pH

The changes in pH during the 28 days of storage of whey-carrot-based mixed beverages with and without the preservatives are demonstrated in Fig 2. During the storage, the pH value of samples doesn't vary significantly ($p > 0.05$) for the beverage stored with and without preservatives, but it is significantly different ($p < 0.05$) for different formulations of the beverage due to different concentrations of whey and carrot juice. The pH of whey-carrot-based functional beverage was noted as T_1 (5.51 ± 0.004-5.4 ± 0.001), T_2 (6.09 ± 0.002-5.97 ± 0.004), and T_3 (6.54 ± 0.003-6.42 ± 0.002) for the samples with and without preservative. Due to an increase in the titratable acidity values of the beverage, which is inversely related to pH, the mixture's pH reduced significantly ($p<0.05$) during the storage. The produced whey-carrot mixed beverages have a pH value in agreement with the results of Chavan et al. (2015), which reported a significant decline in pH after 30 days of storage. Similarly, Ahmed et al. (2023) observed a decrease in pH after 25 days of storage, which may be due to the generation of amino and organic acids during the storage.

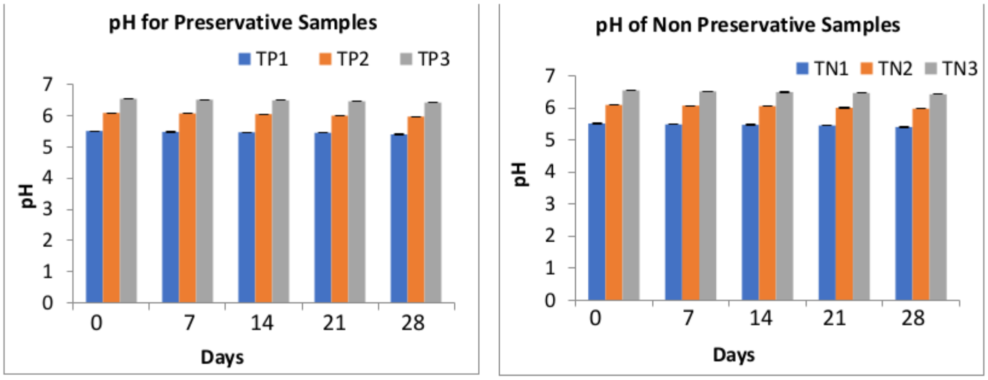

Fig 2 pH changes of beverage during storage with and without preservative

3.2.1 TSS

The total soluble solid is different in the different samples, but it doesn't significantly ($p>0.05$) vary with the storage time from 0 to 28 days (Fig 3). It was found to be high for the samples containing a high amount of carrot juice and a low amount of whey. This result showed consistency with the previous research done by Pandey and Ojha (2020). The other researcher reported an increase in TSS of the whey-based fruit beverage during the storage of 30 days (Alane et al., 2017).

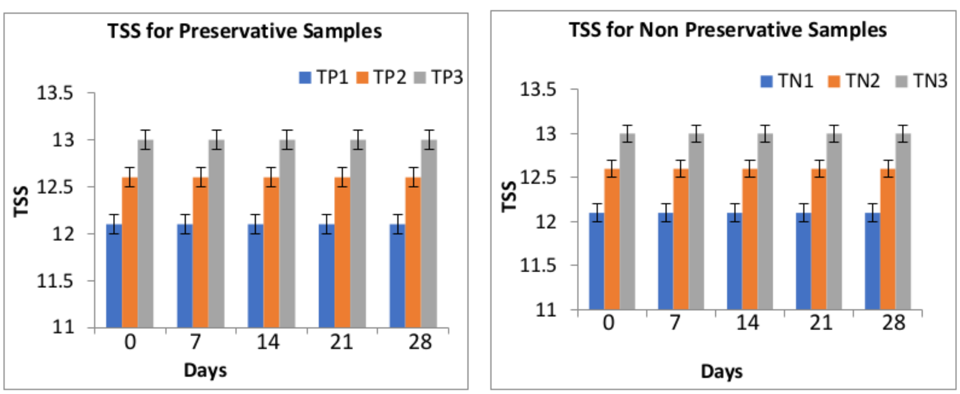

Fig 3 TSS changes of beverage during the storage with and without preservative

3.2.3 Titrable acidity (TA)

The effect of the proportion of whey and carrot juice and the storage time on the acidity of the beverage is demonstrated in Fig 4. During the storage, the acidity of samples doesn't vary significantly ($p > 0.05$) for the beverage stored with and without preservatives, but it is significantly different ($p < 0.05$) for different formulations of the beverage due to different concentrations of whey and carrot juice. The acidity was found to be increased during the storage period. According to the findings of the study, the acidity significantly increased from 0.037 ± 0.001 to 0.054 ± 0.002 for formulation 1, 0.018 ± 0.002 to 0.036 ± 0.003 for formulation 2, and 0.017 ± 0.002 to 0.038 ± 0.001 for formulation 3 after 28 days of storage period with and without the preservatives. Moreover, the proportion of whey and carrot juice shows significant changes in acidity. The possible reason for the increase in acidity might be that lactose and protein are converted into lactic acid and amino acids (Purkiewicz and Pietrzak-Fiećko, 2021). Similar inverse relation of acidity and pH was observed by Yadav et al. (2010), who employed acid whey produced by the acid coagulation of milk. They found that the acidity rises after 20 days of storage from 0.40 to 0.50. Similarly, Oliveira et al. (2022) observed an increase in acidity during 21 days of storage of orange juice whey drink.

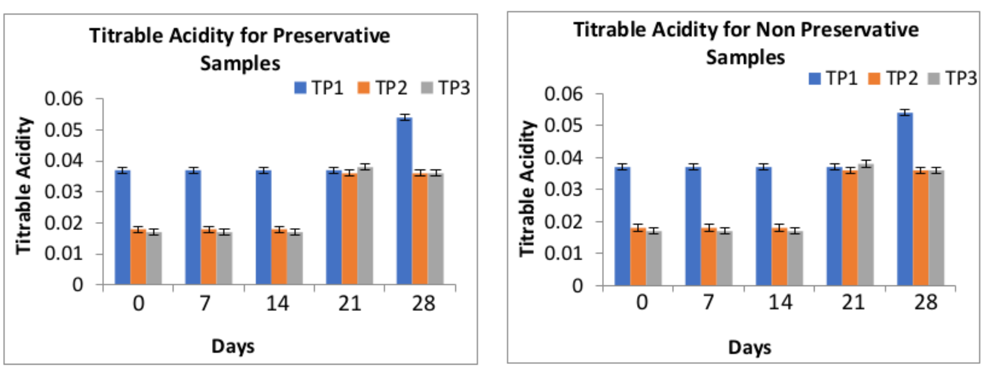

Fig 4 Acidity changes in beverage during storage with and without preservatives

3.2.4 Sweetness

The sweetness change with the change in the proportion of carrot juice and whey and the storage time is shown in Fig 5. It was found that their no significant ($p > 0.05$) changes in the sweetness of the beverages stored with and without the preservative. During the storage of 28 days, the sweetness of the whey-carrot beverage was found to be decreased significantly ($p < 0.05$) from 32.7±0.1 to 22.1 ± 0.2 for sample 1, 70±0.3 to 35±0.2 for sample 2, and 76.4±0.2 to 34.2±0.1 for sample 3 for both the samples stored with and without preservatives. Additionally, there was no change in the sweetness of the sample till the 14th day of storage, but after that, the sweetness starts decreasing. Colaric et al. (2005) concluded that the sweetness of fruits and fruit juices is influenced by the amount of acid and sugar to acid ratio. In continuation, the decreasing trend of sweetness in the prepared beverages during storage may increase the acidity of the samples.

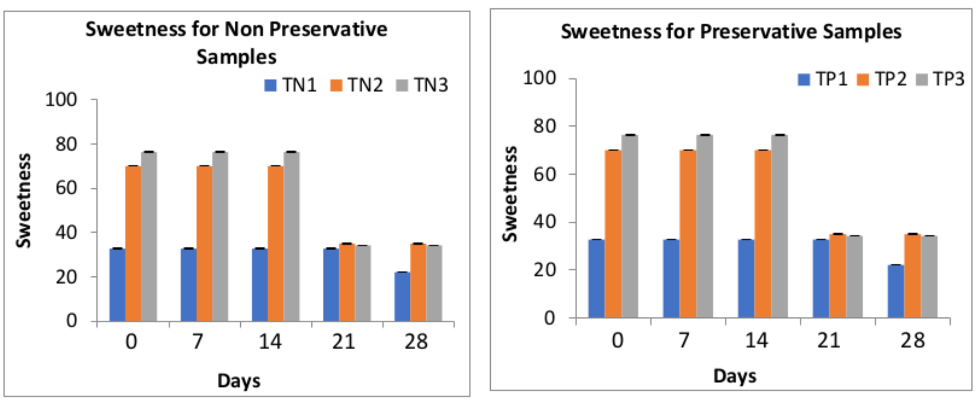

Fig 5 Sweetness changes in beverage during storage with and without preservatives

3.2.5 Reducing sugar (RS)

The changes in RS with storage time and proportion of carrot juice and whey stored with and without the preservative are shown in Fig 6. It was found that the RS significantly ($p < 0.05$) varies for the samples stored with and without the preservative. During the storage of the 28 days of the whey-carrot-based functional beverage, the RS was found to be changed from 29.1 ± 0.15 to 63.1 ± 0.1, 42.7 ± 0.35 to 47.5 ± 0.3, and 47.2 ± 0.35 to 39.8 ± 0.2 for sample 1, sample 2, and sample 3, respectively for the samples with preservatives. For the sample stored without preservatives, it was found to be changed from 22.7 ± 0.4 to 59.8 ± 0.4 for sample 1, 39.7 ± 0.3 to 37.8 ± 0.4 for sample 2, and 43.9 ± 0.2 to 38.6 ± 0.3 for sample 3. The highest RS was observed in sample 3 with a high concentration of carrot juice. It was also observed that the reducing sugar first increases till the 7th and 14th day of the storage and after that it starts decreasing. During the storage, the increase in the RS content may be due to the inversion of non-reducing sugar to reducing the sugar by the acids present in the whey-carrot-based beverage (Bhardwaj and Pandey, 2011). Pandey and Ojha (2020) found that reducing sugar increased with the storage period of whey-mango-based beverages. On the other hand, Barwal et al. (2005), observed a decrease in reducing the sugar of bitter gourd beverages.

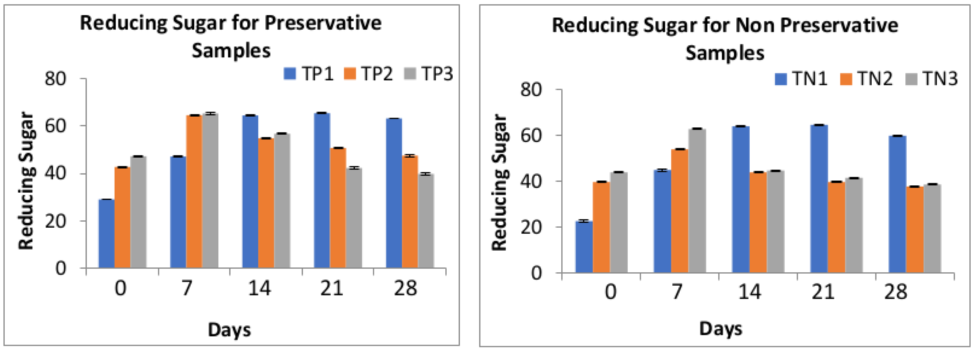

Fig 6 Reducing sugar changes in beverages during storage with and without preservatives

3.2.6 Total phenol content (TPC)

Fig 7 represents the changes in TPC of whey-carrot-based beverages during storage with and without preservatives. The TPC of the prepared beverage significantly varied ($p < 0.05$) for the beverage storage with and without the preservatives. During the storage, it was found to be changed from 0.28 ± 0.002 to 0.403 ± 0.003 for sample 1, 0.32 ± 0.002 to 0.45 ± 0.001 for sample 2, and 0.36 ± 0.003 to 0.467 ± 0.003 for sample 3 for beverages stored with preservatives. For the sample stored without preservatives, it was found to be changed from 0.306 ± 0.001 to 0.379 ± 0.001, 0.302 ± 0.001 to 0.357 ± 0.002, and 0.351 ± 0.001 to 0.312 ± 0.003 for sample 1, sample 2, and sample 3, respectively for the beverages stored without preservatives. The result also showed that there is an increase in TPC during the 21st day of storage, while it gradually decreased on the 28th day of storage. These findings are supported by the other different studies done on sugarcane (Zaman et al., 2023) and carbonated soft drinks (Tireki, 2021).

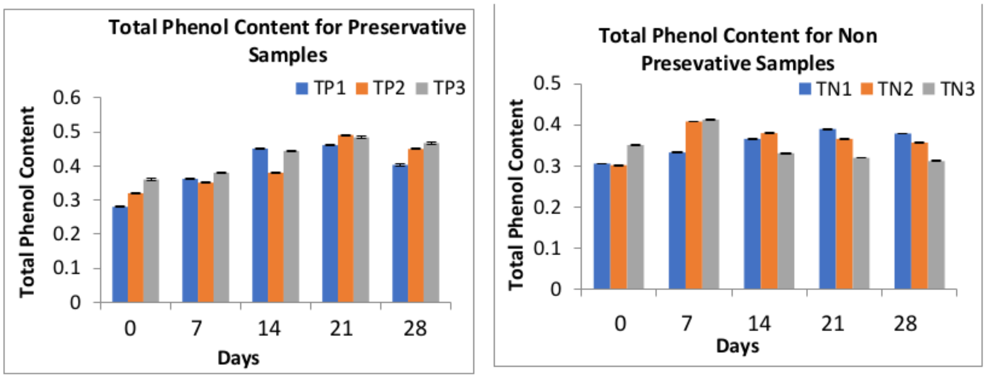

Fig 7 Total phenolic content in beverage during storage with and without preservatives

3.2.7 Percent acceptance (PA)

Fig 8 represents the PA of the whey-carrot-based functional beverage during the 28 days of storage with and without the preservative. It was found that there is decreasing trend in the acceptance percentage of the beverage with the increase in the storage days. The highest acceptance was found for the samples with the low amount of carrot juice i.e., sample 1. There is not much difference in the acceptance percentage of the beverage stored with and without the preservative. The decreasing trend in acceptance percentage during the storage is may due to various chemical changes during the storage of the product.

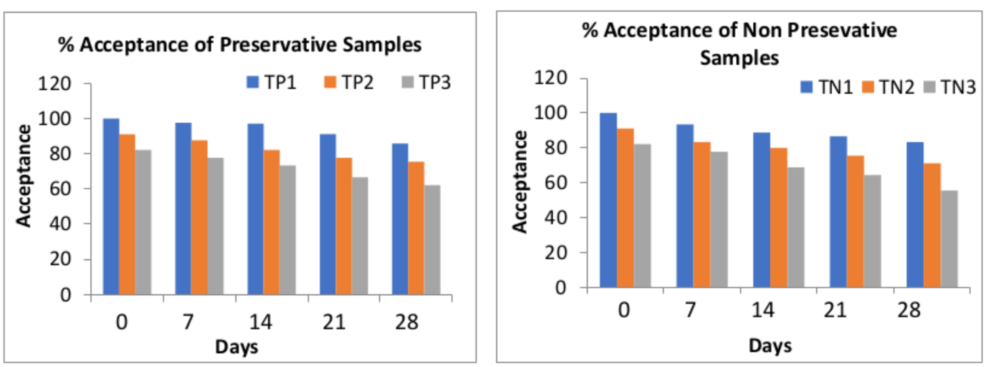

Fig 8 Percent acceptance of beverage during storage with and without preservative

4. Conclusion

The results of the study recommend that adding fruits and vegetables to whey supplements could be a viable alternative for creating nutritious beverages with the best sensory qualities and can be recommended for consumption. It can be hypothesized that the whey-carrot-based beverage could be a fascinating product for beverage industries by giving the benefits of bioactive elements present in both fruit and whey. Therefore, to use this beverage at a commercial scale, more research on shelf life, optimizing process conditions, quality improvement using stabilizer and packaging, and a clinical trial is required for benefits to human health.

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