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Research Article

Effect of different stabilizers on the physiochemical and sensory characteristics of Sea buckthorn berry, Ready-to-serve (RTS) beverage

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Abstract
In the process of product development of Sea buckthorn (*Hippophae rhamnoides*) Ready-To-Serve (RTS) beverages, it is commonly observed that sedimentation occurs prior to the pasteurization process and after pasteurization, that seems to be flocks formation. The present reSearch aimed to determine how stabilisers and concentration affect Sea buckthorn RTS's turbidity, viscosity, and physical stability during storage. The utilisation of three stabilisers, namely Carboxymethyl Cellulose (CMC) ,(GG) Guar Gum, and (XG) Xanthan Gum with various concentrations of were done on the basis of concentrations of CMC ranged from 0.35% to 0.47% , GG ranged from 0.05% to 0.2%, and concentrations of XG ranged from 0.1% to 0.56%. All used concentrations of stabilizers were within permissible limits as per Food Safety and Standards Authority of India (FSSAI) . Six key parameters were examined for stability: sedimentation, gel formation, turbidity, viscosity, physical stability, and sensory/organoleptic during storage period started 0 day to 24 days, room temperature. The present study revealed that Xanthan gum emerged as the most suitable stabiliser for Sea buckthorn RTS beverages compared to guar gum and carboxymethyl cellulose. A notable disparity was noted in the concentrations of stabilizers across varying concentrations. The utilization of a stabilizer did not yield any significant impact on the sensory parameters. Furthermore, total soluble solids (TSS), and pH had also been changed during storage. The addition of a 0.55% concentration of XG as a stabilizer to Cloudy Sea buckthorn juice resulted in the highest acceptance rating among the panellists, averaging at 7.81± 1.49 points. This formulation exhibited no precipitation in the RTS product under room-temperature storage.

Keywords: Sea buckthorn, Carboxymethyl Cellulose, Ready-To-Serve beverages

INTRODUCTION

The Sea buckthorn berry, scientifically known as *Hippophae rhamnoides*, belongs to the plant family *Elaeagnaceae*. Sea buckthorn harvesting is a prominent agronomic practice observed in cold and semiarid regions, particularly in the Himalayan regions. It is worth noting that the cultivation of Sea buckthorn significantly impacts the livelihoods of impoverished and rural communities, which heavily depend on a wide range of plantations comprising both zoological and botanical species to sustain their dietary needs (Chandra *et al*., 2018).

The berry possesses considerable importance as a notable reservoir and significant amounts of flavonoids, carotenoids, flavonol glycosides, and phytosterols have been observed in different plant components like pulp, seed and peel (Kumari and Sharma, 2020).

Xanthan gum (XG) is frequently employed as an additive in beverages containing citrus components and fruit-flavored beverages. It primarily enhances their textural attributes and serves as a stabilising agent for both aroma and flavour profiles. The mass fraction of XG employed in the formulation of these beverages falls within the range of 0.001–0.5%. XG is known for its rapid and thorough dissolution under acidic conditions, making it a valuable aid in achieving the suspension of insoluble components. Incorporating an increased mass fraction of XG within the range of 0.025% to 0.17% has been observed to contribute significantly to developing desirable textural attributes in fruit-flavored beverages, as reported by Zecher and Van Coillie (1992). In the context of orange juice, it has been observed that the addition of a specific combination of XG at a concentration range of 0.02-0.06% and carboxymethyl cellulose (CMC) at a concentration range of 0.02-0.14% serves the purpose of facilitating the suspension of orange pulp. This combination is found to be effective in stabilising the protein content present in the orange pulp, as reported by Pettitt in 1982. RTS beverages, the incorporation of GG as an additive, augment the texture and stability attributes to the product. This particular factor facilitated the prevention of ingredient separation and the achievement of a smooth and consistent mouthfeel. GG, in addition to its primary function, can also serve as a thickening agent, thereby imparting the beverage with a desirable viscosity (Phillips and Williams, 2020).

There is significant challenge in maintaining a uniform suspension of the pulp within the juice. In several RTS, a distinct separation between pulp and water is observed. In the context of fruit pulp, it has been observed that the process of pasteurization in RTS products often leads to the formation of flocks. This phenomenon can be attributed to the high pectin (10.32%) content present in the fruit pulp (Farzaliev *et al*., 2021). Hence, stabilizers such as Carboxymethyl cellulose, XG, and Guar gum are employed to maintain turbidity and suspension, thereby mitigating the occurrence of separation and the formation of flocks.

The degree of dilution before consumption and the quantity of soluble solids in the beverage determine how much Carboxymethyl cellulose or Guar gum is needed for optimum stability. Products that contain a lot of soluble solids are viscous and only need a little Carboxymethyl cellulose and Guar gum. Guar gum and Carboxymethyl cellulose reduces the development of rings around the bottle neck. Ruihuan Lv *et al.* (2017) revealed how Guar gum and its combinations with some other colloids affected orange juice's stability and physical qualities. Based on the findings of particle size distribution, cloudiness, scent analysis, sensory analysis, and rheological properties study, the optimal formulation was determined to be 0.01% Guar gum mixed with 0.37% Carboxymethyl cellulose. It is possible to conclude that Guar gum has the potential to be used as a thickening agent in orange juice. At the time, it is included in fruit products, including juice. It prevents layering and deposition while also giving the beverage a creamy flavor. Maintaining the pulp dispersion steady in fruit solutions like juice and other products containing a lot of pulp for long periods is challenging. However, a small amount of gum, or a suitable blend of natural gums, can produce goods with low viscosity and pleasant flavor. Furthermore, such polymers/gums improve the turbidity consistency of fruit juice held in containers. The ability of guar gum to form h - bonds with water molecules qualifies it for industrial applications. As a consequence, it is primarily used as a thickener and stabilizer. It also aids in managing various health issues, including diabetes, bowel motion, cardiovascular diSease, and even colorectal cancer (Liu *et al*., 2020).

In fruit beverages, Carboxymethyl cellulose is employed as a stabilizer. Fruit drinks are produced from diluted fruit juice and water. A citric acid/citrate buffer is typically made to enhance the texture and flavor of the beverage, and by improving the sensation of the beverage, additional sugar and Carboxymethyl cellulose may be acquired. Low-calorie drinks with no viscous input from sugar added would have been exceedingly thin and watery if no viscosity modifier was used. Because it gives an excellent texture and odor/smell, XG is frequently used as a flavor and taste stabilizer in citrus drinks and other fruit-flavoured beverages because of its effectiveness. The present reSearch aimed to determine how stabilisers and concentration affect Sea buckthorn RTS's turbidity, viscosity, and physical stability during storage.

MATERIALS AND METHODS

Pulp and chemicals procurement

Sea buckthorn pulp under the storage condition of -15^{0}C was purchased from Vital Herbs, New Delhi, India. The pulp was frozen at -15°C post procurement and stored in the same environment until investigation. CMC and Guar Gum were purchased from Himedia, Mumbai, India, and Xantham gum was purchased from Purix, Bakersville India PVT LTD, India. Granulated cane sugar and sodium benzoate were also used in these experiments.

Preparation of Sea buckthorn Ready-To-Serve beverage

The preparation of pure Sea buckthorn juice involved the thawing of the pulp at a controlled room temperature of 27°C. Subsequently, the juice underwent a dual filtration process involving the utilisation of both cheesecloth and a juice strainer. Official Methods of Analysis (AOAC)2012 methodology followed and titration technique was employed utilising a sodium hydroxide solution with a concentration of 0.1 mol/L as titrant.Experiment aimed to determine the overall amount of acid species present in the form of citric acid $(HOC(CH_2CO_2H)_2$. The pH of the freshly extracted Sea buckthorn juice was subsequently modified by employing citric acid to achieve the optimal value. The juice was sweetened using cane sugar syrup until the Total Soluble Solids (TSS) level reached 20° Brix. The stabilisers, namely Carboxymethyl cellulose, Guar gum, and XG, were subsequently incorporated into the mixture as

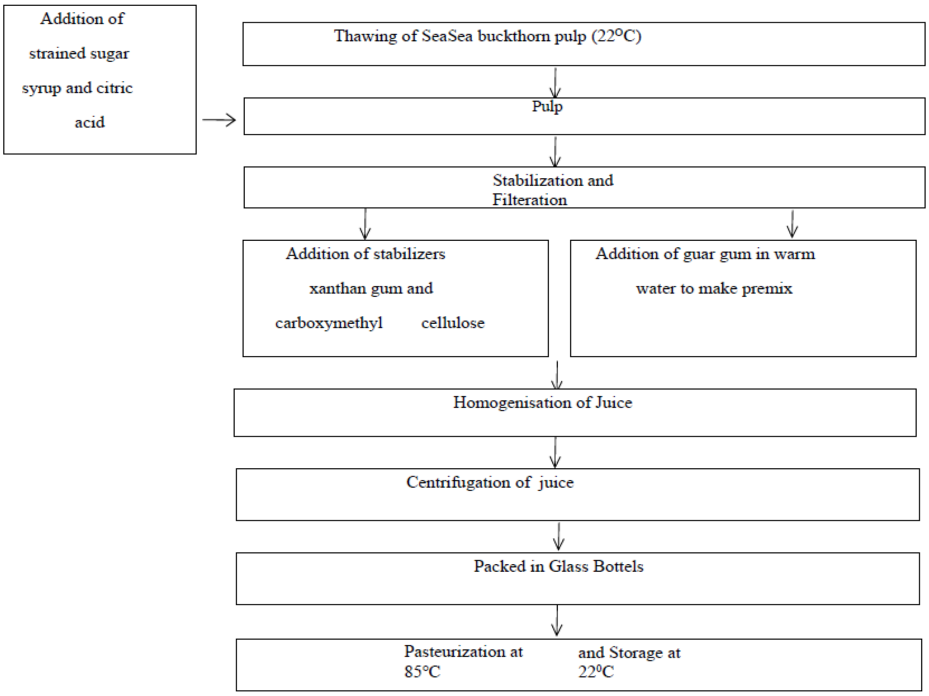

Fig 1. *Flow chart for preparation of Sea buckthorn Readt-To-serve beverage*

depicted in Fig. 1. The concentrations of the three stabilisers were determined in accordance with the guidelines and regulations set forth by the Food Safety and Standards Authority of India (FSSAI), as outlined in Table 1. The sensory effects of stabilisers on turbid RTS Sea buckthorn in pasteurised glass bottles held at room temperature were examined. Guar gum (GG), CMC and XG stabilisers were investigated.

Methodology of parameters

Sea buckthorn RTS was prepared and stored at room temperature for 24 days, and observations were taken every 6th day of sampling.

Total soluble solids (TSS)

Total soluble solids (TSS) were quantified as a percentage of Brix using the ATAGO PAL-α digital refractometer in triplicates. The total soluble solids (TSS) of the Sea buckthorn ready-to-serve (RTS) samples, both the control and fortified variants, were assessed at regular intervals of 06 days over 24 days. This assessment was conducted in triplicate to ensure the accuracy and reliability of the results.

pH (Acidity)

The pH of the Sea buckthorn ready-to-serve (RTS) beverage was determined using a pH Metre (Model: Auto deluxe LT-10, manufactured by Labtronics Instrument Pvt. Ltd, India). The samples were systematically observed at regular intervals of 15 days throughout the sampling period. The observations were recorded in triplicate, as is customary in scientific reSearch.

Viscosity (cP)

Viscosity of Sea buckthorn RTS was expressed in centipoise (cP). Redwood PSAW 1250, viscometer was used to analysed the viscosity of RTS during storage of 24 days. It was observed on every 15th day of samplings in triplicates. Firstly, the vessel was filled with water and regulated the temperature at 25□. 25 ml of RTS was weighed and pour it into the inner vessel. After attaining the temperature, the knob was pulled and time was noted.

Viscosity was calculated by a formula-

$$\gamma = \frac{0.0022t-1.6}{t} x\ specific\ gravity\ of\ sample$$

Eq.1 (Source AOAC Method)

Where,
t= time taken

Turbidity- Turbidity of Sea buckthorn RTS was expressed in Nephlometeric turbidity unit (NTU) as re-

Table 1. Sea buckthorn Ready-To-Serve with different concentrations of stabilizers

Stabilizer	C 1	C 2	C 3 Percent	C 4	C 5	C 6
CMC	0.35	0.37	0.39	0.41	0.43	0.45
GG	0.05	0.06	0.07	0.08	0.09	0.1
XG	0.1	0.2	0.3	0.4	0.5	0.55

C- Concentration, CMC- Carboxymethyl cellulose , GG- Guar gum, XG- Xanthan gum ported by Kumar *et al*., 1990. It was observed by the Decibel Nephlo/turbidity meter in triplicates.

Physical Stability- The physical stability of RTS was observed by the sediment size as per the formula . For 24 days, physical stability was recorded by using formula-

Physical stability= Hs/H_T X 100

Eq. 2 (Source AOAC Method)

Where, H_S- Height of sediment and

H_T- Height of Total

Sedimentation and gel formation- It was observed for 24^{th} days on every 6^{th} day of sampling by observing the bottles.

Sensory evaluation

For sensory evaluation non-trained panelists with age group from 20 years to 35 years selected for consumer acceptability. Some of the non-trained panellists were undergraduate and graduate students, and faculty of Life Sciences from Sharda University Greater Noida, Uttar Pradesh, India. Before sensory analysis, the beverages were chilled and presented in clear cups with clear ventilated lids at 4°C with non-salted wafers and drinking water. The assessment was conducted with all 6 concentrations of 3 stabilizers (XG, Carboxymethyl cellulose and Guar gum). The products have all been codes tagged and sparsely oriented to the respondents. On a 9-point hedonic measure, acceptance testing was used to gauge how much each object was valued, which included factors such as appearance, taste, odor, and overall acceptability, with 10 indicating extreme liking and 1 indicating severe disliking (Appendix 1).

Statistical analysis

All the data were taken in triplicates and taken out for Standard deviation for viscosity and turbidity of RTS. The data were subjected to Analysis of Variance (ANOVA) technique and analyzed according to two factorial completely randomized design (CRD). The critical difference (CD) value at 5 % level was used to compare physiochemical characteristics treated with different stabilizers during storage. Software OP stat (www.hau.ernet.in) was used to analyze the experimental results statistically.

RESULTS AND DISCUSSION

Total soluble solids

The investigation involved the periodic assessment of total soluble solids, with measurements taken consistently every sixth day throughout the designated sampling period.

Table 2 provides a comprehensive overview of the values associated with the three stabilisers utilised in the study. The TSS gradually increased throughout a 24-day storage period for all three stabilisers under investigation. The experiment results indicated that at 0.35% carboxymethyl cellulose (CMC) concentration, the total suspended solids (TSS) ranged from 10.3% to 11.8%. Similarly, at a concentration of 0.39% CMC, the TSS was observed to be between 10.5% and 11.9%. Furthermore, at a concentration of 0.45% CMC, the soluble solids were recorded to be between 10.4% and 11.4%. These findings suggest that the concentration of CMC had an impact on the TSS and soluble solids content in the solution. At a concentration of 0.05%, the total soluble solids (TSS) for GG ranged from 10.3% to 11.5%. Similarly, at a concentration of 0.07%, the TSS was observed to be between 10.3% and 11.8%. Finally, at a concentration of 0.10%, the soluble solids were recorded to be between 10.4% and 11.7%. The experiment results indicate that the concentration of XG at 0.1% yielded a range of TSS between 10.3% and 11.9%. Similarly, at a concentration of 0.4%, the TSS ranged from 10.2% to 11.9%. Furthermore, when the concentration was increased to 0.55%, the range of soluble solids recorded was between 10.3% and 11.8%. Total soluble solids were assessed at consistent intervals of every sixth day throughout the sampling period.

The present findings resemble the outcomes of a previous investigation conducted by Tiitinen *et al*. (2005). Specifically, the observed values fall within a comparable range of 7.4% to 12.6% brix, as reported in their study. The empirical data obtained from the study demonstrates a positive correlation between the duration of storage and the total soluble solids content. This implies that as the storage time elapses, there is a discernible and gradual augmentation in the concentration of dissolved solids. The potential factors that may contribute to this phenomenon are believed to encompass variations in the duration of storage, the materials used for packaging, the stability of ingredients, and the potential occurrence of hydrolysis of polysaccharides (Mgaya-Kilima *et al*., 2014). No statistically significant differences were observed among the various stabilisers (CMS, GG and XG) used to treat RTS products. The total soluble solids (TSS) have exhibited a gradual increase throughout the storage of RTS products.

pH

The study encompassed the systematic evaluation of pH(acidity) measurements were conducted at regular intervals of every sixth day over the specified sampling duration. Table 3 presents a comprehensive summary of the values linked to the three stabilisers employed in the investigation. Throughout the 24^{th}days storage period, it was observed that the pH levels remained consistent for all three stabilisers that were being investigated. The pH values of Sea buckthorn ready-to-serve

Table 2. Total soluble solid of stabilizer treated Sea buckthorn Ready- To Serve beverage

Stabilizer used	Concentration %	Total soluble solids (mg/L)					Mean
		0 day	6th day	12th day	18th day	24th day	
CMC	0.35	10.3	10.7	10.9	11.5	11.8	11.04
	0.37	10.3	10.5	11.2	11.6	11.4	11.00
	0.39	10.5	10.4	11.1	11.5	11.9	11.08
	0.41	10.3	10.8	11.1	11.5	11.9	11.12
	0.43	10.5	10.5	11.3	11.4	11.8	11.10
	0.45	10.4	10.6	11.1	11.6	11.4	11.02
GG	0.05	10.3	10.7	11.0	11.5	11.5	11.00
	0.06	10.2	10.6	11.4	11.6	11.6	11.08
	0.07	10.3	10.7	11.2	11.6	11.8	11.12
	0.08	10.2	10.6	11.3	11.5	11.5	11.34
	0.09	10.1	10.8	11.2	11.5	11.7	11.06
	0.10	10.4	10.7	11.4	11.7	11.7	11.18
XG	0.1	10.3	10.5	10.9	11.4	11.9	11.00
	0.2	10.1	10.6	11.2	11.5	11.9	11.06
	0.3	10.3	10.7	11.2	11.6	11.8	11.12
	0.4	10.2	10.7	11.1	11.6	11.9	11.10
	0.5	10.2	10.8	11.1	11.4	11.8	11.06
	0.55	10.3	10.7	11.3	11.5	11.8	11.12
Mean		10.29	10.64	11.15	11.52	11.74	
CD at 5%	P>0.05 (NS)						

CMC- Carboxymethyl cellulose, GG- Guar gum, XG- Xanthan gum

Table 3. pH of stabilizer treated Sea buckthorn Ready-To-Serve beverage

Stabilizer used	Concentration %	pH					Mean
		0 day	6th day	12thday	18th day	24th day	
CMC	0.35	2.5	2.5	2.5	2.5	2.5	2.5
	0.37	2.5	2.7	2.5	2.5	2.5	2.5
	0.39	2.5	2.5	2.5	2.5	2.5	2.5
	0.41	2.5	2.5	2.5	2.5	2.5	2.5
	0.43	2.5	2.6	2.5	2.5	2.5	2.5
	0.45	2.5	2.6	2.5	2.5	2.5	2.5
GG	0.05	2.5	2.6	2.6	2.6	2.6	2.5
	0.06	2.5	2.7	2.5	2.5	2.5	2.5
	0.07	2.5	2.	2.5	2.5	2.5	2.5
	0.08	2.5	2.6	2.6	2.7	2.7	2.5
	0.09	2.5	2.5	2.5	2.5	2.5	2.5
	0.10	2.5	2.6	2.5	2.5	2.5	2.5
XG	0.1	2.5	2.5	2.5	2.5	2.5	2.5
	0.2	2.5	2.5	2.5	2.5	2.5	2.5
	0.3	2.5	2.5	2.5	2.5	2.5	2.5
	0.4	2.5	2.7	2.5	2.5	2.5	2.5
	0.5	2.5	2.5	2.5	2.5	2.5	2.5
	0.55	2.5	2.5	2.5	2.5	2.5	2.5
Mean		2.5	2.5	2.5	2.5	2.5	
CD at 5%	P>0.05						

CMC- Carboxymethyl cellulose, GG- Guar gum, XG- Xanthan gum

(RTS) remained consistently stable at a level of 2.5 over the course of a 24thday storage period, regardless of the three stabilisers utilised in the reSearch investigation. Based on the obtained experimental data, it can be concluded that the pH levels did not demonstrate any statistically significant alterations after applying the stabiliser treatment.

Viscosity

Observations for carboxymethyl cellulose (CMC)

CMC, also known as carboxymethyl cellulose, is a commonly utilized ingredient in the food and beverage

Table 4. *Viscosity(cP) of different concentrations of carboxymethyl cellulose at storage of 24th day*

Concentration %	0 day	6th day	12th day	18th day	24th day
0.35	1.20 ± 0.01	1.22 ± 0.24	1.24 ± 0.01	1.25 ± 0.08	1.26 ± 0.03
0.37	1.21 ± 0.05	1.23 ± 0.08	1.25 ± 0.03	1.26 ± 0.04	1.26 ± 0.01
0.39	1.24 ± 0.05	1.25 ± 0.14	1.27 ± 0.09	1.28 ± 0.03	1.30 ± 0.06
0.41	1.24 ± 0.04	1.28 ± 0.16	1.31 ± 0.02	1.32 ± 0.09	1.32 ± 0.01
0.43	1.25 ± 0.02	1.29 ± 0.07	1.32 ± 0.01	1.34 ± 0.05	1.36 ± 0.08
0.45	1.28 ± 0.03	1.30 ± 0.02	1.32 ± 0.08	1.35 ± 0.04	1.36 ± 0.04

Results are expressed as Mean±SD for triplicates

Table 5. Viscosity (cP) of different concentrations of Guar gum treated Sea Buckthorn Ready -To-Serve during storage of 24th day

Concentration %	0 day	6th day	12th day	18th day	24th day
0.1	1.22 ± 0.02	1.23 ± 0.01	1.23 ± 0.04	1.24 ± 0.01	1.25 ± 0.04
0.2	1.23 ± 0.03	1.24 ± 0.08	1.25 ± 0.03	1.26 ± 0.12	1.27 ± 0.09
0.3	1.24 ± 0.08	1.25 ± 0.01	1.25 ± 0.01	1.26 ± 0.22	1.27 ± 0.06
0.4	1.24 ± 0.06	1.26 ± 0.00	1.26 ± 0.02	1.27 ± 0.32	1.28 ± 0.09
0.5	1.26 ± 0.01	1.26 ± 0.07	1.27 ± 0.01	1.28 ± 0.14	1.28 ± 0.06
0.55	1.28 ± 0.08	1.28 ± 0.07	1.30 ± 0.01	1.30 ± 0.18	1.30 ± 0.09

Results are expressed as Mean±SD for triplicates

industry, particularly in ready-to-serve (RTS) products. CMC is commonly incorporated into ready-to-serve (RTS) products for various applications, such as stabilisation, thickening, and emulsification.

In the present investigation, CMC was employed at six distinct concentrations, as outlined in Table 4. Sediments were visually detected in the CMC treated RTS samples at concentrations of 0.35%, 0.37%, 0.39%, and 0.41%. The results of our study indicate that increasing the concentration of CMC led to a corresponding increase in viscosity. Specifically, on the initial day of sampling, the viscosity values were measured at 0.41%- 1.24 ± 0.04, 0.43%- 1.25 ± 0.02, and 0.45%- 1.28 ± 0.03 for different concentrations of CMC. As the sampling period progressed to the 24th day, the viscosity values further increased to 0.41%- 1.32 ± 0.01, 0.43%- 1.36 ± 0.08, and 0.45%- 1.36 ± 0.04. These findings align with a previous study conducted by Meihle *et al*. (2021), who also investigated the impact of CMC on diffusion when combined with a glucose solution. The observed concentrations of 0.35%, 0.37%, and 0.39% did not exhibit significant increases in viscosity, as indicated in Table 4. The formation of a gel matrix within a beverage can occur when the concentration of CMC surpasses a specific threshold. This phenomenon transforms the beverage's physical state, causing it to transition from a liquid to a gel-like consistency, as noted by Phillips and Williams in their recent study (2020). Similarly, the present investigation also observed this effect.

Observations for Guar gum (GG)- Ready To Serve beverages, the incorporation of GG as an additive serves the purpose of augmenting the texture and stability attributes of the product. This particular factor facilitated the prevention of ingredient separation and the achievement of a smooth and consistent mouthfeel. GG, in addition to its primary function, can also serve as a thickening agent, thereby imparting the beverage with a desirable viscosity (Phillips and Williams, 2020). In the present study, the addition of GG in Sea buckthorn Ready To Serve beverage, a total of six concentrations were analyzed (Table 5). The recorded data in Table 4 indicates that the beverages under reSearch exhibited elevated levels of viscosity. Akkarachaneeyakorn *et al*. (2015) conducted a study wherein they examined the quantity and type of stabilizers employed in mulberry juice and had similar observations like it has. Furthermore, it was observed that the viscosity decreased at lower concentrations (0.05%, 0.06%, and 0.07%) compared to higher concentrations. A recent investigation by Bochare *et al*. (2020) examined the impact of different concentrations of GG on kiwi fruit RTS beverages infused with lemongrass. The findings revealed that more GG use leads to increased viscosity. The same observation was also observed in the present study.

Xanthan gum (XG)

XG is a polysaccharide that is obtained through the process of fermenting carbohydrates. This compound has the unique capability to modulate and regulate the viscosity of Ready To Serve beverages. The utilisation of XG in a product formulation allows manufacturers to achieve the desired viscosity or texture, resulting in an

Table 6. Viscosity (cP) of different concentrations of Xanthan gum treated Ready-To-Serve during storage of 24th day

Concentration %	0 day	6th day	12th day	18th day	24th day
0.1	1.22 ± 0.02	1.23 ± 0.01	1.23 ± 0.04	1.24 ± 0.01	1.25 ± 0.04
0.2	1.23 ± 0.03	1.24 ± 0.08	1.25 ± 0.03	1.26 ± 0.12	1.27 ± 0.09
0.3	1.24 ± 0.08	1.25 ± 0.01	1.25 ± 0.01	1.26 ± 0.22	1.27 ± 0.06
0.4	1.24 ± 0.06	1.26 ± 0.00	1.26 ± 0.02	1.27 ± 0.32	1.28 ± 0.09
0.5	1.26 ± 0.01	1.26 ± 0.07	1.27 ± 0.01	1.28 ± 0.14	1.28 ± 0.06
0.55	1.28 ± 0.08	1.28 ± 0.07	1.30 ± 0.01	1.30 ± 0.18	1.30 ± 0.09

Results are expressed as Mean±SD for triplicates

Table 7. Turbidity of different concentrations of Xanthan gum treated Ready-To-Serve during storage of 24th day

Concentration %	0 day	6th day	12th day	18th day	24th day
0.35	18.00 ± 1.10	19.00 ± 0.00	20.00 ± 0.01	22.00 ± 0.03	24.00 ±0.01
0.37	20.00 ± 0.05	20.00 ± 0.00	22.00 ± 0.09	24.00 ± 0.00	24.00± 0.03
0.39	22.00 ± 2.03	22.00 ± 0.00	24.00 ± 0.00	26.00 ± 0.00	26.00± 0.04
0.41	24.00 ± 1.10	24.00 ± 0.15	26.00 ± 0.00	26.00 ± 0.00	28.00± 0.00
0.43	25.00 ± 0.08	26.00 ± 0.00	28.00 ± 0.00	28.00 ± 0.03	32.00± 0.09
0.45	28.00 ± 0.06	28.00± 0.19	30.00 ± 0.01	31.00 ± 0.01	32.00± 0.03

Results are expressed as Mean±SD for triplicates

improved sensory experience characterised by a pleasant and smooth mouthfeel (Phillips and Williams, 2020). The Sea buckthorn Ready To Serve beverage, with concentrations of XG at 0.1%, 0.2%, and 0.3%, did not exhibit any significant alterations in its viscosity.

The experimental results indicated that XG exhibited superior performance in various aspects, including sedimentation, gel formation, appearance, taste, viscosity, and turbidity, when tested at a concentration of 0.55%. Notably, no visible flocks were observed in the container containing XG. Therefore, the concentration of XG stabilizer selected for subsequent processing was determined to be 0.55%.

Turbidity

Carboxymethyl Cellulose (CMC)

The investigation entailed an examination of the stability of Sea buckthorn Ready To Serve beverage treated with CMC, with turbidity serving as the analytical parameter. The turbidity of Sea buckthorn ready-to-serve (RTS) beverage increased when subjected to treatment with Carboxymethyl cellulose, as observed during the storage period (Table 7).

During the initial day of the sampling process, the recorded turbidity level was observed to be 18.6±1.10 Nephelometric Turbidity Units (NTU) for a concentration of 0.35%. Subsequently, as the concentration was increased, the turbidity level also exhibited an upward trend, eventually reaching a maximum value of 30 NTU. The observed phenomenon exhibits a positive correlation with time, resulting in the transformation of the solution into a visually opaque state, thereby inducing an escalation in the turbidity of the Ready To Serve. The turbidity levels of various concentrations of Ready To Serve were observed during storage. It was found that the Ready To Serve sample with a concentration of 0.45% exhibited the highest turbidity after the storage period, measuring 32 NTU.

Gaur gum (GG)

The study involved a comprehensive analysis of the stability of Sea buckthorn RTS beverage that was treated with GG. The primary focus of the investigation was to evaluate the impact of GG treatment on the turbidity of the beverage, which was used as the key analytical parameter for assessing stability. The turbidity of the Sea buckthorn RTS beverage demonstrates an observable rise when exposed to treatment with GG, as evidenced by the data presented in Table 8 over the course of the storage period. The turbidity of RTS beverages treated with Guar gum exhibits an increase over time, as indicated in Table 6. The turbidity of GG treated RTS samples was found to be the highest among the three stabilizers tested, namely Carboxy methyl cellulose and XG. Specifically, on the 24th day of storage, the GG treated RTS exhibited a turbidity level of 50 NTU.

Xanthan Gum (XG)

Xanthan gum, a commonly employed food additive, finds frequent application in various food and beverage products, particularly in juice, serving as a stabiliser

Table 8. Turbidity (NTU) of Guar gum treated Sea buckthorn Ready-To-Serve during storage of 24th day

Concentration %	0 day	6th day	12th day	18th day	24th day
0.05	36.00 ± 0.00	38.00 ± 0.00	40.00 ± 0.01	42.00 ± 0.03	44.00 ±0.01
0.06	36.00 ± 1.10	38.00 ± 0.00	42.00 ± 0.09	44.00 ± 0.00	44.00± 0.03
0.07	38.00 ± 0.08	40.00 ± 0.00	44.00 ± 0.00	46.00 ± 0.00	46.00± 0.04
0.08	40.00 ± 0.06	42.00 ± 0.10	46.00 ± 0.00	48.00 ± 0.00	48.00± 0.00
0.09	41.00 ± 1.10	42.00 ± 0.00	46.00 ± 0.00	48.00 ± 0.03	50.00± 0.09
0.1	42.00 ± 0.0	44.00± 0.02	48.00 ± 0.01	50.00 ± 0.01	50.00± 0.03

Results are expressed as Mean±SD for triplicates using ANOVA test

Table 9.Turbidity (NTU) of Xanthan Gum treated Sea buckthorn Ready-To-Serve during storage on 24th day

Concentration %	0 day	6th day	12th day	18th day	24th day
0.1	22.00 ± 0.04	24.00 ± 0.00	24.00 ± 0.00	26.00 ± 0.09	28.00 ±0.00
0.2	24.00 ± 0.03	26.00 ± 0.01	26.00 ± 0.01	28.00 ± 0.00	30.00± 0.00
0.3	24.00 ± 0.05	25.00 ± 0.08	28.00 ± 0.00	30.00 ± 0.01	32.00± 0.01
0.4	28.00 ± 0.02	28.00 ± 0.00	30.00 ± 0.00	30.00 ± 0.03	32.00± 0.00
0.5	28.00± 0.02	28.00 ± 0.01	30.00 ± 0.00	32.00 ± 0.00	32.00±0.02
0.55	30.00 ± 0.01	30.00 ± 0.00	32.00 ± 0.00	34.00 ± 0.02	34.00± 0.00

Results are expressed as Mean±SD for triplicates

and thickening agent. The incorporation of XG into Sea buckthorn ready-to-serve (RTS) products has been observed to yield several beneficial effects. Notably, the addition of xanthan gum has been found to enhance stability, mitigate sedimentation, and positively influence the texture of the RTS formulation. In turbidity, it is noteworthy to mention that XG exhibited a dualistic impact, encompassing both advantageous and disadvantageous aspects. When employed in suitable quantities, XG has the potential to enhance visual clarity by impeding the settling and formation of sedimentary particles. The utilisation of this technique aids in the preservation of a consistent distribution of particles, such as pulp or fruit solids, within the juice. In the specific case of RTS beverages derived from Sea buckthorn pulp, it was observed that a concentration of 0.5% did not meet acceptability standards due to the formation of flocks following the pasteurisation process. However, when the concentration was raised to 0.55%, the RTS beverage became acceptable in terms of sensory attributes. The turbidity of Sea buckthorn RTS gradually increased over time, as observed in the experimental results. Specifically, the turbidity values measured at 0.1% concentration showed a progression from an initial value of 22.00 ± 0.04 NTU to a final value of 28.00 ± 0.00 NTU. At an initial turbidity level of 0.4%, the observed turbidity on day 0 was measured to be 28.00 ± 0.02 NTU. Throughout the storage period, the turbidity increased to 32.00 ± 0.00 NTU values pertaining to turbidity are given in Table 9.

Physical stability

Preserving physical stability in Sea buckthorn Ready To Serve beverages (Table 10) is paramount in ensuring product quality and consumer satisfaction. Stability, in the context of beverages, pertains to the ability of the product to maintain its desired appearance, texture, and uniformity over an extended period without experiencing undesirable alterations such as separation, sedimentation, clumping, or haze formation. The physical stability of ready-to-serve (RTS) products is contingent upon many factors, encompassing homogenization techniques, storage temperature, pH levels, emulsification processes, and stabilisation methods (Patra *et al*., 2021).

Sedimentation and gel formation-Carboxymethyl Cellulose (CMC)

In the current investigation, CMC was employed at six distinct concentrations, as outlined in Table 11. Sediments were visually detected in the CMC-treated RTS (ready-to-serve) beverage samples at concentrations of 0.35%, 0.37%, 0.39%, and 0.41%. No discernible sedimentation was detected in solutions with concentrations of 0.43% and 0.45%. However, a minor formation of gel-like substance was observed. The observed phenomenon could be attributed to an increased CMC concentration. According to Phillips and Williams (2020), the presence of concentrated CMC has been observed to result in thickening. Additionally, It has been noted that visible particles tend to settle at the bottom of the container.

Table 10. Physical stability of Sea buckhorn Ready-To- Serve beverage

Stabilizer used	Concentration %	Physical stability				
		0 day	6th day	12th day	18th day	24th day
CMC	0.35	-	-	-	28	32
	0.37	-	-	28	32	32
	0.39	-	-	32	32	36
	0.41	-	-	32	36	36
	0.43	-	32	36	40	40
	0.45	-	-	36	40	44
GG	0.05	-	-	-	16	20
	0.06	-	20	24	28	32
	0.07	-	20	20	24	28
	0.09	-	32	36	44	44
	0.10	-	32	40	44	44
XG	0.1	-	16	24	28	32
	0.2	-	16	24	24	28
	0.3	-	24	28	32	34
	0.4	-	28	28	32	34
	0.5	-	-	-	16	20
	0.55	-	-	-	-	-

CMC- Carboxymethyl cellulose, GG- Guar gum, XG- Xanthan gum

Table 11. Observations for sedimentation and gel formation of carboxymethyl cellulose treated Sea buc thorn Ready-To-Serve beverage beverage

Concentration %	Sedimentation	Gel formation
0.35	Observed	Not Observed
0.37	Observed	Not Observed
0.39	Observed	Not Observed
0.41	Observed	Slightly jelly formation was observed
0.43	Not Observed	Thick jelly layer was observed
0.45	Not Observed	Thick gel layer was observed

Guar gum (GG) - During the experimental observation, it was noted that three different concentrations, namely 0.05%, 0.06%, and 0.07%, were subjected to sedimentation without any occurrence of gel formation. However, it is worth mentioning that a slight jelly-like texture was observed in the 0.07% concentration (Table 12).

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Sensory evaluation of stabilizer treated Sea buckthorn Ready-To-Serve

Beverages comprising XG, Guar gum and Carboxymethyl cellulose were evaluated using sensory testing, and the overall results showed a significant difference between the three types of gum. But, due to sensory aspects, the different types of stabilizers did not have an effect on any physiochemical measures. However, the untrained panellist preferred the RTS containing XG over Carboxymethyl cellulose or Guar gum. In citrus drinks and other fruit-flavored beverages, XG is frequently used as an odor and flavor stabilizer because it provides an excellent mouth feel and odor.

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Table 12. Observations for sedimentation and gel formation of guar gum treated Ready-To-Serve beverage

Concentration %	Sedimentation	Gel formation
0.05	Observed	Not Observed
0.06	Observed	Not Observed
0.07	Observed	Slight jelly like layer formed
0.08	Not Observed	Observed
0.09	Not Observed	Observed
0.1	Not Observed	Observed

Table 13. Observations for sedimentation and gel formation of Xanthan gum treated Sea buckthorn Ready-To-Serve beverage

Concentration %	Sedimentation	Gel/ flocks formation
0.1	Sedimentation	No gel formation
0.2	Sedimentation	No gel formation
0.3	Sedimentation	No gel formation
0.4	no sedimentation	Flocks' formation
0.5	no sedimentation	Flocks' formation
0.55	no sedimentation	No gel formation

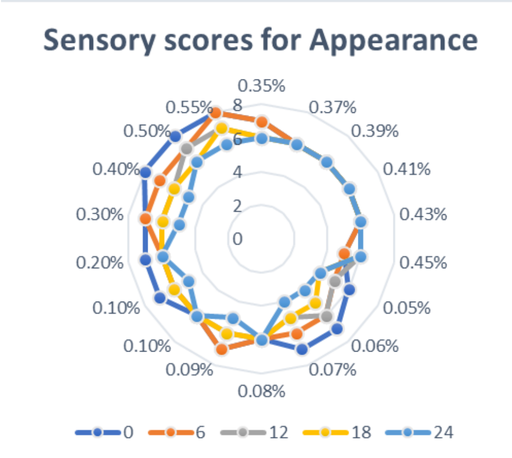

Fig. 2. *Sensory score of stabilizers treated Sea buckthorn Ready-ToServe for appearance*

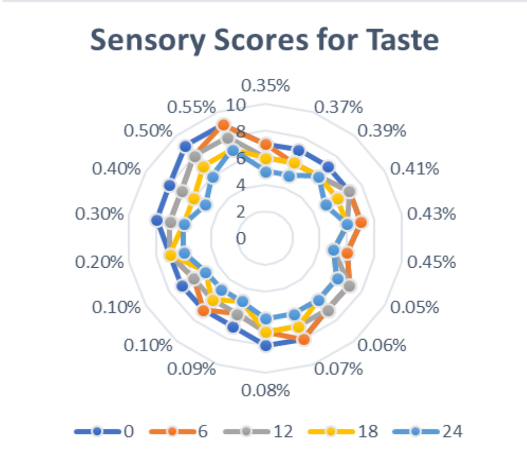

Fig 3. *Sensory score of stabilizers treated Sea buckthorn Ready-To-Serve beverage for taste*

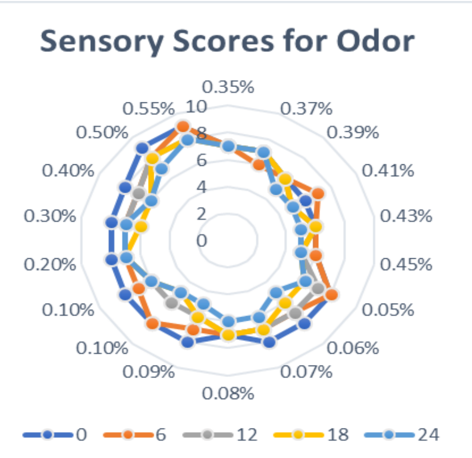

Fig. 4. *Sensory score of Stabilizers treated Sea buckthorn Ready To Serve beverage for odour*

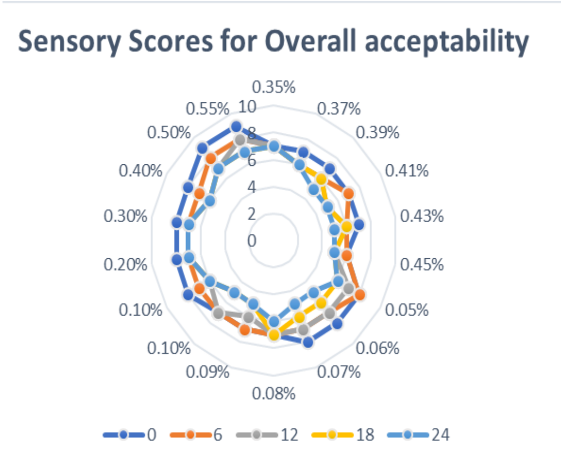

Fig. 5. *Sensory score of stabilizers treated Sea buckthorn Ready-To-Serve beverage for overall acceptability*

trained panellist preferred the RTS containing XG over Carboxymethyl cellulose or Guar gum. In citrus drinks and other fruit-flavored beverages, XG is frequently used as an odor and flavor stabilizer because it provides an excellent mouth feel and odor.

The RTS comprising guar gum concentrations of 0.05%, 0.06% and 0.07% was not acceptable by tasters as the RTS samples were observed as hazy. Although the overall acceptability had average score. But compared with other concentrations of Guar gum, 0.09% and 0.1% had better scores in terms of overall acceptability.

XG (0.55%) treated Sea buckthorn Ready To Serve has slightly different scores with 0.5%. This concentration of XG had increased because, in 0.5%, flocks formed after pasteurization. In terms of taste (Fig 2), odor (Fig 3), appearance (Fig 1) and overall acceptability (Fig 1), XG with 0.55% was most acceptable by non-trained panelists.

Conclusion

With the escalation of the mass fraction of each stabilizer, an elevation was observed in gel formation, sedimentation, turbidity, and viscosity of prepared Sea buckthorn RTS. Among all, xanthan gum with a mass fraction of 0.55% treated RTS showed better physical stability, turbidity, and viscosity results than Carboxymethyl cellulose and Guar gum in better textural characteristics. No sedimentation and gel formation was observed in juice containing XG (0.55%) for 24 days of storage. Further, the type and quantity of stabilizer did not seem to influence the RTS's pH and TSS. However, pH remained constant during the storage of 24 days while TSS progressively increased for all the 3 stabilizers in all 6 concentrations. The appearance, odor, taste, and overall acceptability had markable difference. Sea buckthorn RTS should be a homogenous concentration of Sea buckthorn pulp without any precipitation post-storing. The XG stabiliser (mass fraction 0.55 %) generated a composition without a precipitate following 24 storage days.XG is cost- effective additive and easily available in market and commonly used in value added products. XG is also most suitable for commercial products such as Sea buckthorn berry juice and RTS beverages.

Conflict of Interest

The authors declare that they have no conflict of interest.

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