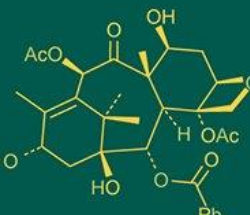


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(6): 1086-1088
www.biochemjournal.com
Received: 08-04-2026
Accepted: 13-05-2026

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Development and standardization of sterilized carrot Kheer: Evaluation of physicochemical, sensory and storage characteristics

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6Sm.8770>

Abstract

The incorporation of vegetables into dairy products is an effective approach to enhance their nutritional and functional value. Carrot (*Daucus carota* L.) is a rich source of β -carotene, vitamins, minerals, dietary fiber, and natural antioxidants, making it a suitable ingredient for the development of value-added dairy products. The present study was undertaken to develop and standardize sterilized carrot kheer and evaluate its physicochemical, sensory, and storage characteristics. Carrot kheer was prepared by incorporating shredded carrot at three levels (20, 30, and 40%) along with 8% sugar, 3% ghee, and 2.5% dry fruits. The shredded carrot was sautéed in ghee to develop characteristic flavour, followed by the addition of milk, sugar, and dry fruits. The mixture was concentrated to the desired consistency, filled into glass bottles, sealed, sterilized, and stored at room temperature. The sensory quality of the product was evaluated using a 9-point Hedonic scale. Among the treatments, carrot kheer containing 30% shredded carrot was most preferred by the sensory panel. The optimized product contained 8.2% fat, 33.30% total solids, 0.17% titratable acidity, and 21.10 °Brix total soluble solids. The overall acceptability score of the fresh product was 7.50, which decreased to 6.50 after 28 days of storage but remained within the acceptable range. The results indicated that incorporation of carrot improved the nutritional quality, sensory attributes, and palatability of kheer, while sterilization effectively enhanced its storage stability and shelf life. Therefore, sterilized carrot kheer may be considered a promising value-added dairy dessert with improved consumer acceptability and extended keeping quality.

Keywords: Carrot kheer, sterilization, milk, β -carotene, sensory evaluation, shelf life, value addition

Introduction

Traditional dairy products play an important role in the Indian diet because of their nutritional value, sensory appeal, and cultural significance. Kheer is one of the most popular milk-based desserts consumed throughout the Indian subcontinent. The incorporation of fruits and vegetables into dairy products has emerged as an effective approach to enhance their nutritional quality and functional properties [8].

Carrot (*Daucus carota* L.) is a nutrient-rich root vegetable and an excellent source of β -carotene, dietary fiber, vitamins, minerals, and phenolic compounds. β -Carotene acts as a precursor of vitamin A and contributes significantly to antioxidant activity, immune function, and vision health [4, 5]. Regular consumption of carotenoid-rich vegetables has been associated with reduced risk of chronic diseases linked to oxidative stress and inflammation [6].

The development of vegetable-fortified dairy products has gained considerable attention in recent years owing to increasing consumer demand for functional foods. Incorporation of carrot into dairy desserts can improve nutritional value, natural color, flavor, and antioxidant potential while enhancing consumer acceptance [3]. Furthermore, the use of natural plant ingredients aligns with current trends toward clean-label and health-promoting foods.

Despite its popularity, traditional kheer has a limited shelf life because of its high moisture content and susceptibility to microbial spoilage. Thermal sterilization is an effective preservation method that ensures microbial safety and extends product shelf life while maintaining acceptable sensory quality [1]. Therefore, the present study was undertaken to develop and standardize sterilized carrot kheer and evaluate its physicochemical, sensory, and storage characteristics.

Materials and Methods

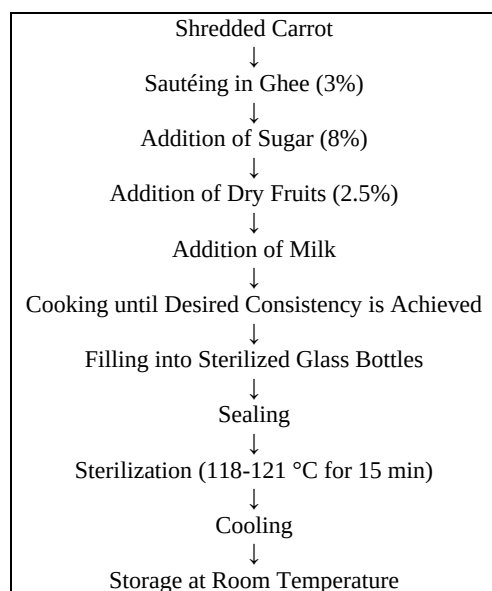
Raw Materials

Fresh cow milk containing 4.1% fat was procured from a private dairy farm located near the College of Dairy Science and Food Technology, Raipur, Chhattisgarh. Fresh carrots (*Daucus carota* L.), cane sugar, ghee, and dry fruits (almond, raisin, and cashew nut) were purchased from the local market and used for the preparation of carrot kheer. Carrot was selected because of its high content of β -carotene, dietary fiber, vitamins, minerals, and antioxidant compounds, which contribute to the nutritional enhancement of dairy-based products [5, 7].

Preparation of Sterilized Carrot Kheer

Sterilized carrot kheer was prepared by incorporating shredded carrot at three different levels, namely 20%, 30%, and 40% (w/w) based on the quantity of milk. Sugar (8%), ghee (3%), and dry fruits (2.5%) were added with respect to the quantity of milk used.

For the preparation of carrot kheer, the predetermined quantity of shredded carrot was sautéed in ghee under low heat until the characteristic flavour was developed. Subsequently, sugar, dry fruits, and milk were added, and the mixture was cooked with continuous stirring until the desired concentration and consistency were achieved [3, 8].



Flow Chart for Preparation of Sterilized Carrot Kheer

The prepared kheer was hot-filled into clean and sterilized glass bottles, sealed using a bottle-capping machine, and subjected to sterilization at 118-121 °C for 15 min. Thermal sterilization was employed to improve microbial safety and extend the storage stability of the product [1, 10]. After sterilization, the bottles were cooled and stored at room temperature for physicochemical and sensory evaluation.

Sensory Evaluation

The sensory quality of fresh and stored carrot kheer samples was evaluated using a 9-point Hedonic scale. A panel of six trained judges assessed the samples for colour and appearance, flavour, mouthfeel, sweetness, overall flavour, and overall acceptability. Sensory evaluation was conducted at 7-day intervals throughout the storage period. The methodology adopted for sensory analysis was in

accordance with standard practices widely used for dairy and food products [9].

The experimental data were analyzed using a Randomized Block Design (RBD) with a split-plot arrangement, and treatment means were compared to determine significant differences among samples.

Physicochemical Analysis

The carrot kheer samples were analyzed for fat, total solids (TS), titratable acidity, pH, and total soluble solids (TSS). Fat content was determined by the Gerber method, total solids by the gravimetric method, and acidity by standard titration procedures following the guidelines of AOAC International [2]. The pH was measured using a calibrated digital pH meter, while TSS was determined using a hand refractometer and expressed as °Brix [2]. All analyses were performed in triplicate, and the results were expressed as mean values.

Results

Physicochemical Characteristics of Carrot Kheer

Carrot kheer was prepared by incorporating shredded carrot at three different concentrations, namely 20% (K1), 30% (K2), and 40% (K3). The prepared products were analyzed for fat, acidity, pH, total solids (TS), and total soluble solids (TSS). The physicochemical characteristics of fresh carrot kheer are presented in Table 1.

The results revealed that increasing the level of shredded carrot resulted in a slight decrease in fat content from 8.4% in K1 to 8.1% in K3. The acidity and pH values remained constant across all treatments at 0.17% and 6.3, respectively. An increase in total solids was observed with increasing levels of carrot incorporation, ranging from 32.0% in K1 to 33.6% in K3. The TSS values ranged from 20.90 to 21.30 °Brix and showed only marginal variation among treatments.

Sensory Evaluation of Fresh Carrot Kheer

The sensory attributes of fresh carrot kheer samples were evaluated using a 9-point Hedonic scale. The mean sensory scores are presented in Table 2.

Among the treatments, K2 containing 30% shredded carrot received the highest overall acceptability score (8.50). K1 and K3 recorded overall acceptability scores of 7.67 and 7.84, respectively.

Storage Stability and Overall Acceptability

The sensory quality of carrot kheer was monitored at 7-day intervals during storage. Fresh samples of K1, K2, and K3 recorded overall acceptability scores of 7.67, 8.50, and 7.84, respectively, which decreased to 6.17, 6.84, and 6.67 after 28 days of storage. Statistical analysis indicated that both treatment and storage period had a significant ($p < 0.05$) effect on overall acceptability, whereas the interaction between treatment and storage period was non-significant.

Discussion

The decrease in fat content observed with increasing carrot incorporation may be attributed to the dilution effect caused by the addition of carrot, which contains negligible fat compared to milk. Similar observations have been reported in vegetable-fortified dairy products where increasing plant material reduced the relative fat concentration [8].

The acidity and pH values remained constant across all treatments, indicating that the incorporation of carrot did not significantly influence the acid-base characteristics of the product. These findings suggest good compatibility between milk and carrot components during product preparation.

The increase in total solids with increasing levels of carrot incorporation can be attributed to the higher solid content contributed by shredded carrot. Similar increases in total solids have been reported in dairy products enriched with fruits and vegetables [8].

The superior sensory acceptability of K2 may be attributed to its balanced carrot flavour, desirable colour, and pleasant mouthfeel. Although K3 exhibited better colour and appearance scores, the higher carrot concentration may have slightly affected flavour balance and texture. Similar findings have been reported for vegetable-enriched dairy products, where moderate levels of incorporation resulted in higher consumer preference than excessive addition levels [3].

The decline in sensory scores during storage may be attributed to minor physicochemical changes occurring in the product over time. Similar reductions in sensory quality during storage have been reported in sterilized dairy desserts and other heat-processed dairy products [10]. Among all treatments, K2 maintained the highest acceptability throughout the storage period, demonstrating its suitability for commercial production. These findings support the potential of carrot as a functional ingredient for the development of value-added dairy products [5, 7].

Table 1: Physicochemical characteristics of fresh carrot kheer prepared with different levels of shredded carrot

Treatment	Fat (%)	Acidity (%)	pH	TS (%)	TSS (°Brix)
K1 (20%)	8.4	0.17	6.3	32.0	21.30
K2 (30%)	8.2	0.17	6.3	33.3	21.10
K3 (40%)	8.1	0.17	6.3	33.6	20.90

Table 2: Effect of carrot concentration on sensory characteristics of fresh carrot kheer

Treatment	Colour & Appearance	Flavour	Mouthfeel	Overall Flavour	Sweetness	Overall Acceptability
K1	6.34	6.34	7.84	7.67	7.50	7.67
K2	7.50	6.50	7.67	8.50	7.84	8.50
K3	7.84	7.67	7.50	7.84	7.50	7.84

Conclusion

The present study successfully developed and standardized a sterilized carrot kheer by incorporating shredded carrot at different levels (20%, 30%, and 40%). The incorporation of carrot significantly enhanced the nutritional value of the product by providing natural carotenoids and other health-promoting compounds without adversely affecting its physicochemical characteristics. Among the treatments, the kheer containing 30% shredded carrot (K2) exhibited the highest sensory acceptability, with superior flavour, colour, mouthfeel, and overall acceptability.

The optimized product contained 8.2% fat, 33.30% total solids, 0.17% titratable acidity, and 21.10 °Brix total soluble solids. The product remained acceptable for up to 28 days under ambient conditions. The formulation containing 30% shredded carrot, 8% sugar, 3% ghee, and 2.5% dry fruits was found to be the most suitable for the production of sterilized carrot kheer. The developed product has good potential for commercial production as a nutritious, palatable, and shelf-stable dairy dessert.

Acknowledgments

The authors are thankful to the Dean, College of Dairy Science and Food Technology, DSVCKV, Raipur, for providing the necessary facilities to carry out the research work. The authors declare no conflict of interest.

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