International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(Research Article)

Development of technologies for cottage cheese and whey drink production with sea buckthorn supplement

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International Journal of Science and Research Archive, 2025, 15(01), 471-478

Publication history: Received on 26 February 2025; revised on 06 April 2025; accepted on 08 April 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.15.1.0946

Abstract

Cottage cheese, a staple dairy product, is experiencing a surge in global demand, driven by consumers seeking healthier and more versatile food options. Consequently, innovation in flavor profiles and functional enhancements is a key focus for dairy producers. This article introduces a novel production method for cottage cheese, featuring the incorporation of sea buckthorn. This approach not only elevates the sensory experience of cottage cheese but also unlocks a unique value proposition by transforming a common dairy byproduct, whey, into a refreshing, vitamin-packed beverage. The proposed production technology is distinguished by its 'zero-waste' philosophy. Traditional cottage cheese production often results in substantial whey disposal, contributing to environmental concerns and lost nutritional potential. Our method, however, repurposes this whey, a rich source of proteins, minerals, and water-soluble vitamins, into a delightful drink. By infusing the whey with the distinct aroma and flavor of sea buckthorn, we create a beverage that is both refreshing and health-promoting. The final product offers consumers a delicious and nutritious dairy experience, while the byproduct beverage provides a valuable, refreshing, and vitamin rich drink, effectively closing the loop on waste and maximizing the value of the dairy production process.

Our proposed refreshing drink made from cottage cheese and whey, prepared with the addition of sea buckthorn, will be a novelty for the market. In addition to its nutritional purpose, cottage cheese and drink will acquire both a dietary and health-promoting function.

Keywords: Cottage Cheese; Sea buckthorn; Vitamins; Mineral substances; Technology

1. Introduction

The worldwide food market is displaying an increased demand for functional foods that contain technologically developed novel ingredients and have extended nutritional impact with beneficial health effects. Milk and dairy products are currently trending topics in the food production industry. Cottage cheese holds a significant position among dairy products due to its diverse taste characteristics and chemical composition. The incorporation of natural compounds with advantageous effects has been used for functional dairy food production. Specifically, a variety of antioxidant supplements, either single phenolic compounds or natural plant extracts (grape or green tea extract, cranberry powder etc.) Novel natural preservatives such as pomegranate rind extract and spices such as black cumin have been widely incorporated in cheeses for improved microbiological safety and sensory characteristics There has

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been increased interest in specialty cheese including cheese with additives like herbs, spices, or vegetables due to their better biological value and improved flavour [1-7].

As a supplement, we incorporated fresh young sea buckthorn fruit sourced from Georgia. Sea buckthorn (Hippophae rhamnoides L.), belongs to the family Elaeagnaceae and is a widely distributed plant with edible and medicinal values The sea buckthorn is widely spread in Georgia, it belongs to the group of wild plants, and its availability has a positive effect on the value of our products because it can be used as an additive in unfrozen form for at least two seasons (the fruit ripens from August to September, although the fruit remains on the bush until spring), but it is possible to use the freezing method for fruits, which prolongs the production period of cottage cheese with the addition of sea buckthorn [8-10].

The sea buckthorn (in the form of fruit) has long been used in folk medicine, it is used to stimulate the digestive system, to improve the work of the liver and heart, and its intake gives a positive prophylactic effect in regulating blood pressure and high cholesterol, strengthens the immune system and exhibits an antiviral impact, promotes serotonin and collagen production in the body [11; 12].

Modern research has shown that sea buckthorn contains flavonoids, tannins, phenolic acids, vitamins, and carotenoids, with antioxidant, anti-cardiovascular disease, antibacterial, anti-inflammatory, anti-fatigue, anti-aging, and other pharmacological activities [13-15]. Meanwhile, sea buckthorn also contains lipids, sugars, proteins, fatty acids, amino acids, organic acids, and other nutrients. Sea buckthorn contains about 20–25 % of fruit oil, which contains a high concentration of lipophilic components, mainly unsaturated fatty acids (UFA), phytosterols, vitamin A and vitamin E, and the fatty acids of sea buckthorn oil play an important role in improving cardiovascular and cerebrovascular diseases. Recent experiments have shown that up to 16.99 % of sea buckthorn oil can be extracted from sea buckthorn pomace using supercritical fluid extraction with carbon dioxide (SFE-CO2) [16-18].

The fruit has a distinctive, pleasant aroma and is rich in biochemical values. It contains oil (up to 15-35 %) and juice (60-85 %). Sea buckthorn is an important source of vitamin C (100-2500 mg/100 ml) and provides certain amounts of vitamins A, K, E, B1, B2, B3, B6, B9, and PP. It is also rich in minerals such as potassium, calcium, magnesium, iron, boron, and phosphorus, as well as amino acids, carotenoids, and flavonoids [19; 20].

This research aimed to formulate and evaluate a technology for producing Cottage Cheese and Whey Drinks supplemented with sea buckthorn. By directly incorporating fresh sea buckthorn fruits, we developed a product demonstrating the potential for increased nutritional value and consumer benefits.

2. Material and methods

We conducted analyses on cow's milk and studied its chemical composition. We studied the characteristics of filtered raw milk fat content, density, dry substances, lactose, proteins, and acidity in the milk with lACTOSCAN MCCWS (Milk analyzer).

Sea buckthorn's protein, fats, carbohydrates, vitamin C, total solid, moisture, and mineral content were studied according to ISO standards. The determination of protein was done using ISO 28198:2018. Two grams of sample were digested in a Kjeldhal flask with a digestion mixture (copper sulfate and potassium sulfate in 1:9 ratio) and concentrated H_2SO_4 (20 ml) till light green color appeared and finally cooled. Ammonia released by distillation of digested samples with saturated NaOH (80 ml) was captured in 0.1N HCl and percent nitrogen was estimated. The total nitrogen determined was converted into protein using conversion factor N×6.25.

Determination of fat content was done by the Soxhlet extraction method. Sample (2 g) was weighed put in the extraction thimble and plugged. It was then placed in the Soxhlet apparatus. Weighed flat bottom flask (B) was thereafter filled to about three-quarters of its volume with petroleum ether. The apparatus was then set up and the experiment was carried out for 4-8 hours for complete extraction. The petroleum ether was recovered by evaporation using a water bath and the remaining sample in the flask was dried in the oven, cooled in a desiccator, and finally weighed. The difference in the weight of the empty flask and the flask with oil gave the oil content, which was calculated as percent fat content.

Determination of ascorbic acid was done by ISO 6557-1:1986 and ISO 6557-2:1984 using 2, 6-dichlorophenol indophenol dye. The dye factor was calculated by titrating 5 ml standard ascorbic acid plus 5 ml (3%) metaphosphoric acid against 2, 6-dichlorophenol indophenol till pink color appeared and the volume used was noted. Ascorbic acid was estimated by taking 5g of sample, volume made up to 100 ml with (3%) metaphosphoric acid and filtered. Then aliquot of 10 ml was taken in a titration flask and titrated against 2, 6-dichlorophenol indophenol till light pink colour appeared (which persisted for 15 seconds).

Determination of total solid content and moisture was done by ISO 1026:1982 - drying under reduced pressure and of water content by azeotropic distillation. The total solids of the sample were determined by drying the samples in hot air oven at 70 ˚C using the following formula. Total solids (%) = 100 - moisture content (%).

Determination of mineral impurities content was completed by ISO 762:2003. The samples (0.8–1 g) were ashed in a muffle furnace at a temperature of 550±10 ˚C for 6 h and the ash obtained was digested with 5 ml 6M HCl on a water bath. After drying 7 ml 0.1M HNO_3 was added and contents were diluted to 100 ml with double deionized water [21-25].

Protein content in cottage cheese was determined by ISO 8968-1:2014 | IDF 20-1:2014 (Kjeldahl principle and crude protein calculation), Fats by ISO 3433:2008 | IDF 222:2008 (Van Gulik method), Total solids content by ISO 5534:2004 method, Determination of Moisture in cottage Cheese were carried out by AOAC International method, Dry substances by ISO 2920:2004 | IDF 58:2004, Determination of the sugar contents was done by ISO 22184:2021 [26-30].

Total phenol content of SB juice was measured using the Folin- Ciocalteu method. Furthermore, 5 mL SB juice was mixed with 20 mL of 80 % methanol solution, ultrasonicated for 15 min, and centrifuged at 10,000 rpm and 4 ∘C for 15 min. This process was repeated three times to consolidate the extracts, which resulted in the crude polyphenol extraction solution. After the polyphenol extract was diluted 10-fold, 0.4 mL of the extract was combined with 2 mL of a 10- fold diluted forintol reagent and 1.8 mL of 7.5 % Na2CO3 solution. Once the reaction was carried out at room temperature for 1 h, the absorbance was measured at 765 nm. The total phenol content was expressed as a milligram gallic acid equivalent per 100 g of the sample. (Vel´azquez-Estrada, R., Hern´andez-Herrero, M., Rüfer, C., Guamis-L´opez, B., & Roig-Sagu´es, A. (2013). Influence of ultra high pressure homogenization processing on bioactive compounds and antioxidant activity of orange juice. Innovative Food Science & Emerging Technologies, 18, 89–94) [31-33].

3. Results and discussion

The compositional analysis of milk (Table 1), in conjunction with sea buckthorn characteristics (Table 2), indicated the milk's suitability for high-quality cottage cheese production.

Table 1 Results of milk analysis (20 ^{0}C)

№	Characteristics of milk	Quantitative indicators
1	Density, °A	29.38
2	Fats, %	3.45
3	Dry substances, %	8.54
4	Lactose, %	4.69
5	Mineral substances, %	0.69
6	Protein, %	3.12

Analysis of sea buckthorn (Table 2) confirms its status as a nutrient-dense fruit, revealing significant levels of fats (8.05 %) and vitamin C (200 mg/100g), alongside a well-proportioned content of carbohydrates (4.35 %) and protein (1.32 %).

The compositional analysis of milk and sea buckthorn (Tables 1 and 2) indicated suitability for product development. A sea buckthorn juice mixture was prepared by blending fruit with sugar (1:1 w/w) to mitigate acidity. This mixture was strained, yielding a juice with a vitamin C concentration of 300 mg/L. This juice was subsequently incorporated into the cottage cheese production process.

Milk was separated into skim milk and cream. The skim milk was then standardized with cream to achieve the desired fat content, pasteurized, and subsequently cooled. A novel acid-rennet method, incorporating filtered sea buckthorn juice into the milk base, was employed for cottage cheese production. A starter culture was introduced, followed by an aqueous calcium chloride solution (proportions detailed in Figure 1). Rennet was then added, and the mixture was thoroughly agitated.

Table 2 Analysis results on Sea buckthorn

№	Characteristics of Sea Buckthorn Fruits	Quantitative indicators
1	Protein, %	1.32
2	Fats, %	8.05
3	Carbohydrates, %	4.35
4	Vitamin C (100 in gram), mg	200
5	Dry matter, %	17.9
6	Moisture, %	82.1
7	Mineral content, %	0.71
8	Total phenolic compounds, mg/kg	3390
9	Total soluble solid, %	4.68

The coagulated mixture was incubated at 30-34 °C for 8 hours. Upon reaching optimal curd firmness, the container was placed in a water bath, and the curd was cut into 2 cm cubes (as depicted in Figure 1). The cut curd was then gently agitated for 15 minutes, resulting in the formation of cottage cheese curds. Subsequently, the curds and whey were separated by self-draining through a Lavsan bag.

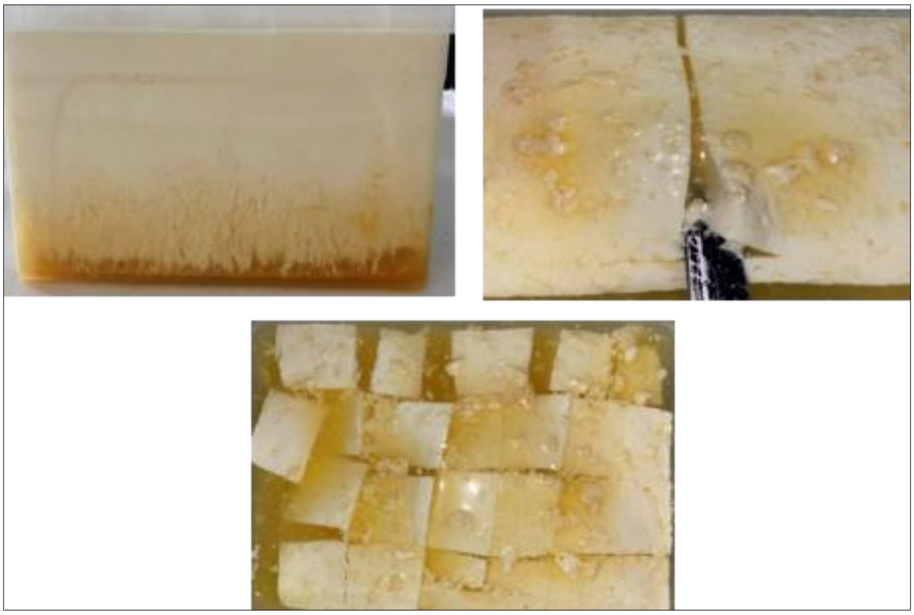

Figure 1 Cutting the leaven

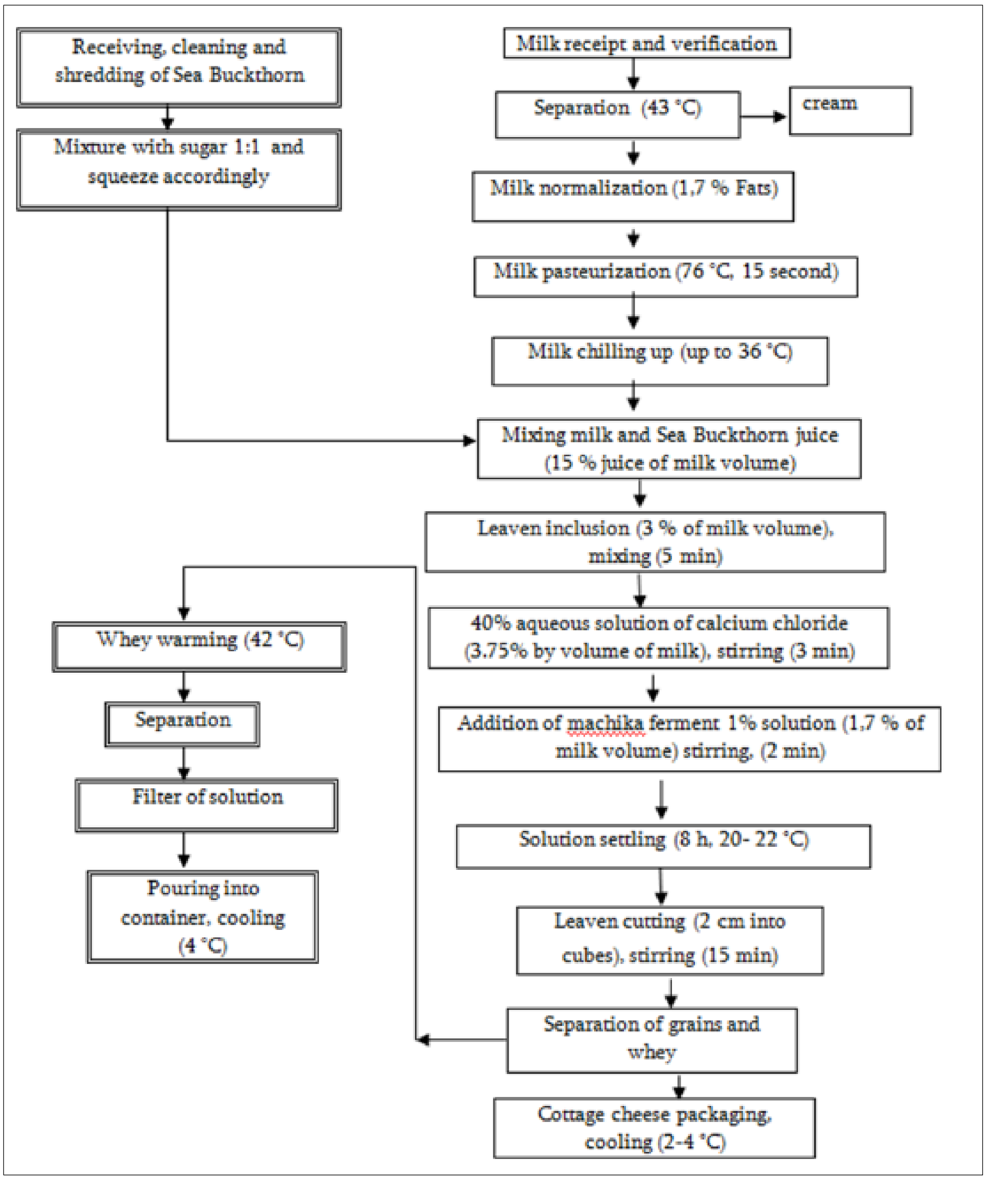

Figure 2 Technological block diagram of cottage cheese and whey drink production

The final cottage cheese product, incorporating sea buckthorn, retained the expected textural and visual characteristics of traditional cottage cheese while exhibiting enhanced sensory attributes. Specifically, the addition of sea buckthorn imparted a pleasant, slightly tart flavor and a distinctive aroma, along with a desirable natural color. Furthermore, the product demonstrated an adjusted acidity profile, contributing to its overall palatability. However, a significant challenge arose concerning the retention of vitamin C. Due to its high water solubility, vitamin C was found to be present in only trace amounts within the cottage cheese. This observation highlighted the substantial loss of water-soluble vitamins in the whey during the separation process. Consequently, we recognized the potential for valorizing the whey by developing a refreshing beverage, thereby recovering the valuable water-soluble nutrients that were otherwise lost.

Table 3 Characteristics of cottage cheese and soft drink with sea buckthorn supplement

№	Characteristics	Cottage cheese with Sea Buckthorn Supplement	Chilled Drinks with Sea Buckthorn Supplement
1	Dry Substances, %	34.76	
2	Moisture, %	65.24	
3	Sugar contents, %	14.50	14.90

4	Acidity, °T	160	52
5	Fats, %	9	0
6	Titratable acidity, ^{0Th}	210	65
7	Vitamin C (100 in g), mg	14	121
8	Total phenolic compounds, mg/kg	1288	2100

To produce a chilled, low-fat whey beverage, the whey byproduct was subjected to heat treatment, resulting in the separation and removal of residual fat globules. The defatted whey solution was then clarified through vacuum filtration, effectively eliminating residual protein particulates. The clarified filtrate was subsequently chilled and stored under refrigerated conditions. The resulting sea buckthorn-enriched whey beverage exhibited a visually appealing yellowish hue, the intensity of which varied depending on the specific color characteristics of the sea buckthorn fruits used. Furthermore, the beverage presented a transparent appearance, indicative of successful clarification. Sensory evaluation revealed a pleasant, refreshing aroma and taste profile, complemented by a notably high vitamin C content. In Table 3 the key characteristics of the developed whey beverage are summarized.

4. Conclusion

In conclusion, through a series of meticulously conducted experiments, we successfully developed two novel, biologically enriched dairy products: sea buckthorn-fortified cottage cheese and a refreshing whey beverage. The latter, derived from the whey byproduct of cottage cheese production, represents a valuable secondary product (as illustrated in Picture 2). This innovative process not only enhances the nutritional profile of traditional dairy products but also offers a comprehensive and efficient technological line for dairy producers. The integration of sea buckthorn into both cottage cheese and whey beverages demonstrates a strategic approach to product diversification and waste valorization. This developed methodology holds significant potential for entrepreneurs seeking to introduce value-added, functional dairy products to the market, thereby capitalizing on consumer demand for health-conscious and sustainable food options.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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