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Process Optimization of Low-Calorie and Cinnamon (*Cinnamomum verum*) Enriched Herbal Shrikhand

Brushabhanu Gadua[1], Urvashi Vikranta[2], Dinesh Chandra Rai[3], Saloni Rai[4]

[1]Brushabhanu Gadua, Post Graduation, Department of Dairy Science and Food Technology, Institute of Agricultural sciences, Banaras Hindu University. Email id: gbrushabhanu@gmail.com

[2]Urvashi Vikranta, Research Scholar, Department of Dairy Science and Food Technology, Institute of Agricultural sciences, Banaras Hindu University. Email id: urvashivikranta@bhu.ac.in

[3]Prof. Dinesh Chandra Rai, Vice-Chancellor, Babasaheb Bhimrao Ambedkar Bihar University, Muzaffarpur, Bihar. Email id: dcrai@bhu.ac.in

[4]Saloni Rai, PhD, Department of Dairy Science and Food Technology, Institute of Agricultural sciences, Banaras Hindu University. Email id: saloni@bhu.ac.in

Abstract

This study investigates the optimization of the process for making low-calorie Shrikhand enriched with cinnamon (Cinnamomum verum) powder and coconut sugar. The primary objective is to develop a healthier alternative to traditional Shrikhand by replacing cane sugar with coconut sugar (low-calorie) and incorporating cinnamon for its potential health benefits. The study examines various treatments, focusing on sensory evaluation, physicochemical properties, microbiological analysis, and shelf life. The results indicate that the optimized herbal Shrikhand with 2% cinnamon powder achieved the highest overall acceptability. Additionally, the incorporation of coconut sugar reduced the calorie content while maintaining the flavor and texture of the product.

Keywords: Low-calorie Shrikhand, Coconut sugar, Cinnamon (Cinnamomum verum), Process optimization, Sensory evaluation, Physicochemical analysis, Shelf life

1. Introduction

Shrikhand is a traditional Indian dairy product known for its creamy texture and rich taste, typically made from curdled milk. It is traditionally sweetened with sugar and flavored with various spices or fruits, making it a popular dessert. However, the increasing prevalence of lifestyle diseases such as obesity and diabetes has sparked interest in healthier alternatives to conventional dairy products. One approach to address these concerns is through the optimization of Shrikhand by replacing high-calorie ingredients with lower-calorie alternatives, such as coconut sugar, and incorporating health-promoting spices like cinnamon (Cinnamomum verum). The conventional Shrikhand is often high in calories due to the inclusion of cane sugar, which is a significant source of carbohydrates and contributes to weight gain and other metabolic disorders (Jenkins, Wolever, & Taylor, 1981). In recent years, there has been a growing trend to replace cane sugar with low-calorie sweeteners to create healthier dairy-based desserts. One such alternative is coconut sugar, which is derived from the sap of the coconut tree. Unlike regular sugar, coconut sugar has a lower glycemic index, making it a more suitable option for individuals managing diabetes (Wrage, Burmester, Kuballa, & Rohn, 2019). It also contains essential minerals such as potassium, zinc, and iron, further enhancing its nutritional profile (Hebbar et al., 2015).

Another ingredient that has gained significant attention for its health benefits is cinnamon (Cinnamomum verum). Cinnamon has been traditionally used not only for its flavor but also for its medicinal properties. It is known for its antimicrobial, antioxidant, and anti-inflammatory effects, which contribute to its popularity in functional foods (Bouhdid et al., 2010; Vidanagamage, Pathiraje, & Perera, 2015). Furthermore, cinnamon has been found to have beneficial effects on blood sugar regulation, making it an ideal ingredient for individuals with metabolic conditions like type 2 diabetes (Ping, Zhang, & Ren, 2010). Therefore, the incorporation of cinnamon in Shrikhand could potentially enhance both the taste and health benefits of the product, aligning it with modern dietary preferences for functional foods (Ho, Chang, & Chang, 2013). The development of low-calorie, functional dairy products has become a key focus in the food industry, driven by consumer demand for healthier alternatives. Traditional dairy products such as Shrikhand are often high in calories and sugar, which has led to the exploration of alternatives like coconut sugar and cinnamon. The use of coconut sugar not only reduces the calorie content of the product but also adds to the nutritional value, while cinnamon enhances its functional properties by providing antioxidants and improving blood sugar regulation (Cardoso-Ugarte, López-Malo, & Sosa-Morales, 2016). Furthermore, the optimization of Shrikhand involves not only altering the ingredients but also fine-tuning the preparation process to maintain the product's sensory qualities, such as flavor, texture, and overall acceptability (De, 2011; Dhotre & Bhadania, 2016).

This study aims to optimize the process of making low-calorie and cinnamon-enriched herbal Shrikhand by replacing cane sugar with coconut sugar and incorporating different levels of cinnamon powder. The objective is to evaluate the sensory attributes, physicochemical properties, and microbial stability of the optimized Shrikhand and compare them with a control Shrikhand made with traditional ingredients. The outcomes of this research could provide insights into developing healthier dairy products that maintain consumer acceptability while offering added health benefits.

2. **Materials and Methodology**

Fresh cow milk was procured from the Dairy Unit of the Department of Dairy Science and Food Technology (DSFT), Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. Sugar was obtained from the local market in Varanasi. Organic coconut sugar was purchased from Phalada Agro Research Foundation Pvt. Ltd., Bangalore. It was used as a low-calorie substitute for cane sugar. Cinnamon bark (Cinnamomum verum) was purchased from the local market in Varanasi, powdered, and used for enriching the Shrikhand. Plastic cups with lids were used for packaging and were procured locally in Varanasi. Analytical reagents (AR) such as phenolphthalein, sodium hydroxide, and others were used for physicochemical analyses. Common laboratory glassware, weighing balances, muffle furnace, incubators, spectrophotometer, and other necessary equipment were used.

2.1. Treatment Combinations

Shrikhand was prepared with varying combinations of coconut sugar and cinnamon powder. The treatment combinations were as follows:

Treatment	Chakka (%)	Cane Sugar (%)	Coconut Sugar (%)	Cinnamon Powder (%)
T1	60	40	0	0
T2	60	0	40	0
T3	60	0	40	1
T4	60	0	40	2
T5	60	0	40	3

2.2. Preparation of Herbal Shrikhand

Shrikhand was prepared following a modified standard procedure (De, 1980). The process involved heating the cow milk to 90°C for 20 minutes, cooling it to 30°C, and inoculating it with a starter culture (Lactococcus lactis). After 12 hours of incubation, the curd was drained through muslin cloth for 8 hours to obtain Chakka. The Chakka was then mixed with coconut sugar and cinnamon powder according to the treatment combinations, kneaded into a smooth paste, and refrigerated for further analysis.

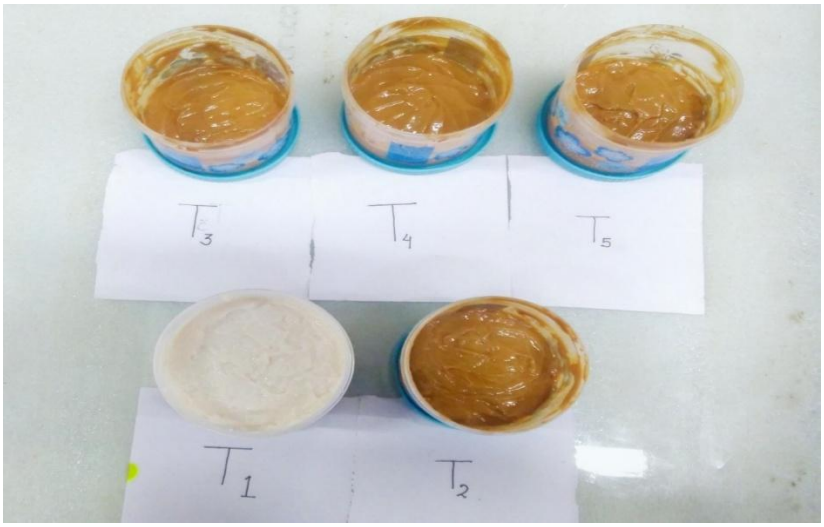

Figure 2.1: Various *Shrikhand* samples blended with Cane sugar, Coconut sugar and different levels of Cinnamon powder

2.3 Sensory Evaluation

A semi-expert panel of judges performed sensory evaluation using the 9-point Hedonic scale. Attributes such as flavor, color and appearance, body and texture, sweetness, and overall acceptability were rated.

Score	Quality Grade
9	Like extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

2.4 Physicochemical Analysis

The physicochemical properties of Shrikhand were evaluated for titratable acidity, pH, fat, protein, moisture, total solids, SNF, ash, and antioxidant content using standard methods. Titrable acidity Measured using the standard method IS: 1479 (1960), by titrating with 0.1 N NaOH. The pH was determined using a digital pH meter (SYSTRONICS, 361) following IS: 1479 (1961). Fat content was determined by the Gerber method as described in IS: 1224 (Part-I, 1977). Total protein was determined using the Kjeldahl method (AOAC, 2005). Moisture and total solids were determined gravimetrically (AOAC, 2000, IS: SP, 1981). Ash content was determined by charring and then burning in a muffle furnace at 525°C (AOAC, 2000). Antioxidant activity was measured using the DPPH method (Brand et al., 1995), and phenolic content was determined by the Folin-Ciocalteu method (Singleton and Rossi, 1965).

2.5 Shelf-Life Study

The shelf life of the optimized Shrikhand was evaluated over 15 days under refrigerated conditions. Sensory scores, pH, titratable acidity, total phenolic content, DPPH activity, and microbiological analysis were conducted every 3 days.

3. Results and Discussion

3.1 Chemical Composition of Cow Milk

The cow milk used in this study had the following composition:

Constituent	Value
Fat	4.66%
SNF	9.33%
Protein	3.65%
Lactose	4.85%
pH	6.43

3.2 Chemical Composition of Coconut Sugar and Cinnamon Powder

Coconut sugar is a rich source of potassium, zinc, and iron, and it has a low glycemic index. Cinnamon powder contains essential oils, primarily cinnamaldehyde, which contributes to its flavor and health benefits.

3.3 Optimization of Cinnamon Level for Shrikhand Preparation

Sensory evaluations showed that the treatment with 2% cinnamon powder (T4) scored the highest in flavor, color, body, sweetness, and overall acceptability. The scores for the sensory attributes were significantly improved as the cinnamon concentration increased.

Table 3.1: Sensory Scores for Different Cinnamon Levels in Herbal Shrikhand

Treatment	Flavor	Color	Texture	Sweetness	Overall Acceptability
T1	7.33	7.33	6.67	7.83	6.83
T2	7.42	7.50	6.83	8.17	7.00
T3	7.83	7.67	7.17	8.33	7.33
T4	8.83	7.83	8.17	8.50	8.67
T5	8.00	7.67	7.50	8.00	7.83

3.4 Physicochemical Analysis

The fat, protein, moisture, total solids, SNF, and ash contents were not significantly affected by the cinnamon powder addition. However, total solids and SNF increased in the optimized Shrikhand (T4).

Table 3.2: Physicochemical Properties of Shrikhand

Property	T1 (Control)	T4 (Optimized)	t-value
Fat (%)	8.44 ± 0.05	8.34 ± 0.01	4.30
Protein (%)	9.13 ± 0.01	9.11 ± 0.01	4.30
Moisture (%)	42.11 ± 0.30	39.64 ± 0.10	10.94
Total Solids (%)	57.88 ± 0.30	60.35 ± 0.09	11.15
SNF (%)	49.53 ± 0.30	52.03 ± 0.10	10.97
Ash (%)	0.86 ± 0.02	0.88 ± 0.04	0.79
Titratable Acidity (%)	1.10 ± 0.02	0.98 ± 0.02	20.78
pH	5.12 ± 0.06	5.35 ± 0.02	5.83

Values are Mean±SD, Where n=3

3.5 Shelf-Life Study

The shelf-life of the optimized Shrikhand was assessed over 15 days. Sensory attributes and microbiological quality decreased gradually with time, but the product remained acceptable within the first 12 days.

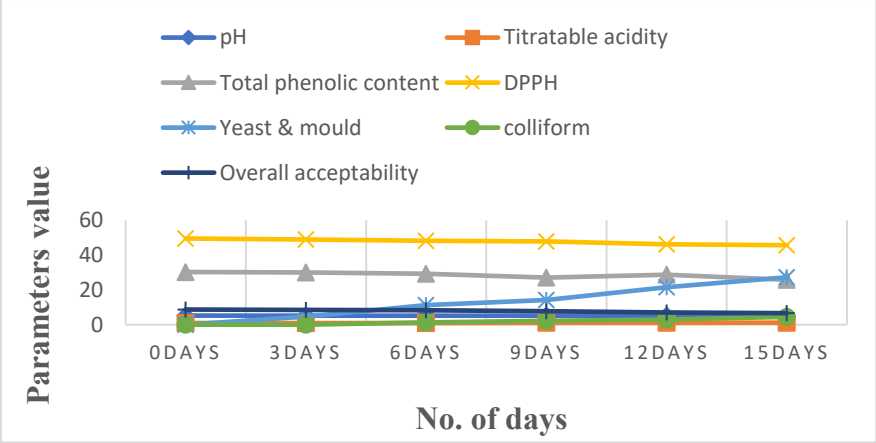

Figure 3.1: Shelf-life study of the optimized product

Table 3.3: Shelf-life Analysis of Herbal Shrikhand

Parameter	Day 0	Day 3	Day 6	Day 9	Day 12	Day 15
pH	5.25 ± 0.02	5.23 ± 0.31	5.20 ± 0.16	5.14 ± 0.30	5.10 ± 0.31	5.01 ± 0.24
Titratable Acidity (%)	0.98 ± 0.02	1.00 ± 0.08	1.03 ± 0.06	1.07 ± 0.05	1.12 ± 0.06	1.17 ± 0.05
Total Phenolic Content (mg GAE/g)	30.34 ± 0.31	30.01 ± 0.63	29.30 ± 0.43	27.17 ± 0.14	28.83 ± 0.27	25.85 ± 0.71
DPPH (%)	49.62 ± 0.81	49.11 ± 0.05	48.26 ± 0.08	47.88 ± 0.35	46.33 ± 0.37	45.79 ± 0.81
Yeast and Mould (cfu/g)	0.00	4.67 ± 0.58	11.2 ± 0.12	14.3 ± 0.23	21.5 ± 0.53	27.3 ± 0.76

Coliform (cfu/g)	0.00	0.00	1.25 ± 0.23	2.25 ± 0.16	3.00 ± 0.19	4.50 ± 0.12
Overall Acceptability	8.73 ± 0.52	8.48 ± 0.23	8.00 ± 0.32	7.83 ± 0.31	7.03 ± 0.45	6.53 ± 0.34

Values are Mean±SD, Where n=3

3.6 Cost of Production

The cost of production for the control Shrikhand (T1) was Rs. 311.47 per kg, while for the optimized Shrikhand (T4), it was Rs. 515.28 per kg due to the higher cost of coconut sugar and cinnamon powder.

4. Discussion

The development of low-calorie and cinnamon-enriched Shrikhand has garnered significant attention as a healthier alternative to traditional dairy products. This study focused on optimizing the process by replacing cane sugar with coconut sugar and incorporating cinnamon powder, which is known for its numerous health benefits. The results from sensory evaluation, physicochemical analysis, and shelf-life studies confirm that the optimized Shrikhand (T4) with 2% cinnamon powder provides the best sensory attributes and retains desirable nutritional characteristics.

The sensory evaluation demonstrated that the addition of cinnamon powder significantly improved the flavor, texture, and overall acceptability of the product. As noted by Chorage et al. (2018), the substitution of traditional sweeteners with coconut sugar did not adversely affect the texture or flavor of dairy products like Shrikhand. The sweetness of the optimized Shrikhand was well received, despite the substitution of cane sugar with coconut sugar, which is known for a more subdued sweetness profile (Lal et al., 2018). This is in line with studies by Vidanagamage et al. (2015), who highlighted that cinnamon can enhance the flavor of dairy products without overpowering the other ingredients. The optimized Shrikhand (T4), with 2% cinnamon powder, showed the highest overall acceptability, with significant improvements in flavor and texture, aligning with similar findings in dairy product formulations where cinnamon was used to improve taste (Ho, Chang, & Chang, 2013).

The substitution of coconut sugar in place of cane sugar contributed to the reduction in the calorie content of the Shrikhand, which is an essential aspect for health-conscious consumers. Coconut sugar has a lower glycemic index compared to cane sugar, which helps in preventing rapid spikes in blood glucose levels (Wrage et al., 2019). Moreover, as Hebbar et al. (2015) explained, coconut sugar contains beneficial minerals such as potassium, zinc, and iron, which enhance the nutritional value of the product. These benefits make coconut sugar a favorable choice over traditional sweeteners, especially for diabetic individuals.

Cinnamon, being rich in cinnamaldehyde, provides additional functional benefits, such as antioxidant, antimicrobial, and anti-inflammatory properties (Bouhdid et al., 2010). Several studies, including those by Ping et al. (2010) and Vidanagamage et al. (2015), have demonstrated that cinnamon supplementation can significantly improve blood sugar regulation, making the final product more suitable for individuals with metabolic disorders. The antioxidant activity of cinnamon in the current study, as measured by DPPH and total phenolic

content, indicates that the optimized Shrikhand (T4) possesses added health benefits, supporting the functional food trends in the dairy sector (Brand-Williams, Cuvelier, & Berset, 1995).

The physicochemical analysis revealed no significant difference in fat, protein, and ash content between the control and optimized Shrikhand, which indicates that the substitution of coconut sugar and addition of cinnamon powder did not negatively affect the basic nutritional composition of the product. However, the moisture content was significantly reduced in the optimized Shrikhand (T4), which could be attributed to the different water retention capabilities of coconut sugar (Lal et al., 2018). The total solids and SNF (solids-not-fat) content were higher in the optimized Shrikhand, further enhancing its texture and mouthfeel, a result that aligns with findings from similar dairy product formulations (Ghatak & Dutta, 1998). The minor decrease in fat content in T4 (8.34%) compared to the control sample (8.44%) is negligible and does not compromise the overall quality of the product.

The shelf-life study demonstrated that the optimized Shrikhand (T4) remained microbiologically stable for up to 12 days under refrigerated conditions. The presence of antimicrobial compounds in cinnamon likely contributed to the inhibition of microbial growth, particularly yeast and mold, as reported by Dussault et al. (2014). The reduction in microbial counts, including the absence of coliforms in both samples, aligns with the findings by Vidanagamage et al. (2015), who found that cinnamon significantly inhibits the growth of unwanted microorganisms in dairy products. Additionally, coconut sugar's mineral content, as discussed by Secretaria et al. (2007), may have further helped preserve the quality of the product. Overall, while the shelf life of the optimized Shrikhand (T4) slightly declined by day 15, the product remained microbiologically safe for a reasonable period, which supports the findings of Dhotre and Bhadania (2016), who highlighted the importance of proper formulation for maintaining the microbial stability of dairy products during storage.

While the optimized Shrikhand (T4) showed superior sensory and functional properties, the higher cost of coconut sugar and cinnamon powder made it more expensive to produce, as evidenced by the cost of production calculations. The cost per kg of the optimized Shrikhand was significantly higher (Rs. 515.28) compared to the control Shrikhand (Rs. 311.47). This increase is consistent with similar findings where the use of alternative ingredients like coconut sugar raised the overall cost of production (Shukla et al., 2007). To make this product commercially viable, further studies could focus on reducing production costs by exploring cost-effective sources of coconut sugar or adjusting the cinnamon concentration while maintaining the product's functional benefits.

5. **Conclusion**

The study successfully developed a low-calorie, cinnamon-enriched Shrikhand by replacing cane sugar with coconut sugar and incorporating different levels of cinnamon powder. The optimized Shrikhand with 2% cinnamon powder achieved the best sensory attributes, including flavor, texture, and overall acceptability. Additionally, the product exhibited significant antioxidant properties, contributing to its potential health benefits. However, the cost of production was higher due to the use of coconut sugar, which needs to be addressed for broader

commercial application. Future research should focus on improving the cost-effectiveness of production while maintaining the high nutritional and sensory quality of the product.

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