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Process optimization for development of cardamom flavour low-calorie Shrikhand

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Abstract
The present study aimed to develop a low-calorie functional shrikhand by replacing sucrose with stevia, with sorbitol incorporated as a bulking agent and grape pulp as a source of additional nutrients and antioxidants. The formulation was standardized by sequentially optimizing the levels of stevia, sorbitol, and addition of cardamom followed by assessment of sensory, compositional, physicochemical, and microbiological properties during refrigerated storage. The study established the potential of stevia and sorbitol as alternatives to sucrose for developing a low-calorie shrikhand,

Keywords: stevia; sorbitol; cardamom ; low-calorie dairy product; storage stability

Introduction
Sucrose is an important component of dairy products and beverages, as it lowers water activity and thereby reduces the availability of water for the growth of microorganisms such as bacteria and fungi. Therefore, complete replacement of sucrose can influence the preservation, texture, and overall quality of food products, requiring suitable alternatives to compensate for its functional properties. Stevia (*Stevia rebaudiana*) is a perennial plant widely recognized as a natural, high-intensity sweetener. Steviol glycosides, particularly stevioside, are responsible for its intense sweetness and provide very low or negligible calories, making stevia a suitable alternative to sucrose in products intended for health-conscious consumers (Goyal *et al*., 2010). However, because stevia is a high-intensity sweetener, it cannot provide the bulk and structural properties normally contributed by sucrose. Sorbitol, a sugar alcohol, can therefore be incorporated as a bulking agent to improve the body, texture, and overall characteristics of sucrose-free products. The combination of stevia and sorbitol offers a promising approach for developing low-calorie dairy products with reduced sugar content.. In view of the increasing consumer preference for healthier and low-calorie foods, the present study was undertaken to develop and optimize grape pulp-enriched low-calorie shrikhand using stevia as a sucrose substitute and sorbitol as a bulking agent, and to evaluate its sensory, physicochemical, nutritional, antioxidant, and microbiological properties during refrigerated storage.

Phases: The low-calorie shrikhand was prepared by acceptable level of stevia, sorbitol and cardamom

Formulation of low calorie shrikhand
Materials and Methods Fresh chilled raw cow milk and cream was procured from Experimental Section, Department of Dairy Technology, College of Dairy Technology, Tirupati, Andhra Pradesh.

Preparation of Dahi
Milk is standardized to 4.5% fat and 8.5% SNF, filtered through muslin cloth and heated in directly at 90°C for 10 minutes and cooled to 37°C. The milk was inoculated with LF 40 strain @ 1.5%. The milk was incubated at 37°C until desired firmness and acidity reached to 0.8-0.9% lactic acid. Preparation of chakka After having the desired acidity and the firmness

in dahi, whey was drained from the curd through suspended muslin cloth and was hanged for 6-8 hours to get solid mass known as chakka.

Standardization of low-calorie shrikhand

Stevia was incorporated at different levels and compared with conventional shrikhand (60 g) prepared using sugar. The selected stevia level was subsequently combined with different levels of sorbitol to compensate for the loss of bulk and mouthfeel caused by complete sugar replacement. Based on sensory and physicochemical characteristics stevia and sorbitol, 80 mg and 30% selected as the appropriate level. For cardamom flavour low calorie shrikhand, a preliminary trail was conducted with five levels of cardamom powder *viz*. 0.05, 0.1, 0.2, 0.3 and 0.4 grams per 100grams of shrikhand. The control sample was low calorie shrikhand without cardamom flavour. It is observed that 0.05 and 0.4 grams of cardamom gives very low and high intensity flavours, so they are rejected. It was observed that 0.1, 0.2, 0.3 grams per 100 grams of chakka were quite acceptable and conducted for storage studies to find out the best level of cardamom flavour low calorie shrikhand.

Microbiological analysis

Coliform and yeast and mould counts were determined during storage using the methods specified in the thesis based on Indian Standards procedures.

Results and discussions

Storage studies for low calorie shrikhand added with different levels of cardamom powder

The commercial acceptability of the product depends upon the keeping quality and maintenance of the quality during the entire period of storage. The stevia and sorbitol levels added to the shrikhand effect on the quality of the product during storage. Hence, in the present study low calorie shrikhand with different levels of cardamom 0.1 (C1), 0.2 (C2) and 0.3% (C3) respectively are added and stored at refrigeration temperature. Thus, the samples were evaluated at 3 days interval for a period of 30 days to establish their storage stability. Cardamom is the naturaloccurring spice commonly used as taste and flavour enhancer in foods, further its antimicrobial property is proved to be a natural preservative in many dairy products in enhancing its shelf-life.

PH and titratable acidity

The changes in pH and titratable acidity of low-calorie shrikhand incorporated with different levels of cardamom during refrigerated storage are presented in Table 12. Titratable acidity increased progressively during storage in all treatments. In shrikhand containing 0.1% cardamom (C1), acidity increased from 1.16 to 1.432% lactic acid (LA), whereas in the 0.2% cardamom treatment (C2), it increased from 1.15 to 1.42% LA. In the 0.3% cardamom treatment (C3), acidity increased from 1.138 to 1.400% LA. The increase in acidity was relatively gradual throughout storage, particularly in C3. Dandile *et al*. (2014) [5]. observed a progressive decrease in pH and increase in acidity in shrikhand containing cardamom and saffron. George *et al*. (2012) also reported a significant ($P \leq 0.05$) increase in titratable acidity in control and artificially sweetened lassi during storage. Ruggeri *et al*. (2008) attributed the reduction in pH of fermented milk products to the continued growth and metabolic activity of lactic acid bacteria, resulting in the accumulation of organic acids.

Table 1: Changes in acidity of low calorie shrikhand with different levels of cardamom during storage

Treatments	0	3	6	9	12	15	18	21	24	27	30
C_s	1.244^{a}±0.07	1.252^{a}±0.05	1.312^{a}±0.1	1.32^{a}±01	1.346^{a}±0.1	1.368^{a}±0.1	1.400^{a}±0.1	1.402^{a}±0.1	1.432^{a}±0.1	1.460^{a}±0.1	1.458^{a}±0.1
C_1	1.166^{b}±0.1	1.252^{b}±0.06	1.244^{b}±0.1	1.23^{b}±01	1.268^{b}±0.1	1.30^{b} ±0.01	1.322^{b}±0.1	1.346^{b}±0.1	1.400^{b}±0.1	1.402^{b}±0.1	1.432^{b}±0.1
C_2	1.156^{b} ±0.1	1.172^{b}±0.07	1.152^{b}±0.1	1.23^{b}±01	1.242^{b}±0.1	1.268^{b}±0.1	1.300^{b}±0.1	1.322^{b}±0.1	1.346^{b}±0.1	1.400^{b}±0.1	1.402^{b}±0.1
C_3	1.138^{c}±0.6	1.156^{c}±0.6	1.166^{c}±0.1	1.21^{c}±01	1.244^{c}±0.1	1.232^{c}±0.01	1.268^{c}±0.01	1.300^{c}±0.01	1.352^{c}±0.01	1.356^{c}±0.01	1.400^{c}±0.01
C.D. (P≤0.05)	0.020	0.028	0.030	0.034	0.021	0.027	0.029	0.030	0.027	0.022	0.026

C_s - Low calorie shrikhand without cardamom
C_1 - Low calorie shrikhand with 0.1% cardamom powder
C_2 - Low calorie shrikhand with 0.2% cardamom powder
C_3 - Low calorie shrikhand with 0.3% cardamom powder

Table 2: Changes in ph of low calorie shrikhand with different levels of cardamom during storage

Treatmes	0	3	6	9	12	15	18	21	24	27	30
C_s	4.29^{c}±0.01	4.196^{b}±01	4.016^{b}±01	3.954±0.4	3.840^{b}±0.3	3.754^{b}±0.1	3.654^{c}±0.5	3.476^{d}±01	3.454^{c}±0.08	3.424^{c}±0.05	3.388^{c}±0.08
C_1	4.330^{b}±0.2	4.228^{b}±0.1	4.072^{c}±0.1	3.968±0.07	3.856^{b}±0.02	3.774^{a}±0.4	3.662^{b}±0.04	3.506^{c}±0.1	3.482^{b}±0.04	3.468^{b}±0.01	3.402^{b}±0.8
C_2	4.354^{b}±0.1	4.294^{a}±0.1	4.108^{a}±0.1	3.978±0.07	3.870^{a}±0.02	3.756^{b}±0.05	3.672^{b}±0.04	3.532^{b}±0.1	3.510^{a}±0.04	3.502^{a}±0.01	3.450^{a}±0.5
C_3	4.396^{a}±0.09	4.322^{a}±0.1	4.132^{a}±0.4	3.978±0.07	3.874^{a}±0.02	3.760^{a}±0.04	3.682^{a}±0.04	3.552^{a}±0.1	3.524^{a}±0.05	3.506^{a}±0.04	3.474^{a}±0.7
C.D. (P≤0.05)	0.038	0.039	0.021	NS	0.011	0.013	0.012	0.019	0.017	0.026	0.021

C_s - Low calorie shrikhand without cardamom
C_1 - Low calorie shrikhand with 0.1% cardamom powder
C_2 - Low calorie shrikhand with 0.2% cardamom powder
C_3 - Low calorie shrikhand with 0.3% cardamom powder

Overall, the results indicate that incorporation of cardamom, particularly at the 0.2% level, helped maintain desirable physicochemical characteristics during refrigerated storage.

Microbial quality

yeast and mould counts increased progressively with storage. The control sample recorded the highest microbial load of 1.75 log CFU/g on the 30th day, while the cardamom-treated samples showed comparatively lower counts. The YMC of C1, C2 and C3 ranged from 1.66 to 1.69 log CFU/g on the 30th day of storage.The comparatively lower microbial counts observed in cardamom-treated samples may be associated with the antimicrobial properties of cardamom and its bioactive

aromatic compounds. Similar observations were reported by Landge *et al*. (2011), who recorded lower yeast and mould counts in shrikhand incorporated with ashwagandha powder compared with the control. Dandile *et al*. (2014) [5], Guggisberg *et al*. (2011) and Yadav *et al*. (2018) also reported progressive changes in microbial quality during storage of shrikhand. Based on the microbiological and sensory observations, the product remained acceptable during refrigerated storage, with the 0.2% cardamom treatment showing the most desirable overall storage stability.

Table 3: changes in yeast and mould count for low calorie shrikhand prepared with different levels of cardamom powder

Treatments	0	3	6	9	12	15	18	21	24	27	30
C_s	1.17^{a} ±0.03	1.32^{a} ±0.02	1.35^{a} ± 0.02	1.46^{a} ±0.02	1.55^{a} ±0.01	1.53^{a} ±0.01	1.60^{a} ±0.02	1.66^{a} ±0.02	1.69^{a} ±0.01	1.74^{a} ±0.02	1.75^{a}±0.02
C_1	1.08^{a} ±0.03	1.23^{b} ±0.02	1.28^{b} ± 0.02	1.32^{b} ±0.02	1.41^{b} ±0.01	1.46^{b} ±0.01	1.44^{b} ±0.02	1.52^{b} ±0.02	1.52^{b} ±0.02	1.63^{b} ±0.02	1.66^{b}±0.01
C_2	1.15^{a} ±0.04	1.19^{b} ±0.02	1.33^{ab}±0.02	1.39^{a} ±0.03	1.38^{a} ±0.01	1.42^{a} ±0.02	1.47^{a} ±0.01	1.53^{a} ±0.03	1.55^{a} ±0.02	1.69^{a} ±0.02	1.67^{a}±0.02
C_3	1.00^{b}±0.03	1.06^{c} ±0.02	1.21^{c} ± 0.02	1.25^{c} ±0.02	1.21^{c} ±0.02	1.31^{c} ±0.02	1.38^{c} ±0.02	1.43^{c} ±0.02	1.52^{c} ±0.02	1.57^{c} ±0.01	1.69^{a}±0.01
CD (P≤0.05)	0.10	0.066	0.049	0.084	0.050	0.044	0.047	0.025	0.048	0.045	0.033

C_s - Low calorie shrikhand without cardamom
C_1 - Low calorie shrikhand with 0.1% cardamom powder
C_2 - Low calorie shrikhand with 0.2% cardamom powder
C_3 - Low calorie shrikhand with 0.3% cardamom powder

Sensory quality The sensory characteristics of low-calorie shrikhand incorporated with different levels of cardamom were evaluated for flavour, colour and appearance, body and texture, and overall acceptability during refrigerated storage. Flavour: The shrikhand containing 0.2% cardamom (C2) recorded higher flavour scores than the control and other treatments during storage, indicating greater consumer preference for this level of cardamom incorporation.Flavour scores generally declined with increasing storage period, particularly after the 9th day. The control sample remained acceptable up to 21 days, whereas the 0.1% and 0.3% cardamom treatments remained acceptable up to 24 days. The 0.2% cardamom treatment retained acceptable flavour characteristics up to 27 days of refrigerated storage. The subsequent decline in flavour may be associated with progressive acid development, resulting in sourness and the development of undesirable stale flavours. Choudhary and Sandey (2009) reported that cardamom incorporation improved the sensory characteristics of a whey-based herbal beverage and contributed to its storage stability.The superior flavour scores of the 0.2% cardamom treatment suggest that this concentration provided an optimum balance between cardamom flavour and the characteristic taste of shrikhand.

Table 4: Changes in flavour scores for different levels of cardamom in low calorie shrikhand during storage

Treatments	0	3	6	9	12	15	18	21	24	27	30
C_s	8.0^{ab}±0.004	8.24^{ab}±0.01	8.34^{b}±0.01	7.88^{b} ±0.04	7.6^{b} ±0.06	7.4^{b} ±0.06	7.18^{b}±0.06	6.82^{b}±0.04	5.96^{b}±0.24	5.34^{b}±0.05	5.22^{b}±0.06
C_1	8.18^{a} ±0.06	8.22^{a} ±0.05	8.08^{b}±0.01	8.08^{ab}±0.01	7.76^{b}±0.06	7.48^{b}±0.04	7.18^{b}±0.06	6.75^{c}±0.03	6.24^{b}±0.09	5.8^{b} ±0.06	5.12^{b}±0.05
C_2	8.12^{a} ±0.04	8.38^{a} ±0.08	8.40^{a}±0.01	8.06^{a} ±0.02	7.88^{a}±0.04	7.56^{a}±0.05	7.12^{a}±0.04	7.06^{a}±0.05	6.74^{a}±0.09	6.46^{a}±0.06	5.38^{a}±0.08
C_3	8.06^{ab}±0.04	8.16^{b} ±0.04	8.26^{c}±0.01	7.56^{c} ±0.05	7.36^{c}±0.05	7.16^{c}±0.05	6.9^{c} ±0.06	6.66^{c}±0.05	5.82^{c}±0.09	5.12^{c}±0.12	4.08^{c}±0.30
C.D. (P≤0.05)	0.181	0.191	0.183	0.123	0.163	0.148	0.153	0.132	0.523	0.267	0.481

Cs = Low calorie shrikhand without cardamom
C_1 = Low calorie shrikhand with 0.1% cardamom powder
C_2 = Low calorie shrikhand with 0.2% cardamom powder
C_3 = Low calorie shrikhand with 0.3% cardamom powder

Colour and appearance

The control sample remained acceptable for 21 days, while the 0.1% and 0.3% cardamom treatments remained acceptable up to 24 days. The 0.2% cardamom treatment retained acceptable colour and appearance up to 27 days of refrigerated storage.The higher scores observed for the 0.2% cardamom treatment may be attributed to the optimum level of cardamom incorporation, which contributed positively to the visual and sensory characteristics of the product.These findings are comparable with Landge *et al*. (2011), who observed improved sensory scores in shrikhand containing selected levels of herbal powder. Dandile *et al*. (2014) [5]. also reported superior sensory characteristics in shrikhand incorporated with cardamom and saffron.

Table 5: Changes in colour and appearance score for different levels of cardamom in low calorie shrikhand during storage

Treatments	0	3	6	9	12	15	18	21	24	27	30
C_s	8.08^{b} ± 0.4	8.12^{bc} ±0.1	8.20^{b}±0.04	7.66^{b} ±0.12	7.42^{b}±0.11	7.28^{b}±0.09	6.66^{b}±0.08	6.14^{b}±0.11	5.84^{c}±0.12	5.58^{c} ±0.15	5.20^{c}±0.07
C_1	8.16^{b}±0.05	8.21^{b}±0.05	8.30^{b}±0.04	8.00^{bc}±0.05	7.60^{a}±0.04	7.48^{a}±0.09	7.22^{a}±0.08	6.76^{a}±0.08	6.46^{b}±0.09	6.06^{b} ±0.06	5.96^{a}±0.01
C_2	8.22^{a}±0.05	8.34^{a}±0.08	8.36^{a}±0.02	8.08^{a} ±0.07	7.80^{a}±0.04	7.54^{a}±0.05	7.16^{a}±0.08	6.80^{a}±0.08	6.50^{a}±0.09	6.28^{a} ±0.06	6.10^{a}±0.06
C_3	8.10^{b}±0.05	8.14^{c} ±0.09	8.20^{c}±0.02	7.60^{bc}±0.03	7.36^{b}±0.05	7.16^{b}±0.05	6.90^{b}±0.06	6.56^{b}±0.05	6.20^{b}±0.11	5.78^{bc}±0.06	5.50^{b}±0.09
C.D. (P≤0.05)	0.147	0.128	0.098	0.208	0.203	0.191	0.217	0.252	0.298	0.305	0.247

C_s - Low calorie shrikhand without cardamom
C_1 - Low calorie shrikhand with 0.1% cardamom powder
C_2 - Low calorie shrikhand with 0.2% cardamom powder
C_3 - Low calorie shrikhand with 0.3% cardamom powder

Body and texture

The scores increased up to the 6th day of storage compared with the initial values and subsequently declined during storage.The control sample remained acceptable up to 21 days, whereas the 0.1% and 0.3% cardamom treatments remained acceptable up to 24 days. The 0.2% cardamom treatment retained desirable body and texture characteristics up to 27 days of refrigerated storage.The decline in body and texture scores at the later stages of storage may be associated with increased acidity and whey separation. In particular, the 0.3% cardamom treatment showed undesirable sourness and whey separation at the later stages of storage. The superior scores obtained by C2 indicate that 0.2% cardamom was the optimum level for maintaining desirable body and texture characteristics. The findings are comparable with those of Landge *et al*. (2011) and Dandile *et al*. (2014) [5], who reported differences in body and texture characteristics of shrikhand incorporated with herbal and spice ingredients.

Table 6: Changes in body and texture score for different levels of cardamom in low calorie shrikhand during storage

Treatment	0 Day	3 Day	6 Day	9 Day	12 Day	15 Day	18 Day	21 Day	24 Day	27 Day	30 Day
Cs	$8.06^{b}\pm0.04$	$8.28^{b}\pm0.04$	$8.12^{bc}\pm0.08$	$7.84^{b}\pm0.07$	$7.54^{bc}\pm0.006$	$7.32^{b}\pm0.05$	$7.08^{c}\pm0.01$	$6.64^{b}\pm0.05$	$5.82^{b}\pm0.09$	$5.52^{b}\pm0.11$	5.36^{c} 0.12
C_1	$8.10^{b}\pm0.05$	$8.28^{b}\pm0.01$	8.18^{b} ±0.06	$8.00^{b}\pm0.05$	7.68^{b} ±0.004	$7.50^{c}\pm0.05$	$7.30^{b}\pm0.06$	$7.02^{a}\pm0.07$	$6.68^{b}\pm0.06$	$5.32^{a}\pm0.08$	$5.90^{a}\pm0.09$
C_2	$8.22^{a}\pm0.06$	$8.54^{a}\pm0.04$	8.36^{a} ±0.05	$8.06^{a}\pm0.02$	7.78^{a} ± 0.06	$7.54^{a}\pm0.04$	$7.48^{a}\pm0.03$	$7.18^{a}\pm0.06$	$6.78^{a}\pm0.06$	$6.10^{a}\pm0.13$	$5.91^{a}\pm0.09$
C_3	$8.04^{b}\pm0.03$	$8.20^{b}\pm0.05$	7.90^{c} ±0.03	$7.60^{c}\pm0.07$	7.42^{c} ± 0.06	$7.22^{b}\pm0.06$	$6.88^{d}\pm0.01$	$6.58^{b}\pm0.80$	$6.14^{b}\pm0.02$	$5.76^{b}\pm0.15$	$5.42^{b}\pm0.13$
C.D. (P≤0.05)	0.132	0.121	0.181	0.167	0.203	0.181	0.167	0.202	0.243	0.372	0.326

Cs = Low calorie shrikhand without cardamom
C_1 = Low calorie shrikhand with 0.1% cardamom powder
C_2 = Low calorie shrikhand with 0.2% cardamom powder
C_3 = Low calorie shrikhand with 0.3% cardamom powder

Overall acceptability: The scores increased up to the 6th day of storage compared with the initial scores and subsequently declined with increasing storage period. The control sample remained acceptable up to 21 days, while the 0.1% and 0.3% cardamom treatments remained acceptable up to 24 days. The shrikhand containing 0.2% cardamom retained desirable overall acceptability up to 27 days of refrigerated storage. The higher acceptability of the C2 treatment can be attributed to its favourable flavour, colour and appearance, body and texture, and overall sensory characteristics.

Table 7: Changes in overall acceptability scores of low calorie shrikhand during storage with different levels of cardamom

Treatmnt	0 Day	3 Day	6 Day	9 Day	12 Day	15 Day	18 Day	21 Day	24 Day	27 Day	30 Day
Cs	$8.113^{bc}\pm04$	$8.273^{bc}\pm0.5$	$8.320^{b}\pm0.6$	$7.793^{b}\pm0.7$	$7.520^{b}\pm0.01$	$7.333^{b}\pm0.6$	$6.973^{b}\pm0.05$	$6.560^{c}\pm0.3$	$6.287^{b}\pm0.2$	$5.620^{b}\pm0$ 04	5.247±0.05
C_1	$8.180^{b}\pm0.5$	$8.233^{bc}\pm0.3$	$8.333^{b}\pm0.5$	$8.020^{a}\pm0.4$	$7.700^{a}\pm0.01$	$7.487^{a}\pm0.3$	$7.267^{a}\pm0.07$	$6.920^{b}\pm0.5$	$6.660^{c}\pm0.3$	$5.620^{b}\pm0.$ 03	5.58^{c} ±0.06
C_2	$8.287^{a}\pm0.2$	$8.353^{a}\pm0.5$	$8.440^{a}\pm0.4$	$8.107^{a}\pm0.1$	$7.813^{a}\pm0.01$	$7.613^{a}\pm0.3$	$7.387^{a}\pm0.02$	$7.093^{a}\pm0.3$	$6.727^{a}\pm0.3$	$6.260^{a}\pm0.$ 05	$5.813^{a}\pm0.7$
C_3	$8.067^{c}\pm0.3$	$8.167^{c}\pm0.3$	8.23^{c} ±0.02	$7.607^{c}\pm0.5$	$7.380^{b}\pm0.04$	$7.180^{c}\pm0.4$	$6.893^{b}\pm0.05$	$6.627^{c}\pm0.5$	$6.233^{c}\pm0.5$	$5.793^{b}\pm0$ 12	$5.587^{c}\pm0.7$
C.D. (P≤0.05)	0.094	0.123	0.140	0.142	0.148	0.136	0.144	0.110	0.110	0.210	0.195

Cs = Low calorie shrikhand without cardamom
C_1 = Low calorie shrikhand with 0.1% cardamom powder
C_2 = Low calorie shrikhand with 0.2% cardamom powder
C_3 = Low calorie shrikhand with 0.3% cardamom powder

Overall conclusion

Based on the physicochemical, microbiological and sensory characteristics, low-calorie shrikhand incorporated with 0.2% cardamom (C2) was identified as the optimum treatment. It exhibited better sensory acceptability and comparatively desirable physicochemical and microbial quality during refrigerated storage. The product remained acceptable for up to 27 days under refrigerated conditions, compared with 21 days for the control and approximately 24 days for the 0.1% and 0.3% cardamom treatments.

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