

## RESEARCH ARTICLE

# Development and evaluation of ginger-honey *shrikhand* – a fermented sweet delicacy

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**Abstract:** *Shrikhand* is a semi-soft, pleasant sweetish-sour, whole milk fermented product popular in the western parts of the India and is prepared by mixing *chakka* with sugar, cream and other ingredients. Levels of milk fat content, sugar: honey ratio and ginger juice concentration were optimized using central composite rotatable design of response surface methodology. Optimized formulation of ginger-honey *shrikhand* contained 3.16 % milk fat, 79.61 sugar: honey ratio (i.e. 20.39 % sugar replaced with honey) and 3.79 % ginger juice concentration (on *chakka* basis) and gave an overall acceptability score of  $8.07 \pm 0.06$  on a 9-point hedonic scale. Ginger-honey *shrikhand* samples packed in polystyrene cups remained acceptable on 30<sup>th</sup> day of storage at  $7 \pm 1$  °C with overall acceptability score of  $7.83 \pm 0.06$ . Responses from 90 consumers indicated wide acceptability of ginger-honey *shrikhand* among consumers with mean overall liking score of 8.25 on 9-point hedonic scale.

**Keywords:** Fermented product, *shrikhand*, ginger, honey, RSM

## Introduction

*Shrikhand* is a traditional fermented milk product popular in the western parts of the India and is prepared by mixing *chakka* (strained yoghurt) with sugar, cream and other ingredients (Aneja et al. 1977; Upadhyay and Dave 1977). Several varieties of *shrikhand* include plain, mango, dry-fruit, saffron, pineapple etc., the name of which are derived from the added ingredients.

Honey is a sweet and syrupy liquid collected by bees from the nectar of flowers (Haydak et al. 1942; Aparna and Rajalakshmi 1999). It contains small amounts of vitamins and minerals, including niacin, riboflavin, thiamine and pyridoxine, pantothenic acid, ascorbic acid and nicotinic acid (Bogdanov et al. 2008). According to Jonathan and White (1978), honey is the only sweetening material that can be stored and used exactly as produced in natural form. In foods, honey is used as flavouring and colouring agents, natural sweetener, binding agent, curing agent, and humectant. Honey has been reported to exhibit various health beneficial properties such as antioxidant (Kek et al. 2017), anti-hypertensive, anti-diabetic (Erejuwa et al. 2012; Erejuwa 2014), anti-inflammatory (da Silva et al. 2016), immunomodulatory (McLoone et al. 2016) and antimicrobial properties (Merican et al. 2007).

Ginger (*Zingiber officinale*) is most commonly used herbal supplement reported for alleviating the symptoms of motion sickness, nausea and vomiting (White 2007). Ginger has also been reported to exhibit anti-hypertensive effects, cancer prevention, regulation of blood glucose levels, anti-oxidant and antimicrobial actions (Shukla and Singh 2007; Khan et al. 2019). Ginger is commonly used as a spice in the preparation of Indian cuisine dishes. It is also preferred as an ingredient in tea preparation due to its pleasant aroma in various parts of Asia. Present research work is an attempt to explore the use of honey as sweetening agent and ginger as flavouring agent in *shrikhand* making.

## Materials and Methods

### Raw Materials

Milk, ginger, cane sugar, honey (Dabur India Limited) and polystyrene cups were procured from the local market of Amreli district. Ginger was washed with plenty of tap water, peeled off to remove the skin and grated using stainless steel grater. Grated ginger was pressed on a strainer to obtain the juice. Ginger juice was indirectly heated to 80 °C for 15 seconds and chilled immediately below 5 °C. Sugar was ground using mixer-grinder and used in the product preparation. *Dahi* culture (NCDC-324) was procured from National Collection of Dairy Cultures of Dairy

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### Preparation of ginger-honey *shrikhand*

Milk was filtered through nylon milk strainer, and standardized for fat content as per the experimental design matrix indicated in Table 1. Milk was heated to 60 °C and homogenized using laboratory milk homogenizer. Homogenized milk was heated to 90 °C for 15 min and cooled to  $42 \pm 1$  °C. Milk was then inoculated with *dahi* culture at the rate 2 %, and incubated at  $42 \pm 1$  °C till acidity reaches 0.80 % of lactic acid. Curd was then transferred to sterilized muslin cloth and drainage of whey was allowed for overnight under refrigerated conditions. Calculated amount of ground sugar, honey and ginger juice as per the experimental design matrix was added and mixed thoroughly using planetary mixer to get homogenous consistency (Aneja et al. 1977; Patel and Chakraborty 1985). Calculation of sugar was made at the rate of 60 % on *chakka* weight basis and replacement of sugar with honey was made as per sugar: honey replacement ratio indicated in experimental design matrix (e.g. 60 indicates: 40 % of calculated sugar amount replaced with honey).

### Optimization of the formulation

Levels of three variables namely milk fat content, sugar: honey ratio and ginger juice concentration were optimized using the Response Surface Methodology (Myers 1971) provided in Design-Expert® V-10 (Stat-Ease Corporation, USA). Based on preliminary trials, lower and higher levels for milk fat content; sugar: honey replacement ratio; and ginger juice content were decided as 1.5 % and 4.5 %; 60:40 and 100:0; and 2 % and 6 %, respectively (on *chakka* weight basis); and experimental design matrix obtained is presented in Table 1. Experiments were conducted in a random manner and replicated three times at least.

Effect of milk fat content ( $x_1$ ), sugar: honey ratio ( $x_2$ ) and ( $x_3$ ) ginger juice concentration were analysed on the sensory quality of ginger-honey *shrikhand*. Results obtained for each responses were statistically analysed using Design Expert® software. Levels of milk fat, sugar: honey replacement ratio and ginger juice concentration were optimized using numerical optimization tool provided in the software. Constraints for variables i.e. milk fat content, sugar: honey ratio and ginger juice concentration were: “in-range”, while for the critical sensory responses i.e. flavour and overall acceptability were: ‘maximized’. Solution with the highest desirability was selected as optimized formulation.

### Physico-chemical analysis

Milk was analysed for fat and solids-not-fat (SNF) content as per methods of IS: SP:18 (Part XI). Acidity of *dahi* was estimated by titration method as suggested in IS:9617 (1980). Acidity of *chakka* and *shrikhand* was estimated by using titration method as per the procedure of described in Appendix D of IS:1166 (1986).

Total solids, ash and fat content of ginger-honey *shrikhand* and market sample was determined by adopting the methods of FSSAI (Manual of methods of analysis of foods, Milk and milk products 2015). Protein content of *shrikhand* was estimated by Kjeldahl method according to the procedure described in IS: SP:18 (Part XI). The total carbohydrate was estimated using phenol-sulphuric method (Dubois et al. 1956; Krishnaveni et al. 1984) as described in book Biochemical Methods (Sadasivam and Manickam 1996).

### Colour and firmness analysis

The colour of samples were measured using Colorflex EZ instrument (HunterLab, USA) and measurements were obtained in Hunter L a b scale (Hunter and Harold 1987) using D65 as an illuminant. Firmness test for *shrikhand* samples were carried out using TA.XT plus texture analyzer (Stable Micro Systems Limited, UK). *Shrikhand* samples were filled in plastic beakers (dia. 5 cm) up to 4 cm and tapped 10 times. A 35 mm aluminum cylinder probe with a flat end was used and allowed to travel up to 20 mm at speed of 2 mm/s with trigger force of 5 g at 10 °C. Test data were analysed using the Exponent Lite (Version 6) software for determination of firmness.

### Sensory evaluation and consumer survey

The samples were presented to the panel of seven trained panelists from the faculty members of Postgraduate Institute of Dairy Education and Research, Amreli. The sample was analysed for different sensory parameters like colour and appearance, body and texture, sweetness, flavour and overall acceptability using a 9-point hedonic scale (Amerine et al. 1965); where, score of 1 indicates ‘dislike extremely’ and 9 indicates ‘like extremely’.

For assessment of consumer responses, optimized formulation of ginger-honey *shrikhand* was distributed to 90 probable consumers (Alvensleben and Schrader 1998) belonging to mixed age group, gender and location of residence. A questionnaire along with the sample was presented to the consumers for collecting data regarding personal information (age, gender and location) and acceptability of the optimized product. Responses were obtained on a 9-point hedonic scale and results were presented in average value.

### Storage study

Samples of ginger-honey *shrikhand* drawn on 0, 10, 20 and 30<sup>th</sup> day of storage and analysed for changes in sensory (colour and appearance, body and texture, sweetness, flavour and overall acceptability), physico-chemical (total solids, acidity, free fatty acids and proteolysis) and microbial quality (standard plate count, coliform count and yeast and mould count) at  $7 \pm 1$  °C. Total free fatty Acids (FFA) content was estimated using extraction titration method of Deeth and Fitzgerald (1976). The extent of proteolysis in the fresh as well as stored samples of ginger-honey *shrikhand* was assessed by adopting the procedure of Church et al. (1983)

using o-phthaldialdehyde (OPA) method. The extent of proteolysis was assessed by plotting standard curve with L-leucine and expressed as mg/g sample. Standard plate count, yeast and mold count and coliform count were enumerated as per methods described in IS SP: 18 (Part: XI) 1981.

**Statistical analysis**

Results are expressed as mean ± standard error (SE). The data obtained during storage analysis were subjected to analysis of variance test in a completely randomized design followed by Duncan’s Multiple Range Test ( $p < 0.05$ ) for multiple sample comparison.

**Results and Discussion**

Sensory quality of ginger-honey *shrikhand* as affected by varying the levels of milk fat, sugar: honey ratio and ginger juice concentration is presented in Table 1. Variation in milk fat content was not more than ± 0.05 % of the values indicated in the experimental design matrix, whereas SNF content varied from 8.63 to 9.11. Acidity of *dahi* for the preparation of *chakka* varied from 0.80 to 0.85 % of lactic acid. Product were prepared in random manner as per experimental design matrix (Table 1).

**Effect of fat, sugar: honey ratio and ginger juice concentration on the sensory quality of ginger-honey *shrikhand***

The colour and appearance score of ginger-honey *shrikhand* ranged from 7.45 to 8.09 (Table 1). Sugar: honey ratio and ginger juice concentration indicated significant influence ( $p < 0.05$ ) on the colour and appearance of ginger-honey *shrikhand* on quadratic level. Colour and appearance scores of ginger-honey *shrikhand* at intermediate levels of ginger juice and honey were higher (Figure 1a). Waghmare et al. (2021) who studied the effect of ginger powder incorporation on the sensory properties of *shrikhand* also observed increase in the colour and appearance score up to certain level with increasing levels of ginger powder, further increasing the levels of ginger powder led to decrease in the scores. The decrease in colour and appearance scores at higher levels of ginger and honey could be attributed to the perceivable changes in the colour and appearance of *shrikhand* from milky white to off white.

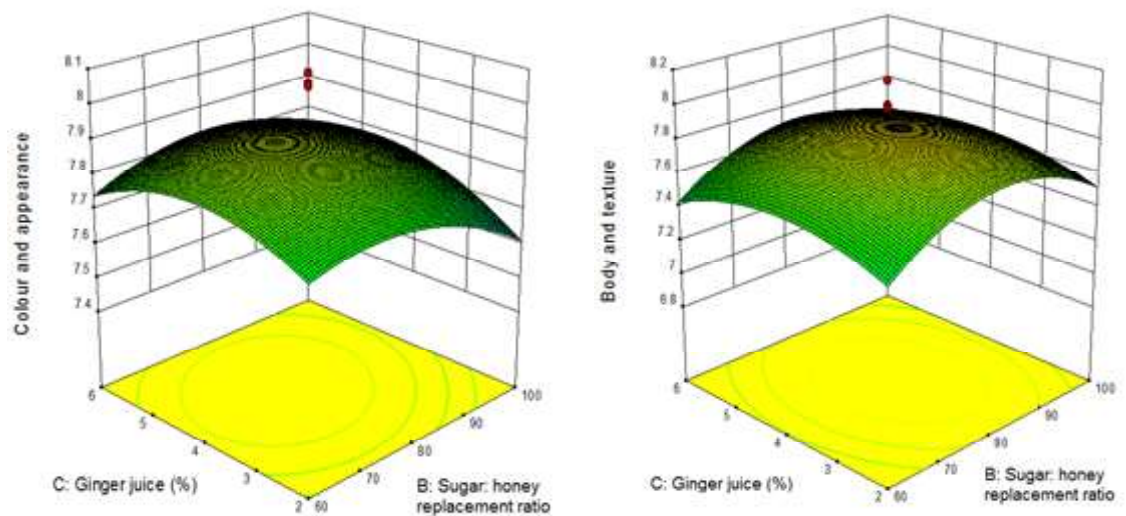
Levels of sugar: honey ratio and ginger juice significantly affected the body and texture score ginger-honey *shrikhand* on quadratic level at  $p < 0.01$  and  $p < 0.05$  level of significance, respectively (Table 2). At intermediate levels of sugar: honey replacement ratio and ginger juice concentration, body and texture score were higher, but a gradual decrease was observed with either increasing or decreasing the levels (Figure 1b). Chorage et al. (2018) reported decrease in the total solids content of *shrikhand* with increasing concentration of ginger juice. The loose body of ginger-honey *shrikhand* at higher levels of honey and ginger juice was not

**Table 1** Experimental design matrix for the effect of milk fat, sugar: honey ratio and ginger juice concentration on sensory responses

Standard order	Actual factors			Sensory scores				
	Milk fat (%)	Sugar: honey*	Ginger juice(%)	C & A	B & T	Sweetness	Flavour	OA
1	1.5	60	2	7.63	7.48	7.70	7.26	7.52
2	4.5	60	2	7.77	7.55	7.59	7.27	7.50
3	1.5	100	2	7.45	7.41	7.61	7.80	7.45
4	4.5	100	2	7.70	7.58	7.65	8.02	7.58
5	1.5	60	6	7.71	7.35	7.52	7.30	7.46
6	4.5	60	6	7.74	7.74	7.87	8.03	7.76
7	1.5	100	6	7.68	7.50	7.52	7.54	7.48
8	4.5	100	6	7.80	7.57	7.70	7.45	7.70
9	0.48	80	4	7.70	8.00	7.83	7.35	7.91
10	5.52	80	4	7.80	7.65	7.65	7.32	7.70
11	3	46.36	4	7.68	6.95	7.52	7.19	7.30
12	3	113.64	4	7.56	7.27	7.40	7.41	7.21
13	3	80	0.64	7.58	7.47	7.47	7.88	7.45
14	3	80	7.36	7.63	7.63	7.25	7.80	7.50
15	3	80	4	7.83	7.78	7.89	8.00	7.78
16	3	80	4	8.09	8.00	8.00	7.66	8.04
17	3	80	4	8.06	7.98	7.90	7.58	8.02
18	3	80	4	7.73	7.71	7.79	7.33	7.73
19	3	80	4	8.05	8.14	8.14	7.71	8.05
20	3	80	4	7.60	7.64	7.70	7.34	7.68

$x_1$ : milk fat content;  $x_2$ : sugar: honey ratio,  $x_3$ : ginger juice concentration; C & A: colour and appearance; B & T: body and texture; OA: overall acceptability; \*ratio (e.g. 60 indicates: 40 % of calculated sugar amount replaced with honey)

**Fig. 1** Response surface plot of sensory attributes: (a) colour and appearance (b) body and texture as influenced by ginger juice concentration and sugar: honey ratio



preferred by the panelists, thus led to decrease in body and texture scores.

Formulation containing maximum level of ginger juice concentration yielded minimum sweetness score (Table 1), which could be attributed to the pungent aroma of ginger masking the sweetness of ginger-honey *shrikhand*. Sweetness score of ginger-honey *shrikhand* significantly varied with the sugar: honey ratio ( $p < 0.05$ ) and ginger juice concentration ( $p < 0.01$ ) at quadratic level (Table 2).

Flavour score of ginger-honey *shrikhand* ranged from 7.19 to 8.03. Differences in the flavour score of ginger-honey *shrikhand* due to sugar: honey ratio and ginger juice concentration were significant ( $p < 0.01$ ) at quadratic level, however, none of the variables indicated significant ( $p < 0.05$ ) influence on flavour score at linear level. Milk fat content indicated positive influence on the flavour score of ginger honey *shrikhand*, and is also evident from the positive coefficient of estimate for milk fat content at linear level (Table 2). Higher fat content improved the richness and mouthfeel of ginger-honey *shrikhand*. Figure 2a indicated higher scores for flavour at intermediate levels of ginger-juice concentration and sugar: honey ratio. However, Waghmare et al. (2021) reported decrease in flavour scores from 7.7 to 6.9, when increased the levels of ginger powder in *shrikhand* formulation from 98:02 to 94:06 for *chakka*: ginger powder ratio. The persistent decrease in the reported result due to ginger powder was attributed to the strong pungent aroma of ginger powder. In our study, flavour scores at lower concentration of ginger juice were low indicating ginger flavour were not perceived at lower levels of juice, whereas higher levels has contributed to the pungency thus led to decrease in flavour scores. The form of addition of ginger i.e. juice or powder influenced the intensity of flavour compounds thus differences in observations from previous reports were noted.

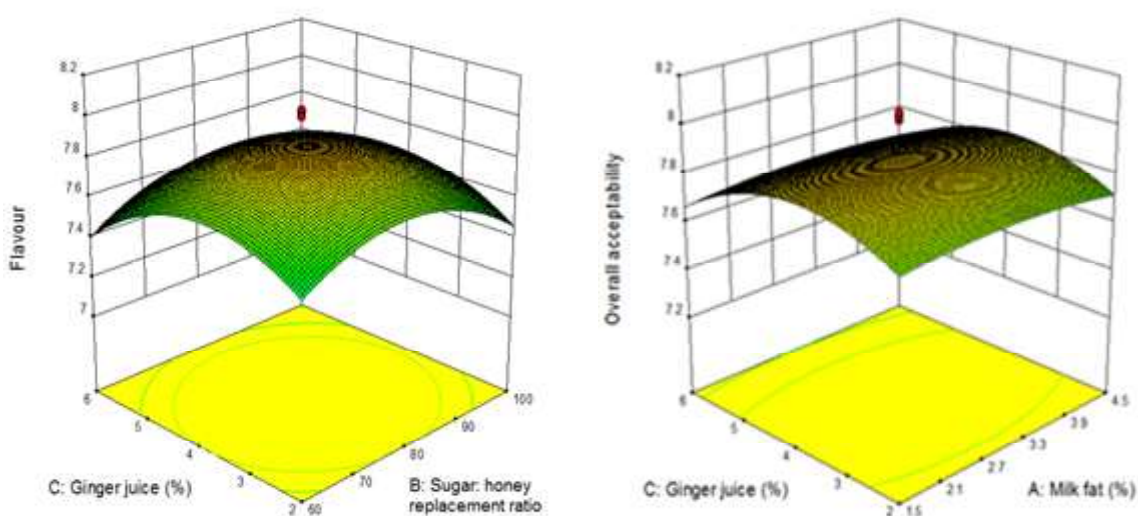
None of the formulation variables indicated significant influence on the overall acceptability of ginger-honey *shrikhand* at linear level, however, effect of sugar: honey ratio and ginger juice concentration was significant ( $p < 0.01$ ) at quadratic level (Table 2). Figure 2b indicates that overall acceptability of ginger-honey *shrikhand* increased with the increase in milk fat content, whereas intermediate levels of ginger juice concentration resulted higher acceptability scores. Findings of Waghmare et al. (2021) who worked on sensory properties of *shrikhand* using ginger powder supported our observations. Similar trend for overall acceptability of herbal ice cream prepared using incorporation of ginger juice (Jadhav et al. 2017) was reported with increasing ginger juice levels in ice cream formulation. Pungent aroma at higher ginger juice levels; loose body at higher levels of honey and ginger juice; and changes in colour and appearance due to addition of honey and ginger juice were the reasons affecting overall acceptability of ginger-honey *shrikhand*.

The  $R^2$  values for the models obtained for sensory parameters varied in the range of 0.59 to 0.85, being the lowest for colour and appearance and highest for flavour scores. High  $R^2$  values generally indicates the how better variability in the responses can be explained by the model. Lack of fit test was non-significant for all the sensory parameters that confirmed the fitness of model.

### Optimized formulation

Optimum formulation obtained as a result of numerical optimization using Design Expert® V-10 contained 3.16 % milk fat, 79.61 sugar: honey ratio (i.e. 20.39 parts of sugar replaced with honey in calculated amount of sugar) and 3.79 % ginger juice concentration. The desirability of selected optimum formulation was 0.82. Sensory evaluation of the optimized product indicated an overall acceptability score of  $8.07 \pm 0.06$ . Comparatively higher scores in market *shrikhand* were reported for colour, texture, flavour and overall acceptability which were

**Fig. 2** Response surface plot of sensory attributes: (a) flavour score as influenced by ginger juice concentration and sugar:honey ratio (b) overall acceptability score as influenced by ginger juice concentration and milk fat concentration.



**Table 2** Regression coefficients of the quadratic model to predict sensory quality in ginger-honey *shrikhand*

Model term	Coefficient estimate				
	C & A	B & T	Sweetness	Flavour	OA
Intercept	7.892012	7.871655	7.898546	7.885594	7.884758
$x_1$	0.051855	0.008155	0.011516	0.027093	-0.00829
$x_2$	-0.03089	0.035013	-0.02942	-0.01651	0.003561
$x_3$	0.033982	-0.00699	-0.0227	-0.04337	-0.03338
$x_1x_2$	0.025	-0.0275	-0.0025	0.02875	-0.025
$x_1x_3$	-0.03	0.0275	0.075	0.00375	0.0025
$x_2x_3$	0.035	0.0025	-0.0175	0.02375	0.0225
$x_1^2$	-0.04204	0.004181	-0.02646	-0.04424	-0.03701
$x_2^2$	-0.088*	-0.24861**	-0.12546*	-0.20687**	-0.23146**
$x_3^2$	-0.09331*	-0.14608*	-0.16081**	-0.22278**	-0.15368**
$R^2$	0.59	0.74	0.70	0.85	0.81

\*\*significant at  $p < 0.01$ , \*significant at  $p < 0.05$ ,  $x_1$ : milk fat content;  $x_2$ : sugar: honey replacement ratio,  $x_3$ : ginger juice concentration; C & A: colour and appearance; B & T: body and texture; OA: overall acceptability

8.70, 8.67, 8.40 and 8.50, respectively (Gupta et al. 2015). Quality analysis of *shrikhand* sold in Kolhapur city indicated colour and appearance, body and texture, flavour, sweetness, and overall acceptability score in the range of 6.46 to 7.50, 6.05 to 7.84, 6.32 to 7.77, 6.01 to 7.29 and 6.50 to 7.35, respectively (Bhagavan et al. 2020). A large variation among the acceptability market samples was noted from previous reports. Such variations are normal to be seen, as large proportion of *shrikhand* is produced by traditional methods at cottage scale, thus leading to lack of uniformity in the production techniques.

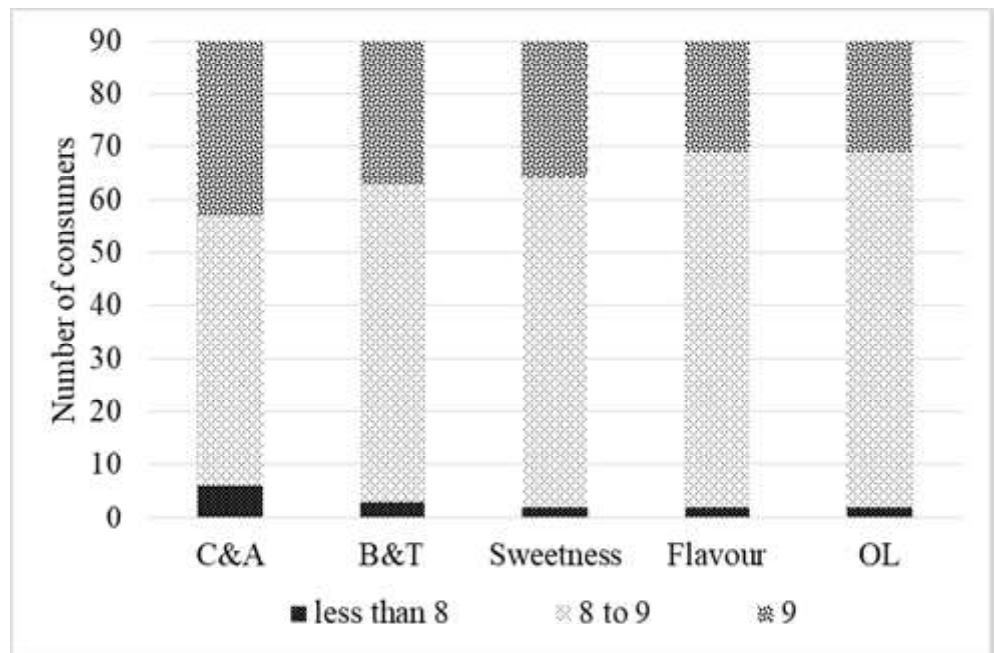
**Physicochemical, microbial and sensory quality of optimized ginger-honey *shrikhand***

Results for physico-chemical, microbial and sensory quality of ginger-honey *shrikhand* prepared using optimized formulation are presented in Table 3. In our study, optimized product contained 52.75 % total solids which is lower than the current prescribed legal standards for *shrikhand*, which could be

attributed to the partial replacement of sugar with honey and addition of ginger juice containing higher moisture content. Mehta (2013) reported total solids content in few market samples *shrikhand* varied in range of 47.55 to 55.77 %. Analysis of the market samples of *shrikhand* sold in Kolhapur city of Maharashtra state indicated total solids in the range of 53.28 to 57.27 % (Jaybhay et al. 2019). Total solids content in symbiotic *shrikhand* samples blended with different levels of papaya pulp and dextrine varied in the range from 51.56 to 54.22 %, whereas control samples were reported to contain 57.35 % total solids (Suryawanshi et al. 2022) when prepared using traditional method. Process interventions such as efficient whey separation by mechanical methods using basket centrifuge or quarg separator, will be helpful in increasing final total solids of the *shrikhand*.

Firmness of optimized ginger-honey *shrikhand* and market sample were 0.52 and 0.48 kg, respectively. In spite of containing higher total solids firmness value in the market samples was lower than

**Fig. 3** Acceptability of ginger-honey *shrikhand* among consumers



**Table 3** Physico-chemical, microbial and sensory quality of ginger-honey *shrikhand*

Characteristics	Ginger-honey <i>shrikhand</i>	Market sample*
<i>Physico-chemical quality</i>		
Fat (%)	5.64±0.07	5.36±0.05
Protein (%)	6.12±0.08	7.70±0.05
Total carbohydrate (%)	39.57±0.45	47.38±0.26
Total solids (%)	52.75±0.25	61.09±0.25
Ash (%)	0.82±0.01	0.76±0.01
Acidity (% LA)	1.11±0.01	1.22±0.06
Firmness (kg)	0.52±0.03	0.48±0.01
L	83.90±0.51	78.27±0.15
a	-0.68±0.03	-0.55±0.02
b	13.03±0.09	13.70±0.05
<i>Microbial quality</i>		
Standard plate count (log cfu/g)	7.84±0.27	3.49±0.23
Yeast and mould count (log cfu/g)	2.43±0.12	2.18±0.30
Coliform count (log cfu/g)	nd	nd
<i>Sensory quality</i>		
Colour and appearance	8.21±0.10	7.78±0.05
Body and texture	8.17±0.08	7.70±0.06
Sweetness	8.11±0.07	7.78±0.06
Flavour	8.04±0.06	7.62±0.06
Overall acceptability score	8.07±0.06	7.78±0.05

\*cardamom flavoured *shrikhand* ; nd: not detected

that of ginger-honey *shrikhand*, which could be attributed to the differences in unit operations involved in manufacturing process. Some manufacturers adopt *chakka* production from skim milk curd, they separation using quarg separator, mixing and thermization of cream and other ingredients using scraped surface heat exchanger (Aneja 2002) causing shear sensitivity on protein network of *shrikhand*. Firmness value of dietetic amrakhand

prepared by incorporating different levels of stevia leaf extracts and mango pulp reported in the range of 1.21 to 1.28 N when estimated using 25 mm cylindrical probe at 23 °C (Tondare and Hembade 2021). Firmness of market sample *shrikhand* was reported as 29.03 g, when analysed using P/0.5 Cylindrical Telrin probe (Gupta et al. 2015). The reported values of firmness were lower than our findings, the reason could be attributed to the

**Table 4** Changes in physico-chemical, microbial and sensory quality of ginger-honey *shrikhand* during storage

Storage interval	0 day	10 day	20 day	30 day
<i>Chemical Quality</i>				
Acidity (% lactic acid)	1.10 ± 0.01 <sup>a</sup>	1.13 ± 0.01 <sup>b</sup>	1.15 ± 0.01 <sup>c</sup>	1.18 ± 0.01 <sup>d</sup>
Free fatty acid (µeq/g)	1.43 ± 0.01 <sup>a</sup>	1.46 ± 0.01 <sup>b</sup>	1.50 ± 0.01 <sup>c</sup>	1.53 ± 0.01 <sup>d</sup>
Total solids (%)	52.33 ± 0.02 <sup>a</sup>	52.38 ± 0.01 <sup>b</sup>	52.50 ± 0.01 <sup>c</sup>	52.55 ± 0.01 <sup>d</sup>
Proteolysis	0.49 ± 0.005 <sup>a</sup>	0.53 ± 0.005 <sup>b</sup>	0.57 ± 0.005 <sup>c</sup>	0.65 ± 0.005 <sup>d</sup>
<i>Microbial quality</i>				
Standard plate count (log cfu/g)	7.38 ± 0.02 <sup>a</sup>	7.89 ± 0.02 <sup>b</sup>	8.19 ± 0.04 <sup>c</sup>	8.44 ± 0.06 <sup>d</sup>
Yeast and mould count (log cfu/g)	2.04 ± 0.02 <sup>a</sup>	2.38 ± 0.04 <sup>b</sup>	2.56 ± 0.06 <sup>c</sup>	2.70 ± 0.03 <sup>d</sup>
Coliform count	nd	nd	nd	nd
<i>Sensory quality</i>				
Colour and appearance	8.21 ± 0.10 <sup>a</sup>	8.16 ± 0.09 <sup>a</sup>	7.88 ± 0.06 <sup>b</sup>	7.76 ± 0.07 <sup>b</sup>
Body and texture	8.17 ± 0.08 <sup>a</sup>	8.09 ± 0.06 <sup>ab</sup>	7.90 ± 0.06 <sup>bc</sup>	7.76 ± 0.07 <sup>c</sup>
Sweetness	8.11 ± 0.07 <sup>a</sup>	8.07 ± 0.05 <sup>ab</sup>	7.92 ± 0.05 <sup>bc</sup>	7.80 ± 0.06 <sup>c</sup>
Flavour	8.04 ± 0.06 <sup>a</sup>	8.02 ± 0.05 <sup>a</sup>	7.95 ± 0.07 <sup>ab</sup>	7.78 ± 0.07 <sup>b</sup>
Overall acceptability	8.07 ± 0.06 <sup>a</sup>	8.04 ± 0.06 <sup>a</sup>	7.97 ± 0.06 <sup>ab</sup>	7.83 ± 0.07 <sup>b</sup>

Means with different superscripts in the same row differ significantly ( $p < 0.05$ ); Values in each cell represent mean  $\pm$  SE,  $n=3$  for physico-chemical and microbial quality,  $n=7$  for sensory quality; nd: not detected

variation in selection of probe used during textural analysis, sample temperature, compositional differences, ingredients used in *shrikhand* making and action of shear forces during mixing of ingredients.

Colour values on Hunter L, a and b scale for optimized ginger-honey *shrikhand* and market *shrikhand* is presented in Table 3. Mean colour values  $L^*$ ,  $a^*$  and  $b^*$  for goat milk *shrikhand* were reported as 77.34, 4.47 and 7.19, respectively (Sahu et al. 2021), where CIE  $L^*$ ,  $a^*$  and  $b^*$  indicate lightness, red/green coordinate and yellow/blue coordinate, respectively. Gupta et al. (2015) observed differences in the colour values of market *shrikhand* and experimental samples.  $L^*$ ,  $a^*$  and  $b^*$  values of market *shrikhand* were 82.70, -2.73 and 13.39, respectively. Colour of *shrikhand* sample can enhance the acceptability of *shrikhand*. However, the colour preference may vary according to the variety of *shrikhand*. Conclusion from previous reports indicate variation in the colour values, which is influenced by the type of milk, ingredients used in the manufacture and colour scale adopted to represent colour values.

Suvera et al. (2017) during development of fiber fortified probiotic *shrikhand* reported standard plate count (SPC) in the range of 5.23 to 5.27 log cfu/g, whereas coliform count was reported nil. In the present study, market sample of *shrikhand* showed lower SPC, which could be due to thermization of *shrikhand* in industrial method of production, which also enhances the shelf life of the product (Aneja et al. 2002; Dhotre and Bhadania 2016).

Sensory quality of ginger-honey *shrikhand* and market sample is presented in Table 3, which indicated ginger-honey *shrikhand* was superior in terms of sensory acceptability. Meena et al. (2016) during study on the sensory preference modelling compared normal and probiotic market *shrikhand* with lab made samples

and observed better sensory acceptability of lab made samples. During development of fiber fortified *shrikhand* total sensory scores for control sample was 89.74 out of 100 (Suvera et al. 2017). Findings of Gupta et al. (2015) indicated better acceptability of market samples compared with experimental samples prepared microencapsulated rice bran oil as fat alternative in *shrikhand* premix. From the published literatures it can be concluded that the acceptability of *shrikhand* varies with the choice of ingredients and practices followed in its manufacture.

#### Effect of storage on the physico-chemical, sensory and microbial quality of ginger-honey *shrikhand*

The data pertaining to changes in the physico-chemical, sensory and microbial quality of ginger-honey *shrikhand* is given in Table 4. The initial titratable acidity (% lactic acid) of ginger-honey *shrikhand* was 1.10 which increased to 1.18 (% lactic acid) after 30 days of storage (Table 4). Significant ( $p < 0.01$ ) increase in the acidity was observed during refrigerated storage of the samples. Increase in the titratable acidity from 1.19 to 1.38 (% lactic acid) was also reported in the control samples of *shrikhand* when stored at  $5 \pm 1$  °C (Jadhav et al. 2019). Consistent increase in the titratable acidity of *shrikhand* samples is due to action of microbes during storage.

The free fatty acids (FFA) content of fresh ginger-honey *shrikhand* samples was  $1.43 \pm 0.01$  (µeq/g), which increased significantly ( $p < 0.01$ ) to  $1.53 \pm 0.01$  (µeq/g) after 30 days of storage at  $7 \pm 1$  °C (Table 4). In previous reports, increase in average FFA content from 3.49 to 8.56 (% oleic acid) in *shrikhand* samples was reported after 35 days storage under refrigeration at  $5 \pm 1$  °C (Raghuwanshi et al. 2014). Jadhav et al. (2019) also observed increase in the FFA content of *shrikhand* samples from 0.27 to 0.38 (% oleic acid) on the 21<sup>st</sup> day of storage at  $5 \pm 1$  °C.

Analysis of ginger-honey *shrikhand* samples for proteolysis indicated increase in L-leucine values from 0.49 mg/g to 0.65 mg/g on 30<sup>th</sup> day of storage. Increase in the soluble nitrogen content of *shrikhand* samples were reported from 0.103 to 0.241 % during 13 days of storage under refrigeration (Sonawane et al. 2007). Soluble nitrogen content in the control samples of *shrikhand* was also reported to increase from 0.50 to 1.19 % after 28 days of storage at  $5 \pm 1$  °C (Jadhav et al. 2019). Increase in the soluble nitrogen content in *shrikhand* samples could be attributed to proteolytic activity of lactic acid bacteria (Wolfschoon 1979; Savijoki 2006).

The initial total solids (TS) content of ginger-honey *shrikhand* increased from 52.33 % to 52.55 % at the end of 30 days of storage under refrigeration (Table 4). Decrease in the moisture content of *shrikhand* from 49.27 % to 47.55 % was reported after 13 days storage under refrigeration (Sonawane et al. 2007). Mehrotra et al. (2014) also observed slight decrease in the moisture content of *shrikhand* from 32.04 to 31.86 % when stored under refrigeration for 21 days. Increase in the total solids content during storage largely depends on the moisture barrier properties of package, temperature and relative humidity of storage conditions.

Changes in the sensory quality of ginger-honey *shrikhand* samples were significant when packed samples were stored at  $7 \pm 1$  °C for 30 days (Table 4). Findings of Mehrotra et al. (2014) supported our observations who reported decrease in colour and appearance, taste and flavour, body and texture, and overall acceptability score of *shrikhand* from 7.86 to 5.81, 7.83 to 5.63, 7.74 to 5.87, and 7.92 to 6.00, respectively during storage up to 21 days at 7 °C. Similar trends for decrease in the sensory scores of *shrikhand* prepared by incorporating cardamom and saffron were also reported when stored at  $7 \pm 1$  °C for 21 days (Dandile et al. 2014). However, extent of changes in sensory quality reported by previous authors were higher. In our study, samples were remained acceptable on 30<sup>th</sup> day of storage with an overall acceptability score of 7.83, which could be attributed to the antimicrobial properties of honey and ginger which slowed down the growth of lactic acid bacteria (Mercan et al. 2007; Khan et al. 2019). Dhotre and Bhadania (2016) during study on the thermization of *shrikhand* using scraped surface heat exchanger reported gradual decrease in the sensory scores in control and thermized *shrikhand* samples when stored at  $8 \pm 2$  °C. However, thermization of *shrikhand* was reported to extend the shelf life up to 45 days.

Standard plate count (SPC) and yeast and mould count (Y&M) of ginger-honey *shrikhand* samples revealed significant increase from initial count of  $7.38 \pm 0.02$  and  $2.04 \pm 0.02$  log cfu/g to  $8.44 \pm 0.06$  and  $2.07 \pm 0.03$  log cfu/g (Table 4), respectively when stored under refrigeration for 30 days. Coliform count was not detected when the first dilution of samples drawn on 0<sup>th</sup>, 10<sup>th</sup>, 20<sup>th</sup> and 30<sup>th</sup> day were plated on violet red bile agar (VRBA). Jadhav et al. (2019) reported nil coliform count in *shrikhand* samples during

21 days storage period under refrigeration, which increased to  $1.84 \log_{10}$  cfu/g on 28<sup>th</sup> day of storage.

### Consumer's acceptability

A total of 90 consumers provided their responses to the optimized ginger-honey *shrikhand* samples. Responses as a result of the sensory perception obtained from the consumers using a 9-point hedonic scale and summarized in Figure 3. Among 90, 88 consumers rated the optimized product more than or equals to 8, which was nearer to 'liked extremely' region of hedonic scale. Average scores of 90 respondents for colour and appearance (C&A), body and texture (B&T), sweetness, flavour and overall liking (OL) score were 8.31, 8.27, 8.27, 8.38 and 8.25, respectively.

### Conclusion

Optimized level of milk fat content, sugar:honey ratio and ginger juice concentrate were 3.16 %, 79.61 (i.e. 20.39 % of sugar replaced with honey) and 3.79 %, respectively. Consumer survey studies indicated wide acceptability of ginger-honey *shrikhand* which combines the health beneficial attributes of lactic acid bacteria, honey and ginger.

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