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Optimization of *Adadiya* - A Milk-Black Gram based Traditional Sweet Delicacy and Evaluation of Combined Effect of Vacuum Packaging and Refrigeration Storage on its Stability

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ABSTRACT

Background: *Adadiya* is a milk-pulse based sweet traditionally manufactured in the Gujarat state, which combines goodness of milk solids, black gram and spices. Sensory attributes of most preferred *adadiya* possess rich flavour of spices, resembles brown to dark brown colour, coarse texture embedded with small pieces of almonds and cashew. In present study, process for manufacture of *adadiya* was developed and formulation was optimized.

Methods: Brief method of preparation involves heating of dehulled black gram coarse flour along with *ghee* with continuous stirring, followed by the addition of *khoa* and further heating till desired colour is obtained. The mixture is then cooled and added with sugar syrup, edible gum, nuts and spices.

Result: Optimum formulation of *adadiya* contained 89.9% *ghee*, 30% *khoa* and 117.8% sugar syrup (73^{o} Bx), on flour basis, which gave overall acceptability score of 8.31 on a 9-point hedonic scale. Vacuum packed *adadiya* samples remained acceptable on 30th day of storage with overall acceptability score of 8.14. Consumer survey indicated wide acceptability of *adadiya* among consumers with rated score of ≥ 8 on a 9-point hedonic scale.

Key words: *Adadiya*, RSM, Sensory Quality, Shelf life.

INTRODUCTION

Traditional dairy products symbolize important aspect of Indian culture and have potential to grow in the market, thus offer opportunities for dairy and food entrepreneurs. Production of traditional dairy products by organized manufacturers offers better consumer satisfaction. Milk is considered as the primary source of nutrition, however remains deficient in few micronutrients like iron and certain vitamins. On the other hand, nutritional importance of pulses is mainly due to high protein and abundance in micronutrients such as minerals (Byanju and Lamsal, 2023). Fortification of herbs and spices in traditional Indian dairy products provides an opportunity for value addition through strengthening of therapeutic potential (Maji *et al.*, 2023). Hence, idea of composite dairy foods brings together benefits of milk with other ingredients such as cereals and pulses.

Adadiya is a traditional sweet treat made from milk-pulse which is frequently consumed during winter season in Saurashtra and Kutch regions of Gujarat state. Most preferred *adadiya* possess rich aroma of spices, has coarse texture, brown to dark brown colour, embedded with small pieces of fried edible gum, nuts like cashews and almonds. It is made by heating coarse dehulled black gram flour with *ghee*, addition of *khoa* and further heating till desired colour is obtained. The mixture is then cooled and added with sugar syrup, edible gum, nuts and spices. Various spices used in the preparation of *adadiya* include cardamom, nutmeg, mace, clove, cinnamon, white pepper, long pepper and dried ginger, many of them have been reported to possess number of health beneficial activities including antioxidant, antimicrobial, anti-carcinogenic and digestive-stimulant properties (Rani *et al.*, 2023). A milk-cereal based sweet delicacy popularly known as *pinni* is consumed widely in the northern parts of country. The widespread acceptance of composite sweet treats creates a market for the popularization of regionally distinct traditional dairy products. *Adadiya* is mostly prepared and sold by home and shop-based confectioners, which results in a wide variation of product attributes. Furthermore, there is a dearth of scientific information on *adadiya* preparation. A publication on the scope of technological impression in indigenous dairy product sector highlighted the importance of initiatives required its preservation and promotion for rural development (Asgar and Chauhan, 2023). Present research work was an attempt to optimize the formulation of *adadiya* and evaluate its stability during storage.

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MATERIALS AND METHODS

The research work was carried out at College of Dairy Science, Amreli, Gujarat during year 2018-19. Milk, *ghee*, cane sugar, black gram (urad) splits, nuts (cashew and almond), spices and edible gum arabic were procured from the local grocery store.

Optimization of the formulation for *adadiya*

Levels of 3 variables namely, *ghee*, *khoa* and sugar syrup were optimized using the central composite rotatable design of the response surface methodology (Myers and Montgomery, 2002) provided in Design-Expert® V-10 (Stat-Ease Corporation, USA). Based on preliminary trials, lower and higher levels for formulation variables *viz., ghee*, *khoa* and sugar syrup were decided and design matrix is presented in Table 1. Effect of *ghee* (x_1), *khoa* (x_2) and (x_3) sugar syrup levels were investigated on the sensory quality and hardness of *adadiya* and optimized using numerical optimization technique considering sensory responses.

Preparation of *adadiya*

Black gram splits were cleaned, washed with tap water followed by drying in a tray drier at 55°C for 5-6 h, which was later converted in coarse flour (should pass through BSS 22) at local flour mill. Milk (6% fat and 9% SNF) was converted in *pindi khoa* by heat desiccation (De and Ray1952) in stainless steel *karahi*. Spice mix (100 g) was prepared by mixing different spices and herbs namely cardamom (10 g), white pepper (10 g), dried mace (5 g), nutmeg (5 g), cinnamon (5 g), dried ginger (50 g), clove (5 g) and long pepper (10 g) followed by conversion in powder using mixer-grinder. Sugar syrup of 73°Bx (20°C) was prepared by mixing and boiling cane sugar in water. Edible gum (6.5% on flour basis) was fried in *ghee* for 1-2 minutes. Approximately, 70% proportion was converted in powder form and 30% kept as whole fried gum for garnishing purpose. *Adadiya* was prepared in the manner as described in flow chart (Fig 1).

Physico-chemical analysis

Fat and solids not fat (SNF) content of milk were estimated by procedure of as described in IS: SP:18 Part XI (1981). Moisture and ash content of black gram flour was estimated using the methods of the Association of Official Analytical Chemists (AOAC, 1998). The protein content (N x 6.25) of flour and *adadiya* samples was determined by micro-Kjeldahl method (AOAC, 1998). Crude fat (ether extract) of flour sample was estimated by method of AOAC (2003) using SOCS PLUS instrument (Pelican Equipment, India). The moisture and ash content of *adadiya* was determined using the method described for *khoa* in IS SP: 18 (Part: XI) 1981. The fat content of *adadiya* samples was estimated by acid hydrolysis method of AOAC (1998). The total carbohydrate was calculated by difference method (Merill and Watt, 1973). Titratable acidity of *adadiya* sample was measured by mixing 1 g sample with 10 ml of warm distilled water (65°C). The content was cooled and titrated against 0.1 N sodium

Table 1: Experimental design matrix and effect of ghee, *khoa* and sugar syrup levels on the sensory scores and hardness of *adadiya*.

Standard order	Actual factors (%)			Sensory scores					Hardness
	Ghee (x_1)	*Khoa* (x_2)	Sugar syrup (x_3)	C and A	B and T	Sweetness	Flavour	OAS	(kgf)
1	70	10	100	7.72	7.75	7.83	7.92	7.83	4.50
2	100	10	100	7.46	7.57	7.43	7.50	7.61	4.80
3	70	30	100	8.28	8.35	7.69	7.72	7.75	3.66
4	100	30	100	8.27	8.50	8.47	8.27	8.33	3.34
5	70	10	150	7.23	7.19	7.50	7.62	7.50	3.11
6	100	10	150	7.28	7.51	7.29	7.61	7.50	3.17
7	70	30	150	7.63	7.13	7.56	7.56	7.78	2.97
8	100	30	150	7.31	7.35	7.03	7.56	8.38	3.40
9	59.77	20	125	7.61	7.22	7.56	7.5	7.22	4.43
10	110.23	20	125	7.74	8.09	7.85	8.03	7.58	1.86
11	85	3.18	125	7.71	7.75	7.57	7.89	7.89	3.11
12	85	36.82	125	8.77	7.77	8.42	8.42	8.5	2.65
13	85	20	82.96	7.38	7.19	7.28	7.03	7.06	3.88
14	85	20	167.04	7.43	6.89	7.03	7.46	7.32	2.84
15	85	20	125	8.61	8.56	8.39	8.39	8.39	2.43
16	85	20	125	8.67	8.43	8.40	8.27	8.27	2.62
17	85	20	125	8.50	8.31	8.25	8.00	8.25	2.80
18	85	20	125	8.75	8.68	8.43	8.54	8.61	2.68
19	85	20	125	8.81	8.44	8.23	8.38	8.41	2.85
20	85	20	125	8.10	7.82	8.25	7.63	8.10	2.61

x_1: *Ghee*; x_2: *Khoa*, x_3: Sugar syrup level; C and A: Colour and appearance; B and T: Body and texture; OAS: Overall acceptability score.

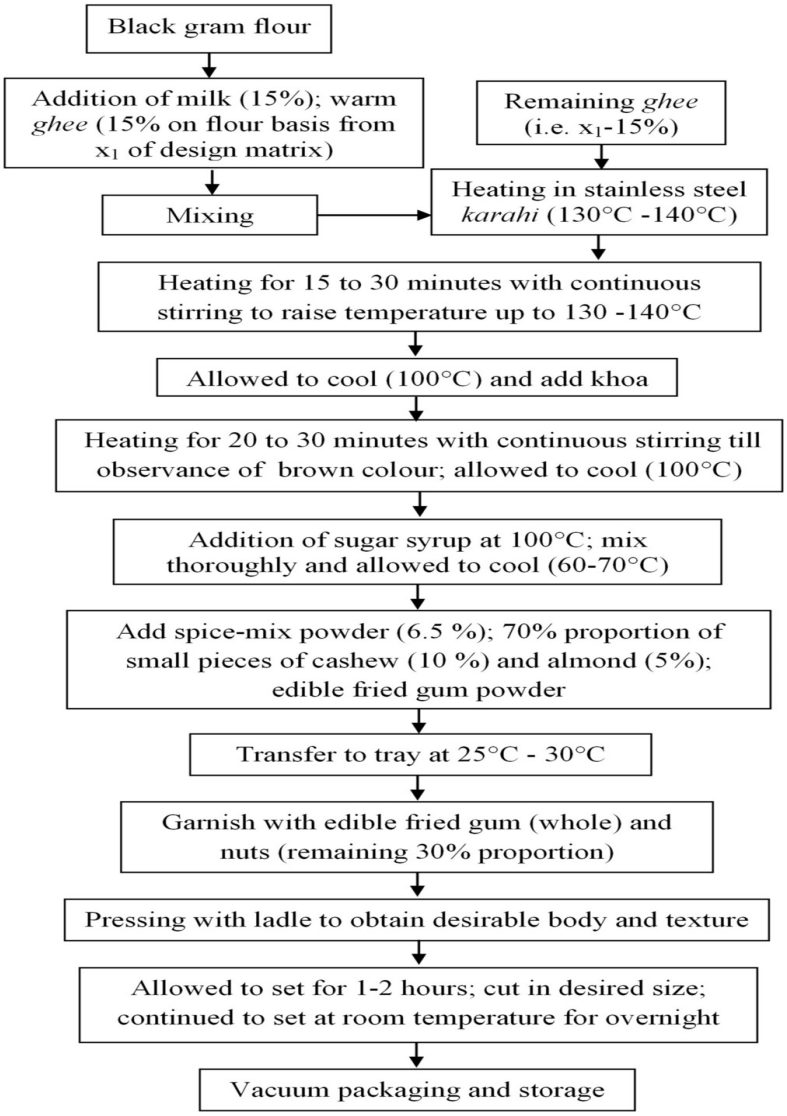

Fig 1: Flow chart for the preparation of *adadiya*.

hydroxide solution using phenolphthalein as indicator and results was expressed as percent lactic acid. Free fatty acids (FFA) content was estimated by adopting titration method of Deeth and Fitzgerald (1976) with slight modifications. Briefly, 5 g *adadiya* sample was taken in a stoppered test tube, added with 5 ml of distilled water. Ten ml of extraction mixture was added and shaken vigorously for 15 s. Additional 6.0 ml of petroleum ether was added and estimation of FFA (μeq/g) was continued in the manner as suggested.

The colour of the *adadiya* samples was measured on Hunter L, a, b scale using Colorflex EZ instrument (Hunter Associates Laboratory, Virgina, USA) with D65/10 as an illuminant. For estimation of hardness, *adadiya* samples (3 × 3 × 3 cm^3) were subjected to a compression test at 25°C in TA.XT plus texture analyzer (Stable Micro Systems Limited, UK) equipped with 50 kg load cell and 50 mm cylinder probe (P50). Test settings included test speed of 2.0 mm/s, trigger force 5 g, distance 15 mm and post-test speed 10 mm/s.

Microbiological analysis

Standard plate count (SPC), yeast and mould (YandM) count and coliform count were enumerated as per IS SP: 18 (Part: XI) 1981 methods. By mixing 11 g of *adadiya* sample with 99 ml of sterile phosphate buffer 1:10 dilution was obtained. Further dilutions were prepared by transferring 1 ml into 9 ml dilution blanks.

Sensory evaluation, consumer reponses and storage study

The samples of *adadiya* were presented to the panel of sensory judges consisting of 7 trained panelists from the faculty members of College of Dairy Science, Amreli. Samples were analysed for colour and appearance, body and texture, sweetness, flavour and overall acceptability using a 9-point hedonic scale, where score preference of 9

indicates 'like extremely' and 1 indicates 'dislike extremely'. Consumer responses (n=80) for optimized *adadiya* samples were obtained on a 9-point hedonic scale for perception about colour and appearance, body and texture, flavour, sweetness and overall liking.

For storage study, the product was vacuum packed in low density polyethylene (LDPE) pouches (thickness: 80µm) in tabletop vacuum packaging machine and stored under refrigeration at 7±1°C. The samples were analysed for changes in sensory, physico-chemical (moisture, acidity and free fatty acids) and microbial quality (SPC, coliform and Yand M) on 0th, 10th, 20th and 30th day.

RESULTS AND DISCUSSION

Effect of *ghee*, *khoa* and sugar syrup level on the sensory attributes and hardness of *adadiya*

Milk fat and SNF content of milk used in the preparation of *khoa* for *adadiya* making varied from 6.1 to 6.2 and 9.1 to 9.3%, respectively. Analysis of black gram flour indicated 8.73% moisture, 1.58% crude fat, 2.68% ash and 21.27% protein. The average sensory scores for different formulations of *adadiya* is presented in Table 1 and the dependence of sensory responses with respect to formulation variables such as *ghee*, *khoa* and sugar syrup in the form of the quadratic coefficient is presented in Table 2. Goodness of fit for different responses is expressed in terms of coefficient of determination (R^2) which ranged from 0.69 to 0.89.

Among the three formulation variables *i.e. ghee*, *khoa* and sugar syrup level, *khoa* had significant (p<0.01) influence on colour and appearance of *adadiya* at linear level, whereas other two variables indicated significant (p<0.01) influence at quadratic level (Table 2). It is evident from Table 1 that *ghee* and sugar syrup at intermediate levels resulted better scores for colour and appearance. Thesiya *et al.* (2023) during the manufacture of peanut based *thabdi* also observed decrease in colour and appearance scores at higher fat: SNF ratio. Dry appearance of the *adadiya* samples at lower *ghee* level, whereas greasy appearance beyond optimum levels could be the reasons for decreasing appearance scores when deviated from the intermediate levels.

Levels of sugar syrup in *adadiya* significantly affected the body and texture score at linear (p<0.05) as well as quadratic (p<0.01) levels (Table 2). At intermediate levels of sugar syrup, body and texture score were higher, but a gradual decrease was observed by increasing or decreasing the concentration of sugar syrup (Table 1). The negative sign for the coefficient of estimates indicated an adverse effect of sugar syrup level on the body and texture score of *adadiya*, which could be attributed to softening effect with increasing syrup levels, which was not preferred by the judges. Similar trend was recorded in the findings of Acharya *et al.* (2008) for texture scores of a *khoa* based product *gundpak* when sugar levels when were varied from 0 to 25% and higher scores were reported at intermediate sugar levels. Changes in the hardness of peanut based *thabdi peda* was also observed with varying levels of sugar and peanut flour indicating influence of ingredients in the textural parameters (Sejani *et al.*, 2023). Such changes in hardness of the product reflects variation in the body and texture score during sensory evaluation of traditional products.

Differences in flavour score due to variation in *khoa* levels indicated significant (p<0.05) influence at the linear level. Highest score for flavour was obtained for formulation containing 85% *ghee*, 20% *khoa* and 125% sugar syrup levels. Response surface plot of sugar syrup and *khoa* on the flavour of *adadiya* (Fig 2) indicated an increase in flavour scores with increasing *khoa* levels. However, sweetness of *adadiya* beyond optimum sugar level resulted decrease in sweetness score. Singh *et al.* (2019) reported positive influence of wheat flour, *ghee* and sugar on the flavor score of *pinni* a milk cereal based sweet delicacy, whereas in our findings *ghee* and *khoa* levels (Table 2) indicated positive

Table 2: Regression coefficients of the quadratic model to predict sensory attributes and hardness hardness of *adadiya*.

Model term	Coefficient estimate†					
	C and A	B and T	Sweetness	Flavour	OAS	Hardness
Intercept	8.576	8.366	8.324	8.201	8.329	2.650
x_1	-0.024	0.144	0.009	0.074	0.115	-0.282
x_2	0.262**	0.098	0.156*	0.099**	0.207**	-0.218
x_3	-0.161	-0.256*	-0.180*	-0.025	0.006	-0.395*
x_1x_2	-0.015	0.029	0.108	0.123*	0.175*	-0.031
x_1x_3	0.000	0.071	-0.140	-0.018	0.030	0.064
x_2x_3	-0.118	-0.219	-0.138	-0.085	0.065	0.299
x_1^2	-0.334**	-0.204*	-0.214**	-0.149	-0.272**	0.267
x_2^2	-0.134	-0.167	-0.111	-0.011	0.009	0.174
x_3^2	-0.429**	-0.421**	-0.408**	-0.332**	-0.346**	0.343*
R_2	0.88	0.81	0.88	0.69	0.89	0.69

†for final equation in terms of coded factors (*e.g.* coded factors for five levels x_1 are -1.682, -1, 0, 1 and +1.682 representing 59.77, 70, 85, 100 and 110.23, respectively in Table 1).

x_1: Ghee; x_2: *Khoa*, x_3: Sugar syrup; **Significant at p<0.01, *Significant at p<0.05.

influence on the flavour scores. Rich and mellow flavour contributed by ghee was attributed for the positive influence on the flavour attributes of *adadiya*.

Overall acceptability of *adadiya* indicated relative preference of the panelists based on different sensory attributes, which varied from 7.06 to 8.61 as a result of different formulations (Table 1). Overall acceptability of *adadiya* was significantly ($p<0.01$) affected by the *khoa* levels at linear level. Khan *et al.* (2008) during development of groundnut *burfi* studied effect of formulation variables namely sugar, condensed milk and water and observed significant ($p<0.01$) influence of sugar on the taste and overall acceptability. Increasing condensed milk level resulted increase in overall acceptability up to some extent, which declined with further increasing the levels.

The hardness (peak force in force deformation curve) of *adadiya* samples was affected significantly ($p<0.05$) by sugar syrup levels at linear and quadratic levels (Table 2). Softening effect by sugar syrup, incorporation of nuts such as cashew and almonds during the preparation of *adadiya* and its distribution in the mass have resulted large variation in the hardness of the samples. Kaur *et al.* (2018) reported hardness of milk cake - a traditional milk based confection in the range of 4.5 to 6.8 kg with the varying levels of sweetener and milk fat content. Hardness of peanut flour based *thabdi peda* varied in the range of 17.24 to 36.31 kgf with positive influence of sugar and peanut flour levels (Sejani *et al.*, 2023). Variation among reported results could be attributed to selection of probe for textural analysis, temperature during test and compositional differences.

Optimization and evaluation of optimized *adadiya*

Solution for optimum formulation (desirability: 0.922) obtained as a result of numerical optimization tool (Design-Expert® V-10) contained as 89.9% *ghee*, 30% *khoa* and 117.8% sugar syrup level. Optimized product was prepared and evaluated for sensory acceptability, which indicated an overall acceptability score of 8.31±0.14, which is comparable with findings of Khan *et al.* (2008) who optimized groundnut *burfi* using RSM and reported overall acceptability score of 8.20.

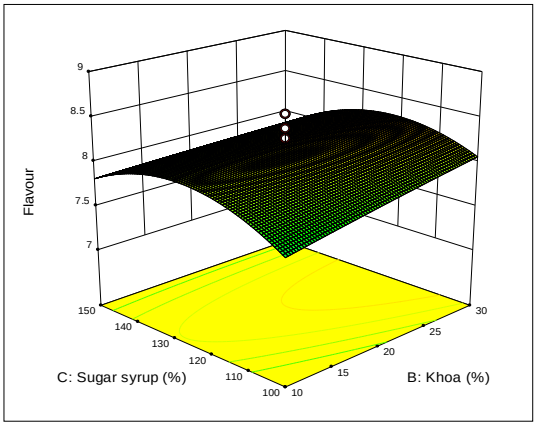

Fig 2: Effect of sugar syrup and *khoa* levels on the flavour score of *adadiya.*

Consumer acceptability test of optimized *adadiya* samples (n=80) indicated wide acceptability and obtained overall acceptability score e" 8 on a 9-point hedonic scale which was near to 'liked extremely' region of hedonic scale. Mean scores of 80 consumers' responses for colour and appearance, body and texture, sweetness, flavour and overall acceptability score were 8.56, 8.25, 8.33, 8.53 and 8.36, respectively.

Optimized *adadiya* samples (Fig 3) were analysed for various physico-chemical and sensory attributes and observations are presented in Table 3. Compositional and sensory attributes of any traditional dairy product depends on choice of ingredients and method of manufacture which varies largely from product to product. Scientific data on *adadiya* preparation and its physico-chemical quality is scanty. *Pinni* a traditional sweet, generally prepared by roasting cereal flour after addition of ghee and sugar was reported to contain 9.67% protein, 27.76% crude fat, 53.67% carbohydrates and 3.10% ash content with an overall acceptability score of 8.02 on a 9-point scale (Arora *et al.*, 2023).

Effect of refrigeration storage on quality of *adadiya*

Significant ($p<0.01$) increase in the acidity of *adadiya* samples from 0.473±0.003 to 0.526±0.009 was observed during storage at 7±1°C on 30th day, which could be attributed to mcirobial activity during storage. Increase in FFA from 0.76±0.02 to 1.3±0.06 (μeq/g) of *adadiya* samples was observed in 30 days of storage at due to action of lipases. FFA content of groundnut *burfi* samples was reported to increase from 0.68 to 0.91 (% oleic acid) when packed in polypropylene pouches and stored under ambient conditions (Khan *et al.*, 2008). An increase in the FFA content of a composite sweetmeat *doda burfi* from 0.604 to 1.017 (μeq/g) was reported during storage up to 21 days in thermoformed polyethylene terephthalate trays and stored under refrigeration (Chawla *et al.*, 2021). Thesiya *et al.* (2023) reported increase in acidity from 0.315 % to 0.387% lactic acid on 28th days of storage in vacuum packed peanut based *thabdi* samples when stored under refrigerated conditions. Slight loss in the initial moisture content of *adadiya* was observed which decreased from 9.90 ± 0.01 to 9.79±0.01 (%) in LDPE pouches at the end of storage period. Loss of moisture during storage mainly depends on the water vapour barrier properties of packaging material and storage conditions.

Data pertaining to SPC and Y and M (Log_{10}CFU/g) of vacuum packed samples of *adadiya* revealed significant increase from 4.06±0.01 to 4.43±0.01 and 1.21±0.00 to 1.64±0.01, respectively during storage up to 30 days. However, coliform colonies were not detected throughout storage study. Observations were in accordance with the findings of Londhe *et al.* (2012) who reported an increase in the total viable counts and Y and M count in the vacuum packed samples of brown *peda* during storage, whereas,

Table 3: Physico-chemical and sensory quality of *adadiya*.

Characteristics	Mean ±SE
Physico-chemical quality	
Fat (%)	30.05±0.15
Protein (%)	9.84 ±0.10
Total carbohydrates (%)	48.71±0.21
Moisture (%)	10.08±0.13
Ash (%)	1.32±0.04
Acidity (% LA)	0.47±0.02
L	35.62±0.25
a	8.71±0.14
b	11.52±0.17
Sensory quality	
Colour and appearance	8.33±0.13
Body and texture	8.25±0.15
Sweetness	8.29±0.12
Flavour	8.25±0.13
Overall acceptability score	8.31±0.14

Values in each cell represent mean ± SE; n=3 for physico-chemical and n=7 for sensory quality.

Fig 3: Optimized *adadiya* samples.

coliform was reported absent during storage. An increase in the total plate count (log_{10} cfu/g) from 4.87 to 6.46 and yeast and mould count (log_{10} cfu/g) from 2.85 to 3.34 in 30 days of storage was reported when air packed *kalakand* samples were stored at 10°C. Authors reported growth of microbes can be retarded and shelf life can be doubled with the application of modified atmospheric packaging (Jain *et al.*, 2015).

Changes in the sensory quality of *adadiya* samples were not significant for all studied sensory parameters when vacuum packed samples were stored at 7±1°C for 30 days. Slight decrease in the overall acceptability score from 8.29±0.18 to 8.14±0.14 (n=7) was observed on 30th day of storage. However, none of the judges reported the perception of any off flavour in stored *adadiya* samples up to 30 days. Our observation were in accordance with the findings of Londhe *et al.* (2012) who reported minimal changes in the sensory scores of vacuum packed brown *peda* samples when stored up to 20 days, thereafter a nominal change in the scores were reported with the extension of storage period. Accessible plenty nutrients and free fat content in *khoa* based traditional sweets along with high water activity have been reported to limit their (Badola *et al.*, 2023). Application of antimicrobial coating and combination of modified atmospheric packaging were successful in doubling shelf life of *doda burfi* a composite milk product (Chawla *et al.*, 2021). High barrier packaging material i.e. polyester/nylon/LDPE based multilayered film was reported to indicate better control in physico-chemical and microbiological changes in the quality of vacuum packed yak milk *panner* samples assuring slow spoilage in comparison to LDPE films (Singh *et al.*, 2022). In our study, combined effect of vacuum packaging, refrigeration storage, presence of herbs and spices were helpful to preserve *adadiya* samples during storage study of 30 days. From the cited literatures, it can also be observed that future study on the MAP in high barrier packages will be beneficial in the shelf life extension of the *adadiya* samples.

CONCLUSION

The present study was an attempt to optimize the formulation of *adadiya*. Consumer survey of *adadiya* indicated wide acceptability among consumers. *Adadiya* has wide potential for commercialization, as it offers nutritional benefits derived from milk and black gram and may also contribute to health benefits associated with spices.

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