

Research Article

Development of *Thabdi* milk sweets of Gujarat State, India utilizing Ghee residue as an ingredient

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Abstract

Thabdi an ethnic khoa based milk sweet of Gujarat State, which is famous for its characteristic colour texture and flavour, was prepared using ghee residue as an ingredient in order to provide a way to effectively utilize the by-product. Ghee residue was added in milk at different rates viz. T1 (control), T2 (2%), T3 (4%), T4 (6%), T5 (8%) and T6 (10 %). Addition of ghee residue in milk for making *Thabdi* was found to significantly ($P \leq 0.05$) increase the fat, protein and ash content, Free fatty acids (FFA), Thiobarbituric acid (TBA) value and acidity significantly ($P \leq 0.05$) decreased the hardness of the products. Addition of ghee residue resulted in elimination of the 40 min holding period generally used for making *Thabdi*. Sample T4 (containing 6 % ghee residue) yielded the most acceptable product in terms of sensory attributes of product. It had a glossy brown colour, soft body, uniform grainy texture and pleasing rich nutty caramel flavour. During storage of sample T4 at cabinet temperature ($20 \pm 1^\circ\text{C}$) and room temperature (37°C), the acidity, FFA, HMF (Hydroxymethyl Furfural), TBA and hardness increased significantly ($P \leq 0.05$) and sensory scores, moisture, water activity and pH decreased significantly ($P \leq 0.05$). It can be concluded that the most acceptable quality *Thabdi* could be prepared by addition of ghee residue at the rate of 6 % w/w of milk with improved shelf-life of 28 days at $20 \pm 1^\circ\text{C}$ and 14 days at $37 \pm 1^\circ\text{C}$ as compared to 21 and 12 days for control respectively. Thus, *Thabdi* sweet prepared with the use of ghee residue as an ingredient will provide a way to effectively utilize the by-product.

Keywords: Ghee, Ghee residue, *Khoa*, Milk sweet, *Peda*, *Thabdi*

INTRODUCTION

Thabdi is an ethnic milk sweet manufactured in Saurashtra region of Gujarat State. It is famous for its brown colour which ranges from creamish brown (traditionally compared with the skin of the offspring of Camel) to dark brown, granular loose texture having small pools of melted fat or a smear of solidified fat on the surface and its rich caramelized, cooked, rich nutty, ghee like flavour along with the rich milk fat aroma. It is marketed in Saurashtra region of Gujarat State in the form of small rectangular shaped pieces and also in loose form (Hirpara et al., 2015). *Thabdi* is also known as *Thabdi Peda* in some region of Gujarat (Modha et al., 2015). Ghee residue is an essential

dairy by-product being produced in a bulk volume per annum as a result of increasing ghee production. It contains innumerable nutrients in varying quantities, depending on the process of the ghee preparation (Chauhan et al., 2010). Ghee residue has robust nutrients and energy: the fat, protein, lactose and ash content is approximately up to levels of 33.0-63.0 %, 18.0-30.0%, 2.0-14.0 % and 3.0-8.0 % respectively (Santha and Narayanan, 1978a and Janghu et al., 2014). Patel et al. (2012) reported a huge variation in all quality attributes of market *Thabdi*. The process standardization of *Thabdi* or *Thabdi Peda* was done by Hirpara et al. (2015), Krupa et al. (2013) and Modha et al. (2015). This ethnic sweet is consumed in large quantity during festivals and ceremonies in the

regions of Gujarat. So, it is of time need to develop *Thabdi* with increased nutritional value and it provides a way to effectively utilize the by-product i.e. ghee residue obtained during ghee making. Therefore, in the present study, an attempt was made here to develop a method of production of *Thabdi* utilizing ghee residue with desired characteristics and cost-effective production of *Thabdi* with a way to utilize the by-product.

MATERIALS AND METHODS

Materials used: Whole milk, ghee and ghee residue (prepared from direct cream method) used for manufacturing of *Thabdi* was procured from Anubhav Dairy, Anand Agriculture University, Anand. Good quality granular sugar of Madhur brand was used.

Ghee residue (GR): GR obtained by direct cream (DC) method, and creamery butter (CB) method was utilized in the manufacture of *Thabdi*. The fat content of cream and white butter employed in ghee making was 45.0 % and 82.0 % respectively. The average yield of GR obtained during the preparation of ghee using DC and CB methods was 9.58 % and 2.80 % respectively. The GR obtained through DC method of ghee making had larger grain size (visual) as compared to that obtained using CB method, which was more suitable for use in *Thabdi* making. Hence, GR obtained in ghee making by DC method was used in this study. The compositional and physico-chemical properties of ghee residue used in the experiment are presented in Table 1.

Preparation of *Thabdi*: Control *Thabdi* (T1) was manufactured according to the process described by Hirpara *et al.* (2015) with slight modifications i.e incorporation of ghee residue and elimination of 40 min holding period. In experimental samples, ghee residue was added in milk at different rates viz. T2(2%), T3(4%), T4 (6%), T5(8%) and T6(10%). *Thabdi peda* was prepared using milk standardized to fat/SNF ratio of 0.53. In all experimental samples (except control, T1), ghee residue was added after pre-pat formation stage and the 40min holding period was eliminated. This resulted in reduced production time without any adverse effect on grain development, as observed in preliminary trials.

Compositional and physico-chemical analysis: The moisture of *Thabdi* samples was determined by a standard procedure using Mojonnier Milk Tester Model -D (Laboratory Manual, 1959). Fat extraction of *Thabdi* was determined as per the procedure described in Indian Standard: 2311 (1963). Total nitrogen/protein of *Thabdi* was determined by Semi-microkjeldahl method (Indian Standard: 1479-Part-II, 1961), using Kjehl-plus digestion system (Model-KPS 006L, M/s. Pelican Instruments, Chennai) and Kjehl-plus semi-automatic distillation system (Model-Distil M, M/s. Pelican Instruments, Chennai). Total carbohydrate content of *Thabdi* was determined by subtracting fat, proteins and ash content from the total solids content. Ash content of *Thabdi* was determined by procedure described in Indian Standard: 1547 (1985). The titratable acidity of

Thabdi samples were determined by method described in Indian Standards (IS: 1166 1968) for condensed milk. The pH of *Thabdi* samples was measured using Systronic digital pH meter, Model 335. The method described by Franklin and Sharpe (1963) for cheese was used. The water activity of *Thabdi* samples, tempered to 25°C, was measured using Rotronic Hygroskop Model: Hygrolab-3 (M/s. Rotronic ag, Switzerland) connected to a sensing element (AW-DIO) with a measuring range of 0-100 % relative humidity (RH). The Free Fatty Acids (FFA) content was determined as per the procedure described by Thomas *et al.* (1954). The quantitative method presented by Keeney and Bassette (1959) for quantifying (Hydroxymethyl Furfural) HMF by spectrophotometric measurement of the maillard reaction product was used to assess the extent of browning in *Thabdi* samples. The extent of oxidation of fat in *Thabdi* was measured in terms of thio barbituric acid (TBA) value according to the extraction method described by Strange *et al.* (1977) using Spectrophotometer analysis for absorbance reading at 532nm.

Texture profile: Five samples of each experimental *Thabdi* were subjected to uniaxial compression to 70% of the initial sample height, using a Food Texture Analyzer of Lloyd Instruments LRX Plus material testing machine, England; fitted with 0-500 kg load cell. The force-distance curve was obtained for a two-bite deformation cycle employing a Cross Head speed of 50 mm/min, Trigger 10 gf and 70% Compression of the samples to determine various textural attributes of *Thabdi* held for 1 h at 23±1°C and 55% RH. The complete work of calculations of area under the force-distance curve, statistical analysis of data generated and their conversion into various textural attributes were carried out by direct transfer of the data to Lloyd Instruments NEXYGEN data analysis and applications software.

Sensory analysis: For the sensory evaluation of *Thabdi*, 8 judges were selected (on the basis of duo-trio test). The *Thabdi* samples were evaluated using a 100 point linear intensity rating scale. The score-card

Table 1. Compositional and physico-chemical properties of ghee residue.

Parameter	Mean value
Moisture (%)	17.12
Fat (%)	47.37
Protein (%)	24.85
Ash (%)	2.8
Total carbohydrate (%)	7.85
FFA (% Oleic Acid)	0.655
Acidity (% LA)	0.22
pH	6.3
TBA (mg malonidehyde/g product)	0.135
HMF (µ moles/100g)	161.37

Mean values are average of 3 replications

suggested for *Khoa* by Gupta and Pal (1985) was used for judging the product *Thabdi* during this study. The judges were also requested to give criticism for each attribute of the samples.

Microbiological analysis: Samples were analyzed for the Standard Plate Count (SPC), coliform count and yeast and mold count (YMC) by the methods described in Indian Standards (IS: 5550, 2005).

Packaging and storage: Both control (C) and T4 *Thabdi* were packed in polypropylene (PP) boxes and the physico-chemical, textural (hardness), sensory and microbial properties (standard plate count, yeast and mould count and coliform count) were monitored at after every 7 days for cabinet ($20\pm 1^\circ\text{C}$) and 2 days for room temperature ($37\pm 1^\circ\text{C}$) until the product was rejected on the sensory basis.

Statistical analysis: Data was subjected to statistical analysis using a completely randomized design using statistical software developed by Anand Agricultural University (AAU), Anand.

RESULTS AND DISCUSSION

Effect of rate of addition of ghee residue on compositional and physico-chemical properties and yield of *Thabdi*: As shown in Table 2, the average moisture content in experimental *Thabdi* varied from 19.07 % (T6) to 22.02 % (T2). The moisture content of all the samples except T2 containing ghee residue was significantly ($P\leq 0.05$) lower than that of control. The moisture content of all the experimental samples was within the range of that reported in the literature for *Burfi* added with ghee residue, i.e. 19 to 20% (Prasad *et al.*, 2012; Chaudhary, 2017). Chaudhary (2017) stated that with an increase in addition to ghee residue from 10 to 30 %w/w of *Khoa*, the moisture content of *Burfi* decreased from 19.63 to 15.23 %. Similarly, Prasad *et al.* (2012) found that with the addition of ghee residue from 5 to 20 % in *khoa*, moisture content of *Burfi* decreased from 30.09 to 25.39 % respectively.

Addition of ghee residue in milk for making *Thabdi* was found to significantly ($P\leq 0.05$) increase the fat, protein and ash content of experimental samples. The increase in fat content might be associated with the higher fat content of the ghee residue, i.e. 47.37%. The present finding is in alignment with the trend reported by Chaudhary (2017) who reported that increase in the rate of addition of ghee residue in *khoa* from 10 to 30 % resulted in an increase in the fat content of *Burfi* from 17.64 to 25.62 %, protein content from 12.74 to 15.25 % and an ash content of *Burfi* increased from 2.74 to 3.18 % and total carbohydrate content of *Burfi* decreased from 47.25 to 40.72 %. Prasad *et al.* (2012) also reported a similar trend in *Burfi* by addition of ghee residue. The average yield in experimental *Thabdi* varied from 26.86 % (T2) to 34.87 % (T6). Addition of ghee residue significantly ($P\leq 0.05$) increased the yield of experimental *Thabdi*.

Table 3 shows the changes in the physico-chemical properties of *Thabdi* on the varying rate of addition of ghee residue. The acidity in experimental *Thabdi* varied from 0.42 % LA (T2) to 0.57 % LA (T6). The pH in experimental *Thabdi* varied from 5.96 (T6) to 6.31 (T2). Addition of ghee residue in milk for making *Thabdi* was found to significantly ($P\leq 0.05$) increase the acidity and decrease the pH of experimental *Thabdi*. This increase in acidity of *Thabdi* or decrease in pH of *Thabdi* may be due to the higher acidity of ghee residue i.e. 0.22%LA as was also reported by Chaudhary (2017) that with addition of ghee residue from 10 to 30 % on *Khoa* weight basis and acidity of *Burfi* increased from 0.41 to 0.50 %LA and pH of *Burfi* decreased from 6.44 to 6.13. The effect of the addition of ghee residue on water activity of prepared *Thabdi* was found non-significant ($P> 0.05$).

The FFA in experimental *Thabdi* varied from 0.64 (T2) to 0.97 (T6) % oleic acid. Addition of ghee residue in milk for making *Thabdi* resulted in significant ($P\leq 0.05$) increase in the FFA content in experimental *Thabdi*. Hirpara *et al.* (2015), Krupa *et al.* (2013) and Modha *et al.* (2015) reported a similar range of FFA in *Thabdi* and *Thabdi Peda*. The increase in the free fatty acid content of *Thabdi* as the increasing rate of addition of ghee residue was largely the result of the higher FFA content of added ghee residue (0.665% oleic acid).

The TBA in experimental *Thabdi* varied from 0.145 (T2) to 0.251 (T6) mg malonidehyde/ kg of product. The TBA increased significantly ($P\leq 0.05$) with the rate of addition of ghee residue in milk. The HMF content decreased significantly ($P\leq 0.05$) with the increase in the rate of addition of ghee residue in milk. The HMF in experimental *Thabdi* varied from 311.66 (T6) to 401.83 (T2) $\mu\text{moles}/100\text{g}$ product. The effect of the rate of addition of ghee residue in milk for making *Thabdi* was found to significantly ($P\leq 0.05$) decrease the HMF content of experimental *Thabdi*. Krupa *et al.* (2013), Patel *et al.* (2012) and Modha *et al.* (2015) reported a similar range of TBA and HMF in *Thabdi* and *Thabdi Peda*.

Effect of rate of addition of ghee residue on texture profile of *Thabdi*: Table 4 shows the changes in textural attributes of *Thabdi* upon the varying rate of addition of ghee residue. It was observed from the table that the average value of hardness of control *Thabdi* (T1) was 75.73 N. The average value of hardness in experimental *Thabdi* varied from 43.08 (T6) N to 65.88 (T2) N. Addition ghee residue in milk for *Thabdi* making was found to significantly ($P\leq 0.05$) decrease the hardness of experimental *Thabdi*. The decreasing result in hardness of *Burfi* was stated by Chaudhary (2017) that with the addition of ghee residue from 10 to 30 % on *Khoa* weight basis, the hardness of *Burfi* was decreased from 30.71 to 16.65 N. The average value of stiffness of control *Thabdi* (T1) was 25.98 N/mm. The average value of stiffness of experimental *Thabdi* was 24.14, 23.78, 21.29, 20.69

Table 2. Effect of rate of addition of ghee residue on composition and yield of *Thabdi*.

Constituents %	T1	T2	T3	T4	T5	T6	CD (0.05)
Moisture	22.92 ^a ± 0.12	22.02 ^{ab} ± 0.79	21.15 ^b ± 0.21	20.59 ^{bc} ± 0.66	19.96 ^{bcd} ± 0.81	19.07 ^d ± 0.74	1.36
Fat	26.44 ^a ± 0.32	23.09 ^b ± 0.41	24.25 ^c ± 0.62	25.59 ^d ± 0.45	26.51 ^d ± 0.27	27.83 ^e ± 0.42	0.94
Protein	7.51 ^a ± 0.07	8.09 ^b ± 0.14	8.81 ^c ± 0.14	9.25 ^c ± 0.34	9.84 ^d ± 0.08	10.70 ^e ± 0.33	0.48
Ash	2.48 ^a ± 0.02	2.57 ^a ± 0.08	2.65 ^{ab} ± 0.07	2.72 ^{bc} ± 0.15	2.78 ^{bcd} ± 0.09	2.87 ^{cd} ± 0.09	0.20
Total Carbohydrate	40.64 ^a ± 0.33	44.22 ^b ± 1.15	43.13 ^{bc} ± 0.56	41.83 ^{cd} ± 0.85	40.89 ^d ± 0.94	39.52 ^d ± 0.81	1.79
Yield (% w/w)	28.47 ^a ± 0.16	26.86 ^{ab} ± 0.89	28.65 ^{ab} ± 0.63	30.83 ^c ± 1.60	32.27 ^c ± 0.66	34.87 ^d ± 0.52	1.89

Each observation is a mean ± SD of three replicate experiment (n=3); ^{a-e} Superscript letters following numbers in the same column denote significant difference (P<0.05)

Table 3. Effect of rate of addition of ghee residue on physico-chemical properties of *Thabdi*.

Attribute	T1	T2	T3	T4	T5	T6	SEm	CD (0.05)	CV %
Acidity (%LA)	0.40 ^a ± 0.01	0.42 ^{ab} ± 0.01	0.44 ^{abc} ± 0.02	0.46 ^{bcd} ± 0.01	0.49 ^{cd} ± 0.04	0.57 ^e ± 0.04	0.02	0.05	5.62
pH	6.41 ^a ± 0.01	6.31 ^{ab} ± 0.01	6.24 ^{bc} ± 0.02	6.14 ^{cd} ± 0.11	6.09 ^{cde} ± 0.06	5.96 ^e ± 0.12	0.05	0.16	1.49
Water Activity (a _w)	0.65 ± 0.03	0.64 ± 0.21	0.63 ± 0.90	0.62 ± 0.51	0.61 ± 0.10	0.60 ± 0.01	0.02	NS	4.16
FFA (%Oleic Acid)	0.57 ^a ± 0.03	0.64 ^a ± 0.04	0.77 ^b ± 0.04	0.84 ^b ± 0.01	0.96 ^c ± 0.04	0.97 ^c ± 0.02	0.03	0.08	5.79
TBA* (O.D. at 532 nm)	0.117 ^a ± 0.02	0.145 ^{ab} ± 0.01	0.155 ^b ± 0.04	0.211 ^c ± 0.07	0.233 ^{cd} ± 0.11	0.251 ^d ± 0.27	0.01	0.03	8.35
HMF (μ moles/100g)	412.52 ^a ± 0.33	401.83 ^b ± 0.32	391.78 ^c ± 0.06	362.22 ^d ± 0.04	333.92 ^e ± 0.92	311.66 ^f ± 0.38	0.59	2.43	4.48

*TBA value is expressed in mg malonidehyde/ kg of product; Each observation is a mean ± SD of three replicate experiment (n=3); ^{a-f} Superscript letters following numbers in the same column denote significant difference (P<0.05)

and 18.24 N/mm, i.e. for T2, T3, T4, T5 and T6 respectively. The average value of stiffness in experimental *Thabdi* varied from 18.24 (T6) N/mm to 24.14 (T2) N/mm. Addition of ghee residue in milk for *Thabdi*, making lead to significant (P≤0.05) decrease in the stiffness of experimental *Thabdi*.

The average value of cohesiveness of control *Thabdi* (T1) was 0.060. The average value of cohesiveness of experimental *Thabdi* was 0.062, 0.084, 0.085, 0.087 and 0.097 i.e. for T2, T3, T4, T5 and T6 respectively. Increase in rate of addition ghee residue increased the cohesiveness of the product. The average value of cohesiveness in experimental *Thabdi* varied from 0.062 (T2) to 0.097 (T6). Addition of ghee residue in milk for *Thabdi* making significantly (P≤0.05) increased the cohesiveness of experimental *Thabdi*. The increasing trend in the cohesiveness of *Burfi* has also been stated by Chaudhary (2017).

The average value of adhesiveness of control *Thabdi* (T1) was 7.57 N mm. The average value of adhesiveness of experimental *Thabdi* was 7.68, 7.71, 8.21, 8.48 and 9.97 N mm, i.e. for T2, T3, T4, T5 and T6 respectively. The average value of adhesiveness in experimental *Thabdi* varied from 7.68 (T2) N mm to

9.97 (T6) N mm. Addition of ghee residue in milk for making *Thabdi* significantly (P≤0.05) increased the adhesiveness of experimental *Thabdi*.

The average value of chewiness of control *Thabdi* (T1) was 7.99 N mm. The average value of chewiness of experimental *Thabdi* was 6.09, 5.83, 4.85, 3.94 and 3.45 N mm, i.e. for T2, T3, T4, T5 and T6 respectively. The average value of chewiness in experimental *Thabdi* varied from 3.45 (T6) N mm to 6.09 (T2) N mm. Addition of ghee residue in milk for *Thabdi* making significantly (P≤0.05) decreased the chewiness of experimental *Thabdi*. The decreasing trend in chewiness of *Burfi* was reported by Chaudhary (2017) that with the addition of ghee residue from 10 to 30 % on *Khoa* weight basis, chewiness of *Burfi* decreased from 3.61 to 2.22 N mm.

Effect of rate of addition of ghee residue on sensory score of *Thabdi*: Table 5 shows changes in the different sensory attributes as varying the rate of addition of ghee residue in *Thabdi* making. The effect of the addition of ghee residue on colour and appearance was found significantly (P≤0.05) different; and colour and appearance score 14.10 of T4 was non-significantly (P>0.05) higher compared to T3 and sig-

Table 4. Effect of rate of addition of ghee residue on texture profile of *Thabdi*.

Attribute	T1	T2	T3	T4	T5	T6	CD (0.05)
Hardness, N	75.73 ^a ± 3.02	65.88 ^{ab} ± 3.15	60.69 ^{bc} ± 1.25	57.89 ^{bcd} ± 1.64	51.10 ^{cde} ± 4.49	43.08 ^e ± 12.14	12.29
Stiffness, N/mm	25.98 ^a ± 1.67	24.14 ^{ab} ± 0.91	23.78 ^{abc} ± 0.26	21.29 ^{bcd} ± 0.63	20.69 ^{bcde} ± 2.66	18.24 ^{de} ± 2.16	3.54
Cohesiveness	0.060 ^a ± 0.04	0.062 ^a ± 0.01	0.084 ^b ± 0.06	0.085 ^{bc} ± 0.07	0.087 ^{bcd} ± 0.03	0.097 ^{bcd} ± 0.10	0.014
Adhesiveness, N mm	7.57 ^a ± 0.31	7.68 ^{ab} ± 0.24	7.71 ^{abc} ± 0.35	8.21 ^{abcd} ± 0.14	8.48 ^{abcd} ± 0.55	9.97 ^e ± 1.22	1.29
Chewiness, N mm	7.99 ^a ± 0.88	6.09 ^b ± 0.46	5.83 ^{bc} ± 0.42	4.85 ^{bcd} ± 0.93	3.94 ^{de} ± 0.43	3.45 ^e ± 0.24	1.34

Each observation is a mean ± SD of three replicate experiment (n=3); ^{a-e} Superscript letters following numbers in the same column denote significant difference (P<0.05)

Table 5. Effect of rate of addition of ghee residue on sensory score of *Thabdi*.

Sample	Colour & Appearance (out of 15.00)	Body & Texture (out of 35.00)	Flavour (out of 45.00)	Total Score (out of 100.00)
T1	10.86 ^a ± 1.09	28.16 ^a ± 0.39	35.42 ^a ± 1.59	80.66 ^a ± 1.07
T2	11.75 ^a ± 0.33	29.89 ^b ± 0.49	37.66 ^{ab} ± 1.22	81.64 ^a ± 1.12
T3	13.25 ^b ± 0.52	31.42 ^c ± 0.41	40.56 ^{bc} ± 0.15	88.54 ^b ± 1.25
T4	14.10 ^b ± 0.76	32.65 ^c ± 0.12	42.34 ^c ± 0.65	95.23 ^c ± 2.19
T5	10.75 ^c ± 0.51	30.09 ^c ± 0.90	38.54 ^{cd} ± 1.03	84.99 ^d ± 0.82
T6	10.43 ^c ± 0.47	28.66 ^d ± 1.01	36.01 ^d ± 2.46	80.74 ^e ± 1.31
CD (0.05)	1.45	1.38	3.03	2.97

*In total score calculation, package score is considered 5 out of 5; each observation is a mean ± SD of three replicate experiment (n=3); ^{a-e} Superscript letters following numbers in the same column denote significant difference (P<0.05)

nificantly (P≤0.05) higher compared to T1, T2, T5 and T6. Increase in rate of addition ghee residue increased the colour and appearance score of products till T4, beyond which the colour and appearance score gets reduced significantly (P≤0.05).

The effect of addition of ghee residue on body and texture was found to be significant (P≤0.05). The body and texture score T4 and T3 were at par (P>0.05) with each other, significantly (P≤0.05) higher compared to T1, T2, T5 and T6. Increase in rate of addition ghee residue increased the body and texture score of the product till T4, beyond which the body and texture score were reduced significantly (P≤0.05).

The average flavour score of control *Thabdi* (T1) was 35.42. The flavour score of experimental *Thabdi* was 37.66, 40.56, 42.34, 38.54 and 36.01, i.e. for T2, T3, T4, T5 and T6 respectively. The effect of addition of ghee residue on flavour score was found to be significantly (P≤0.05) different and flavour score 42.34 of T4 was non-significantly (P>0.05) higher as compared to T3 and significantly (P≤0.05) higher as compared to T1, T2, T5 and T6. Increase in rate of addition ghee residue increased the flavour score of the product till T4, beyond which the flavour score got reduced significantly (P≤0.05).

The total score of control *Thabdi* (T1) was 80.66. The total score of experimental *Thabdi* was 81.64, 88.54, 95.23, 84.99 and 80.74, i.e. for T2, T3, T4, T5 and T6 respectively. The effect of the addition of ghee residue on the total score was found significantly (P≤0.05) different and total score 95.23 of T4 was significantly (P≤0.05) higher compared to T1, T2, T3, T5 and T6. Increase in rate of addition of ghee residue increased the total score of the product till T4, beyond which the total score gets reduced significantly (P≤0.05).

Chaudhary (2017) stated that with the addition of ghee residue from 10 to 30 % on *khoa* weight basis, colour and appearance score, body and texture score, flavour score as well as overall acceptability scores of *Burfi* increased to a certain level of addition of ghee residue and then decreased. Prasad *et al.* (2012) reported that with the addition of ghee residue from 5 to 20 %, there was an increase in colour and appearance score body and texture score, flavour score as well as overall acceptability of *Burfi*. Janghu *et al.* (2014) also reported that the candy, chocolate and *Burfi* prepared with the addition of ghee residue had improved colour and appearance score, body and texture score, flavour score, as well as overall acceptability, compared to burfi prepared without the addition of ghee residue. Table 6

Table 6. Judges' comments during sensory evaluation of experimental *Thabdi*.

Sample	Comments
T1 (Control)	Slightly dull brown colour, slightly hard, Chewy & sticky body and lacks richness in flavour.
T2 (2% GR)	Slight dull brown colour, slightly hard, chewy body and slightly cooked caramel flavour.
T3 (4% GR)	Slight glossy brown colour, slightly hard body, soft grains and slightly cooked caramel flavour.
T4 (6% GR)	Glossy brown colour, soft body, uniform grainy texture and pleasing rich nutty caramel flavour.
T5 (8% GR)	Dark brown to blackish colour, soft body & granular texture and ghee residue flavour.
T6 (10% GR)	Dark brown to blackish colour, very soft body and pronounced cooked and ghee residue flavour.

*The comments were compiled from the sensory score cards.

shows the judges' comments allocated to experimental *Thabdi* during the sensory evaluation of the product.

The result of the present study indicated that most acceptable *Thabdi* could be prepared by addition of 6 % ghee residue in milk (on w/w basis of milk, T4). According to BIS system for grading of milk and milk products (IS:7768, 1975), a sample can be rated as "excellent" if the total score is above 90. As seen in Table 5, the average total score of T4 was 95.23 ± 2.19 . Hence the product was found to be highly acceptable. So this formulation of developed *Thabdi* was selected and used for storage study.

During storage at cabinet temperature ($20 \pm 1^\circ\text{C}$) of *Thabdi* (optimized, T4), the acidity (% LA), FFA (% oleic acid), HMF (μ moles/100g product), TBA (mg malonidehyde/kg product), hardness (N) increased significantly ($P \leq 0.05$) and moisture, water activity, pH decreased significantly ($P \leq 0.05$) from 0.46 to 0.75, 0.840 to 1.377, 362.22 to 396.29, 0.211 to 0.233, 57.89 to 123.08 and 20.59 to 18.41, 0.62 to 0.57, 6.14 to 5.04 respectively, while, the sensory score i.e. colour and appearance, body and texture, flavour and total score decreased significantly ($P \leq 0.05$) from 14.10 to 10.07, 32.65 to 25.06, 42.34 to 32.76 and 94.09 to 72.88 respectively from 0 d up to 28 days. SPC (log cfu/g) significantly ($P \leq 0.05$) increased from 3.44 to 5.14 from 0 d up to 28 days. Yeast and mould count (cfu/g) were increased from 0.00 to 10.00 from 0 days up to 28 days. The product was found devoid of coliform count throughout the storage period. At cabinet temperature ($20 \pm 1^\circ\text{C}$), the optimized *Thabdi* (T4) had a shelf life up to 28 days as compared to control *Thabdi* (T1) i.e. 21 d.

During storage of optimized *Thabdi* (T4) at room temperature ($37 \pm 1^\circ\text{C}$), the acidity (% LA), FFA (% oleic acid), HMF (μ moles/100g product), TBA (mg malonidehyde/kg product), hardness (N) increased

significantly ($P \leq 0.05$) and moisture, water activity, pH decreased significantly ($P \leq 0.05$) from 0.46 to 0.78, 0.840 to 1.433, 362.22 to 415.03, 0.211 to 0.239, 57.89 to 134.71 and 20.59 to 17.06, 0.62 to 0.57, 6.14 to 5.18 respectively, while, the sensory score i.e. colour and appearance, body and texture, flavour and total score decreased significantly ($P \leq 0.05$) from 14.10 to 10.04, 32.65 to 22.08, 42.34 to 30.67 and 94.10 to 67.79 respectively from 0 days up to 14 days. SPC (log cfu/g) significantly ($P \leq 0.05$) increased from 3.44 to 6.22 from 0 days up to 14 days. Yeast and mould count (cfu/g) was increased from 0.00 to 8.33 from 0 days up to 14 days. The product was found devoid of coliform count throughout the storage period. At room temperature ($37 \pm 1^\circ\text{C}$), the optimized *Thabdi* (T4) had a shelf life up to 14 days as compared to control *Thabdi* (T1), i.e. 12 days.

Conclusion

It was concluded that the acceptable quality of *Thabdi* could be prepared by addition of ghee residue at the rate of 6 % in milk (% w/w of milk) with improved shelf-life up to 28 days at cabinet temperature ($20 \pm 1^\circ\text{C}$) and 14 days at room temperature ($37 \pm 1^\circ\text{C}$) when stored in polypropylene boxes. Addition of ghee residue resulted in the elimination of the 40 min holding period generally used for making *Thabdi* thus saving manufacturing time. The preparation of *Thabdi* sweets using ghee residue as an ingredient has provided a way to effectively utilize the by-product with improved acceptability, reduction in manufacturing time and increase in shelf life compared to product prepared without addition of ghee residue.

Conflict of interests

The authors declare that they have no conflict of interests.

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