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Optimization of Processing Parameters for Mechanized Production of *Thabdi*

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Present investigation has been aimed to study the effect of various processing parameters for mechanized production of *Thabdi*. The mechanized system based on steam jacketed kettle was used to manufacture *Thabdi*. Trials were conducted with different operating conditions with batch size of 6 kg milk. In research trials operation conditions were studied at steam pressure (0.8 kg/cm^2, 1.5 kg/cm^2, 2.0 kg/cm^2) and scraper speed (15,20 and 25 rpm) for first and second stage, while (2.0 and 2.5 kg/cm^2) steam pressure and (10 and 15 rpm) for last stages in mechanized kettle. Optimization of process parameters of product manufacturing was done by judging sensory attributes of final product. The sensory quality of *Thabdi* was found superior by adopting steam pressure 1.5 kg/cm^2, scraper speed 25 rpm and batch size 6 kg during first and second stage. The

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third stage involved quiescent holding for fixed period of time. For the fourth stage, steam pressure 2.5 kg/cm^2, scraper speed 10 rpm and batch size 6 kg were optimized for manufacture of *Thabdi*. In present study also compare the product manufactured under optimized conditions were compared with market sample, and it showed better results in terms of cost and sensory attributes.

Keywords: Thabdi; mechanized system; process parameters; optimization.

1. INTRODUCTION

India enjoys dual distinction – it is both the world's largest milk producer and the world's largest milk consumer. Milk production in the country was 221.1 million tonnes during 2021-22 and 230.6 million tonnes during 2022-23, and per capita vailability of 459 g /day (Anonymous, 2024 [1]. Traditional Indian dairy products (TIDP) provide a mean for preservation of precious milk solids for a longer duration with most profitable segment. Out of total milk production in India 50-55 per cent is diverted for preparation of indigenous milk products [2]. The production and marketing of TIDP by organized sector can bring about remarkable value addition to the extent of 200 per cent, as compared to only 50 per cent obtained from western products. The consumption of traditional dairy products is likely to grow at an annual growth rate of more than 20 per cent as compared to Western dairy products, which varies from 5-10 per cent [3 and 4], still a large number of products are prepared by traditional way at home or cottage level and sold loose by local halwais. The small-scale operation mainly associates with inefficient use of energy, labour intensive, non-uniformity in product, etc. In order to overcome these drawbacks, it is necessary to develop mechanized system for commercial production of traditional dairy product with uniform quality and better shelf-life. The mechanized production of sweetmeats offerings a unique prospect to the organized dairy sector and even small-scale entrepreneurs to adopt mechanization and provide higher profitability and export potential.

Thabdi, is one such region-specific heat desiccated milk product manufactured traditionally in Saurashtra region of Gujarat state and now it's gaining more popularity even in other parts of the country due to its typical taste, flavour, body and texture. Most of *Thabdi* sold in market is being made by small scale sweetmeat makers or unorganized dairy sector using the traditional method and but the process of mechanized production of *Thabdi* is not standardized. [5] made a milk based peanut thbdi product and found that the product remained acceptable on 21st day with overall acceptability score of 7.21±0.10 (stored at 7±2°C).Research work performed related to process standardization of Thabdi peda [6], also [7] works on optimization of sugar addition rate in thabdi but still mechanization of Thabdi was found lacking. Hence, attempt has been made for optimization of processing parameters for manufacture of *Thabdi* in mechanized system.

2. MATERIALS AND METHODS

The present study conducted at S.M.C. College of Dairy Science KU, Anand. In *Thabdi* production, steam jacketed hemi spherical kettle was used.

2.1 Raw Materials

The pasteurized whole milk having 6.0% milk fat and 9.0 % SNF was used in preparation of *Thabdi* during all experimental trials. The pure *ghee* was procured from the local market of Anand, for the preparation of control and experimental product. Fine crystalline sugar (sucrose) of commercial grade was obtained from the local market of Anand.

2.2 Steam Jacketed Hemi Spherical Kettle

Mechanized system for *Thabdi* production is based on of steam jacketed hemi spherical kettle. The kettle is designed from AISI 304 stainless steel. The kettle was provided with all mountings like pressure gauge, steam trap, steam safety valve, air release valve, steam regulating valve, worm and worm wheel mechanism for unloading of hot processed product and lid for covering the kettle. To get desired attributes of the product, the unit is also consisting of specially designed scraper assembly provided with VFD to have variations of speed in the range of 1 to 50 rpm.

Fig. 1. Steam jacketed hemi spherical kettle

2.3 Scraper Assembly

The scraper assembly of mechanized system is designed with vertical circular agitator with adjustable Teflon scraper blades. The inner shell has stainless steel of 30 mm diameter, which is coupled with 0.25 HP gear motor by motor coupling. There are two scraper blades separately supported by arms to the main shaft. The Teflon blades are adjustable to provide necessary clearance to fix it on the SS strip using nut and bolt. The design is such that the blades sweeps the product settled on the circumference of the inner shell as well as at the bottom of the hemispherical kettle. The design is made hygienic, to facilitate cleaning and to avoid any contamination.

2.4 Drive of Scraper

The scraper assembly is driven by three phase gear motor (0.25 HP, 0.57 amp, 415 volts, 1360 rpm, 50 Hz) The gear motor is connected with VFD (Voltage: 3 Phase 380 to 440 V, +/- 10/-15, 1.5 HP, 50 Hz Frequency). The drive unit can give the speed of rotor in the range 1 to 50 rpm. The motor is connected with Variable Frequency Drive (VFD), for better control over the speed of scraper assembly for various stage of experimental trials.

2.5 Measuring and Controlling Instruments

A Bourdon tube pressure gauge (Range: 0 - 7 kg/cm2, Resolution: 0.2 kg/cm2) was fitted on the jacket to measure the steam pressure in the jacket during operation. The temperature of milk and product at various stages were measured by using infrared digital temperature indicator. Various temperatures required for calculation of heat utilization and heat losses were measured using different types of probes (needle, surface, button probes). The electrical input variables were measured by using power analyzer (3-Phase 4-wire power analyzer, 440-Volt) and energy meter (1 kWh = 300 revolution, 50 Hz, 4 wire, AC static watt hour meter).

2.6 Energy Supply

The scraper assembly of the system is operated by three phase electrical motor. It is supplied with three phase connection with VFD through power analyzer. The steam is generated in the boiler was supplied to the system at required pressure by regulating the steam valve.

2.7 Preliminary Study

From the scientific study of experimental trails by employing different operating variables to the manufacture of *Thabdi* by traditional method, it was observed the four significant stages i.e. i) first boiling ii) pre-pat formation iii) quiescent holding iv) intensive heating and working. Experimental trials revealed that these four stages were crucial to achieved desirable sensory and rheological attributes of *Thabdi,* which required optimization of steam pressure

and speed of scraper assembly as well as batch size for each stage independently.

2.8 Experimental Procedure of *Thabdi*

The pasteurized whole milk was selected and basic tests were performed to ensure quality of milk. Then the milk was poured in to the steam jacketed kettle, after ensuring removal of air from the jacket through air vent. Then after scraper unit was kept at required speed, followed by the supply of steam at required pressure. Initially by sensible heating milk was boiled, then sugar was added at the rate of 8 per cent w/w of milk. In the second stage, the concentration was commenced and continued up to pre-pat formation stage. Followed by third stage, turning off the steam supply and scraper to make it quiescent holding for 20 minutes of fixed period time to develop grains, because the formation of grains was decisive characteristics of *Thabdi.* In the beginning of last stage ghee was added at the rate of 1.2 per cent w/w of milk, to the concentrated mass then steam supply and agitator were started for intensive heating and working. It took around 12-15minutes then product was unloaded in the tray and cooled to room temperature.

2.9 Process Parameters

Each stage of manufacturing of *Thabdi* has its own importance to control final product quality. Trials were conducted with different operating variables such as batch size (B1-4 kg, B2-6 kg, B3-8 kg), steam pressure (P1 = 0.8 kg/cm^2, P2 = 1.5 kg/cm^2, P3 = 2.0 kg/cm^2) for first and second stage, while (P1 = 2.0 kg/cm^2, P2 = 2.5 kg/cm^2) for fourth stage and scraper speed (R1 = 15 rpm, R2 = 20 rpm, R3 = 25 rpm) for first and second stages, while (R1 = 10 rpm, R2 = 15 rpm) for fourth stage of mechanized kettle. The stage involved quiescent holding for 20 minutes of fixed period. Before optimizing process parameters for first and second stages, we had first optimized process parameters of fourth stage based on sensory score.

3. RESULTS AND DISCUSSION

Thabdi is the product which is very famous for its typical characteristics that is colour, graininess, chewiness and flavour. Mechanization of manufacture of *Thabdi* needs to divide the entire process in the different stages and to control the process variable for each stage. The first stage of manufacturing was first boiling and it has to be completed within 3-7 min. based on the batch size. This requires intense heat treatment but at the same time it should not out of the kettle, there for quantity of milk to be taken in the kettle was restricted and steam pressure also needs to be controlled. In the second stage to reach up to pre-pat formation need major concentration of the product by latent heating, this stage also needs optimization of steam pressure and scraper speed as concentration goes area utilization decrease and due to increase in the TS contribution the mode of heat transfers by conduction increases compared to convection. This needs to be considered for optimizing process parameter for first and second stages. The third stage of mechanized production of *Thabdi* keeping the product stagnant for a fixed period of time was crucial stage to develop typical grains with desirable chewiness. This is required to initiate grain formation at higher temperature. This will help in development of growth of grains during fourth stage. Fourth stage is very critical to develop desire colour, flavour and body and texture, therefore process parameters for the fourth stage were optimized first based on the sensory evaluation score from the judging panel. During this experimental trial process parameters for the first and second stages were fixed based on the experience of trials for the similar product. So, fourth stage was optimized at first instance.

3.1 Effect of Different Operating Conditions of Mechanized Unit on Total Score of *Thabdi* for First and Second Stage

The total scores of *Thabdi* prepared in mechanized units are shown in Table 1. The total score of *Thabdi* inclusive of colour and appearance, flavour, body texture and package. The mean overall acceptability scores for P1, P2 and P3 were 86.53, 89.03 and 88.12 respectively. The mean overall acceptability scores were 86.61, 89.16 and 87.60 for B1, B2 and B3. The average total scores for S1, S2 and S3 were 87.87, 87.83 and 88.39 respectively.

Table 1. Total score of *Thabdi* manufactured in mechanized system for first and second stage

Steam pressure P (kg/cm^2)	Scraper speed S (rpm)	Total score (out of 100) Batch size B (kg)			Average (S)	Average (P)
		B1 (4)	B2 (6)	B3 (8)		
P1 (0.8)	**S1 (15)**	84.63±0.45	87.11±0.36	85.20±0.95	85.73	86.53
	S2 (20)	85.33±0.53	87.58±0.54	86.43±0.78	86.43	
	S3 (25)	85.74±0.62	88.02±0.50	88.55±0.49	87.44	
P2 (1.5)	**S1 (15)**	87.26±0.37	90.70±0.44	87.90±0.42	88.71	89.03
	S2 (20)	87.34±0.48	91.09±1.22	88.00±0.70	88.81	
	S3 (25)	88.11±0.21	91.28±0.24	88.34±0.47	89.57	
P3 (2.0)	**S1 (15)**	87.16±0.06	87.10±0.02	87.14±0.54	87.16	88.12
	S2 (20)	86.77±0.50	88.96±0.08	88.06±0.37	88.26	
	S3 (25)	88.65±0.62	89.35±0.03	88.95±0.36	88.94	
Average (B)		86.61	89.16	87.60		
Source	**SEm**		**CD (0.05)**		**CV%**	
P	0.141		0.408		0.68%	
S	0.141		0.408			
B	0.141		0.408			
P×S×B	0.422		NA			

Each observation is a mean ±SD of three replicate experiments (n=3); NS= non-significant at 5 % level of significant. The total score is inclusive of package score (5).

It was observed that total score of *Thabdi* for first and second stage was significantly (P<0.05) effected by main effect of scraper speed, batch size and steam pressure. Interaction of steam pressure, scraper speed and batch size (P×S×B) had no significant (P>0.05) effect on total score of *Thabdi* manufactured in mechanized system. The combination of P2S3B2 had showed higher score of final products. It may be due to effective area utilization with higher temperature gradient and required residence time, by optimizing process parameters. To get a desired characteristic in final product it is essential that to optimize the process parameters like steam pressure and scrapper rpm in the first and second stages of processing

3.2 Effect of Different Operating Conditions of Mechanized System on Total Score of *Thabdi* for Fourth Stage

The total score is the indicative parameter of sensory quality of product in totality and consists of colour and appearance, flavour, body and texture characteristics. The average value of total score of experimental *Thabdi* is given in Table 2.

Table 2. Total score of mechanized manufacture of *Thabdi* for fourth stage

Steam pressure P (kg/cm^2)	Scraper speed S (rpm)	Total scores (out of 100) Batch size B (kg)			Average (S)	Average (P)
		B1 (4)	B2 (6)	B3 (8)		
P1 (2.0)	**S1 (10)**	88.44±0.62	89.26±0.38	88.84±0.49	88.83	88.50
	S2 (15)	88.07±0.48	88.32±0.42	88.11±0.37	88.17	
P2 (2.5)	**S1 (10)**	89.77±0.32	91.04±0.39	90.45±0.70	90.42	89.97
	S2 (15)	89.38±036	89.65±0.41	89.52±0.46	89.52	
Average (B)		88.91	89.57	89.23		
Source	**SEm**		**CD (0.05)**		**CV%**	
P	0.169		0.510		0.66%	
S	0.169		0.510			
B	0.207		NS			
P×S×B	0.414		NS			

Each observation is a mean ±SD of three replicate experiments (n=3); NS= non-significant at 5 % level of significant. The total score is inclusive of package score (5)

The statistical analysis of total found that the main effect of scraper speed and steam pressure had significant (P<0.05) effect on flavour score of *Thabdi*. While effect of batch size and interaction effect three variables (P×S×B) had no significant (P>0.05) difference on flavour score of *Thabdi*. The combination of P2S2B2 gave higher score as compared to other combination of treatment. Steam pressure contributed great impact on various sensory attributes such as flavour, body and texture, colour and appearance by controlling concentration and intensive heating. Speed of rotor has functioned in to most required characteristic of *Thabdi* is graininess. The size of grains and stiffness can only be maintained by scraper speed with adequate residence time. Based on above finding of total score of fourth stage for the mechanized manufacture of *Thabdi,* 2.5 kg/cm^2 steam pressure, 10 rpm scraper speed and 6 kg batch size were optimized for manufacture of product. Batch size had non-significant (P>0.05) effect on total score on the last stage of finished product. [8] made a Thabdi peda by addition of peanut flour and found acceptable sensory quality and also [6] optimized process developed with 10 kg batch of milk having 6 % fat, 8.33% rate of sugar addition produced most acceptable product.

3.3 Comparison of Sensory Attributes of Optimized *Thabdi* with Control and Market Samples

The total score of optimized *Thabdi*, control and market samples of *Thabdi* are shown in Table 3. From the Table 3, it was observed that the optimized product was superior compared to other samples. It may be due to better control of processing conditions as well as scientific approach for production of *Thabdi*. It can be seen from that Table 3, that there was non-significant (P>0.05) difference in all the sensory properties except body and texture. The body texture score of optimized *Thabdi* was significantly (P<0.05) higher than control and market sample. Therefore, optimization of process parameters for each stages helped in achieving the uniformity in the product. Similarly, the colour score of optimized *Thabdi* was at par with the control and market samples. But golden yellow colour of optimized *Thabdi* was more preferable than dark brown colour of the other samples as remarked by the sensory panel. It was concluded that the mechanized manufacture of *Thabdi* with optimized process parameters provides excellent sensory properties. Consequently, mechanization of *Thabdi* also governs the large commercial scale production which has great potential in the market of sweetmeats due to uniform product quality, better hygienic conditions with time and labour saving process technology. [9] also reported that sensory attributes of Thabdi made in different cities in Saurashtra have a significant difference found color & appearance score might be due to wide variation in raw material, amount of sugar and other additives. That study also conclude that appearance is generally based on the local preference of the public residing in a particular location. [10] conclude that Sugar addition at the rate of 8% of milk taken for the manufacture of Thabdi significantly improves all the sensory attributes of final product.

Fig. 2. Picture of Thabdi peda

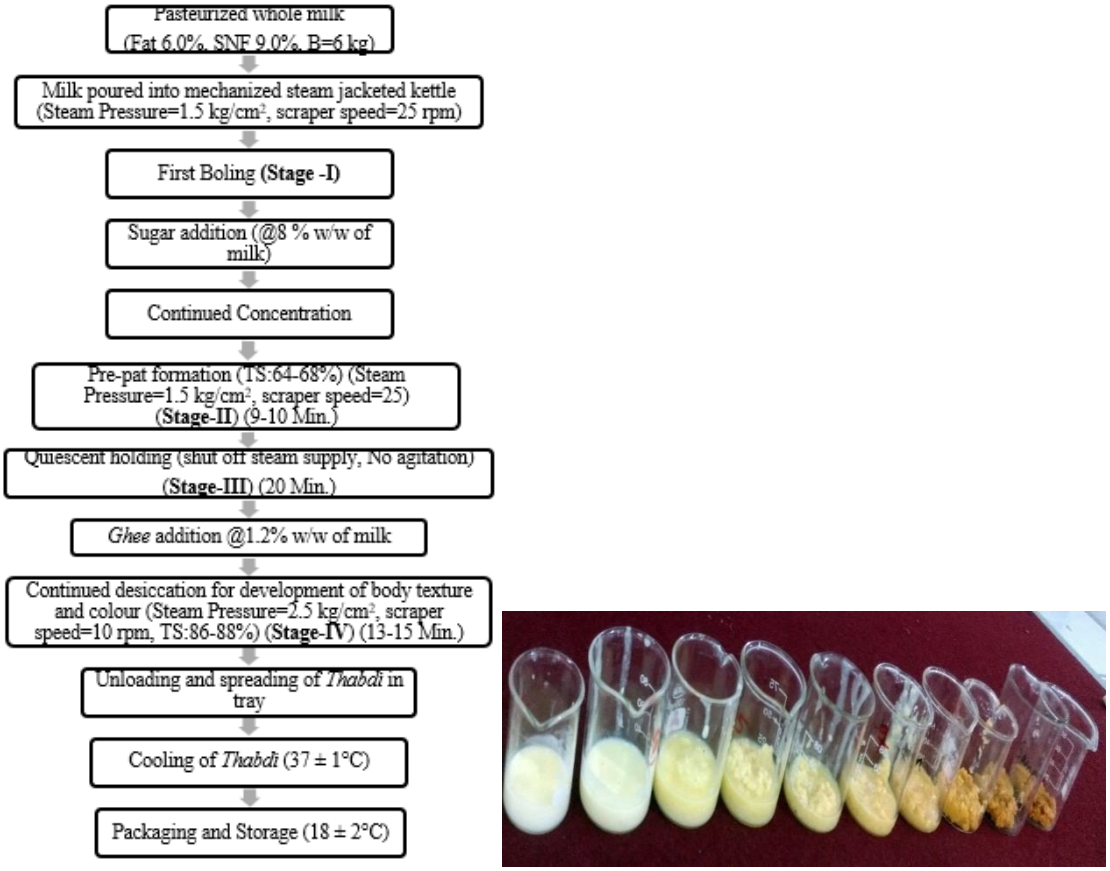

Chart 1. Optimized method of mechanized manufacture of Thabdi

Table 3. Sensory scores of optimized *Thabdi* with control and market samples

Treatments	Sensory Score			
	Colour & appearance (15)	Body & texture (35)	Flavour (45)	Total score (100)
OT	12.12 ±0.25	32.16±0.43	42.01±0.56	91.29±0.85
CT	12.37±0.30	31.59±0.45	41.96±0.62	90.92±0.96
MT	12.10±0.35	31.52±0.59	41.90±0.57	90.52±0.89
SEm	0.10	0.18	0.24	0.37
CD (0.05)	NS	0.56	NS	NS
CV %	2.15	1.46	1.48	1.05

Each observation is a mean ± SD of 7 replicate experiments (n=7); NS= non significant, OT=Optimized Thabdi, CT= Control Thabdi, MT= Market Thabdi. The total score is inclusive of package score (5)

3.4 Cost analysis of the Product Manufactured in the Mechanized Kettle

The cost analysis was carried out in order to evaluate the cost of product manufactured in mechanized kettle as shown in Table 4. The cost analysis is based on optimized operating condition among the parametric combination studied. In that batch size consider as 6 kg, 1.5 kg/cm^2 Steam pressure1,25 rpm Scraper speed,1.55 kg Product output and 46 min was the time for preparation of final desired quality product. [11] characterize the market Thabdi sample similar study also found by [9] that study also compare the characteristics of Thabdi purchased from different cities in saurashtra region of Gujarat.

Table 4. Cost of *Thabdi* manufactured in mechanized system

Material cost				
Sr. No.	**Materials**	**Rate (₹)**	**Quantity**	**Total cost (₹)**
1.	Whole milk	51 /lit.	6.0 kg	297.0
2.	Sugar	45/kg	0.480 kg	21.60
3.	Ghee	430/lit	0.072 kg	34.21
Total material Cost (A)				352.81
Operating Cost				
4.	Thermal energy (Steam supply)	4.5/kg	10.6	47.7
5.	Electric energy	7.0/kWh	0.132 kWh	0.92
6.	Labour cost	350/person/day	-	33.54
7.	Interest on the cost of machine	10% of the equipment (Cost of equipment: ₹. 1,50,000)	-	3.95
8.	Depreciation	12% of the equipment cost	-	4.75
9.	Repair and maintenance	5% of the equipment cost	-	1.97
Total operating cost (B)				92.83
Total Cost (A+B)				**445.64/batch**

Cost of Thabdi/kg = 445.64/1.55 = ***₹287.50.*** *Raw material cost/kg product = 352.81/1.55 =* ***₹227.61*** *(79 % of the total cost)*

Processing cost/kg product = 92.83/1.55 = ***₹59.85*** *(21 % of the total cost)*

4. CONCLUSIONS

The sensory quality of *Thabdi* manufactured in mechanized system under optimized conditions for 6 kg batch size was found superior by adopting steam pressure 1.5 kg/cm^2, scraper speed 25 rpm during first and second stages. The third stage involved quiescent holding for 20 minutes of fixed period. For the fourth stage, steam pressure 2.5 kg/cm^2(g), scraper speed 10 rpm and batch size 6 kg were optimized for manufacture of *Thabdi*. Batch size has non-significant effect on total score of *Thabdi*. The sensory quality of optimized *Thabdi* was at par with control product prepared traditionally and market samples. The body and texture score of optimized *Thabdi* was significantly higher than control and market samples. The estimated cost for the manufacture of *Thabdi* in mechanized system worked out to be ₹287.50 (raw material cost:79%, operating cost:21% of the total cost) per kg of product. The processing cost of *Thabdi* manufactured using mechanized system was approximate 74% less compared to *Thabdi* manufactured traditionally.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous; 2024. Available:www.nddb.coop Anonymous (2024),www.downtoearth.org.in.
2. Velpula S, Bhadania AG, Umapathy KS, Aravind T, Sripad S. Commercial production scenario of traditional Indian dairy products: A review. Bulletin of Environment, Pharmacology and Life Sciences. 2018;7(3):82-87.
3. Bandyopadhaya P. Technological advancement on traditional India Desiccated and Heat Coagulated Dairy Products. Indiian. Dairyman. 2006;58(11): 59-65.
4. Chauhan IA, Bhadania AG, Patel AD. Mechanized Production of Kheer. Indian Journal of Dairy Science. 2018;71(1): 20-27.
5. Thesiya AJ, Ahuja KK, Sindhav RG, Hariyani AS, Vachhani NM. Development of milk-based thabdi by using peanut as an ingredient. Asian Journal of Dairy and Food Research; 2023. doi, 10.
6. Modha HM, Patel NM, Patel, HG, Patel KN. Process standardization for the manufacture of Thabdi Peda. Journal of Food Science and Technology. 2015; 52:3283-3290.

7. Hirpara KB, Patel HG, Prajapati JP. Standardization of rate of sugar addition for the manufacture of Thabdi. Journal of food science and technology. 2015;52: 1152-1157.
8. Sejani VM, Dhamsaniya NK, Rathod PJ. Preparation of peanut flour based Thabdi peda. Asian Journal of Dairy and Food Research. 2023;42(2):237-241.
9. Prasad S. Physico-chemical, sensory, colour and textural characteristics of thabdi (Brown) and kesar (Yellow) Peda in Saurashtra Region.
10. Prajapati JP. Krupa B. Hirpara, HG Patel. J Food Sci Technol. 2015;52:1152-1157.
11. Patel KN, Patel HG, Prajapati JP, Prajapati PS. Characterization of market Thabdi. Indian Journal of Dairy Science. 2012; 65(2):122.

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