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Krunal M Raval
Junior Executive, Department of Quality Assurance, Banas Dairy, Banaskantha, Gujarat, India

Nirav D Joshi
Assistant Professor, College of Food Technology, S.D. Agricultural University, Sardarkrushinagar, Dantewada, Banaskantha, Gujarat, India

Corresponding Author:
Krunal M Raval
Junior Executive, Department of Quality Assurance, Banas Dairy, Banaskantha, Gujarat, India

Effect of modified atmosphere packaging on shelf life of Thabdi Peda

Krunal M Raval and Nirav D Joshi

Abstract
The study's goal was to evaluate *Thabdi Peda's* shelf life utilising particular packing materials and subjecting them to changing atmospheric packaging. *Thabdi Peda* were created using a conventional procedure and then transferred into packaging made of clear PVC under sanitary conditions. These trays were placed inside pre-sterilized (with UV radiation) pouches made of Met-Polyester/Polyfilm pouches (65µ) (M1) and Polyester/Polyfilm pouches (92µ), stored at 20±2°C, and periodically tested for compositional, physico-chemical, textural, microbiological, and sensory characteristics over the course of 10 days to 30 days of storage. In storage, *Thabdi Peda's* moisture, acidity, FFA, HMF, and soluble nitrogen content all increased, but its pH, water activity, and head space O_2 concentration dramatically decreased (P 0.05). Throughout the duration of the investigation, neither the fresh nor the preserved samples of *Thabdi Peda* displayed any coliform count. After being flushed with N_2, *Thabdi Peda* developed more stiffness, hardness, chewiness, adhesiveness, and less cohesion. The decrease in Thabdi Peda's colour and appearance, body and texture, flavour, and overall acceptability scores as the storage period wore on may be attributed to the product's decreased moisture and increasing HMF and FFA concentration. The packing materials studied showed very equivalent performance in terms of compositional, textural, microbiological, and sensory alterations caused by storage, but the package Polyester/PE pouch (M2) can be favoured due to cost considerations.

Keywords: *Thabdi Peda*, packaging material, storage, polyester/PE, met-polyester/Polyfilm

Introduction
Our Indian culture is not complete without the traditional dairy products, which are also very important from a social, spiritual, cultural, medicinal, and economic standpoint. The conversion of milk into traditional milk products has been caused by the greater supply of milk during the flush season as well as insufficient infrastructure to keep liquid milk fresh during transit from rural producing areas to urban markets. According to a calculation, approximately half of the 127.3 million tonnes of milk that India produces annually are turned into traditional milk products. Traditional dairy products not only enjoy a thriving domestic market in India but also have significant international export potential. (Rao and Raju, 2003) [16]. According to Aggarwal (2007) [1], the market for this most important and rapidly expanding sector of the Indian dairy industry is more than 50,000 crores. The Government of India's ongoing efforts to support various research programmes on these products demonstrate the significance of such products. *Thabdi Peda* is a *Thabdi* variety that is only available in Saurashtra, Gujarat State, and is not well recognised elsewhere in Gujarat. Such conventional dairy products are marketed in a conventional manner, much like the items themselves. Packaging and hygienic handling procedures receive very little attention (Patil, 2003) [14]. Low shelf life of the products is the main problem that manufacturers encounter on a commercial basis. (Misra, 2000; Aneja *et al.*, 2002; Patil, 2005) [13, 2, 15]. *Thabdi Peda* is often consumed fresh and has a short shelf life of 7-8 days in its current form. It requires a longer shelf life to gain popularity outside the conventional producing area.

Materials and Methods
Preparation of *Thabdi Peda*
Patel (2013, Personal communication) produced *Thabdi Peda* using the procedure standardised in the Dairy Technology Department, AAU, Anand. Fresh milk that has been standardised to 6.0% fat and 9% SNF was purchased from Anubhav Dairy of the Sheth M.C. College of Dairy Science, AAU, Anand. *Thabdi Peda* was made using this standardised milk in quantities of 10 kg.

Packaging
Thabdi Peda were hygienically transferred to clear PVC tray packages and then placed within Met-Polyester/Polyfilm pouches (65µ) and Polyester/Polyfilm pouches (92µ) pouches. To prevent contamination via shipments, pre-sterilized pouches and trays were both employed. A partial vacuum was established within the package to eliminate the head space gases before the filled packages were heat sealed, and the package was also flushed with N_2 gas at the same time. A vacuum of 110 mm Hg was kept for 8–10 seconds, and N_2 gas flushing—which lowered the O_2 levels to up to 2-4% was done for 1 second at a pressure of 2 kg/cm^2 gas cylinder pressure. M/S. High-tech Industries, in Ahmedabad, provided the hoover and gas flushing device that was used. Met-Polyester/Polyfilm and Polyester/Polyfilm pouches were purchased from Vidya Dairy, AAU, Anand and M/S. Marudhar Industries, respectively. The trays and pouches used were large enough to hold 10 to 12 pieces of *Thabdi Peda*, each weighing around 18 to 20 g, or about 250 g of product.

Keeping & analysis
The study involves evaluating the composition, physico-chemical, textural, microbiological, and sensory aspects of fresh and preserved *Thabdi Peda* in two distinct packaging at regular intervals of storage. The containers were stored at 20±2 °C. The samples kept at a constant temperature of 20±2 °C were examined every 0, 10, and 30 days at a relative humidity of 65%.

Analysis of compositional attributes
The compositional characteristics of fresh and preserved *Thabdi Peda* samples were examined as indicated under:

The moisture
According to the method outlined in the Laboratory Manual (1959) [12], the moisture of the *Thabdi Peda* samples was assessed using standard technique and a Mojonnier Milk Tester Model-D.

Fat
Thabdi Peda's fat extraction was calculated in accordance with the method outlined in IS: 2311-1963.

Total protein
By adopting the Semi-Micro-Kjeldahl technique (IS: 1479 Part-II, 1961), Kjel-plus digestion system (Model-KPS 006L) and Kjel-plus semi-automatic distillation system (Model-Distil M) from M/s. Pelican Instruments, Chennai, were used to determine the total nitrogen/protein of *Thabdi Peda.*
Sugar (reducing and non-reducing) Reducing (lactose) 93 and non-reducing (sucrose) were calculated using the volumetric approach described in BIS (IS 2802, 1964) for ice cream.
Note: Standard sugar solution was made in accordance with BIS Handbook, BIS: Part XI, 1981.

The ash
The BIS (IS: 1547-1985) technique was used to determine the ash content of all the samples.

Physico-chemical attributes analysis
Head space oxygen (O2)
Using a Check Point Handheld Gas Analyser (M/S. PBI Dansensor, Denmark), the Head Space O_2 of the *Thabdi Peda* Package was measured. The Check Point Handheld Gas Analyser was turned on, the needle retainer was adhered to the package, and the needle was then inserted into the package through the needle retainer to measure the O_2 level. The instrument's built-in pump begins to suction measurement gas through the needle when the start switch is depressed. After 10 seconds, the pump stops, and the result is shown as percent O_2 of the package's head space.

Acidity that is titratable
The BIS Handbook, BIS: Part XI, 1981 technique was used to determine the Titratable acidity of all samples.

pH
With the use of a Systronic digital pH metre, Model 335, the pH of *Thabdi Peda* was determined. The Franklin and Sharpe (1963) [5] method for making cheese was applied. The pH of the homogenate created by combining 20 g of sample with 20 ml of glass distilled water was measured.

Water activity (aw)
Rotronic Hygroskop Model: Hygrolab-3 (M/s. Rotronic ag, Switzerland) attached to a sensor element (AW-DIO) with a measurement range of 0-100% Relative Humidity (RH) was used to assess the water activity of *Thabdi Peda* samples, tempered at 25 °C temperature.

Soluble nitrogen
The method described by Kosikowski (1982) was used to quantify the amount of soluble nitrogen in the *Thabdi Peda* sample.

Free fatty acids
To calculate the FFA content of *Thabdi Peda*, Deeth *et al*.'s (1975) [4] technique was employed.

5-Hydroxy methyl furfural (HMF)
The degree of browning in *Thabdi Peda* samples was determined using a slightly modified version of the quantitative method described by Keeney and Bassette (1959) [11] for measuring HMF by spectrophotometric detection of the 2-thiobarbituric acid (TBA) reaction product.

Analysis of the texture profile
Using a Food Texture Analyser of Lloyd Instruments LRX Plus, material testing equipment, England, equipped with a 0-500 kg load cell, four samples of each experimental *Thabdi Peda* were compressed uniaxial to 80% of the starting sample height. To assess different textural characteristics of *Thabdi Peda* kept for 1 h at 23±1 °C and 55% RH, the force-time curve was acquired for a two-bite deformation cycle using a Cross Head speed of 50 mm/min, Trigger 10 gf, and 80% Compression of the samples. By directly transferring the data to Lloyd Instruments' NEXYGEN data analysis and applications software, the whole process of calculating the area under the force-time curve, statistically analysing the data obtained, and converting those data into other textural properties was carried out.

***Thabdi Peda's* sensory assessment**
For sensory quality evaluation, the packages were opened and served to a panel of judges made up of institute faculty members. Before serving the judges, the samples that had been kept at 20±2 °C were tempered to around 30°C. A linear

intensity rating scale of 100 points was used to assess the *Thabdi Peda* samples. For grading the *Thabdi Peda* in this study, the score-card proposed for Khoa by Gupta and Pal (1985) was utilised with certain changes. The judges were also asked to provide feedback for each feature of the samples.

Microbiological Analysis
All *Thabdi Peda* samples were examined using BIS (IS: 5550, 1970) procedures with minor modifications for Standard Plate Count (SPC), Coliform Count, and Yeast and Mould Count (YMC). Prior to statistical analysis, log transformation was applied to the data from the microbiological analyses.

Testing for packaging materials
The thickness
The technique developed by BIS (1966) was used to determine the thickness of packing materials. With the use of a sheet holder and micrometre, thickness was measured. A pack of at least five specimens measuring 20 x 25 was obtained for the thickness examination. The lever was then raised to deliver this to the sheet holder. To enable the moving member to touch the pack with a constant pressure of 1.0 ± 0.1 kg/cm^2, the lever was slowly let to relax. To verify for thickness uniformity, tests were conducted five times, close to the edges and in the centre of the test piece.

Statistical analysis
According to Steel and Torrie (1980) [17], the mean values produced by the study of *Thabdi Peda* sample data gathered in three replications were subjected to statistical analysis using Completely Randomised Design (CRD).

Results and Discussion
Prior to the storage research, *Thabdi Peda* was examined for its compositional, physico-chemical, textural, sensory, and rheological characteristics, as shown in Table 1. As demonstrated in Tables 1, 2, 3, and 4, Storage-Related Changes in *Thabdi Peda* Packed in Selected Packaging Materials

Compositional attributes changes
Only a change in moisture was noticed in *Thabdi Peda's* compositional characteristics during storage at 20±2 °C, as reported in Table. 1.

Moisture
The average data shown in Table 1. show that storage of *Thabdi Peda* at a temperature of 20±2 °C had a significant (p< 0.05) impact on the moisture content of the plant. *Thabdi Peda's* moisture content decreased significantly (p<0.05) in two packages during all storage durations at both temperatures, and the product was later deemed unsatisfactory owing to apparent mould development. However, it was determined that the interaction impact of the package and the amount of time stored at the two temperatures was not significant (p< 0.05).

Physico-chemical attributes changes
Acidity, pH, FFA, HMF, soluble nitrogen, water activity, and head space oxygen were all found to alter throughout the *Thabdi Peda's* storage at 20±20 °C. Table. 1. illustrates these modifications in terms of values.

Acidity: The kind of package and storage time had a significant (p<0.05) impact on the acidity content of *Thabdi Peda*. *Thabdi Peda* was stored at 20±2 °C, and from day 0 to day 20, there was a substantial (p<0.05) rise in acidity content. These findings suggest that the package chosen had no significant (p<0.05) impact on *Thabdi Peda* packed in M1 and M2 and that their influence on the rise in acidity was equal. Additionally, the interaction between the packaging and the storage duration was determined to be non-significant (p<0.05).

pH: When *Thabdi Peda* was packaged in either of the two containers at a temperature of 20±2 °C, the pH decreased. *Thabdi Peda's* pH may have dropped during storage as a result of microbial development, which can increase acidity or reduce pH in dairy products. Thus, as a result of the storage being investigated in two packages, pH fell considerably (p<0.05).

FFA
The mean data show that the kind of packaging, the length of storage, and their interactions all had a significant (p<0.05) impact on the FFA content of *Thabdi Peda*. Up to 20 days of *Thabdi Peda* storage at 20±2 °C saw a substantial (p<0.05) rise in FFA concentration in both packages, however after that point the product had become unsatisfactory due to apparent mould development.

5-Hydroxymethyl furfural (HMF)
The average data show that the kind of package had no significant (p<0.05) impact on the HMF (moles/100g) content of *Thabdi Peda*, but that the length of storage had an impact. A substantial (p<0.05) rise in HMF concentration was seen in both packages of *Thabdi Peda* during storage at 20±2 °C for up to 20 days, after which the product was deemed unsatisfactory owing to apparent mould development.

Soluble nitrogen
Thabdi Peda had a substantial (p<0.05) rise in soluble nitrogen content in both packages for up to 20 days while being kept at 20±2 °C, at which point the product was deemed unsatisfactory owing to apparent mould development.

Water activity (aw)
A substantial (p<0.05) drop in water activity was seen in both packages of *Thabdi Peda* during storage at a temperature of 20±2 °C for up to 20 days, after which the product was deemed unsatisfactory owing to apparent mould development.

Head space O2
There was a decrease in Head space O2 in *Thabdi Peda* packages during storage at 20±2 °C. This decrease in Head space O2 of packages might be due to the rapid microbial growth in *Thabdi Peda* which causes reduction in O2 content or decrease in Head space O2.

Microbiological attribute changes
Table 2 shows the changes in microbiological characteristics that occurred while *Thabdi Peda* was stored at 20±2 °C.

Standard plate count
Thabdi Peda was stored at 20±2 °C for 20 days, during which time mean SPC values in both packages increased significantly (p<0.05), and after that the product was deemed

unsatisfactory owing to apparent mould development. Additionally, the interaction between the package and the storage duration was determined to be statistically insignificant (p<0.05).

Yeast and Mold Count

As can be observed from the figures reported, the yeast and mould count grew throughout the course of storage at a temperature of 20±2 °C.

Changes in rheological attributes

Table. 3 shows the rheological characteristics that changed while *Thabdi Peda* was stored at 20±2 °C.

Stiffness (N/mm)

After 20 days of storage at 20±2 °C, *Thabdi Peda's* stiffness value increased significantly (p<0.05) in both packages, and the product was deemed unsatisfactory owing to apparent mould development. The results demonstrate that the stiffness values of *Thabdi Peda* held at a temperature of 20±2 °C are significantly affected by the length of storage.

Hardness (N)

Thabdi Peda showed a substantial (p<0.05) improvement in hardness after storage at 20±2 °C for the first 20 days, however after that the product was deemed unsatisfactory owing to apparent mould development. The findings suggest that *Thabdi Peda* storage in M1 (Met-Polyester/Polyfilm pouch) and M2 (Polyester/Polyfilm pouch) packaging increases the hardness (N) values.

Cohesiveness

Packages M1 or M2 had no statistically significant (p<0.05) impact on the cohesion of *Thabdi Peda*.

Chewiness (N mm)

According to the storage study's findings, storing *Thabdi Peda* at a temperature of 20±2 °C has a significant (p<0.05) impact on how chewy it is. Each storage period saw a substantial rise in the values (p<0.05).

Adhesiveness (N mm)

The adhesiveness value in both packages of *Thabdi Peda* increased significantly (p<0.05) after storage at 20±2 °C for the first 20 days, after which the product was deemed unsatisfactory owing to evident mould development. This shows that the *Thabdi Peda* packaged in M2 packaging saw the least amount of rise in adhesiveness value during the course of the investigation.

Modifications to sensory attributes

Table 4 shows how the sensory characteristics of *Thabdi Peda* changed when it was stored at 20±2 °C.

Colour and appearance

At 20±2 °C, the colour and appearance ratings started to deteriorate, showing that there were differences in the sensory qualities of *Thabdi Peda*. The speed of the decline, however, relied on the kind of packing material and storage temperature. The product's microbiological, chemical, and textural changes can be blamed for the fall in *Thabdi Peda* scores after storage.

Body and texture

When the product was held at 20±2 °C, the body and texture scores changed. The loss of moisture and potential crystallisation of the additional sugar might be the cause of the product becoming dry, hard, sandy, and brittle.

Flavour

Throughout the whole duration of storage, none of the judges noted the existence of any disagreeable off flavours, such as oxidised, rancid, acidic, etc.

Overall acceptability

Thabdi Peda's overall acceptability ratings may have fallen as a result of alterations to the food's flavour, body, and texture. The storage duration had a substantial impact on all the sensory aspects that were examined, including colour and appearance, flavour, body, and texture, which together had an impact on the total acceptability scores.

Cost of packaging

No.	Particulars	No. of Packages/Kg	Cost of different Packages, (₹)	
			M1	M2
1	Package (250 g)	4	2.35 x 4=9.40	1.50 x 4=6.00
2	Inner Tray (250 g)	4	2.00 x 4=8.00	2.00 x 4=8.00
3	N2 gas flushing	4	0.68 x 4=2.72	0.68 x 4=2.72
	Cost of Packaging (₹)/Kg product		20.12	16.72

M1 = Met-Polyester/PE pouch (65 µ); M2= Polyester/PE pouch (92 µ)

Table 1: Compositional And Physico-Chemical Changes in *Thabdi Peda* when stored at 20±2 ^{0}C temperature

	Package	0 day	10 day	20 day	Average for Package
Moisture (%)	M1	17.48±0.319	16.02±0.324	15.31±0.320	16.14±0.893
	M2	17.48±0.319	16.10±0.292	15.30±0.344	16.16±0.893
	C.D.0.05, Package: NS, Period:0.337, Pa*P:NS				
Acidity (%LA)	M1	0.347±0.004	0.397±0.005	0.463±0.007	0.402±0.058
	M2	0.347±0.004	0.397±0.000	0.459±0.002	0.401±0.056
	C.D.0.05, Package: NS, Period:0.06, Pa*P:NS				
pH	M1	6.428±0.015	6.360±0.014	6.253±0.033	6.347±0.087
	M2	6.428±0.015	6.360±0.008	6.263±0.017	6.350±0.082
	C.D.0.05, Package: NS, Period:0.02, Pa*P:NS				
FFA (µ eq/g)	M1	0.795^a±0.006	0.998^c±0.004	1.205^e±0.007	0.999^e±0.204
	M2	0.795^a±0.006	0.948^b±0.009	1.103^d±0.005	0.949^f±0.154
	C.D.0.05, Package: NS, Period:0.006, Pa*P:0.009				
HMF (µ moles / 100g)	M1	119.3±5.377	140.8±7.320	160.5±5.259	140.2±20.60
	M2	119.3±5.377	141.5±8.583	163.8±4.5	141.5±22.22
	C.D.0.05, Package: NS, Period:6.54, Pa*P:NS				

Soluble Nitrogen (%)	M1	1.020[a]±0.008	1.088[c]±0.010	1.260[e]±0.014	1.123[e]±0.123
	M2	1.020[a]±0.008	1.065[b]±0.005	1.238[d]±0.005	1.108[f]±0.115
	C.D.0.05, Package: 0.008, Period:0.009, Pa*P:0.013				
Water Activity (a_w)	M1	0.793±0.006	0.764±0.002	0.742±0.002	0.766[e]±0.030
	M2	0.793±0.006	0.759±0.004	0.733±0.004	0.762[f]±0.026
	C.D.0.05, Package: 0.004, Period:0.004, Pa*P:NS				
Head space O_2	M1	3.65±0.387	3.03±0.170	2.68±0.236	3.12±0.493
	M2	3.65±0.387	3.18±0.556	2.70±0.270	3.18±0.475
	C.D.0.05, Package: NS, Period:0.376, Pa*P:NS				

M1=Met-Polyester/PE pouch (65µ); M2= Polyester/PE pouch (92 µ)

Table 2: Changes In Microbiological Quality of *Thabdi Peda* when stored at 20±2 ^{0}C temperature

	Package	0 day	10 day	20 day	Average for Package
SPC (cfu/g, log transformed)	M1	3.660±0.108	4.380±0.247	5.548±0.170	4.529±0.952
	M2	3.660±0.108	4.265±0.059	5.465±0.099	4.463±0.919
	C.D.0.05, Package: NS, Period:0.152, Pa*P:NS				
Yeast and Mold count (cfu/g, log transformed)	M1	2.455±0.149	4.473±0.249	5.725±0.173	4.218±1.650
	M2	2.455±0.149	4.258±0.213	5.605±0.204	4.106±1.580
	C.D.0.05, Package: NS, Period:0.203, Pa*P:NS				

M1=Met-Polyester/PE pouch (65µ); M2= Polyester/PE pouch (92 µ)

Table 3: Changes in Rheological Attributes of *Thabdi Peda* when stored at 20±2 ^{0}C temperature

	Package	0 day	10 day	20 day	Average for Package
Stiffness (N/mm)	M1	283.3±1.708	295.5±0.577	303.3±0.538	294.0[e]±10.118
	M2	283.3±1.708	293.0±0.816	300.5±1.080	292.3[f]±8.649
	C.D.0.05, Package: 1.007, Period:1.234, Pa*P:NS				
Hardness (N)	M1	521±15.81	548.3±13.86	580.0±13.97	551.5±29.528
	M2	521±15.81	550.8±15.04	584.3±11.87	552.0±31.643
	C.D.0.05, Package: NS, Period:15.123, Pa*P:NS				
Cohesiveness	M1	0.180±0.013	0.140±0.012	0.092±0.012	0.137±0.044
	M2	0.180±0.013	0.143±0.012	0.102±0.009	0.142±0.039
	C.D.0.05, Package: NS, Period:0.012, Pa*P:NS				
Chewiness (N mm)	M1	5.545±0.551	6.102±0.316	6.634±0.090	6.090±2.419
	M2	5.545±0.551	6.043±0.302	6.543±0.111	6.049±2.315
	C.D.0.05, Package: NS, Period:0.388, Pa*P:NS				
Adhesiveness (N mm)	M1	12.31±2.760	21.35±2.493	30.29±2.466	21.32±8.987
	M2	12.31±2.760	21.07±2.949	28.85±2.829	20.74±8.270
	C.D.0.05, Package: NS, Period:2.852, Pa*P:NS				

M1=Met-Polyester/PE pouch (65µ); M2= Polyester/PE pouch (92µ)

Table 4: Changes in Sensory Attributes of *Thabdi Peda* when stored at 20±2^{0}C temperature

	Package	0 day	10 day	20 day	Average for Package
Colour & Appearance score (out of 15)	M1	13.40±0.115	12.48±0.096	11.58±0.096	12.48±0.912
	M2	13.40±0.115	12.60±0.081	11.50±0.081	12.50±0.954
	C.D.0.05, Package: NS, Period:0.104, Pa*P:NS				
Body & Texture score (0ut of 35)	M1	31.75±0.289	30.28±0.05	29.60±0.141	30.54±1.099
	M2	31.75±0.289	30.38±0.25	29.88±0.25	30.67±0.970
	C.D.0.05, Package: NS, Period:0.24, Pa*P:NS				
Flavour score (out of 45)	M1	41.00±0.408	39.13±0.250	38.28±0.262	39.47±1.394
	M2	41.00±0.408	39.28±0.320	38.15±0.238	39.48±1.435
	C.D.0.05, Package: NS, Period:0.339, Pa*P:NS				
Overall acceptability (out of 100)	M1	91.15±0.750	86.88±0.287	84.45±0.058	87.49±3.391
	M2	91.15±0.750	87.25±0.436	84.53±0.05	87.64±3.327
	C.D.0.05, Package: NS, Period:0.508, Pa*P:NS				

M1=Met-Polyester/PE pouch (65µ); M2= Polyester/PE pouch (92 µ)

Conclusion

The purpose of the current experiment was to evaluate *Thabdi Peda's* shelf life utilising various packaging materials and methods. The packages Met Polyester/Polyfilm pouches (M1) and (M2) were employed in the investigation, where a partial vacuum was established and N_2 gas was flushed at the same time to lower the head space O_2 level well below 3 to 4% and prevent the production of superfluous air pressure inside. The packaged *Thabdi Peda* samples were found to be OK for up to 20 days in both packages before it became unsuitable due to the discovery of evident mould development. The packing materials studied showed statistically equal performance in terms of compositional, textural, microbiological, and sensory alterations caused by storage, although the package Polyester/PE pouch (M2) might be recommended due to cost considerations.

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