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Effect of Modified Atmospheric Packaging on Shelf Life of Thabdi Peda

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Abstract
The study was planned with an objective to assess the shelf life of *Thabdi Peda* using selected packaging materials and subjected to modified atmospheric packaging. *Thabdi Peda* were prepared according to the standardized method and then transferred under hygienic conditions to transparent PVC tray packages. These trays were packed into pre-sterilized (with UV radiation) pouches made of Met-Polyester/Polyfilm pouches (65µ) (M1) and Polyester/Polyfilm pouches (92µ), and were stored at 20±2^{0}C and were assessed for Compositional, Physico-chemical, Textural, Microbiological and Sensory characteristics at regular interval of 10 days up to 30 days of storage. During storage, moisture, acidity, FFA, HMF, Soluble Nitrogen increased whereas pH, Water activity and Head space O_2 content of *Thabdi Peda* decreased significantly ($P<0.05$). The fresh as well as stored samples of *Thabdi Peda* showed no coliform count during the entire study. *Thabdi Peda* subjected to N_2 gas flushing treatment, increased stiffness, hardness, chewiness, adhesiveness and decreased cohesiveness. The colour and appearance, body and texture, flavour and overall acceptability scores of *Thabdi Peda* in both of the packages declined as storage period progressed, may be due to the reduced moisture and increased HMF, FFA content on storage. On the basis of storage related changes in compositional, textural, microbial and sensory attributes,the packaging material evaluated exhibited comparatively similar performance but based on cost criteria, the package Polyester/PE pouch (M2) can be preferred.

Keywords: Thabdi Peda, Packaging Material, Storage, Polyester/PE, Met-Polyester/Polyfilm

INTRODUCTION

The traditional dairy products are an integral part of our Indian culture and have a great social, spiritual, cultural, therapeutic and economic importance. The increased availability of milk during the flush season coupled with inadequate facilities to keep liquid milk fresh during transit from rural production areas to urban market has led to the conversion of milk into traditional milk products. An estimate says that from a total of 127.3 million tonnes of annual milk produced in India, about 50% of milk is converted into traditional milk products. Traditional dairy products have not only established market in India but also have a great export potential in abroad. (Rao and Raju, 2003). Market of this largest and fastest growing segment of Indian dairy industry is estimated at more than 50,000 crores (Aggarwal, 2007). The importance of such products is also seen from the continuous efforts of the Government of India by sponsoring different research schemes on these products in order to make it popular throughout the country.

Peda, one of the most widely consumed traditional product throughout India is packed in paper cartons or duplex board boxes. Many workers have reported studies on changes in physico-chemical parameters during storage of Peda.

However, storage life of about 15 – 20 days at room temperature (25 – 30^{O}C) has been reported by some workers depending on the type of packaging material used and addition of sugar.

MATERIALS AND METHODS

Preparation of *Thabdi Peda*

Thabdi Peda were prepared according to the method standardized in Dairy Technology Department, AAU, Anand by Modha *et.al.,* (2014). Fresh milk procured from Anubhav Dairy of Sheth M.C. College of Dairy Science, AAU, Anand and standardized to 6.0% fat and 9% SNF. This standardized milk in batches of 10 kgs was used for the manufacture of *Thabdi Peda*. The manufacture of *Thabdi Peda* was carried out in a stainless steel, variable speed revolving kettle having thick bottomed iron plate and having specially designed vertical and horizontal scrapers facility. The heating of milk inside the revolving kettle was carried out by indirect heating of the bottom plate using LPG gas as fuel.

Packaging

Thabdi Peda were transferred under hygienic conditions to transparent PVC tray packages and these trays were inserted into pouches made of Met-Polyester/Polyfilm pouches (65µ) and Polyester/Polyfilm pouches (92µ). Both, trays as well as pouches used were pre-sterilized by UV radiation to avoid contamination through packages. Immediately before the heat sealing of the filled packages, a partial vacuum was created inside the package to remove the head space gases and simultaneously flushed with N_2 gas. A vacuum of 110 mm Hg was maintained for 8-10 sec. and N_2 gas flushing was carried out for 1 sec at 2 kg/cm^2 gas cylinder pressure to excessive pressure development along with the reduced O_2 levels i.e. upto 2-4%. The vacuum and gas flushing machine used was procured from M/S. Hightech Industries, Ahmedabad. Met-Polyester/Polyfilm and Polyester/Polyfilm pouches were procured from M/S. Marudhar Industries, Ahmedabad and Vidya Dairy, AAU, Anand, respectively. The size of the trays and pouches used were sufficient to contain ~ 250g product i.e. 10 - 12 pieces of *Thabdi Peda* weighing ~ 18-20 g each.

Storage and Analysis

The study involved the assessment of fresh and stored *Thabdi Peda* in two different packages for compositional, physico-chemical, textural, microbiological and sensory characteristics at regular interval of storage. The packages were kept at 20±2^{0}C. The samples stored at 20±2^{0}C were evaluated at regular interval of 0, 10, 20 and 30 days, at 65% RH.

Compositional Attributes Analysis

Fresh and stored *Thabdi Peda*samples were subjected to various compositional attributes as described under. No modifications were been done in the sample preparation and the analytical part being carried out.

Moisture

The moisture of the *Thabdi Peda*samples was determined by standard procedure using Mojonnier Milk Tester Model-D as per the process prescribed in the Laboratory Manual (1959).

Fat

Fat extraction of *Thabdi Peda* was determined as per the procedure described in IS: 2311-1963.

Total Protein

Total nitrogen/protein of *Thabdi Peda* was determined by Semi-microkjeldahl method (IS: 1479-Part-II, 1961), using Kjel-plus digestion system (Model-KPS 006L) and Kjel-plus semi-automatic distillation system (Model-Distil M) of M/s. Pelican Instruments, Chennai.

Sugar (reducing and non-reducing) Reducing (lactose) and non-reducing (sucrose) were determined by the volumetric method specified for ice-cream in BIS (IS 2802, 1964).

{Note: Standard sugar solution was prepared as per BIS Handbook, (BIS: Part XI, 1981)}.

Ash

Ash content of all the samples was determined by procedure described in BIS (IS: 1547-1985).

Physico-Chemical Attributes:

Head Space Oxygen (O_2)

Head Space O_2 of *Thabdi Peda* Package was measured using Check Point Handheld Gas Analyzer (M/S. PBI Dansensor, Denmark)

To measure the O_2 level, the Check Point Hand held Gas Analyzer was switched on, and then the needle retainer was stuck on the package and then needle was entered in the package through needle retainer. On pressing start switch, the built-in pump in the instrument starts to suck measuring gas through the needle. The pump stops after 10 seconds, and the result is displayed in % O_2 of the head space of the package.

Titratable Acidity

Titratable Acidity of all the samples were determined by procedure described as per BIS Handbook, BIS: Part XI, 1981.

pH

The pH of *Thabdi Peda* was measured using Systronic digital pH meter, Model 335. The method described by Franklin and Sharpe (1963) for cheese was used. The homogenate prepared by diluting 20 g of sample in 20 ml of glass distilled water was subjected to pH measurement.

Water Activity (a_w)

The water activity of *Thabdi Peda* samples, tempered at 25^0C temperature, was measured using RotronicHygroskop Model: Hygrolab-3 (M/s. Rotronicag, Switzerland) connected to a sensing element (AW-DIO) with a measuring range of 0-100 % Relative Humidity (RH).

Soluble Nitrogen

The soluble nitrogen content of *Thabdi Peda* sample was determined by the procedure outlined by Kosikowski (1982).

Free Fatty Acids

The method prescribed by Deeth *et al.* (1975) was used to estimate the FFA content of *Thabdi Peda*.

5-Hydroxy Methyl Furfural (HMF)

The quantitative method presented by Keeney and Bassette (1959) for quantifying HMF by spectrophotometric measurement of the 2-thiobarbituric acid (TBA) reaction product was used to assess the extent of browning in *Thabdi Peda* samples with slight modification.

TEXTURE PROFILE ANALYSIS

Four samples of each experimental *Thabdi Peda* were subjected to uniaxial compression to 80% 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-time curve was obtained for a two-bite

deformation cycle employing a Cross Head speed of 50 mm/min, Trigger 10 gf and 80% Compression of the samples to determine various textural attributes of *Thabdi Peda* held for 1 h at 23±1^{0}C and 55% RH. The complete work of calculations of area under the force-time 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 Evaluation of *Thabdi Peda*

The packages were opened and served to a panel of judges drawn from the institute's faculty, for evaluation of sensory quality. The samples stored at 20±2^{0}C were tempered to about 30^{0}C before serving to judges. The *Thabdi Peda* samples were evaluated using a 100 point linear intensity rating scale. The score-card suggested for Khoa by Gupta and Pal (1985) was used with some modifications for judging the *Thabdi Peda* during this study the judges were also requested to give criticism for each attributes of the samples.

Microbiological Analysis

All the *Thabdi Peda* samples were analyzed for the Standard Plate Count (SPC), Coliform Count and Yeast and Mold Count (YMC) by the methods as per BIS (IS: 5550, 1970), with slight modification. The data of microbiological analyses were log transformed before subjecting them to statistical analysis.

Testing For Packaging Materials

Thickness

Thickness of packaging materials was determined as per the method by BIS (1966). Thickness was determined using micrometer with sheet holder. For the purpose of analysis of the thickness, a pack of not less than 5 specimen of a size 20 x 25 was taken. This was then introduced to the sheet holder by raising the lever. The lever was allowed to relax gently to enable the moving member to fall down and touch the pack at a steady pressure of 1.0±0.1 kg/cm^2. Test was done at 5 places, near the edges as well as in the center portion of the test piece to check for uniformity of thickness.

Statistical Analysis

The mean values generated from the analysis of samples of *Thabdi Peda*, obtained in three replications were subjected to statistical analysis using Completely Randomized Design (CRD) as per Steel and Torrie (1980)

RESULTS AND DISCUSSION

After preparation of Thabdi Peda, they were analyzed for their compositional, physico-chemical, textural, sensory and rheological properties of the product prior to the storage study, as given in Table:1.

Table 1: Average proximate chemical composition, physico-chemical properties and microbiological quality of *Thabdi Peda* manufactured by standardized process.

ATTRIBUTES	***THABDI PEDA***	**ATTRIBUTES**	***THABDI PEDA***
Compositional Attributes		**Microbiological Count**	
Moisture (%)	17.48 ±0.319	Standard Plate Count (cfu/g, log transformed)	3.66 ±0.108
Fat (%)	16.80 ±0.135	Yeast and Mold Count (cfu/g, log transformed)	2.45±0.149
Total Protein (%)	11.25 ±0.073	Coliform Count (cfu/g, log	0

		transformed)	
Lactose (%)	20.95 ±0.271	**Rheological Properties**	
Sucrose (%)	29.99 ±0.211	Stiffness (N/mm)	283.3 ±1.708
Ash (%)	3.53 ±0.018	Hardness (N)	521.0 ±15.81
Physico-Chemical Attributes		Cohesiveness	0.180 ±0.013
Acidity (% L.A.)	0.348 ±0.004	Chewiness (N)	5.545 ±0.551
pH	6.428 ±0.015	Adhesiveness (N mm)	12.31 ±2.760
Free Fatty Acid (FFA) (µ eq./ gm)	0.795 ±0.005	**Sensory Attributes**	
5-Hydroxy Methyl Furfural (HMF) (µ moles / 100g)	119.3 ±5.377	Colour and Appearance (out of 15)	13.40 ±0.115
Soluble Nitrogen (%)	1.020 ±0.008	Body and Texture (out of 35)	31.75 ±0.289
Water Activity (a_w)	0.793 ±0.006	Flavour (out of 45)	41.00 ±0.408
Head space O_2	3.65 ±0.387	Overall Acceptability (out of 100)	91.15 ±0.750

CHANGES IN COMPOSITIONAL ATTRIBUTES:

During storage of *Thabdi Peda* at 20±2^{0}C, only change in moisture was observed in terms of its compositional attributes, which is as shown in Table.1.1

Table. 1.1 : Compositional And Physico-Chemical Changes in *Thabdi Peda* when stored at 20±2^{0}C temperature.

	Package	20±2^{0}C Temperature			
		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 (% l.a)	**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: 0.005, 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 x P: NS				

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

MOISTURE:

The mean values presented in the Table 1.1 reveals that moisture content of *Thabdi Peda* was significantly (P<0.05) influenced by the storage period at 20±2^{0}C temperature of storage. During storage, a decrease in moisture content in two packages at all the periods of storage was observed and thereafter the product was found unacceptable due to visible mold growth.The moisture declined significantly (P<0.05) from initial 17.48±0.000 percent at 0 day to 16.06±0.061 percent at 10th day and 15.31±0.006 percent at 20th day on storage. However the interaction effect of package and period of storage at both the temperatures was found non-significant (P<0.05).The packages, though were showing some difference in decline of moisture content, statistically the decline was non-significant (P<0.05) in package M1 and M2) at the end of storage. Thus, moisture loss during storage is a natural phenomenon as reported by several workers and this is evident from two packaging materials employed for this study.

CHANGES IN PHYSICO-CHEMICAL ATTRIBUTES

During storage of *Thabdi Peda* at 20±2^{0}C, there was change observed in the acidity, pH, FFA, HMF, soluble nitrogen, water activity and head space oxygen. These changes in terms of values have been depicted in Table.1.1.

ACIDITY

The titratable acidity (expressed as percent lactic acid) is an important degradative chemical change which can occur in *Thabdi Peda* during storage. The influence of storage period on acidity is a normal biochemical process in dairy products which might be the result of additional fragmentation of proteins and degradation of lactose and also because of shift of minerals from serum to colloidal state.

The acidity content of *Thabdi Peda* was significantly (P<0.05) influenced by the type of package and storage period.During storage of *Thabdi Peda*, at 20±2^{0}Ca significant (P<0.05) increase in acidity content of 0.347±0.000 percent LA at 0 day increased to 0.397±0.005 percent LA at 10th day and 0.461±0.002 percent LA at 20th day. These observations imply that *Thabdi Peda* packed in M1 and M2 package was not affected significantly (P<0.05) by the package selected and their influence on the

acidity increase was at par. The interaction effect of package and period of storage was also found non-significant (P<0.05). The table values exhibited here indicates that the titratable acidity values of *Thabdi Peda* in both packages increased during storage period at 20±2^{0}Ctemperature. The increase in acidity of *Thabdi Peda* during storage might be attributed to the production of lactic acid and other acids due to fermentation by microorganisms.

pH

There was a decrease in pH in *Thabdi Peda* packaged in both of the packages during 20±2^{0}C temperature. During storage of *Thabdi Peda* also, a significant (P<0.05) decrease in pH from 6.428 ±0.000 at 0 day decreased to 6.360 ±0.011 at 10th day and 6.258 ±0.006 at 20th day of storage, after which the product was unacceptable due to visible mold growth in the product.The decrease in pH of *Thabdi Peda* during storage may be due to microbial growth in dairy products which causes increase in acidity or decrease in pH.Thus pH decreased significantly (P<0.05) as the storage under study in two packages.Here, the effect of package as well as the interaction effect of package and period of storage was found non-significant (P<0.05). This result is also in support to the changes in acidity in both these packages.

FFA

FFA (µ eq/g) content reflects the extent of lipolysis (lipolytic rancidity or hydrolytic rancidity) in milk and milk products. Lipolysis, regardless of cause, seriously degrades the quality of the stored products by imparting off flavours and also may be responsible for the development of rancidity. During storage of processed foods, FFAs are liberated as a result of hydrolytic reactions and the degree of lipolysis is measured in terms of FFA (µ eq/g) content.

The mean values presented reveals that FFA content of *Thabdi Peda* was significantly (P<0.05) influenced by the type of package, storage period as well as their interaction effect. During storage of *Thabdi Peda*, at 20±2^{0}C a significant (P<0.05) increase in FFA content from 0.795±0.000 µ eq/gat 0 day increased to 0.973±0.035 at 10th day and 1.154±0.071 µ eq/g at 20th day of storage and thereafter the product was unacceptable due to visible mold growth. The values indicate that *Thabdi Peda* packed in M2 have undergone minimum increase in FFA during as compared to the other package M1 employed in this study.The interaction effect of package and period of storage was also found significant (P<0.05) which shows the similar trend in the average values. The results show that the pace of increase in FFA (µ eq/g)content of heat treated milk product like *Thabdi Peda* can be minimized on storage at appropriate temperature as well as selection of appropriate package.

5- Hydroxymethyl furfural (HMF)

Hydroxy methyl furfural (HMF) (µ moles / 100g) also known as 5-(Hydroxy methyl) furfural is an organic compound derived from dehydration of sugars. This organic compound is involved in non-enzymatic reactions of glucose. HMF value is most important in case of *Thabdi Peda*, as the product is recognized and is popular due to its characteristic brown colour and caramelized flavor. The determination of 5-HMF in *Thabdi Peda* is attempted here to measure the extent of browning changes during storage.

During storage of *Thabdi Peda*, at 20±2^{0}C, a significant (P<0.05) increase in HMFcontent from 119.3±0.000 µ moles / 100g at 0 day, 141.2±0.53 µ moles / 100g at 10th day to162.2±0.2.298 µ moles / 100g at 20th day, and thereafter the product was unacceptable due to visible mold growth. The mean

values presented reveals that HMF (µ moles / 100g) content of *Thabdi Peda* was not influenced significantly (P<0.05) by the type of package but significantly influenced by storage period.
The results show that though browning cannot be stopped on storage of heat desiccated milk products, it can be prolonged by use of proper temperature and packages.

SOLUBLE NITROGEN

Soluble nitrogen is the measure of water soluble nitrogenous portion of milk proteins. This may result from the degradation of milk proteins because of proteolysis. In heat desiccated products such as *Thabdi Peda*, it may serve as an indicator of storage related deterioration of milk proteins and some minor solubilization of micellar proteins due to vigorous heat and agitation employed in the process for manufacture of *Thabdi Peda*.
The soluble nitrogen content of *Thabdi Peda* was significantly (P<0.05) influenced by the type of package, storage period as well as their interaction effect**.** During storage of *Thabdi Peda*, the initial mean soluble nitrogen content of 1.02±0.000 percent at 0 day increased to 1.076 ±0.016 at 10^{th} day and 1.249±0.016 percent at the 20^{th} day, after which the product was found unacceptable due to visible mold growth. The higher soluble nitrogen content observed could be attributed to the heat treatment employed. On the other hand survival of heat resistant groups of bacteria and heat stable enzymes capable of protein breakdown could be also considered for proportionately higher soluble nitrogen content during storage.
Thus, the increase in soluble nitrogen content during storage might be the direct consequence of degradation of protein content of *Thabdi Peda.*

WATER ACTIVITY (a_w)

Higher a_w substances tend to support more microorganisms. Bacterial growth potential can be correlated with moisture in the product concerned. Thus, water activity is helpful in deciding the shelf life of the product either by support or otherwise to the bacterial growth or change in the textural properties due to water transfer.
The water activity of Thabdi Peda was significantly (P<0.05) influenced by the type of package and storage period. During storage of *Thabdi Peda*, significant (P<0.05) decrease in water activity from 0.793 ±0.000 at 0 day to 0.761±0.004 at 10^{th} day and 0.738 ±0.007 at the 20^{th} day was observed and, thereafter the product was found unacceptable due to visible mold growth in the product.
The result also indicates that Thabdi Peda packed in package M2 have undergone minimum decrease in water activity during storage throughout the study. Thus, it can be inferred that storage of Thabdi Peda leads to decrease in water activity of the stored product.

HEAD SPACE O_2

The Head Space O_2 decreases in packages during storage due to its utilization implying the growth of microorganisms particularly molds and yeasts or because of continuation of the browning reaction which has been started during heat desiccation process. Hence, it can act as indicator for the increase or decrease of macrobiotic in the product as well as darkening of colour because of the oxidative browning reaction and hence affects its acceptability by the consumers and ultimately shelf life.
During the storage of *Thabdi Peda*, at 20±2^0C, a significant (P<0.05) decrease in Head space O_2 content from 3.65 ±0.000 percent at 0 day to 3.10±0.106 at 10^{th} day and 2.69±0.0176 percent at the 20^{th} day in

both the packages was observed and thereafter, the product was unacceptable due to visible mold growth.Here also, the effect of package as well as the interaction effect of package and period of storage was found statistically non-significant (P<0.05). There was a rapid decrease in Head space O_2 in *Thabdi Peda* packages during storage. The decrease in Head space O_2 of *Thabdi Peda* packages during storage might be due to the rapid microbial growth in *Thabdi Peda* which causes reduction in O_2 content or decrease in Head space O_2.

CHANGES IN MICROBIOLOGICAL ATTRIBUTES

Changes in microbiological attributes during storage of *Thabdi Peda* at 20±2^{0}C has been depicted in Table.1.2.

Table. 1.2 : Changes In Microbiological Quality Of *Thabdi Peda* When Stored At 20±2^{0}C Temperature:

	Package	20±2^{0}C Temperature			
		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 (92µ)

STANDARD PLATE COUNT

Standard Plate Count (SPC) (log cfu/g) is a collective enumeration of the overall microbiological quality of the product after production and during its storage period. It gives the idea about the status of *Thabdi Peda* in terms of its microbiological quality during storage. During storage of *Thabdi Peda* at 20±2^{0}C, a significant (P<0.05) increase in mean values from 3.660±0.00 log cfu/g at 0 day to 4.323±0.081 log cfu/g at 10th day and 5.506±0.058 log cfu/g at 20th day was observed.

This indicates that *Thabdi Peda* packed in M1 and M2 packages have undergone statistically similar increase in SPC during storage throughout the study. The interaction effect of package and period of storage was also found statistically non-significant (P<0.05). Thus, among both of the packaging materials under study, the *Thabdi Peda* packed in M1 or M2 showed comparatively less SPC count when stored at 20±2^{0}Ctemperature.

YEAST AND MOLD COUNT

For most of the intermediate moisture Indian dairy foods, mold growth tends to be a major problem and often most important single factor limiting their shelf life. Yeast and molds are undesirable and their presence in sufficient numbers to exhibit themselves reduces the keeping quality of *Thabdi Peda.*During storage of *Thabdi Peda* a significant (P<0.05) increase in yeast and mold count in both of the packages from 2.455±0.000 log cfu/g at 0 day, 4.365 ±0.152 log cfu/g at 10th day and 5.665±0.084 log cfu/g at 20th day was observed and thereafter the product was found unacceptable due to visible mold growth.

This indicates that the packages M1 and M2 have shown statistically similar increase in yeast and mold count during storage throughout the study. The interaction effect of package and period of storage was also found statistically non-significant (P<0.05). Thus, it can be inferred from the results obtained that though the packages M1 and M2 did not show significantly different yeast and mold counts, the product on storage showed a marked rise in the count.

CHANGES IN RHEOLOGICAL ATTRIBUTES

Changes in rheological attributes during storage of *Thabdi Peda* at 20±2^{0}C has been depicted in Table.1.3.

Table: 1.3 Changes In Rheological Attributes Of *Thabdi Peda* When Stored At 20±2^{0}c Temperature:

	Package	20±2^{0}C Temperature			
		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)

STIFFNESS (N/mm)

Stiffness value is the resistance of an elastic body to deformation by an applied force. It is an extensive material property. During storage of *Thabdi Peda* at 20±2^{0}C a significant (P<0.05) increase in stiffness values in both the packages from 283.25±1.708 N/mm at 0 day to 303.33 ±0.538 and 300.5±1.080 N/mm at the 20th day was observed and thereafter the product was found unacceptable due to visible mold growth. Thus, the results show that there is a significant effect of period of storage on stiffness values of *ThabdiPeda* stored at 20±2^{0}C temperature.

HARDNESS (N)

Hardness (N) refers to the peak force that result from a sample being compressed to a given distance, time, or percent deformation. During storage of *Thabdi Peda* at 20±2^{0}C, a significant (P<0.05) increase in hardness of the packed products was observed from 521±0.00 N at 0 day to 550.7±1.768 at 10 day

and 583.7±3.005N at 20th day after which the product was found unacceptable due to visible mold growth.It is inferred from the results obtained that storage of *ThabdiPeda* in M1 and M2 packages leads to increase in hardness (N) values. The increase in hardness of samples of *Thabdi Peda* during storage could be attributed to the decrease in moisture content of *Thabdi Peda* and the water vapour permeability of the package which plays a role in maintaining the initial moisture of the product.

COHESIVENESS

Cohesiveness refers to the extent to which a material can be deformed before it ruptures. In other words, it refers to how a food product stays together after deformation. During storage of *Thabdi Peda* at 20±2^{0}C, a significant (P<0.05) decrease in cohesiveness in both of the packages was observed from 0.180±0.013 at 0 day to 0.092 ±0.012 and 0.102 ±0.009 at 20th day and thereafter the product was found unacceptable due to visible mold growth. This indicates that *Thabdi Peda* packaged in M1 or M2 undergone statistically similar decrease in cohesiveness during storage throughout the study. The decrease in cohesiveness might be due to decrease in moisture content on storage resulting into less cohesion of the matrix of the *Thabdi Peda*.

CHEWINESS (N mm)

Chewiness refers to a combination of gumminess and springiness. This is the amount of effort that goes into preparing a solid product ready for swallowing. During storage of *Thabdi Peda* at 20±2^{0}Ca non-significant (P<0.05) increase in chewiness from 5.545±0.551 N mm at 0 day increased to 6.634 ±0.090 and 6.543 ±0.111 N mm at the 20th day in both the packages, after which the product was found unacceptable due to visible mold growth. The increase in chewiness values of *Thabdi Peda* during storage may be due to increase in hardness values resulting from moisture loss as depicted earlier. The results of the storage study indicates that the chewiness of *ThabdiPeda* are influenced significantly (P<0.05) by storage at 20±2^{0}C

ADHESIVENESS (N mm)

Adhesiveness is sometimes referred to as stickiness, which is related to how a food adheres to the palate during chewing.

During storage of *Thabdi Peda* at 20±2^{0}C, a significant (P<0.05) increase in adhesiveness value in both of the packages from 12.31±0.000 N mm at 0 day increased to 21.21±0.195 at 10th day and 29.47±1.02 N mm at 20th day, and thereafter the product was unacceptable due to visible mold growth.This indicates that the *Thabdi Peda* packed in M2 package have undergone minimum increase in adhesiveness value during storage throughout the study. Thus based on the observations from storage products, it can be said that moisture loss during storage mainly affects the textural changes which is the inner makeup of the products. These changes have played a major role in deciding the acceptability of stored products, particularly at 20±2^{0}C.

CHANGES IN SENSORY ATTRIBUTES

Changes in sensory attributes during storage of *Thabdi Peda* at 20±2^{0}C has been depicted in Table.1.3.

Table: 1.4 Changes In Sensory Attributes Of *Thabdi Peda* When Stored At 20±2^{0}C Temperature.

	Package	20±2^{0}C Temperature			
		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 (92µ)

COLOUR AND APPEARANCE

Colour and appearance is one of the attributes among the various sensory attributes of *Thabdi Peda* playing vital role in its acceptance by the consumers due to its appealing nature. As in the case with all of the dairy products during storage, *Thabdi Peda* undergoes various physico-chemicals, textural and microbial changes which concomitantly affect the sensory profiles of the product as like colour and appearance.

Storage of samples at 20±2^{0}C,gave initial mean colour and appearance score of 13.40±0.000 (out of 15) at 0day that decreased to 12.54±0.088 at 10th day and 11.54 ±0.053 at the 20th day. This indicates that *Thabdi Peda* packed in M1 or M2 package have undergone statistically similar decrease in colour and appearance score during storage throughout the study. The interaction effect of package and period of storage was also found statistically non-significant (P<0.05).

The changes in colour and appearance scores indicated that sensory characteristics of *Thabdi Peda* varied; the extent of decline was however depended on the type of packaging material and storage temperature. The decline in scores during storage of *Thabdi Peda* can be attributed to microbial, chemical and textural changes in the product. The reason for this change might be due to the reduced moisture and increased HMF content on storage. The higher temperature of storage aggravates the situation whereas there was no statistically significant (P<0.05) effect of type of package.

BODY AND TEXTURE

The body and texture of the product helps in its marketing value. It also shows product's inner makeup. Storage of samples at 20±2^{0}C, gave initial mean body and texture score of 31.75±0.000 at 0 day that decreased to 30.33±0.07 at 10th day and 29.74±0.194 at the 20th day. This indicates that *Thabdi Peda* packed in M1 or M2 have undergone statistically similar decrease in body and texture score during

storage throughout the study. The interaction effect of package and period of storage was also found statistically non-significant (P<0.05).

The product on storage at 20±2^{0}C became dry, hard, sandy, and brittle which might be ascribed to the loss of moisture and possible crystallization of added sugar. The reason for this change might be due to the reduced moisture and increased Chewiness and hardness on storage. Therefore, body and texture is considered as important criteria for determining the acceptability of *Thabdi Peda* during storage study particularly at 20±2^{0}C.

FLAVOUR

The flavour of any food product including *Thabdi Peda* is most important sensory attribute, as far as consumer likes is concerned because it determines its acceptance or rejection.

Storage of Thabdi Peda at 20±2^{0}C, gave an initial mean flavour score of 41.00±0.000 (out of 45) at 0 day that decreased to 39.20±0.106 at 10th day and 38.21±0.0.088 at 20th day. This indicates that the *Thabdi Peda* packed in M1 or M2 package have undergone statistically similar decline in flavour score during storage throughout the study. The interaction effect of package and period of storage was also found statistically non-significant (P<0.05).None of the judges reported the presence of any objectionable off flavour such as oxidized, rancid, acidic etc. during entire period of storage.

OVERALL ACCEPTABILITY

The initial mean overall acceptability score of *Thabdi Peda* stored at 20±2^{0}C was 91.15±0.000 (out of 100) at 0day that subsequently decreased to 87.06±0.262 at 10th day and 84.49±0.057 at the 20th day.The decline in overall acceptability scores of *Thabdi Peda* might be due to changes in flavour and body and texture characteristics. The influence of storage period was significant for all the changes of sensory attributes such as colour and appearance, flavour and body and texture which gave their cumulative influence on the overall acceptability scores. It means that the individual attributes such as temperature of storage and package used had additive effect during storage which however is not reflected significantly in the scores given by the judges for overall evaluation.

COST OF PACKAGING:

Table: 1.5 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	N_2 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 (65µ); M2= Polyester/PE pouch (92µ)

CONCLUSION

The study was based on assessing the shelf life of *Thabdi Peda using* different packaging materials and techniques. The study conducted used the packages Met-Polyester/Polyfilm pouches (M1) and Polyester/Polyfilm pouches (M2) wherein partial vacuum was created and simultaneously N2 gas was flushed to reduce the head space O_2 level well below 3 to 4 percent and avoiding creation of unnecessary

air pressure inside. It was observed that the packed *Thabdi Peda* samples remained acceptable up to 20 days in both of the packages and thereafter the visible mold growth was observed on *Thabdi Peda* making it unacceptable. On the basis of storage related changes in compositional, textural, microbial and sensory attributes, the packaging material evaluated exhibited comparatively statistically similar performance but based on cost criteria, the package Polyester/PE pouch (M2) can be preferred.

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