

## From Tradition to Innovation: Exploring Indian *Peda*, Shelf Life, and Value Creation

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### Abstract

Khoa is a base ingredient utilized in producing several types of confectionery. Various regions of India provide distinct varieties of khoa-based products such as *peda*, each characterized by its own distinctive flavour, texture, colour appearance and preparation method. The product life of *peda* poses a significant obstacle for dairy entrepreneurs. In Indian market due to tropical conditions, khoa-based *peda* is not able to retain its quality and deteriorates due to prolonged time of supply chain from production to consumer. Several approaches have been used to enhance the shelf life of *peda*, such as partial dehydration and the incorporation of natural preservatives, antioxidants, and other ingredients. The utilization of MAP (Modified Atmosphere Packaging) and advanced packaging and food packaging materials significantly contribute to enhancing the shelf life of products. The value addition in *peda* associated with health benefits is an emerging trend. This review study provides an overview of the characteristics of different types of *peda* available throughout India, highlighting their unique features, value addition, and technological advancements.

**Keywords:** Traditional dairy product, Khoa, Khoa-based sweets, *peda*. Nutritional value, Packaging applications, Shelf life, value addition

### Introduction

India is globally recognized as the largest producer of milk, with an impressive total output of 230.6 million tonnes in 2022-23 (DAHD, 2023). The daily per capita milk consumption has experienced a significant increase from 307 g/day in 2013-2014 to 459 g/day at present, representing an impressive growth rate of 49.51% (NDDB, 2023). Around 55% of the milk that is generated is utilized in the production of diverse dairy products, whereas the

remaining 45% is consumed as liquid milk. A considerable proportion, approximately 40% is utilized for the production of ample dairy products. Out of 40%, approximately 55% is designated for product manufacturing particularly Traditional Indian dairy delicacies such as *khoa*, *peda*, *burfi*, *kalakand*, *milk cake*, *rasogolla*, *chhana*, *paneer*, and others. Since ancient times, traditional Indian dairy products have been an important part of various religious, cultural, social, and financial reasons and celebrations. It is noteworthy that India's annual *khoa* production amounts to an impressive amount of 1.5 million tonnes, representing a substantial economic achievement with an estimated minimum value of Rs 18,000 crore (Indiatimes, 2023).

This serves as a testament to the extensive scale of milk production in India and the diverse structure of its dairy sector. *Peda* is a traditional *khoa*-based heat-desiccated sweet that is produced through the process of heating a blending of *khoa* and sugar, along with the incorporation of natural and/or artificial flavorings and colors, until the desired textural and flavour profile is achieved. *Peda* is typically formed into 20-25g round balls through a process involving rolling between the palms and flattening (Pal, 2000) or using any mechanized *peda* shaping machine.

*Peda* is a remarkably nutritious delight, comprising an amalgamation of milk solids, sugar, and additional components. This Indigenous milk confection is prepared through a process of heating a blend of *khoa* and sugar until it attains the appropriate granular, solid consistency and distinctive flavour. *Peda* appears in a variety of colours, such as including white, yellow, and dark reddish brown. In India, the production of *peda* surpasses the production of all other indigenous milk-based sweets, making it an integral part of various celebrations, from weddings to inaugural functions, year-round (Ghule *et al.*, 2013; Puri *et al.*, 2018).

Renowned for its caramelized essence and delightful taste, *peda* holds a special place among traditional Indian sweets. However, it's essential to note that *peda* and other *khoa*-based products have a limited shelf life. They are prone to moisture loss, surface dryness, growth of surface mold, and rancidity during the storage period (Londhe and Pal, 2007). On the other hand, these products are largely prepared on a small scale particularly, local *halwais*. Thus, the unorganized sector still holds a significant share of this industry, which is not surprising given the volume of demand for *khoa* and sweets based on it. Low-shelf stability items are produced when unstandardized and unsanitary methods are employed during product preparation. Moreover, inadequate handling and improper packaging methods cause rapid deterioration and

hence decreases the shelf life with concerning threats towards public health (Puri *et al.*, 2018; Kumar *et al.*, 2023).

Many scientists have tried to upgrade the conventional process of preparing khoa and khoa based sweets owing to the increasing demand and popularity. Researchers and business owners are looking forward to developing new varieties of *peda* with an affordable packaging material that would potentially extend the shelf life without compromising its quality characteristics as well as consumer health. Additionally, consumers are now looking for beneficial products which not only provide nutrition but also some health benefits. Entrepreneurs in the dairy industry are also trying to produce low-calorie, sugar-free *peda* for people with diabetes (Viji *et al.*, 2023; Jha *et al.*, 2015). Hence, there are a lot of investigation had been conducted for the ingredients that should be able to integrate with milk/khoa components seamlessly without compromising the final product quality in addition to enhancing the product longevity and multiple health benefits. This review comprises the various techniques to extend the shelf life and value addition of *peda* that had been probed by researchers.

### FSSAI Standards (2011) for Khoa

As per FSSR (2011) of India, khoa is prepared from buffalo/cow/ sheep/ goat milk or milk solids or a combination followed by desiccation/ drying. The final product should have milk fat content of more than 30% based on dry weight and citric acid less than 0.1% by weight. It should be free from added sugar, starch and colouring matter.

**Table 1:** FSSAI standard of Composition of different types of *khoa*

Characteristic	Type of Khoa		
	<i>Pindi</i>	<i>Dhap</i>	<i>Danedar</i>
<b>Moisture (in %)</b>	31-33	37-44	35-40
<b>Total Solid (in %)</b>	67-69	56-63	60-65
<b>Fat (%)</b>	21-26	20-23	20-25
<b>Ash (%)</b>	3.0	3.0	3.0
<b>Acidity (%LA)</b>	0.8	0.6	0.9
<b>Final product</b>	<i>Burfi, Peda</i>	<i>Gulabjamun, Pantooa ,</i>	<i>Milk cake Kalakand,</i>

		<i>Kalajamun , Halwa</i>	
<b>Coliform count</b> (cfu per g)	Not more than 90/g		
<b>Aerobic count</b> (cfu per g)	Not more than 50000/g		
<b>Yeast and mold</b> (cfu per g)	Not more than 250/g		

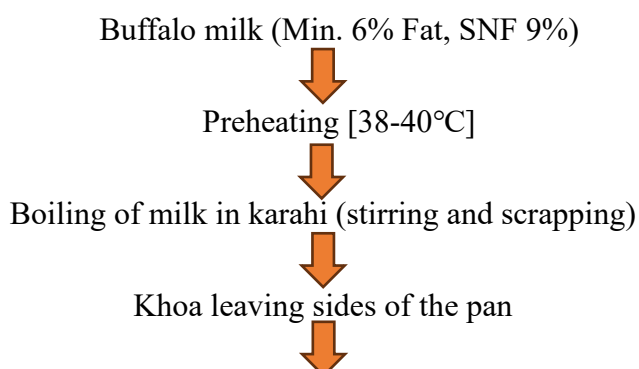
### Microbiological Standard for Khoa and Khoa-based sweets (FSSR 2011)

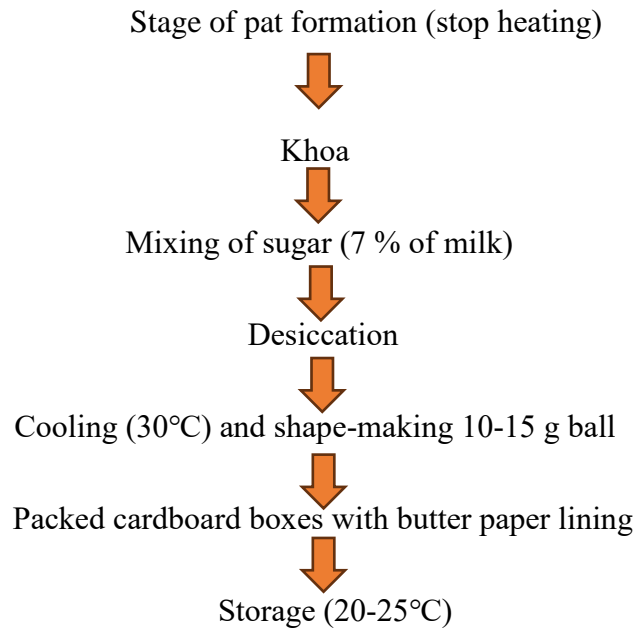
**Table 2:** FSSAI Microbial standard of Khoa

Microbiological parameters	Sampling plan		Limit (cfu)	
	N	C	m	M
<i>Listeria monocytogenes</i>	5	0	Absent/ g	NA
<i>Sulphite Reducing Clostridia</i>	NA	NA	NA	NA
<i>Enterobactersakazakii</i>	NA	NA	NA	NA
<i>Aerobic Plate Count</i>	5	3	2.5x10 <sup>4</sup> / g	7.5x10 <sup>4</sup> /g
<i>Coliform Count</i>	5	2	50/g	1x10 <sup>2</sup> / g
<i>Staphylococcus aureus</i> (Coagulase positive)	5	3	10/g	1x10 <sup>2</sup> /g
<i>Yeast and mold count</i>	5	3	10/g	50/g
<i>Escherichia coli</i>	5	0	<10/g	NA
<i>Salmonella sp</i>	5	0	Absent/ 25 g	NA
<i>Bacillus cereus</i>	NA	NA	NA	NA

Where, NA- Not Applicable n = Number of units comprising a sample c = Maximum allowable number of units having microbiological counts above m for 2-class sampling plan and between m and M for 3-class sampling plan. m = Microbiological limit that separates unsatisfactory from satisfactory in a 2- class sampling plan or acceptable from satisfactory in a 3-class sampling

### Preparation Flow chart of *Peda*





### Characteristics of different types of *peda*

Out of all the khoa varieties, the Pindi kind has the largest total solids content and can be produced by desiccating larger volumes of liquid during preparation. This form of khoa should not be consumed if burned particles or any other indication of extreme heat treatment is present. Its grains are dry and very fine. Peda, burfi, and other desserts with comparatively low moisture content are the main uses for it (Aggarwal et al., 2018). The typical shape of *peda*, known as "*Doodh*" in India, is white or creamy white in colour, smooth in texture, and shaped like a spherical ball with a small flattening of the surface and low moisture content (Kumar et al., 2004). India is home to numerous regional variants of *peda*, including *Kunthalgiri peda*, *Dharwad peda*, *Mathura peda*, *Lal peda*, and *Bal Mithai* (Rasane et al., 2012; Prasad et al., 2023).

#### 1. *Dharwad Peda*

*Dharwad peda*, a unique variety of *peda*, hails from the *Dharwad* district in Karnataka state. It is distinguished by its dark brown colour, owing to a higher level of browning which not only imparts a unique flavour but also extends its shelf life (Asgar and Chauhan, 2019). *Dharwad peda* which was collected from *Dharwad* had a natural brown colour with a powdered sugar coating on the surface, lending it a caramelized flavour due to the browning reaction, making it slightly more acidic compared to other varieties. This browning is potentially due to the caramelization of added sugar and maillard browning between milk components (lysine and lactose) occurring at high temperatures ( $>80^{\circ}\text{C}$ ) during preparation of *peda* (Sutariya, et al., 2017). Vasu, (2007) reported that *Dharwad peda* was composed of approximately ~13.33%

moisture, ~14.21% fat, ~14.17% protein, ~17.34% lactose, ~38.97% sugar, and ~2.80% ash with an acidity level of ~0.84% lactic acid. Apart from its distinct flavour characteristics, it exhibits higher hardness, gumminess, springiness, and chewiness when compared to other *peda* varieties. Cohesiveness was found too higher in *Dharwad peda* but the difference was not statistically significant. The browning reaction significantly elevates the pH, resulting in lower acidity levels compared to other *peda* varieties, thereby granting *Dharwad peda* an extended shelf life of extra seven days when compared to control *peda* (Londhe *et al.*, 2012). The uniqueness of *Dharwad peda* makes it different from others based on rheological and external characteristics and chemical composition.

## **2. Mathura peda**

*Mathura peda* is well-recognized by the region basis as brown *peda* for its distinct caramel flavour, colour and appearance. It's often referred to by regional names such as *Dharwad peda* (Puri *et al.*, 2018). *Mathura peda* stands out with its light brown hue and pronounced cardamom essence. These delectable sweets are typically manufactured using powdered sugar and adorned with a few cardamom seeds. In terms of composition, *Mathura peda* contains around 13.33% moisture, 20.18-23.10% fat, 15.70-16.80% protein, 20.95-22.67% lactose, 30.80-32.80% sugar, and 2.80% ash. Compositional, sensory attributes, and rheological properties of manufactured *Mathura peda* in mechanized steam jacketed kettle (Sharma *et al.*, 2024). *Mathura peda* provides approximately 82 kcal of energy. *Peda* varieties with a brownish colour, like *Mathura peda* and *Dharwad peda*, are relished for their caramelized flavour and enjoy popularity due to their pleasant taste and relatively extended shelf life (Londhe and Pal, 2008).

## **3. Thirattupal**

*Thirattupal*, a delectable variety of *peda*, finds its roots in the southern states of India, particularly gaining fame in Tamilnadu and Kerala. In Tamil, '*Thirattu*' means continued stirring to bring the components into concentration (Sutariya *et al.*, 2017). and '*pal*' means milk. What sets *Thirattupal* apart is its unique production process, featuring the use of the *danedar* variety of khoa, which imparts a specific level of acidity. One or two spoonsful of sour curd added to milk partially coagulating it before adding sugar and completing the desiccation process. *Thirattupal* shows a distinctive texture characterized by a light to medium brown colour, a subtle free-fat appearance, a granular texture with tender grains and a delightful caramelized flavour complemented by pleasant nutty and cardamom essence. Its composition typically comprises 16.68-23.94% moisture, 16.96-19.94% fat, 12.57-16.00% protein, 12.81-

16.55% lactose, 36.09-41.48% sucrose, 1.74-2.33% ash content, and an acidity level of 0.37-0.44 (%lactic acid). Microbial investigation of *Thirattupal* market samples revealed moderate levels of coliform, yeast, and mould, as well as standard plate counts (SPC). A worthy aspect of *Thirattupal* is its anticipated water activity, which should fall below 0.90 (; Aggarwal *et al.*, 2018; Viji *et al.*, 2023). This contributes to its unique texture and shelf life, making it a beloved treat in the southern regions of India.

#### **4. *Lal peda***






*Lal peda* is a well-liked Indigenous dairy sweet which is a heat-desiccated product. It is particularly popular in Varanasi, Uttar Pradesh, because of its cooked flavour and somewhat longer shelf life (Jha *et al.*, (2014). *Lal peda* is a delectable confection manufactured through the mixing of khoa and sugar, then heating the mixture until it turns a distinctive reddish-brown colour. The distinctive texture, reddish-brown colour, and caramelized flavour of *Lal Peda* are all largely attributes of sugar (Jha *et al.*,2015). This sweet not only offers a delightful taste but is also a valuable source of energy. Notably, cow milk typically yields around 17-19% of khoa by weight, whereas buffalo milk boasts a slightly higher yield of 21-23% by weight. The distinctive reddish-brown colour of *the lal peda* results from the caramelization of sucrose during the heat processing stage (Kumar *et al.*,2012; Alam, 2017) A research study about the composition of *lal peda* by Jha *et al.* (2012) revealed that it has approximately 12.4% moisture, 18.5% fat, 16.7% lactose, 17.2% protein, 3% ash, and 32.2% sucrose. Pandey *et al.*, (2007) observed that *lal peda* prepared from mixed milk with 60% sugar produced the highest yield. These characteristics contribute to the unique appeal of *Lal peda* as a delightful and energy-rich treat.

#### **5. *Thabdi (Brown peda)***

Patel *et al.*, (2012) stated that *Thabdi* is a well-known dehydrated milk confection manufactured and sold in huge quantities in the Saurashtra district of Gujarat. Furthermore, he found a significant variance in every quality feature of the market *Thabdi*. According to Modha *et al.* (2015), *Thabdi peda* is another name for *Thabdi* in certain regions of Gujarat. This unique sweet is known for its soft and delightful texture. It is known for its rich caramelized, cooked, nutty, ghee-like flavour and the rich aroma of milk fat. Its colour ranges from creamish brown, which is commonly compared to the skin of a camel's offspring, to dark brown. It also has a loose, granular texture, little melted fat pools, and a film of hardened fat on the top (Hirpara *et al.*, 2015). The average composition of standardised *Thabdi peda* had been found to be 16.80% fat, 17.48% moisture, 11.25% protein, 20.95% lactose, 29.99 % sucrose, 3.53% ash, and 28.75 %

yield. (Thesiya *et al.*, 2023; Sejani *et al.*, 2022). For *Thabdi peda* to be highly accepted and consistently of excellent quality, processing criteria including standardizing the fat content of the milk, the rate at which sugar is added, and the consistency of the final heat treatment are important. The good quality *thabdi peda* could be prepared using milk standardized at 6 % fat and 8.33 % sugar addition at the time of first boiling of milk. When making *Thabdi peda*, a distinctive approach is employed, incorporating a modest amount of caramelized sugar into the milk to attain the desired characteristics Modha *et al.* (2015).

#### Composition of different types of peda in India

<i>Types</i>	<i>Images</i>	<i>Moisture (%)</i>	<i>Fat (%)</i>	<i>Protein (%)</i>	<i>Lactose (%)</i>	<i>Sucrose (%)</i>	<i>Ash (%)</i>
<b><i>Dharwad Peda</i></b>		13.33	14.21	14.17	17.34	38.97	2.80
<b><i>Mathura Peda</i></b>		13.33-15.26	20.18-23.10	15.70-17.80	20.95-22.67	30.80-32.80	2.80
<b><i>Thirattipal</i></b>		16.68-23.94	16.96-19.94	12.57-16.00	12.81-16.55	36.09-41.06	0.37-0.44
<b><i>Lal Peda</i></b>		12.6	18.5	17.2	16.7	32.2	3.0
<b><i>Thabdi</i></b>		17.48	16.80	11.25	20.95	29.99	3.53

**Table 3:** Composition of different types of *peda* in India

#### Innovative ways to improve the shelf-life of *peda*

*Peda*, a traditional dairy product popular in northern India that has been heat-desiccated, has a poor shelf life because of rancidity, mould development, and surface moisture loss. The addition of antioxidants and vitamins, modifications to the production method, and packaging system can all extend the shelf life. Packaging serves as essential for regulating the development of microorganisms and metabolic alterations.

##### 1. Effect of MAP and Vacuum packaging techniques



Research conducted by Londhe *et al.*, (2012) Among samples packed under MAP and vacuum packing, the samples held at 30°C showed the greatest drop in moisture, pH, and water activity after 20 days. These samples were packaged in cardboard boxes. It was found that vacuum-packed brown *peda* could be kept for 40 days at room temperature (30°C) without experiencing a significant reduction in quality. The reduced barrier qualities of cardboard lined with butter paper about the water vapour transpiration rate may be the cause of the greater moisture loss in cardboard boxes.

The MAP technique involves using specialized packaging that contains a controlled gas mixture. This gas combination prolongs the shelf life of food goods by slowing down the development of microbes and the rate of oxidation. (Farber 1991). MAP commonly involves the use of CO<sub>2</sub>, O<sub>2</sub>, and N<sub>2</sub>. Under specific circumstances, it has the potential to improve food safety and has been employed to preserve the quality of various food items. (Day, B. P. (2008); Opara *et al.*, 2019). Modifying the ratios of atmospheric gases can impact respiration rate, microbial growth, and oxidation reactions, ultimately influencing the shelf life of food products (Mangarj and Goswami, 2009). As per the study conducted by Jha *et al.* (2015), The Lal *Peda* samples were preserved at a temperature in polyethene bags containing various gas compositions (air, 70% N<sub>2</sub>, 30% CO<sub>2</sub>, and 98% N<sub>2</sub>). Since the HMF concentration of 70% N<sub>2</sub>: 30% CO<sub>2</sub> is lower than that of 98% N<sub>2</sub>, the combination of 70% N<sub>2</sub>: 30% CO<sub>2</sub> shows greater acceptance and is thus more attractive for storage. MAP showed shelf stability of *lal peda* for up to 60 days.

Gunvantsingh *et al.*, 2023 developed the reduced calorie *peda* with whey protein concentrate-70 as a fat replacer and packed in cardboard. MAP packing with laminated plastic tray provided up to 3 times more shelf life than convention packaging in cardboard. According to the storage study conducted by Jha *et al.* (2012), The control sample packed in air had a loss of 12.5 to 15.5% moisture. When the samples were held at 70% N<sub>2</sub> and 30% CO<sub>2</sub> for 60 days, the least amount of moisture loss was seen. According to the sensory assessment of the *lal peda* samples with moisture contents between 12.5 and 15.5% are the best for a desirable product texture. Therefore, the sample packets were kept in storage at 37°C and 4°C, the sensory properties of *lal peda* diminished after 9 and 31 days, respectively. The physiochemical changes that occur during storage include an increase in HMF (106.5 to 107.36 µmoles/100 g), TBA a (0.179 to 0.281) change in absorbance at 532 nm, and FFA values (increase in 11.63 to 14.87 µeq/g) respectively, in *lal peda* kept at both 4 and 37°C.

Raval & Joshi (2023) used two different packages of pre-sterilized pouches made of Met Polyester/Polyfilm pouches (65u) and (92u) establishing a partial vacuum and flushing N<sub>2</sub> gas

which were employed in the investigation of *Thabdi peda* shelf life. The pouches were kept at a temperature of  $20 \pm 2^\circ\text{C}$  and examined every 10 days for a total of 30 days. There was an increase in various factors such as moisture, acidity, FFA, HMF, and soluble nitrogen content, as well as stiffness, hardness, chewiness, and adhesiveness. On the other hand, pH, water activity, head space  $\text{O}_2$  concentration, sensory score, and cohesion experienced a significant decrease during storage of 20 days.

Research conducted by Londhe *et al.*, (2012) Among samples packed under MAP and vacuum packing, the samples held at  $30^\circ\text{C}$  showed the greatest drop in moisture, pH, and water activity after 20 days. These samples were packaged in cardboard boxes. It was found that vacuum-packed brown *peda* could be kept for 40 days at room temperature ( $30^\circ\text{C}$ ) without experiencing a significant reduction in quality. The reduced barrier qualities of cardboard lined with butter paper about the water vapour transpiration rate may be the cause of the greater moisture loss in cardboard boxes.

## **2. Use of antioxidants and preservatives**

Yadav *et al.*, (2009) investigated the effects of *peda* made from 6% fat buffalo milk by using concentrations of sodium ascorbate at 400, 600, and 800 ppm and tocopherol at 10, 12, and 16 ppm rates. The *peda* received a 0.2% (w/w) addition of potassium sorbate as a preservative. *Peda* samples were stored for future study after being packaged in LDPE (50-55 microns). After physical-chemical, sensory, and microbiological evaluation it was revealed that *peda* sample with 10 ppm of tocopherol and 400 ppm of sodium ascorbate was shown to be stable at  $15^\circ\text{C} \pm 2$  for over 60 days. Using potassium sorbate was an effective way to control the SPC of *peda* during storage.

Chowdhury *et al.*, (2017) researched on modified atmosphere packaging (MAP) technology and benzoic acid as a preservative may extend the shelf life of khoa at  $27 \pm 2^\circ\text{C}$  and 65% relative humidity. The studies were conducted during storage to identify discernible differences between the modified atmosphere technology (MAP) packaging and regular packaged Khoa (with and without preservative) samples. Khoa usually has a two-day shelf life in ambient conditions. The product was found to alter its properties more slowly when it was packaged in the changing environment.

According to the storage study, samples packed in usual packaging with or without preservatives were suitable for consumption for up to 8 days, while samples packed in a modified atmosphere were suitable for consumption for up to 12 days.

Andhare *et al.*, (2017) greatly extend the shelf life of produced *lal peda* combined with nisin and low-temperature storage, packed in modified atmosphere packaging. Because the

control sample's critical microbiological load was found higher than that of the MAP and included nisin. According to the study, *lal peda* kept in MAP-nisin with gas combinations of 50% CO<sub>2</sub>:50%N<sub>2</sub>, 75% CO<sub>2</sub>:25%N<sub>2</sub>, and 25% CO<sub>2</sub>:75% N<sub>2</sub> showed a shelf life of up to 40 days at 20°C with better sensory quality *lal peda*.

Singh *et al.*, 2021 manufactured *peda* from mixed milk which contained 25% cow and 75% buffalo milk used for manufacturing the base material *khao*. Citric acid was used for 0.01% and sugar was added to 8% of the milk at the time of boiling. The consistency of the dough is produced by continuously drying the milk, then 0.20 % potassium sorbate is added. After three to four hours of chilling, it took on the shape of a *peda*. This *peda* was known as Hansi-type *peda*. It was then wrapped in cardboard cut to the appropriate size and sealed in polythene sachets. An enhanced shelf life of 10 to 15 days and 30 to 45 days at 37°C and 50°C was observed for the Hansi-type *peda*. Ray *et al.*, (2000) also observed the effect of sorbic acid at 0.02 and 0.05% on the shelf life of cow milk *peda*. *Peda* with 0.02% sorbic acid had a shelf life of 9 days at 30±1°C and 45 days at 7±1°C. *Peda* with sorbic acid at 0.05% had a shelf life of 60 days at 7±1°C, but a typical flavour developed.

The shelf life of brown *peda* was 30 days and 40 days when stored in MAP, and vacuum packaging, respectively while it decreased to 20 days when packaged in cardboard boxes. By incorporating BHA at 0.02% and 0.01% along with 0.1% potassium sorbate during the final manufacturing stage and utilizing vacuum packaging, the shelf life of brown *peda* has been extended to 50 to 60 days at 30 °C (Londhe *et al.*, 2012).

### **3. Effect of food packaging material**

Das *et al.*, 2022 evaluated the impact of packaging materials on the stability of *thabdi* storage at both ambient (30±1°C) and refrigerated (7±1°C) temperatures. *Peda* was manufactured at lab scale after standardization of cow milk (4.5% fat and 8.5% SNF) with a mixing of 8% sugar based on milk and kept without packaging as well as packaged in two most suitable packaging materials viz. paper box and polypropylene pouches. Most of the quality-degrading metrics were found to decline quickly in the absence of packing, with paper boxes and polypropylene pouches coming at both storage temperatures. According to the findings, *peda* samples were best preserved at room temperature for up to 4 days without packaging, 8 days in paper boxes, and 14 days in polypropylene pouches; in contrast, samples kept well in the refrigerator for up to 20 days without packaging, 30 days in paper boxes, and 50 days in polypropylene pouches.

Lomate *et al.*, (2018) used a lab-scale doctor blade film applicator in *peda* packaging, 120 µm thin food packaging films were developed by incorporating copper nanoparticles (Cu-

NPs) ranging from 0.5 wt % to 3.0 wt % into an LDPE matrix. The mechanism by which Cu-NPs inhibited the development of microorganisms primarily depended on the concentration and size of the nanoparticles. The nanocomposite film represented a potential reduction in the number of tested microorganisms in *peda*. A film composed of an LDPE/Cu nanocomposite may be appropriate for use in food packaging. High stability, antifungal activity, and superior antibacterial action against gram +ive and gram -ive food-deteriorating microorganisms. Cu-NPs significantly improve barrier qualities, and the presence of long-lasting antimicrobial copper nanoparticles demonstrated complete growth inhibition of bacteria in the antimicrobial arrangement of the LDPE/Cu nanocomposite films against *S. Aureus* and *E. coli*.

#### **4. Utilization of dairy ingredients to optimize the process**

Kondiba *et al.*, (2006) optimized the process of manufacturing brown-type *peda* with SMP and ghee instead of khoa. Although it was not as good as standardized products. It was found that heating a mixture of boora sugar at the khoa stage for 15 minutes at 80°C produced characteristics like caramel flavour and brown colour. The browning of *peda* may be achieved by modifying TSSHE to produce khoa continuously and enhancing the desired flavour and colour by adding sugar during the blending stage. The chemical composition of brown *peda* was reported as 13.26% moisture, 16.15% fat, 12.56% protein, 15.73% lactose, 39.42% sugar, and 2.56% ash.

Hirpara *et al.*, 2020 developed *Thabdi* sweet prepared by effective utilization of by-products ghee residue, incorporated into milk at different rates (2%, 4%, 6%, 8%) and 10%. It was found that adding ghee residue to *Thabdi* sweets considerably increased the amount of fat, protein, and ash. The product's hardness was significantly reduced due to the decrease in acidity, thiobarbituric acid (TBA) value, and free fatty acids (FFA). The conventional 40-minute holding time for preparing *thabdi* was eliminated with the inclusion of ghee residue. It had a pleasant rich nutty caramel flavour, a glossy brown colour, a soft body, and a uniform gritty texture. During storage of the optimized *peda* sample, which included 6% ghee residue, showed significant increases in acidity, FFA, HMF, TBA, and hardness. At the same time, there were noticeable decreases in sensory scores, moisture, water activity, and pH. The shelf-life of *thabdi* was extended to 28 days at 20±1°C and 14 days at 37±1°C. In comparison, the control had a shelf-life of 21 days at 20±1°C and 12 days at 37±1°C.

#### **5. Partial dehydration**

*Peda* was reported to be partially dehydrated by Dhobale *et al.* (2013) using vacuum tray drying technology at 30-35 °C and 630-665 mm hg vacuum over varying time intervals, including 1 h, 2 h, 3 h, and 4 h. The shelf-life of the experimental *peda* was 14 days, 21 days,

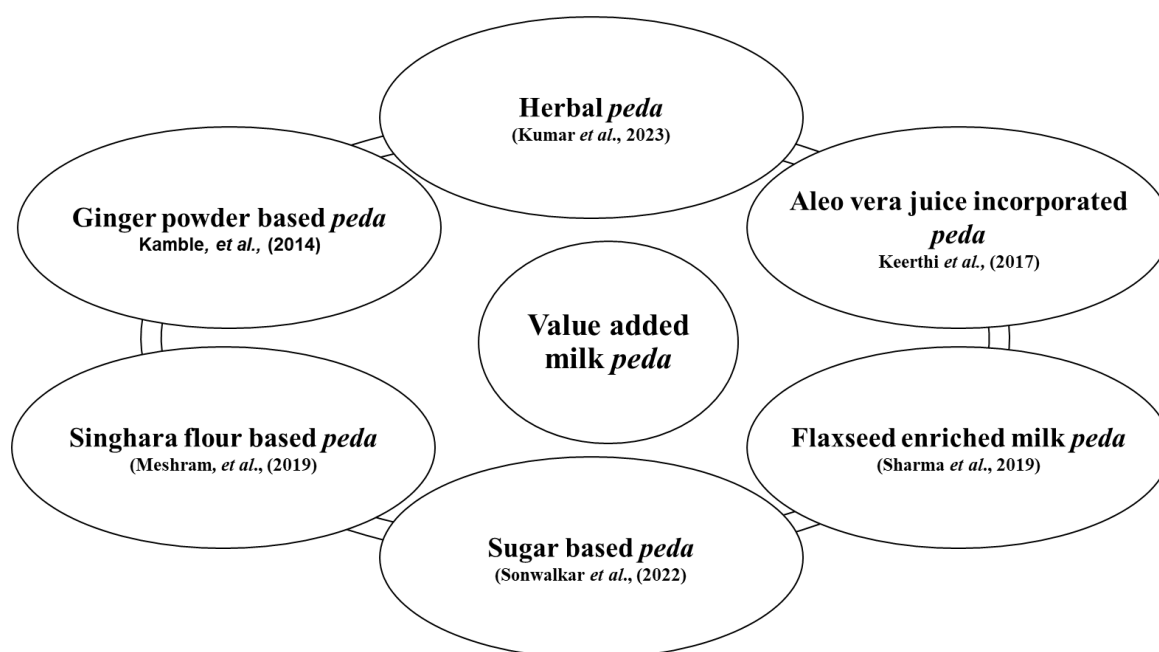
and 28 days after dehydration for one, two, and three hours, respectively (Pal *et al.*, 2017). This *peda* was kept at 20°C after being placed in a PVC tray that has been presterilized and covered with a polyester/Polyfilm bag (-85u). A two-hour dehydrated petal sample earned the highest score, with a 21-days shelf life compared to a control sample's 7-day shelf life.

S No	Study	Product	Key Finding	Reference
1	Effect of MAP packaging on the shelf life of <i>lal peda</i>	<i>Lal peda</i>	The MAP technique involving a controlled gas mixture (CO <sub>2</sub> , O <sub>2</sub> , N <sub>2</sub> ) extends shelf life by slowing microorganism growth and oxidation. Samples with 70% N <sub>2</sub> :30% CO <sub>2</sub> had better shelf stability, showing microbial load critical limits after 60 days. Moisture loss was the least in 70% N <sub>2</sub> :30% CO <sub>2</sub> samples. Sensory evaluation favoured a moisture content of 12.5–15.5%.	Jha <i>et al.</i> , 2015
2	Effect of MAP and Vacuum packaging techniques on the shelf life of <i>brown peda</i>	<i>Brown peda</i>	<i>Brown peda</i> preserved for up to 40 days at 30°C with vacuum packaging. Cardboard box (20 days), MAP (30 days), Vacuum Packaging (40 days).	Londhe <i>et al.</i> , 2012
3	Shelf-life extension of <i>Thabdi</i> milk sweets using ghee residue	<i>Thabdi</i> sweets	Ghee residue incorporation increased fat, protein, and ash in <i>Thabdi</i> sweets. Shelf life extended to 28 days at 20±1°C and 14 days at 37±1°C with 6% ghee residue.	Hirpara <i>et al.</i> , 2020
4	Extension of the shelf life of <i>peda</i> by partial dehydration	<i>Peda</i>	Dehydration at 30-35 °C for varying times extended shelf life to 14, 21, and 28 days. Two-hour dehydrated <i>peda</i> had the highest score.	Dhobale <i>et al.</i> , 2013
5	Use of antioxidants and preservatives for extending the shelf life of <i>peda</i>	<i>Peda</i>	Tocopherol and sodium ascorbate stabilized <i>peda</i> for 60 days. Modified atmosphere packaging with nisin extended shelf life to 40 days.	Khare <i>et al.</i> , 2019; Chowdhury <i>et al.</i> , 2017
6	Production of antimicrobial LDPE/Cu nanocomposite food packaging film	<i>Peda</i>	Cu-NPs in LDPE film inhibited microorganisms, extending <i>peda</i> shelf life.	Lomate <i>et al.</i> , 2018
7	Development of a process for manufacture and shelf life extension of <i>brown peda</i>	<i>Brown peda</i>	BHA, potassium sorbate, and vacuum packaging extended shelf life to 50-60 days at 30°C.	Kondiba <i>et al.</i> , 2006
8	Shelf-life extension of <i>Thabdi peda</i> by using	<i>Thabdi peda</i>	MAP with polyester/PE pouches (M2) extended shelf life to 20 days. Various characteristics changed during storage.	Raval & Joshi 2023

	MAP with different packaging material			
9	Extend the shelf life of Hansi type <i>peda</i>	Hansi-type <i>peda</i>	Citric acid, sugar, and potassium sorbate enhanced shelf life to 10-15 days at 37°C and 30-45 days at 50°C	Singh <i>et al.</i> , 2021

### Recent advancements in value-added *peda*

Recent advancements in value-added *peda* show innovative approaches to enhance the flavour, nutrition, and shelf life of *peda* (Figure 1).



**Fig.1 Value addition in milk *peda***

#### 1. Herbal admix *peda*

Herbs and species are important ingredients used by humans since ancient times. They have been used as medical and enhancers of flavour (El-Sayed *et al.*, 2019). Consuming herbal as a whole is challenging as exhibits bitter taste. It is better to mix herbal optimum quantity with sweets which increases the nutritive value of products (Panday *et al.*, 2013). Panday *et al.*, (2018) investigated the impact of adding black pepper and turmeric on the product's shelf life. Black pepper powder and turmeric act as a natural preservative, extending the product's shelf life. The ingredients for the herbal *peda* were 30% sugar, 1% black pepper, and 1% turmeric. Free fatty acid and peroxide values increased from 0.051% to 0.09% oleic acid, 1.168 millimoles/kg to 1.925 millimoles/kg of fat up to 32 days in the control sample and from 0.04% to 0.096 % oleic acid, 1.152 millimoles/kg to 1.936 millimoles/kg of fat up to 48th day in herbal

*peda* respectively during storage at  $7\pm 10^{\circ}\text{C}$ . It was found that the herbal *peda* had a 48-day shelf life at  $7^{\circ}\text{C}$ .

In another study conducted by Kumar *et al.*, (2023) *khoa* was prepared with *S. grandiflora* as an herb rich in Vitamins A, folate, thiamine, and niacin. *S. grandiflora* contain anti-inflammatory, analgesic, and antipyretic properties and are high in vitamins and minerals (Tamboli *et al.*, 2000). There were three concentrations of herbs *S. grandiflora* viz. 1.5%, 3.0% and 3.5% were used for the preparation of herbal *peda*. Compared to the control *peda*, the *peda* with the *S. grandiflora* flower powder yielded a much lower colour score. Additionally, an increase in *S. grandiflora* flower powder concentration ranges from 1.5 to 4.5 % considerably significant decline in colour, body, texture and sweetening score.

Brahmi and Ashwagandha herbs could be essential for treating the curing of the debilitating Alzheimer's disease. (Patnaik, 2016). The addition of *peda* 2, 4, and 6% *ashwagandha* and *brahmi* powder *peda* had significantly ( $p<0.05$ ) lower fat, protein and moisture than the control. The sugar content of the *peda* increased due to the inclusion of *brahmi* powder and *ashwagandha* at 2, 4, and 6% (Singh *et al.*, 2022).

Ginger has been regarded by Ayurvedic practitioners for its numerous therapeutic benefits. Based on studies, ginger could offer temporary relief for nausea and vomiting caused by pregnancy. Ginger is known for its preservative properties (Palatty *et al.*, 2013). Kamble *et al.*, (2014) examined the chemical composition, sensory evaluation, shelf life and microbial quality of ginger mixed *peda*. Different levels of ginger powder by weight of *Khoa* were added, including 0%, 2%, 4%, and 6%. Based on the overall acceptability, it was determined that the product made with 2% ginger powder was the most acceptable. The fresh samples showed a significantly lower average standard plate count of  $6 \times 10^3$  cfu/ gm. No traces of yeast, mould, or coliform count were found in the fresh *peda* samples. The optimized *peda* received a higher overall acceptability score of 8.01, compared to the scores of 7.52 and 6.89 for the other treatments.

There are numerous health benefits associated with aloe vera juice. Its leaves contain essential elements that the human body requires, including vitamins, minerals, amino acids, polysaccharides, enzymes, plant steroids, saponins, lignin, anthraquinones, and salicylic acid. Aloe vera has antiseptic, antibacterial, antiviral, anti-diabetic, anti-carcinogenic, and anti-inflammatory properties (Maan *et al.*, 2018). Aloe vera juice was successfully applied in dairy products (Manoharan *et al.*, 2012). Srikanth *et al.* (2017) investigated the effects of adding aloe vera juice to fresh *peda* recipes. The juice was added to four distinct batches (10%), (15%), and (20%) by weight of *khoa* of the experimental *peda* samples. To manufacture of a control



*peda* using standardized buffalo milk was done at the patting step. The control exhibited the lowest chewiness (51.87 g.mm) and hardness (1634.64 g). When it comes to cohesiveness, gumminess, and springiness, the *peda* samples with aloe vera juice showed no significant difference compared to the control group in terms of statistical variation. Interestingly, incorporating Aloe vera juice had a noticeable impact on the texture and sensory qualities of the fresh *peda* samples.

## **2. Flaxseed enriched *peda***

Nutritionists and medical researchers are increasingly interested in flaxseed because of the possible health benefits related to its biologically active components-ALA lignin Secoisolariciresinol di glycoside (SDG) and dietary fibre (Kajla *et al.*, 2015). Honey has several medicinal uses, including laxatives, blood purifiers, treatment for burns, throat discomfort, eye conditions, and the prevention of colds, coughs, and fevers (Srivastava 1998). The chemical composition and sensory evaluation of a flaxseed-enriched *peda* were evaluated. The experimental *peda* were also prepared using a varying combination of *khoa* and flaxseed, with the addition of 2, 2.5, and 3% flaxseed. The results of the chemical evaluation showed that the treated product had a significant increase in fat (14.57 to 15.67 %), protein (13.33 to 15.43 %), ash (2.76 to 3.42 %), fibre (0.00 to 3.42 %), and antioxidant activity (0.00 to 40.6 mg/g) after the addition of flaxseed. The moisture (18.44 to 17.49 %) and the sensory score decreased as increasing the content of flaxseed in the *peda*. *Peda* admixed with 2% flaxseed powder was found to be highly acceptable among the other combinations by sensory evaluation (Sharma *et al.*, 2019; Trivedi *et al.*, 2023).

## **3. Flour and bran admixed *peda***

Singhara is effective on jaundice and loose motion due to its detoxifying properties. It is rich in polyphenolic and flavonoid compounds (Zhan *et al.*, 2014). Meshram *et al.*, (2019) manufactured *peda* from *khoa*, combined with various levels of singhara flour 0%, 5%, 10%, 15% and 30% sugar. The taste, sweetness, body, texture, colour, and appearance of singhara flour *peda* were all significantly impacted by the varying amounts of singhara flour. Based on the results, the *peda* made with 95% *khoa* + 5% singhara flour and 30% sugar *khoa* with 5% singhara flour had the highest rating (86.47 out of 100) and was considered the most satisfactory product. In contrast to other methods, adding singhara flour to *khoa* considerably reduces the amount of fat, protein, and ash in the food, while increasing the amount of total solids.

Wheat bran was discovered to have higher levels of protein and fibre (Cheng *et al.*, (2022). 0.4 % of wheat bran might be successfully included in *peda* with negligible influence on

sensory qualities. The *peda* made with 0.6 % wheat bran had the lowest hardness value, while the control *peda* had the maximum hardness value. The buffalo milk *khoa* blend with wheat bran was used to make the *peda*, and varying percentages of wheat bran—0.2, 0.4, and 0.6 %—were added. The moisture of the control *peda* context was found to be substantially lower than the *peda* blend that included wheat bran. The control *peda* displayed the highest level of chewiness and gumminess among all treatments, whereas the *peda* blended with 0.4 % wheat bran displayed the lowest chewiness (Shinde *et al.*, 2015).

Sejani *et al.*, (2022) research on a cost-effective way to combine high-valued protein with plant-based components. For manufacturing Thabdi *Peda*, it was found that peanut flour with 17.04% buffalo milk weight per kilogram was the most appropriate. Compared to traditional Thabdi *peda*, this improved sample exhibited a smaller quantity of sugar and an increased amount of actual protein content. When compared to conventional Thabdi *peda*, the actual protein content increased by 42.86% at the optimal peanut flour level. The cost of peanut flour-based Thabdi *peda* was found to be 21.27% less than the traditional Thabdi *peda*.

Thabdi *peda* based on peanuts was also researched by Thesiya *et al.* in 2023. The fat/SNF ratio of milk was determined to be optimal at 1.11, with 21% of the milk solids being heat-treated and pulverized peanuts and 80% sugar (%w/w) of the milk solids. The optimized thabdi samples exhibited superior acceptance, scoring  $8.54 \pm 0.03$  overall, in comparison to the market samples. The product remained acceptable on the 21st day when packed and stored at  $7 \pm 2^\circ\text{C}$ .

### **Sugar-free *peda***

Sugar intake is linked to diabetes, which is linked to a host of other conditions, including hypertension, dental caries, obesity, diabetes, and hyperglycaemia. Consumer preferences are shifting in the modern era to include low-calorie and sugar-free products. Some research justifies the use of natural and artificial sweeteners in sugar substitutes in *khoa*-based sweets.

#### **a). Partial sugar substitute with natural sweetener in *Peda***

Jaggery commonly referred to as "medicinal sugar," is a component of many pharmacological compositions. Jaggery is rich in minerals and contains a lot of phenol. A few of the health benefits of jaggery include better digestion, liver cleansing, constipation relief, increased energy, blood purification, anti-toxic and anti-carcinogenic qualities, tension relief, treatment of lung or bronchial infections, premenstrual syndrome (PMS), and antioxidant activity (Verma *et al.*, 2019, Shrivastav *et al.*, 2016). Jondhale *et al.*, (2023) the optimized quantity of jaggery powder to substitute sucrose in *peda*, a popular festive dairy dessert. To replace sucrose,

different concentrations of jaggery powder—31, 41, and 51%—were utilized. In terms of sensory qualities, it was found that the standardized *peda* with 41% jaggery powder and 59% sucrose was found better comparable to the control with 100% sucrose.

Date sugar possesses antimutagenic properties, strong free radical scavenger properties, and a powerful antioxidant. Date sugar improves the nutritional value by increasing the concentrations of vitamins and minerals (Chaira et al., 2009). Sonwalkar *et al.*, (2022) investigated the physico-chemical analysis of *peda* and optimized the amounts of date (*Phoenix dactylifera* L.) syrup in *peda*. Based on the results of sensory evaluation, three levels of date syrup viz., 15%, 20% and 25% were chosen. Fresh *peda* samples were measured for mean fat (22.51), protein (15.39), total solids (83.82), reducing sugar (15.65), total sugar (42.89), vitamin A (157 IU), 0.35% L.A., pH (6.31), fibre (2.49%), ash (3.02%), and oleic acids (0.09 to 0.18 %). 58% of consumers assessed the date (20% date syrup) *peda* overall quality evaluating as outstanding.

#### **b). Sugar-free *peda* using low calories artificial sweetener**

To replace sugar in products, the market of varieties of low-sugar and low-calorie sweeteners is increasing gradually (Jain *et al.*, 2013). In 2019, Khare and their coworker conducted research on a low-calorie *peda* sample that was manufactured by substituting sugar with sorbitol, mannitol, and sucralose. Two preservatives, salt of sorbic acid and propionic acid, were used in various concentrations (200 ppm, 400 ppm, 600 ppm, and 800 ppm) in both ambient and refrigerated temperatures, along with appropriate packaging (polyethene zip pouches), to extend shelf life. Throughout storage, moisture was continuously lost, with a greater rate of loss at 30 °C. The FFA content of *peda* increased as it was being stored. The shelf life of prepared, optimized sugar-free *peda* was shown to be longer than control *peda*, lasting 30 days at ambient temperature and 42 days in refrigeration respectively. Jain *et al.*, (2017) conducted research on *lal peda* produced using artificially sweetened bulking ingredients. Artificial sweeteners, such as aspartame, acesulfame-K, and sucralose, were substituted for sugar, and optimal concentrations of either Litesse (15%,20%,25%,30%) or Inulin (0.5%,1.0%,1.5%,2.0%) were added. *Lal peda* prepared with 0.17% aspartame and 25% Litesse had the best result in terms of texture, colour, and sweetness.

The optimum product was obtained by preparing *lal peda* with 25% Litesse and 0.17% aspartame. According to HPLC analysis, aspartame in artificially sweetened *Lal Peda* samples

was shown to be stable for up to six days at 20°C and 37°C. The acidic pH *lal peda* stabilized the aspartame and delayed its breakdown for up to six days.

Sugar-free *peda* manufactured from soya milk and buffalo milk was prepared from different combinations of buffalo milk, soya milk and aspartame in the ratio of T0 (100:00:00), T1 (85:10:5) T2 (80:13:7) T3 (75:16:9). It was additionally found that the content of sugar-free *peda* produced from soy and buffalo milk reduced in fat, ash, and moisture and increased in protein, carbohydrate, total solids, and acidity as the proportion of soy milk and aspartame increased. The soya milk and aspartame could be very well utilized for the preparation of palatable, nutritious, low-cost and high sensory score *peda* by mixing 13 % soya milk and 7 % aspartame with 75% buffalo milk on a weight basis (Singh et al., 2019; Asres et al., 2022). Soybeans include a variety of phytochemicals that have been linked to several health advantages, including reducing cholesterol, preventing cancer, and preventing osteoporosis (Isanga et al., (2008).

S No	Product	Study	Finding	Reference
1	Ginger Powder-Based <i>Peda</i>	<i>Peda</i> with different ginger powder concentrations (0%, 2%, 4%, 6%)	<i>Peda</i> with 2% ginger powder showed optimal acceptability. Lower microbial counts. Higher overall score.	Kamble <i>et al.</i> , 2014; Kaushal <i>et al.</i> , 2017
2	Herbal <i>Peda</i>	<i>Peda</i> with black pepper and turmeric; <i>Khoa</i> with <i>S. grandiflora</i> as an herb; <i>Peda</i> with Brahmi and Ashwagandha herbs	Black pepper and turmeric acted as natural preservatives. <i>S. grandiflora</i> affected colour and sweetness. Brahmi and Ashwagandha Improved chemical and microbiological attributes	Panday <i>et al.</i> , 2018; Kumar <i>et al.</i> , 2023; Singh <i>et al.</i> , 2022
3	Aloe Vera Juice enriched <i>Peda</i>	<i>Peda</i> with aloe vera juice at different concentrations (10%, 15%, 20%)	Aloe vera juice impacted texture and sensory qualities. Noticeable changes in chewiness and hardness	Keerthi <i>et al.</i> , 2017
4	Flaxseed Enriched <i>Peda</i>	<i>Peda</i> with varying concentrations of flaxseed (2%, 2.5%, 3%)	Increased flaxseed content enhanced fat, protein, ash, fibre, and antioxidant activity. T1 (2% flaxseed) is highly acceptable.	Sharma <i>et al.</i> , 2019
5	<i>Singhara</i> Flour-Based <i>Peda</i>	<i>Peda</i> with different levels of <i>singhara</i> flour (0%, 5%, 10%, 15%)	<i>Singhara</i> flour influenced taste, sweetness, and overall satisfaction. 95% <i>khoa</i> + 5% <i>singhara</i> flour received the highest rating.	Meshram <i>et al.</i> , 2019

6	<i>Peda</i> Admixed with Wheat Bran	<i>Peda</i> with varying percentages of wheat bran (0.2%, 0.4%, 0.6%)	0.4% wheat bran showed optimal hardness and sensory qualities.	Shinde <i>et al.</i> , 2015
7	Peanut Flour-Based Thabdi <i>Peda</i>	Thabdi <i>Peda</i> with peanut flour (17.04% per kg of buffalo milk)	Optimized treatment showed higher true protein content, lower sugar, and a 21.27% cost reduction.	Sejani <i>et al.</i> , 2022; Thesiya <i>et al.</i> , 2023
9	Sugar-Free <i>Peda</i>	a) <i>Peda</i> Blended with Date Sugar: <i>Peda</i> with varying levels of date syrup (15%, 20%, 25%)	20% of date syrup was rated excellent by 58% of customers.	Sonwalkar <i>et al.</i> , 2022
		b) Partial Sugar Substitute with Jaggery: <i>Peda</i> with different concentrations of jaggery powder (31%, 41%, 51%)	<i>Peda</i> with 41% jaggery powder was comparable to the control with 100% sucrose.	Jondhale <i>et al.</i> , 2023
		c) Sugar-free <i>peda</i> with soya milk and buffalo milk: <i>Peda</i> with varying combinations of buffalo milk, soya milk, and aspartame	Best results with 13% soya milk and 7% aspartame.	Singh <i>et al.</i> , 2019
		d) Sugar-Free <i>Peda</i> Using Low-Calorie Artificial Sweetener: <i>Peda</i> with sorbitol, mannitol, and sucralose; optimized with preservatives	Shelf life extended up to 42 days, with stability in texture and sensory characteristics.	Khare <i>et al.</i> , 2019; Jain <i>et al.</i> , 2017

## Conclusion

The technique of khoa-based *peda* preparation varies from region to region and culture due to which it brings out the distinct taste, colour and textural attributes. Various types of *peda* are suffering in the Indian market due to shorter shelf life. In the pursuit of extending the shelf life of various *peda* varieties, cutting-edge technologies have emerged as instrumental tools. Modified Atmosphere Packaging (MAP), with its precise gas mixtures, has proven highly effective in inhibiting microorganism growth and oxidation, significantly extending the shelf life of Lal *peda*. Vacuum packaging, particularly in the case of Brown *peda*, has been identified as a superior technique, providing a noteworthy shelf life of 40 days at 30°C. Additionally, innovations such as incorporating ghee residue, partial dehydration through vacuum tray drying, and the strategic use of antioxidants, preservatives, and nanocomposite films have each played a crucial role in extending the longevity of different *peda* varieties. These technological

interventions showcase a holistic approach to dairy entrepreneurs for preserving *peda*, addressing various aspects from composition to packaging materials, thereby enhancing the overall quality and shelf life of these traditional sweets in the tropical condition of the Indian market. As health-conscious people are demanding milk sweets with additional value and health benefits. So value-added milk *peda* might be a future emerging sweet. Now in the era of diabolic people are searching for sugar-free sweets. *Peda* sweetened with natural and artificial sugar are becoming trending sweets in the Indian market.

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