

Research Article

Physico-Chemical, Sensory, Colour and Textural Characteristics of Thabdi (Brown) and Kesar (Yellow) Peda in Saurashtra Region

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Abstract

Thabdi (brown) and Kesar (yellow) peda are popular milk-based sweet in Saurashtra region of Gujarat state. The present studies were conducted to evaluate the physico-chemical, sensory, colour and textural characteristics of thabdi and kesar peda collected from eight different cities in Saurashtra region. Average percentage (mean±sd) of moisture, fat, protein, ash and total carbohydrate of thabdi and kesar peda were evaluated 14.80±1.57, 21.46±1.74, 14.29±1.28, 2.54±0.04, 47.21±2.35 and 15.91±1.23, 23.44±2.67, 14.54±2.00, 2.73±0.06, 43.39±1.99 respectively. In sensory attributes likes, Color & Appearance, Body & Texture, Sweetness, Flavour and Overall acceptability of thabdi and kesar peda were evaluated 8.22±0.28, 8.18±0.40, 8.09±0.39, 8.16±0.39, 8.19±0.31 and 7.93±0.35, 8.09±0.37, 7.84±0.36, 7.97±0.45, 7.94±0.35 respectively in 9-point hedonic scale. In average values of colour values and its indexes likes Lightness (L*), redness (a*), yellowness (b*), Chroma (C*), whiteness index (WI), Browning index (BI) and Yellowing index (YI) of thabdi and kesar peda were estimated 37.74±4.88, 9.12±1.21, 13.56±2.47, 16.35, 35.63, 61.50, 51.33 and 61.44±2.44, 12.87±3.86, 35.50±1.47, 37.92, 46.03, 97.81, 82.55 respectively. In texture properties viz., Hardness (g), Adhesiveness (g.sec), Springiness, Cohesiveness, Gumminess (g), Chewiness (g) and Resilience of thabdi, and kesar peda were obtained 2583±489, -6.44±1.92, 0.21±0.04, 0.12±0.02, 312.94±58.47, 65.01±8.05, 0.036±0.001 and 3317±384, -9.56±4.18, 0.17±0.02, 0.15±0.01, 462.56±36.21, 74.40±8.97, 0.039±0.004 respectively.

Keywords: Thabdi peda, Hardness, Browning index, Sensory, Texture, Color difference.

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Introduction

India is rising as the world's largest dairy market in the twenty-first century. The dairy business in India is critical to the nation's socioeconomic growth and a large element of the rural economy. Milk production in 2020-21 and 2021-22 is 209.96 and 221.06 million tonnes respectively, and annual growth rate 5.29% yearly. In 2021-22, milk availability per capita is approximately 444 grams/day according to Annual report 2022-23 [1]. Around 55% of milk produced is used in product production, while the remaining 45% is eaten as liquid milk. Around 40% of the milk utilised in product manufacturing is used to make Indian traditional dairy products. This demonstrates the enormous market potential for traditional dairy products (TDPs). Gujarat is a developed state in India and has historically a leader in milk production operations, with an annual milk production of 15,292 thousand tonnes in 2019-20, it placed fourth in the country, contributing for around 8% of total production (NDDB 2021) [2].

India is noted for its rich cultural heritage in many social and historical aspects, including food and cuisines. It is home to hundreds of different types of sweetmeats, the flavor of which has been passed down through centuries. Several traditional food are mentioned in ancient artefacts and are still popular now [3]. The khoa/mawa used as base material to make number of milk-khoa based sweets like gulabjamun, kalajamun, burfi, kalakand, milk cake, peda, rabri, khurchan, basundi, pantua, kunda, lalmohan, balmithai and thirattupal. These sweets are regionally specialized and locally accessible in India that people likes for their particular flavour and texture [4].

Peda is an indigenous heat desiccate milk sweet produced from khoa and sugar, heated with natural and/or artificial colour and flavour until the right texture and flavour emerges [5]. This milk based sweet has several spellings and names, including pedha, penda (in Gujarati) and pera. For peda preparation, buffalo milk is favoured over cow and goat milks because it generates a soft and homogenous body with a smooth, compact, and homogeneous texture [6]. Peda has a longer shelf life because it contains less moisture. The texture of Peda is gritty and the colour is

light yellow. Its quality is determined by its chemical composition, body and texture, appearance, and microbiological quality [7]. In India, peda production significantly higher than that of any other indigenous milk-based sweet [8].

Thabdi (brown) Peda is a heat-desiccated indigenous milk sweet produced and marketed in large quantities in Saurashtra [9]. In first stage in the preparation of thabdi (brown) peda was filtered and standardised of fresh milk to the requisite 4 to 8% fat and 9% SNF. The sugar is added 6 to 10% (w/w) of milk at the beginning of the boiling process, and the process of heating and agitation is continued until the pre-pat formation stage. This quantity of heat treatment in the first half was to create the patties and graininess, while the second half helped with moisture removal, colour changes, and grainy texture development. It is notable for its brown colour, which ranges from creamish brown to dark brown, granular loose texture and its rich caramelised, cooked, rich nutty, ghee-like flavour, as well as the rich milk fat scent in Saurashtra [10]. It is made from khoa, which is obtained by scalding fresh milk in an open pan with the appropriate amount of sugar until the moisture content is decreased and the ideal granular, hard texture and flavour emerges [11]. Kesar (yellow) Peda is flattened-round confection with saffron flavour and colour. Due to high cost and less availability, the use of saffron on an industrial scale for colouring is limited.

Sixty four (64) samples of Thabdi (brown) and Kesar (yellow) peda were collected from four famous shops of eight selected cities in Saurashtra region of Gujarat state over a period of one year. The present studies were conducted to evaluate the physico-chemical, sensory, colour and textural characteristics of thabdi and kesar peda. Such investigations help in defining the usual characteristics of items and outcomes will serve as the foundation for future product development efforts.

Materials and Methods

Collection of samples of Peda

Samples of thabdi (brown) and kesar (yellow) peda were collected from four prominent sweet shops in eight cities. i.e. Amreli (C1), Bhavnagar (C2), Rajkot (C3), Junagadh (C4), Porbandar (C5), Dwarka (C6), Jamnagar (C7) and Botad (C8) of Saurashtra region of Gujarat state. The peda are promptly put in cardboard boxes after being collected. To avoid moisture gain or loss during shipping, the cardboard boxes were packed and sealed in polyethylene bags. The samples were kept at room temperature before being analysed for various quality characteristics in college laboratories. Further data such as sampling date, type of package utilized, packing material of samples, date of manufacturing of samples, and best before date of samples are also recorded in collected samples.

Chemical analysis

The moisture content of peda was determined using the drying technique specified in IS: (SP: 18) [12]. The total fat content was calculated using the Gerber technique (at 87%) as described ISI: 1224 [13]. Protein content estimated by semi-micro kjeldahls technique reported by Arora et al. [14]. The total carbohydrate content was calculated by subtracting the total solids content from the total fat, protein, and ash content. Ash content of peda was determined by procedure described at IS: 1547[15].

Sensory evaluation

A group of 7 judges (i.e. faculty members) from the College of Dairy Science, Amreli evaluated the sensory quality of peda on a 9-point hedonic scale (1=disliked extremely, 2=disliked very much, 3=disliked moderately, 4=disliked slightly, 5=neither liked nor disliked, 6=liked slightly, 7=liked moderately, 8=liked very much, 9=liked extremely [16]. The judges were also asked to provide feedback on each of the samples. During sensory examination, the samples for evaluation were properly coded.

Estimation of Colour values and different colour indexes of peda

The colour of the peda was measured using a colorimeter model called Color Flex EZ in the L^*, a^*, b^* (CIELAB system) scale. The equipment was calibrated before the test with standard black and white tiles recommended by the manufacturer. Parameter L^* indicates (0-50) dark and (50-100) bright scores. The parameter a^* takes positive values for reddish colours and negative values for greenish colours, whereas the parameter b^* takes positive values for yellowish colours and negative values for bluish colours [17].

Chroma (C^*) is a quantitative feature of colorfulness that is used to measure the degree of difference between a hue and a grey colour of the same luminance. According to Bermdez-Aguirre et al. [18], the higher the Chroma values, the greater the colour intensity experienced.

$$C^* = (a^{*2} + b^{*2})^{0.5} \quad (1)$$

The **whiteness index (WI)** indicates the degree of whiteness by combining brightness and yellow-blue into a single component. It is calculated using the following equation reported by Vargas et al.[19].

$$WI = 100 - ((100 - L^*)^2 + a^{*2} + b^{*2})^{0.5} \quad (2)$$

Browning index (BI) is defined as the level of brown colour and is one of the most predominant measures of browning in sugar-containing food items.

$$BI = 100 \left(\frac{a^{*+1.75L^*} - 0.31}{(5.645L^* + a^{*-3.012}b^{*0.17})} \right) \quad (3)$$

Yellowing index (YI) is a colour measurement that is associated to browning index.

$$YI = 142.86 b^*/L^* \quad (4)$$

Color difference (ΔE^*)

Total colour difference (E^*) used to calculate colour differentiation. Using the following equation given by Fernandez-Avila et al.[20], total colour difference reflects the extent of colour difference between any two samples.

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \quad (5)$$

The human eye can differentiate two colours based on their overall colour difference, ($\Delta E^* < 1$) color differences that could not be perceptible to the human eye, ($1 < \Delta E^* < 3$) minor color differences that could be perceptible to the human eye, and ($\Delta E^* > 3$) color differences that could be perceptible to the human eye reported by Quintanilla et al. [21].

Textural properties of peda samples

Sample were cut into 25.4 mm x 25.4 mm sizes by metal cutter mould and Texture Profile Analysis (TPA) of peda was performed using Texture Analyzer (model TA-XT Plus, Stable Micro Systems Ltd.,UK) equipped with 50 kg load cell. For texture profile examination of samples, a 75 mm cylinder probe was used. The product was compressed twice using a probe up to a distance of 10 mm. The resulting two-bite test force distance compression curve was produced. Using the Exponent programme, force-time curves, numerical values of peda sample height, hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness, and resilience of peda samples were produced (version 6.0.16.0). For each experiment, five cubic samples of peda were utilized at a temperature of 25°C, and the average value of these measurements was recorded. The textural properties of the peda samples were directly presented on the computer monitor as a graph (Load vs. time, i.e. g vs. s) and derived values in tabular form. Cohesiveness is quantified instrumentally by calculating the ratio of the area of the second bite to the area of the first bite [22-23]. The height regained by the sample during the force relaxation interval between the first and second bite compression cycles is referred to as springiness [24]. Gumminess is defined as the amount of energy necessary to disintegrate a semi-solid meal into a state suitable for ingesting [22]. Chewiness is a result of hardness, cohesiveness, and springiness and refers to the amount of energy required to masticate food into a swallowable form [24].

Statistical analysis

Data from Peda samples were statistically analyzed using one way ANOVA and SPSS software to determine the differences in samples between marketplaces and peda types.

Results and Discussions

The Results obtained from the present study on chemical composition (viz Fat, moisture, protein, ash and total carbohydrate), sensory characteristics, colour & colour indexes and textural properties of peda of market samples of peda are depicted in Tables 1-5 and Figures 1-2.

Chemical composition

The compositional attributes (i.e. moisture, fat, protein, ash and total carbohydrate) of four different shops of eight city of Thabdi (brown) and Kesar (yellow) peda were chemically analyzed and statistically significant ($p < 0.05$) among the different samples as shown in **Table 1**.

Table 1 Average proximate composition of Thabdi (brown) and Kesar (yellow) peda samples from different cities of Saurashtra region

City	%Moisture	% Fat	% Protein	%Ash	% Total carbohydrate
Thabdi(Brown) peda					
C1	13.15 ^a ±1.15	21.68 ^d ±0.54	14.68 ^a ±0.91	2.51 ^e ±0.04	50.49 ^{db} ±0.56
C2	15.83 ^{bc} ±1.08	22.33 ^d ±0.47	15.84 ^b ±0.82	2.53 ^e ±0.07	43.47 ^f ±0.54
C3	16.72 ^c ±1.09	22.33 ^d ±1.81	13.56 ^a ±0.66	2.56 ^e ±0.01	44.83 ^f ±0.47
C4	14.25 ^a ±0.74	21.68 ^d ±1.70	14.55 ^{ab} ±1.22	2.58 ^e ±0.04	46.94 ^{db} ±0.65
C5	14.56 ^{ab} ±1.37	19.65 ^d ±0.47	13.88 ^a ±1.56	2.6 ^e ±0.09	49.31 ^{db} ±0.43
C6	14.65 ^{ab} ±1.37	20.25 ^d ±1.71	13.75 ^a ±0.35	2.54 ^e ±0.12	48.81 ^{db} ±0.87
C7	15.84 ^{bc} ±0.98	22.25 ^d ±2.87	14.25 ^{ab} ±1.71	2.55 ^e ±0.09	45.11 ^f ±1.20
C8	13.42 ^a ±1.52	21.55 ^d ±2.00	13.83 ^a ±1.73	2.48 ^e ±0.11	48.72 ^{da} ±0.98
Avg. value	14.80 ^{ab} ±1.57	21.46 ^d ±1.74	14.29 ^{ab} ±1.28	2.54 ^e ±0.04	47.21 ^{da} ±2.35
Kesar(Yellow) peda					
C1	15.30 ^{bc} ±0.98	25.00 ^e ±1.41	14.28 ^{ab} ±1.25	2.63 ^e ±0.08	42.79 ^f ±0.78
C2	15.45 ^{bc} ±0.84	24.00 ^e ±0.82	14.48 ^{ab} ±1.30	2.65 ^e ±0.11	43.42 ^f ±0.53
C3	16.24 ^c ±1.75	24.00 ^e ±1.63	17.25 ^c ±1.71	2.71 ^f ±0.08	39.8 ^c ±0.48
C4	14.35 ^a ±0.83	26.00 ^e ±2.83	14.26 ^{ab} ±2.52	2.81 ^f ±0.05	42.58 ^f ±0.78
C5	16.35 ^a ±1.20	20.23 ^d ±2.34	13.78 ^a ±2.21	2.75 ^f ±0.08	46.89 ^{db} ±0.90
C6	16.45 ^{ab} ±1.20	20.85 ^d ±3.30	14.25 ^{ab} ±1.71	2.77 ^f ±0.12	45.68 ^f ±0.47
C7	16.80 ^c ±0.60	23.25 ^d ±1.50	14.25 ^{ab} ±1.71	2.73 ^e ±0.06	42.97 ^f ±1.14
C8	16.32 ^c ±1.38	24.16 ^e ±2.39	13.75 ^a ±2.50	2.79 ^f ±0.04	42.98 ^f ±0.48
Avg. value	15.91 ^{bc} ±1.23	23.44 ^d ±2.67	14.54 ^{ab} ±2.00	2.73 ^e ±0.06	43.39 ^f ±1.99
Each observation is a mean ±SD of three replicate experiment of four shop (n=12), a-f superscript letters following numbers in the same column denote significant difference ($p < 0.05$)					

Average percentage (mean±sd) of moisture of thabdi and kesar peda was 14.80±1.57 and 15.91±1.23 respectively. The moisture content of peda samples from different towns was found to differ considerably ($P < 0.05$) as shown in Table 1. Gavhane et al. [30] documented moisture level of 18.38 % in peda prepared by using buffalo milk, show higher moisture content than both varieties of peda. The variation in the moisture content mainly due to the difference in method of manufacture, amount of sugar added. Average percentage (mean±sd) of fat content of thabdi and Kesar peda were 21.46±1.74 and 23.44±2.67 respectively. There was no significant different ($P < 0.05$) between the different cities of thabdi (brown) peda, whereas, no significant difference was observed between C1, C2, C3, C4 and C8 city kesar (yellow) peda. The difference in the fat content of peda samples might be attributed to the variation in the type of milk used (buffalo/cow) and their fat content. Average percentage (mean±sd) of protein content of thabdi and kesar peda was 14.29±1.28 and 14.54±2.00 respectively. Statistical analysis revealed highly significant ($P < 0.05$) difference between the different cities thabdi and kesar peda whereas no significant difference was observed between C1, C3, C5, C6 and C8 cities thabdi (brown) peda and no significant ($P < 0.05$) difference between C1, C2, C4, C6 and C7 cities kesar (yellow) peda. Londhe et al. [29] noted a fat and protein percentage of 16.15% and 12.56 % in brown peda samples respectively, which are lower than our thabdi peda fat 21.46% and protein 14.29%.

Average percentage (mean±sd) of ash of thabdi (brown) and kesar (yellow) peda were 2.54±0.04 and 2.73±0.06 respectively. Average percentage (mean±sd) of total carbohydrate of thabdi (brown) and kesar (yellow) peda were 47.21±2.35 and 43.39±1.99 respectively.

Sensory Quality

The Average Sensory qualities (i.e. Color & Appearance (CA), Body & Texture (BT), Sweetness(S), Flavour (F) and Overall acceptability (OA)) of all eight city of thabdi and kesar peda were subjectively evaluated of different samples as shown in **Figure 1** and **Table 2**.

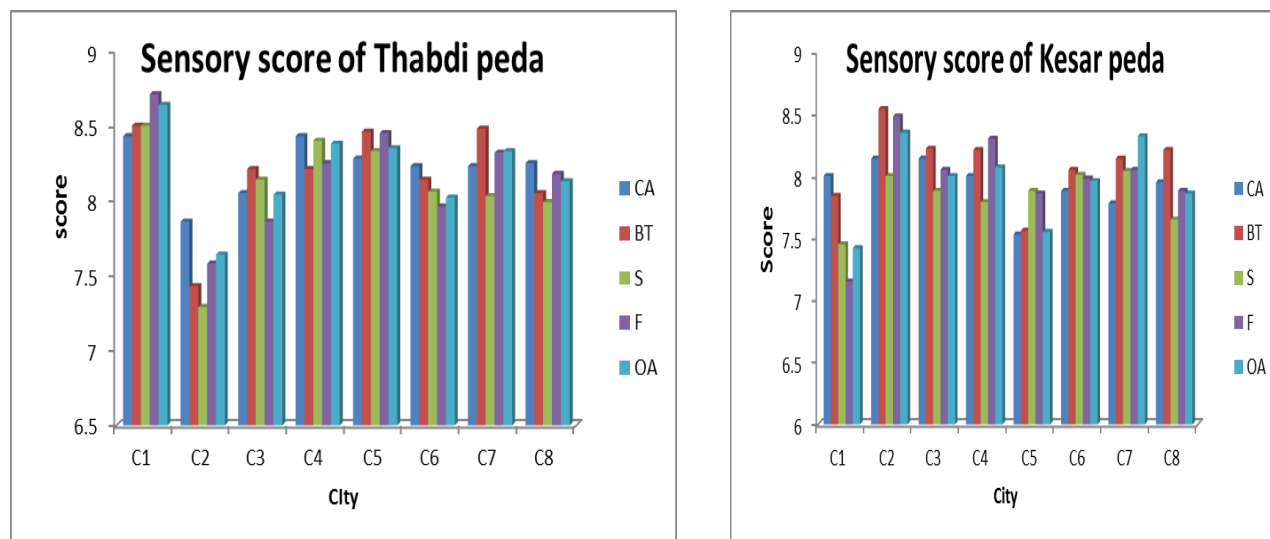


Figure 1 Average sensory score of all eight cities of Thabdi (brown) and Kesar (yellow) peda

Table 2 Sensory score of market peda samples of different cities of Saurashtra region of Gujarat State

City	CA	BT	S	F	OA
Thabdi (Brown) peda					
C1	8.43 ^b ±0.09	8.50 ^b ±0.21	8.50 ^b ±0.20	8.71 ^d ±0.19	8.64 ^d ±0.11
C2	7.86 ^a ±0.27	7.43 ^a ±0.16	7.29 ^a ±0.16	7.58 ^a ±0.13	7.64 ^a ±0.08
C3	8.05 ^{ab} ±0.34	8.21 ^{ab} ±0.29	8.14 ^{ab} ±0.09	7.86 ^{ab} ±0.42	8.04 ^{ab} ±0.09
C4	8.43 ^b ±0.10	8.21 ^{ab} ±0.12	8.40 ^{ac} ±0.29	8.25 ^{ab} ±0.17	8.38 ^{ac} ±0.19
C5	8.28 ^b ±0.17	8.46 ^b ±0.26	8.33 ^{ac} ±0.09	8.45 ^{ac} ±0.26	8.35 ^{ac} ±0.06
C6	8.23 ^{ab} ±0.49	8.14 ^{ab} ±0.41	8.06 ^{ab} ±0.08	7.96 ^{ab} ±0.18	8.02 ^{ab} ±0.17
C7	8.23 ^{ab} ±0.05	8.48 ^b ±0.18	8.03 ^{ab} ±0.26	8.32 ^{ac} ±0.15	8.33 ^{ac} ±0.17
C8	8.25 ^b ±0.13	8.05 ^{ab} ±0.24	7.99 ^{ab} ±0.20	8.18 ^{ab} ±0.17	8.13 ^{ab} ±0.17
Avg. value	8.22 ^{ab} ±0.28	8.18 ^{ab} ±0.40	8.09 ^{ab} ±0.39	8.16 ^{ab} ±0.39	8.19 ^{ab} ±0.31
Kesar (Yellow) peda					
C1	8.00 ^{ab} ±0.37	7.84 ^a ±0.31	7.45 ^a ±0.37	7.15 ^a ±0.11	7.42 ^a ±0.18
C2	8.14 ^{ab} ±0.24	8.54 ^b ±0.52	8.00 ^{ab} ±0.51	8.48 ^b ±0.46	8.35 ^b ±0.13
C3	8.14 ^{ab} ±0.11	8.22 ^{ab} ±0.21	7.88 ^{ab} ±0.33	8.05 ^{ab} ±0.37	8.00 ^{ab} ±0.27
C4	8.00 ^{ab} ±0.37	8.21 ^{ab} ±0.22	7.79 ^{ab} ±0.33	8.30 ^b ±0.14	8.07 ^b ±0.27
C5	7.53 ^a ±0.33	7.56 ^a ±0.18	7.88 ^{ab} ±0.17	7.86 ^a ±0.42	7.55 ^a ±0.13
C6	7.88 ^{ab} ±0.48	8.05 ^{ab} ±0.34	8.01 ^{ab} ±0.40	7.98 ^{ab} ±0.17	7.96 ^{ab} ±0.18
C7	7.78 ^{ab} ±0.26	8.14 ^{ab} ±0.08	8.04 ^{ab} ±0.14	8.05 ^{ab} ±0.13	8.32 ^b ±0.05
C8	7.95 ^{ab} ±0.37	8.21 ^{ab} ±0.20	7.65 ^a ±0.37	7.88 ^{ab} ±0.25	7.86 ^{ab} ±0.14
Avg. value	7.93 ^{ab} ±0.35	8.09 ^{ab} ±0.37	7.84 ^{ab} ±0.36	7.97 ^{ab} ±0.45	7.94 ^{ab} ±0.35

Each observation is a mean ±SD of three replicate experiment of four shop (n=28),
^{a-d} superscript letters following numbers in the same column denote significant difference (p<0.05)

Colour and appearance

Average Color & Appearance score of thabdi (brown) and kesar (yellow) peda were 8.22±0.28 and 7.93±0.35 respectively. These findings diverged from those published by Shinde et al. [28], who gave colour and appearance 8.75 out of 9.0 of brown peda. The mean color & appearance value differed significantly (P<0.05) among cities, whereas no significant difference was observed between C1, C4, C5 and C8 cities of thabdi peda. In case of kesar peda, no significant difference was observed between C1, C2, C3, C4, C6, C7 and C8 cities samples. Difference in the color & appearance score might be due to wide variation in raw material and additive like kesar, amount of sugar based maillard and appearance is generally based on the local preference of the public residing in a particular location. Sharma et al. [25] recorded that increase in fat percentage in khoa resulted in improvement in its colour.

Body and Texture

Average body & texture score of thabdi (brown) and kesar (yellow) peda were 8.18±0.40, and 8.09±0.37 respectively.

There was highly significant ($P < 0.05$) difference between the different cities of thabdi (brown) and kesar (yellow) peda whereas no significant difference was observed between C1, C3, C4, C6, C7 and C8 in thabdi peda and between C3, C4, C6, C7 and C8 in kesar peda. With respect to this parameter also, C2, C1 and C5, C8 city recorded the lowest and highest scores in thabdi and kesar peda respectively. It might be due to wide variation in chemical composition particularly fat and sugar levels. These findings agreed with the result of Londhe and Pal [26], reported that significant effect on the body and texture score of brown peda with increase in the level of fat in milk and sugar, but to a certain extent Banjare et al.[5], concluded that there is highly significant difference among all the samples.

Sweetness

Average sweetness score of thabdi and kesar peda were 8.09 ± 0.39 and 7.84 ± 0.36 respectively. The maximum and minimum sweetness score of thabdi (brown) and kesar (yellow) peda were C1 (8.50), C2 (7.29) and C7 (8.04), C1 (7.45) respectively. The mean sweetness value was highly significantly among the samples. The highest sweetness in this peda samples might be and time of desiccation, composition of base material. The reports also suggested by Desale et al.[27], studied the effect of compositional variables on the quality of peda.

Flavour

Average flavour score (max. 9) of thabdi and kesar peda were 8.16 ± 0.39 and 7.97 ± 0.45 respectively. The results were almost in tune with those obtained by Shinde et al.[28]. The statistical analysis revealed no significant ($P < 0.05$) difference between C3, C4, C6, C7 and C8 the different city of thabdi (brown) peda and whereas no significant difference C3, C6, C7 and C8 of kesar (yellow) peda.

Overall acceptability

Average overall acceptability score (max. 9) of thabdi and kesar peda were 8.19 ± 0.31 and 7.94 ± 0.35 respectively. The maximum and minimum overall acceptability score of thabdi (brown) and kesar (yellow) peda were C1 (8.64), C6 (8.02) and C2 (8.35), C1 (7.42) respectively. Shinde et al.[28] recorded an overall acceptance score of 8.66 on a 9-point hedonic scale.

Table 3 Colour Value (in L*, a* & b* scale) and different colour indexes (C*, WI, BI & YI) of thabdi and kesar market peda

City	L*	a*	b*	C*	WI	BI	YI
Thabdi(Brown) peda							
C1	41.55 ^c ±2.69	9.85 ^{de} ±0.72	15.41 ^{fg} ±0.87	18.29	38.76	62.95	52.98
C2	38.21 ^b ±1.46	8.94 ^d ±0.19	13.59 ^f ±1.19	16.27	36.10	60.39	50.81
C3	40.25 ^{bc} ±1.00	9.35 ^{de} ±0.70	14.26 ^f ±0.73	17.05	37.86	60.06	50.61
C4	39.54 ^{bc} ±0.98	9.13 ^{de} ±0.50	14.01 ^f ±0.86	16.72	37.27	59.97	50.62
C5	41.55 ^c ±1.86	10.35 ^e ±0.63	15.87 ^g ±1.17	18.95	38.56	65.54	54.57
C6	40.87 ^c ±0.76	9.84 ^e ±0.27	15.59 ^{fg} ±0.80	18.44	38.06	64.87	54.49
C7	30.43 ^a ±1.78	8.16 ^d ±0.82	10.74 ^e ±0.82	13.49	29.13	62.42	50.42
C8	29.53 ^a ±1.17	7.38 ^d ±2.00	8.98 ^d ±0.69	11.62	28.58	53.92	43.44
Avg.	37.74 ^b ±4.88	9.12 ^{de} ±1.21	13.56 ^f ±2.47	16.34	35.63	61.50	51.33
Kesar(Yellow) peda							
C1	60.45 ^d ±3.13	14.24 ^f ±1.59	36.42 ^a ±2.27	39.1	44.38	104.91	86.07
C2	62.48 ^d ±4.76	16.46 ^g ±0.82	36.30 ^a ±1.04	39.86	45.26	102.46	83.00
C3	60.46 ^d ±0.87	15.00 ^f ±1.13	34.40 ^a ±1.70	37.53	45.49	98.87	81.28
C4	60.67 ^d ±1.12	15.35 ^f ±0.81	35.20 ^a ±0.80	38.4	45.03	101.53	82.89
C5	61.55 ^d ±1.89	15.46 ^f ±1.04	35.92 ^a ±0.95	39.11	45.16	102.10	83.37
C6	61.88 ^d ±3.39	13.06 ^e ±1.10	35.60 ^a ±2.11	37.92	46.23	97.42	82.19
C7	62.24 ^d ±2.05	7.10 ^c ±0.78	35.17 ^a ±1.01	35.88	47.91	87.92	80.73
C8	61.80 ^d ±1.27	6.32 ^c ±1.26	34.99 ^a ±1.30	35.56	47.81	87.21	80.88
Avg.	61.44 ^d ±2.44	12.87 ^e ±3.86	35.50 ^a ±1.47	37.76	46.03	97.81	82.54

Each observation is a mean ±SD of three replicate experiment of four shop (n=12),
^{a-g} superscript letters following numbers in the same column denote significant difference ($p < 0.05$)

Colour Values and Colour Indexes

The Colour Value (in L^* , a^* & b^* scale) and different calculated colour indexes i.e. Chroma (C^*), whiteness index (WI), brownness index (BI) and yellowness index (YI) of all eight city of Thabdi and Kesar peda were objectively evaluated by colorimeter among the different samples as shown in **Table 3** and **Figure 2**.

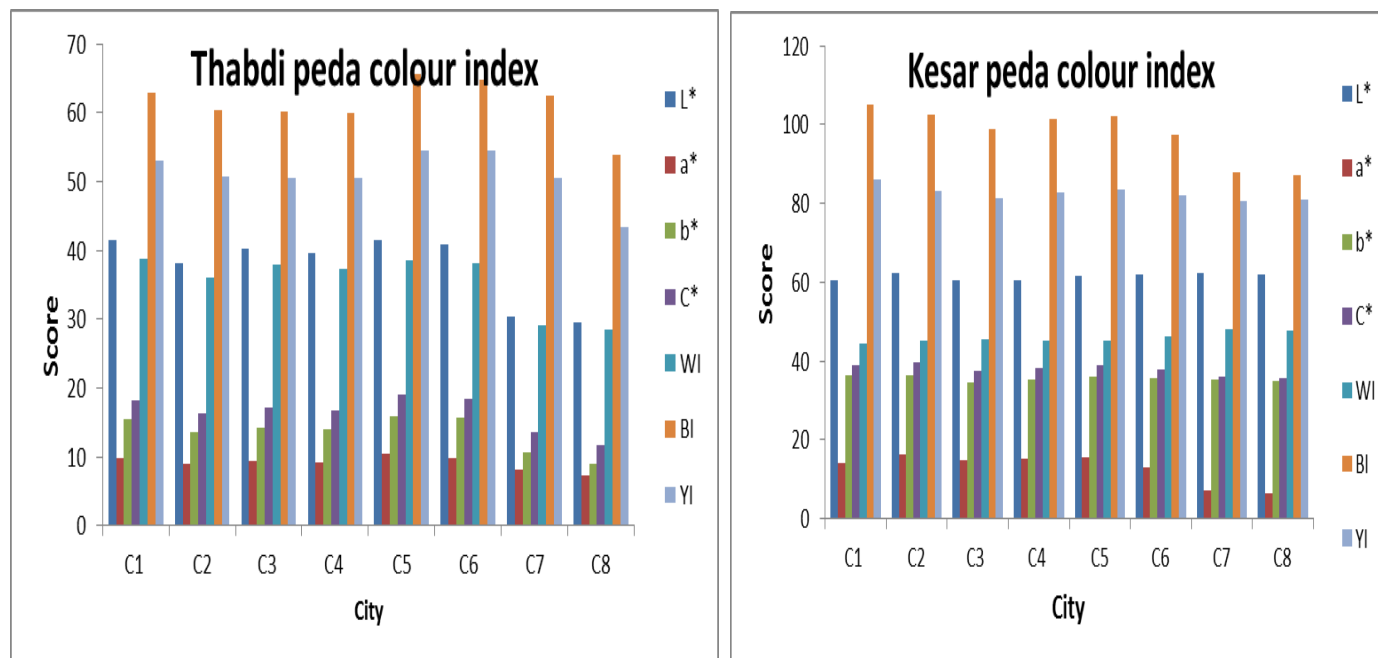


Figure 2 Colour value (L^* , a^* , b^*) and different colour indexes of all eight city of Thabdi (brown) and Kesar (yellow) peda

Average (mean \pm sd) values of Lightness (L^*), Redness (a^*), Yellowness (b^*) of thabdi (brown) and kesar (yellow) peda were 37.74 ± 4.88 , 9.12 ± 1.21 , 13.56 ± 2.47 and 61.44 ± 2.44 , 12.87 ± 3.86 , 35.50 ± 1.47 respectively. There was highly significant ($P < 0.05$) difference between the different cities of thabdi (brown) peda whereas no significant difference was observed between cities in Kesar (yellow) peda. Londhe et al. [29] recorded Lightness (L^*), Redness (a^*) and Yellowness (b^*) of brown peda were 45.54, 14.02 and 30.84 respectively, which is higher value than our results. Average values (mean) of Chroma Value (C^*), Whiteness index (WI), Browning index (BI), Yellowing index (YI), of Thabdi (brown) and Kesar (yellow) peda were 16.35, 35.63, 61.50, 51.33 and 37.92, 46.03, 97.81, 82.54 respectively.

Color difference (ΔE^*)

Measured as total color difference between two samples. Colour differences of thabdi (brown) and kesar (yellow) peda between cities as shown in **Table 4**.

Average color difference between thabdi (brown) and kesar (yellow) peda was found 32.51, this was very high for color differences that could be perceptible to the human eye. In thabdi peda maximum colour difference between C5 and C8 peda and its value is 14.2 and in kesar peda maximum colour difference between C2 and C8 peda and its value is 10.2.

Textural attributes

The Textural attributes (i.e. Hardness, Adhesiveness, Springiness, Cohesiveness, Gumminess, Chewiness and resilience) of Thabdi and Kesar peda of all eight city were objectively evaluated of different samples as shown in **Table 5**.

Average value (mean \pm sd) of Hardness (g), Adhesiveness (g.sec), Springiness, Cohesiveness, Gumminess (g), Chewiness (g) and Resilience of thabdi were 2583 ± 489 , -6.44 ± 2.92 , 0.21 ± 0.04 , 0.12 ± 0.02 , 312.94 ± 58.47 , 65.01 ± 8.05 and 0.036 ± 0.001 respectively. Average value (mean \pm sd) of Hardness (g), Adhesiveness (g.sec), Springiness, Cohesiveness, Gumminess (g), Chewiness (g) and Resilience of Kesar peda were 3317 ± 402 , -9.56 ± 4.18 , 0.17 ± 0.02 , 0.15 ± 0.01 , 462.56 ± 36.21 , 74.40 ± 8.97 and 0.039 ± 0.004 respectively.

Table 4 Colour differences of thabdi (brown) and kesar (yellow) peda between cities

	C1	C2	C3	C4	C5	C6	C7	C8
Thabdi(Brown) peda								
C1	0.0	3.9**	1.8*	2.6*	0.7	0.7	12.2**	12.5**
C2	3.9**	0.0	2.2**	1.4*	4.3**	3.4**	8.3**	10.0**
C3	1.8*	2.2*	0.0	0.8	2.3*	1.5*	10.5**	12.1**
C4	2.6*	1.4*	0.8	0.0	3.0*	2.2*	9.7**	11.3**
C5	0.7	4.3**	2.3*	3.0*	0.0	0.9	12.4**	14.2**
C6	0.7	3.4**	1.5*	2.2*	0.9	0.0	11.6**	13.4**
C7	12.2**	8.3**	10.5**	9.7**	12.4**	11.6	0.0	2.1*
C8	12.5**	10.0**	12.1**	11.3**	14.2**	13.4**	2.1*	0.0
Kesar(Yellow) peda								
C1	0.0	3.0*	2.2*	1.7*	1.7*	2.0*	7.5**	8.2**
C2	3.0*	0.0	3.1**	2.4*	1.4*	3.5**	9.4**	10.2**
C3	2.2*	3.1**	0.0	0.9	1.9*	2.7*	8.1**	8.8**
C4	1.7*	2.4*	0.9	0.0	1.1*	2.6*	8.4**	9.1**
C5	1.7*	1.4*	1.9*	1.1*	0.0	2.4*	8.4**	9.2**
C6	2.0*	3.5**	2.7*	2.6*	2.4*	0.0	6.0**	6.8**
C7	7.5**	9.4**	8.1**	8.4**	8.4**	6.0**	0.0	0.9
C8	8.2**	10.2**	8.8**	9.1**	9.2**	6.8**	0.9	0.0

*minor color differences that could be perceptible to the human eye,
** color differences that could be perceptible to the human eye.

Table 5 Average textural attributes of Thabdi (brown) and Kesar (yellow) peda samples from different city of Saurashtra region

City	Hardness (g)	Adhesiveness (g.sec)	Springiness	Cohesiveness	Gumminess (g)	Chewiness (g)	resilience
Thabdi(Brown) peda							
C1	2508 ^b ±139	-8.24 ^d ±0.09	.169 ^h ±.004	.168 ^h ±.003	366 ^c ±3	61.8 ^c ±2.3	.038 ^f
C2	2190 ^a ±87	-6.91 ^c ±0.18	.234 ⁱ ±.021	.115 ^f ±.007	267 ^a ±27	62.5 ^c ±1.5	.035 ^d
C3	2370 ^{ab} ±127	-6.30 ^e ±1.48	.244 ⁱ ±.026	.118 ^f ±.002	289 ^b ±10	74.6 ^d ±0.9	.037 ^f
C4	2490 ^b ±181	-7.50 ^{de} ±1.21	.244 ⁱ ±.004	.115 ^f ±.004	267 ^a ±7	70.5 ^d ±1.7	.035 ^d
C5	2220 ^{ab} ±179	-7.05 ^{de} ±1.09	.242 ⁱ ±.018	.112 ^f ±.007	258 ^a ±5	61.5 ^c ±1.9	.036 ^e
C6	2188 ^a ±207	-6.92 ^e ±0.99	.234 ⁱ ±.024	.116 ^f ±.002	267 ^a ±1	62.7 ^c ±1.3	.036 ^e
C7	3258 ^c ±74	-6.30 ^e ±0.91	.191 ^h ±.024	.121 ^f ±.008	394 ^d ±7	75.1 ^d ±2.0	.036 ^e
C8	3445 ^c ±211	-2.27 ^f ±1.16	.134 ^g ±.026	.115 ^f ±.006	394 ^d ±8	51.4 ^b ±7.6	.035 ^e
Avg.	2583 ^b ±489	-6.44 ^e ±1.92	0.21 ^h ±0.04	0.12 ^f ±0.02	313 ^b ±58	65.0 ^c ±8.1	.036 ^e
Kesar(Yellow) peda							
C1	3550 ^{cd} ±138	-8.77 ^d ±0.29	.151 ^g ±.003	.147 ^d ±.004	436 ^c ±21	66.0 ^c ±2.6	.037 ^f
C2	3140 ^{bc} ±202	-11.76 ^e ±2.59	.161 ^h ±.002	.137 ^c ±.006	465 ^f ±35	75.0 ^d ±2.4	.036 ^e
C3	4180 ^d ±184	-13.84 ^g ±3.85	.171 ^h ±.003	.157 ^e ±.004	471 ^f ±8	71.1 ^d ±3.1	.037 ^f
C4	3150 ^c ±202	-13.77 ^g ±4.24	.151 ^g ±.012	.147 ^d ±.005	485 ^f ±14	73.4 ^d ±2.9	.037 ^f
C5	3250 ^c ±76	-8.58 ^d ±0.75	.159 ^g ±.022	.147 ^d ±.004	427 ^e ±5	66.1 ^c ±4.3	.037 ^f
C6	3196 ^c ±188	-9.76 ^d ±1.64	.162 ^h ±.016	.139 ^c ±.001	453 ^f ±18	72.6 ^d ±1.6	.037 ^f
C7	2910 ^{bc} ±78	-2.05 ^f ±0.80	.176 ^h ±.012	.149 ^d ±.003	433 ^e ±8	76.3 ^d ±1.0	.041 ^g
C8	3160 ^c ±247	-7.92 ^d ±1.37	.178 ^h ±.022	.168 ^h ±.008	532 ^g ±6	94.8 ^f ±3.5	.048 ^h
Avg.	3317 ^c ±402	-9.56 ^d ±4.18	0.17 ^h ±0.02	0.15 ^e ±0.01	463 ^f ±36	74.4 ^d ±9	.039 ^g

Each observation is a mean ±SD of three replicate experiment of four shop (n=16), ^{a-i} superscript letters following numbers in the same column denote significant difference (p<0.05)

It is the most commonly evaluated characteristic in determining the texture of *peda*. Moisture content of the *peda* sample, lower content of moisture in *peda* sample increases the hardness. Range of hardness of thabdi (brown) and kesar (yellow) peda were found 2188±207 to 3445±211 and 2910±78 to 4180±184 (g) respectively. Londhe et al. [26]

observed variance in hardness market sample of brown pedha as 93.22 - 78.16 (N). The ratio of the area under the second bite curve before reversal compression to the area under the first bite curve is referred to as cohesiveness. Cohesiveness ranges of thabdi (brown) and kesar (yellow) peda were found 0.112 ± 0.007 to 0.168 ± 0.003 and 0.137 ± 0.006 to 0.168 ± 0.008 respectively. Rasane et al. [31] reported average values of market yellow pedha cohesiveness ranging from 0.21 to 0.44. Adhesiveness is related to the sensory stickiness and indicated by a negative peak following the first peak. Adhesiveness range of thabdi (brown) and kesar (yellow) peda were found -2.27 ± 1.16 to -8.24 ± 0.09 and -2.05 ± 0.80 to -13.84 ± 3.85 (g.sec). Rasane et al. [31] showed that the adhesiveness of market yellow pedha ranged from 0.30 to 60.00 (g.sec). Average springiness (mean \pm sd) of thabdi (brown) and kesar (yellow) peda were found 0.21 ± 0.04 and 0.17 ± 0.02 respectively.

Gumminess is defined as the amount of energy necessary to disintegrate a semi-solid food. Gumminess (g) range of thabdi (brown) and kesar (yellow) peda were found 258 ± 5 (C5) to 394 ± 8 (C8) and 427 ± 5 (C5) to 532 ± 6 (C8). Chewiness is a product of hardness, cohesiveness, and springiness. Chewiness (g) range of thabdi (brown) and kesar (yellow) peda were found 51.4 ± 7.6 (C8) to 75.1 ± 2.0 (C7) and 66.0 ± 2.6 (C1) to 94.8 ± 3.5 (C8). The mean value of chewiness differed significantly ($P < 0.05$) among cities, whereas no significant difference was observed between C1, C2, C5 and C6 cities of thabdi peda. In case of kesar (yellow) peda no significant difference was observed between C2, C3, C4, C6 and C7 cities samples. Londhe et al. [29] recorded gumminess and chewiness of the fresh brown peda samples were 13.17 N (1343 g) and 2.13 N (217 g) respectively, which was higher than this results. The greatest amount of energy that be absorbed per unit volume without causing irreversible deformation. Range of resilience of thabdi (brown) and kesar (yellow) peda were found 0.035 to 0.038 and 0.036 to 0.048 respectively. Textural qualities of the yellow peda samples varied greatly, adhesiveness values ranging from 0.301 to 60.007 g.sec, gumminess 792.24 to 1027.912, chewiness 195.337 to 426.831, springiness 0.186 to 0.504, cohesiveness 0.214 to 0.44, and resilience 0.07 to 0.144 reported by Rasane et al. [31].

Conclusions

In the present study, sixty-four distinct samples of thabdi (brown) and kesar (yellow) peda were obtained from four popular stores in eight different cities in the Saurashtra area, and physico-chemical, sensory, colour, and textural properties were studied. According to the results of the study, the fat content of all the samples was greater than the FSSAI criteria (minimum of 37%) for khoa. In maximum colour difference of thabdi peda between C5 and C8 city (14.2) and kesar peda between C2 and C8 city (10.2). In terms of sensory quality, there is a difference in overall acceptability due to the variance in chemical composition as well as the addition of colour and flavour of market peda. Significant variations in textural characteristics exist between the cities of thabdi and kesar peda, owing to differences in preparation procedure and varying amounts of sugar and moisture content.

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