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Research Article

Quality of market khoa from middle region of Gujarat

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Abstract

Khoa, a heat desiccated product prepared from milk, is a base material for several sweetmeats. The quality of these products depends on the physicochemical properties of khoa. A total of 54 khoa samples were collected from Anand, Ahmedabad and Vadodara cities of the middle Gujarat region of India and analyzed for various quality parameters. The moisture, fat, protein, carbohydrate and ash content in the khoa samples ranged from 26.91–48.53, 7.22–50.37, 13.42–23.75, 9.88–29.17 and 2.47–4.92 per cent, respectively. The titratable acidity (% lactic acid) content in the khoa samples ranged from 0.20–0.84 per cent. These parameters were differing significantly ($p<0.05$). The considerable variation in the mineral content of khoa samples was also observed as values observed in terms of mg/100g were, iron (0.27–6.57), manganese (0.01–0.39), zinc (2.16–6.07), copper (0.11–0.31), calcium (454.99–729.29), magnesium (36.36–58.34), sodium (80.71–122.83), potassium (257.90–419.03) and phosphorus (364.53–496.17). Presence of adulterants was detected in many khoa samples: one khoa sample were found to contain each with starch and sucrose; two khoa samples with maltodextrin, four khoa samples with neutralizers and 25 khoa samples with glucose. The study revealed considerable variability in khoa quality and composition, emphasizing the need for strict quality assurance and regulatory control to protect consumer health and product quality.

Keywords: Adulteration, Composition, Khoa, Minerals, Quality

Highlights

- The compositional parameters of the khoa samples differed significantly ($p<0.05$).
- The mineral content of the khoa samples had wide variations.
- Starch, sucrose, maltodextrin, neutralizers and glucose were detected in many khoa samples.
- Strict quality and regulatory control are required to safeguard the consumer.

INTRODUCTION

In India, milk and dairy products rank second only to cereals in dietary consumption, constituting 16 per cent of total food expenses. Due to the perishable nature and limited shelf life of milk, it is converted into diverse traditional dairy products (Kumar, 2013). Around 50–55 per cent of India's milk production is transformed into various traditional value-added dairy products, which account for over 90 per cent of all dairy items consumed nationally (Gupta & Gupta, 2013). In India, an estimated 1.5 million tonnes of khoa is produced annually, which is worth about Rs.18000 crores (Badola et al., 2023).

Indian sweet meats prepared from milk is an integral food component of the country's culinary heritage. The majority of sweets are prepared from intermediate base material obtained from milk, i.e. khoa, chhana and chakka. According to Pai (2006), the sweet production is largely small-scale and mainly handled by *Halwais* (traditional sweet makers). Demand for commercially produced khoa (a milk-based product) significantly rises during festive periods (Bajaj et al., 2013), leading to the possibility of widespread intentional addition of edible or non-edible non-milk constituents. Lack of stringent quality regulations for khoa has resulted in widespread adulteration at every stage of its production and distribution (Amruthakala, 2012).

Recent media reports have highlighted the widespread sale of alleged "synthetic khoa" in bulk quantities, which is commonly used in preparing traditional khoa-based sweets such as burfi, peda and kalakand. This synthetic version is reportedly composed of various adulterants, including lower-cost oils and fats, raising concerns about potential health risks for consumers. There is currently little

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comprehensive data on the quality of khoa and khoa-based sweets available in Indian markets. Therefore, keeping the above aspects in mind, the current study focuses on the studies on the physicochemical evaluation and analysed selected adulterants of market khoa samples.

MATERIALS AND METHODS

Collection of market khoa samples: Khoa samples were collected from the middle region of Gujarat. The selected cities included Anand (MS_1 to MS_9), Ahmedabad (MS_{10} to MS_{13}) and Vadodara (MS_{14} to MS_{18}). Total 54 samples of khoa were collected and kept in refrigerated conditions until its analysis. The samples were grated using laboratory grater. The grated khoa was then mixed thoroughly and transferred to an air-tight container until analysis in the refrigerator.

Analysis of khoa samples: Khoa samples were analysed for their compositional parameters, minerals and presence of adulterants.

Moisture, fat, protein, ash and titratable acidity were determined by the method of the Food Safety and Standards Authority of India [FSSAI] (2022). Protein was determined by the Block Digestion/Steam Distillation method (Association of Official Analytical Chemists [AOAC], 2006). Carbohydrate was calculated by difference.

Prepared ash was dissolved in 5 mL of the 1 mol/L hydrochloric acid solution, and the content was transferred in 50 mL volumetric flask using double-distilled water was used for analyzed mineral content. Sodium and Potassium were determined using a flame photometer by ISO 8070: 1987 (E). Phosphorus was determined by the Vanado-molybdate method (Hanson, 1950).

Calcium, magnesium, and zinc were determined by inductively coupled plasma optical emission spectroscopy (ICP-OES), a method given by BS EN 16943: 2017.

Sucrose, starch, maltodextrin, glucose and vegetable fat are some of the most prevalent adulterants in khoa. For the detection of common adulterants in market khoa samples, various qualitative tests were used as suggested by Aparnathi et al. (2020).

RESULTS

Analysis of khoa samples for compositional parameters: The results of the compositional parameters of the khoa samples are shown in Table 1.

Table 1. Compositional parameters of market khoa samples

Khoa Samples	Moisture Mean±SD	Fat	Protein	Carbohydrate	Ash	Acidity
MS_1	42.86±1.96	27.79±5.77	17.46±1.06	14.63±2.30	3.41±0.24	0.31±0.13
MS_2	40.53±4.22	26.05±3.50	18.04±1.49	17.46±1.30	3.34±0.34	0.44±0.13
MS_3	42.15±1.02	29.64±2.52	15.24±0.59	16.44±2.31	3.34±0.08	0.31±0.09
MS_4	41.51±0.32	29.68±2.66	15.97±0.35	16.40±1.39	3.26±0.30	0.32±0.07
MS_5	38.41±1.44	29.19±0.43	16.02±0.43	19.50±0.94	3.48±0.14	0.31±0.02
MS_6	39.33±2.75	21.10±12.63	18.71±0.69	21.53±7.26	3.63±0.24	0.33±0.03
MS_7	39.66±1.42	13.75±2.64	18.38±0.68	25.80±0.83	4.10±0.04	0.56±0.12
MS_8	36.94±1.56	31.38±2.06	16.44±2.68	19.54±1.86	3.21±0.16	0.49±0.04
MS_9	38.66±1.90	38.50±2.26	16.93±1.52	13.50±3.14	3.13±0.19	0.46±0.02
MS_{10}	44.58±2.51	16.79±7.21	16.35±1.11	21.44±3.25	3.48±0.44	0.53±0.14
MS_{11}	41.72±5.91	22.84±3.31	17.76±0.68	18.21±7.22	3.74±0.24	0.40±0.07
MS_{12}	34.49±0.69	31.28±1.31	17.46±1.23	20.76±2.34	3.47±0.12	0.40±0.11
MS_{13}	41.16±2.88	20.40±10.54	15.61±0.89	23.69±4.92	2.99±0.54	0.61±0.14
MS_{14}	41.96±1.08	25.65±9.85	17.32±0.15	17.73±5.71	2.91±0.25	0.36±0.04
MS_{15}	27.32±0.48	41.99±7.28	21.79±0.51	17.98±3.74	3.46±0.10	0.57±0.02
MS_{16}	28.26±1.33	32.51±3.70	23.38±0.34	19.52±0.82	4.35±0.53	0.77±0.08
MS_{17}	33.33±2.25	39.26±3.05	21.61±1.00	13.65±2.72	3.23±0.32	0.34±0.12
MS_{18}	31.73±1.18	29.59±1.45	19.91±0.44	21.94±0.50	3.59±0.30	0.72±0.05
SEm	1.36	3.29	0.61	2.06	0.17	0.052
CD	3.9	9.45	1.75	5.91	0.48	0.149
CV%	6.2	20.24	5.85	18.91	8.39	19.73

n=3; SEm: Standard Error of Mean; CD: Critical Difference (0.05% level of significance); CV: Coefficient of Variance

The moisture content of the market khoa samples ranged from 26.91 in MS_{15} to 48.53 per cent in MS_{11}. The fat content of the market khoa samples ranged from 7.22 per cent in MS_6 to 50.37 per cent in MS_{15}. The protein content in the present investigation in market khoa samples ranged from 13.42 per cent in MS_8 to 23.75 per cent in MS_{16}. The carbohydrate content in the market khoa samples ranged from 9.88 per cent in MS_{11} to 29.17 per cent in MS_6. The ash content of the market khoa samples ranged from 2.47 per cent in MS_{13} to 4.92 per cent in MS_{16} over the samples collected from different places. The titratable acidity in the khoa samples ranged from 0.20 per cent in MS_1 to 0.84 per cent in MS_{16}.

Mineral content in khoa: The collected market khoa samples were also analysed for selected minerals to understand the compositional variation. The iron, manganese, zinc, copper, calcium, magnesium, sodium, potassium and phosphorus content of the market khoa samples ranged between 0.27 to 6.57, 0.01 to 0.39, 2.16 to 6.07, 454.99 to 729.29, 36.36 to 58.34, 80.71 to 122.83, 257.90 to 419.03 and 364.53 to 496.17 mg/100 g, respectively (Table 2).

Detection of the presence of selected adulterants in khoa samples: For the detection of common adulterants in market khoa samples, various qualitative tests were used as suggested by Aparnathi et al. (2020). None of the samples analyzed during the first replication showed the presence of starch; however, sample S_{18} showed the presence of starch during subsequent two replications (Fig. 1). All samples of khoa analyzed except sample S_{11} (2 instances), tested negative for the presence of maltodextrin (Fig. 2).

A total of 25 samples tested positive for glucose among all 54 khoa samples, i.e. three replications of 18 samples. In the first, second and third replications, 8 samples (S_3, S_4, S_5, S_6, S_7, S_{14}, S_{15}, and S_{18}), 9 samples (S_{10}, S_{11}, S_{12}, S_{13}, S_{14}, S_{15}, S_{16}, S_{17}, and S_{18}) and 8 samples (S_3, S_6, S_7, S_8, S_{14}, S_{15}, S_{16}, and S_{18}), respectively, were tested positive for glucose (Fig. 3).

All samples of khoa analysed except sample S_{15} tested negative for the presence of sucrose (Fig. 4). Sucrose is also generally indicated to be a common adulterant in khoa, however in our result doesn't indicate so.

Four samples were found to be neutralizer positive out of a total of 54 samples, i.e. three replications of

Table 2. Mineral content of market khoa samples

Khoa Sample	Fe mg/100 g	Mn	Zn	Cu	Ca	Mg	Na	K	P
MS_1	0.34	0.02	3.12	ND	643.86	53.08	105.30	298.64	485.88
MS_2	0.75	0.03	2.91	ND	621.81	49.08	108.27	333.99	487.54
MS_3	0.99	0.06	3.49	ND	660.27	55.27	106.75	301.07	459.54
MS_4	0.87	0.01	3.66	ND	572.97	47.48	108.84	324.15	425.35
MS_5	0.27	0.02	2.89	ND	647.23	49.59	100.59	299.52	483.01
MS_6	2.18	0.06	2.32	ND	657.82	48.03	102.48	297.45	491.47
MS_7	0.58	0.02	4.68	ND	648.94	54.82	122.83	394.58	493.66
MS_8	0.60	0.05	2.26	ND	558.59	46.38	95.31	312.74	454.07
MS_9	1.13	0.05	2.55	ND	539.41	43.26	94.34	285.24	437.61
MS_{10}	1.28	0.02	6.07	ND	598.97	45.82	98.30	301.09	457.75
MS_{11}	0.28	0.02	5.72	ND	729.29	57.14	102.11	343.84	496.17
MS_{12}	2.52	0.03	2.80	ND	644.57	44.19	92.71	297.24	470.31
MS_{13}	0.48	0.02	4.10	ND	454.99	36.36	80.71	257.90	364.53
MS_{14}	5.98	0.06	2.16	ND	592.93	44.28	97.80	307.68	473.40
MS_{15}	6.57	0.03	3.44	ND	604.22	54.15	97.87	340.83	476.25
MS_{16}	5.64	0.39	5.76	ND	591.39	58.34	108.95	419.03	477.90
MS_{17}	0.65	0.02	2.51	ND	577.68	47.03	95.90	277.78	449.68
MS_{18}	2.14	0.02	2.29	ND	546.34	50.13	116.11	376.48	440.19
CV%	84.89	253.53	56.87		8.09	8.98	6.93	9.09	6.34
SEm	1.11	0.09	1.40		34.60	3.12	5.00	20.60	20.74
CD	3.29	NS	NS		102.81	9.27	14.85	61.22	61.63

n=2; SEm: Standard Error of Mean; CD: Critical Difference (0.05% level of significance); CV: Coefficient of Variance

18 samples. In the first replication, three samples (S_3, S_4, S_7) tested positive. In the second replication, all samples tested negative for neutralizer. In the third replication, one sample (S_{10}) was found to be neutralizer positive (Fig. 5).

DISCUSSION

Analysis of khoa samples for compositional parameters: All the compositional parameters, viz. moisture, fat, protein, carbohydrates, ash and titratable acidity differed significantly ($p<0.05$) among the khoa samples. The lowest mean moisture content was observed in MS_{15} (27.32 per cent), while the highest value was in MS_{10} (44.58 per cent). With respect to fat content, ample MS_{15} had the highest mean fat content (41.99 per cent), while, MS_7 had the lowest mean fat content (13.75 per cent). The highest mean protein content was observed in MS_{16} (23.38 per cent), while, MS_3 had the lowest protein content (15.24 per cent). With respect to carbohydrate content, MS_7 exhibited the highest mean carbohydrate content (25.80 per cent), while MS_9 had the lowest carbohydrate content (13.50 per cent). For ash content of the khoa samples, MS_{16} exhibited the highest ash content (4.35 per cent), while MS14 had the lowest mean ash content (2.91 per cent). MS_{16} recorded the highest mean acidity (0.77 per cent), while, the lowest titratable acidity value was observed in MS_5 (0.31 per cent). Variation in the compositional parameters like moisture, fat, protein, carbohydrates, ash and titratable acidity in various khoa samples might be due to methods of khoa making and the type of milk used (cow, buffalo or a combination thereof).

Aggarwal et al. (2019) prepared khoa from buffalo milk and lactose-hydrolysed buffalo milk, and reported the moisture content as 21.76±0.32 per cent and 22.13±0.30%, respectively. Sharma et al. (2023) analysed market Dhap khoa samples and reported the moisture content to be in the range of 40.77±0.33% to 43.77±0.15%. Prasad and Shah (2025) have reported moisture content in cow and buffalo milk khoa as 29.23±3.02 and 32.20±1.40. The moisture content in khoa is reported to vary from 18.5 per cent (SaiPrakash, 1981; Gothwal & Bhavdasan, 1992) and 35.5 per cent (Kumar & Srinivasan, 1982; Miyani, 1988; Sapre & Deodhar, 1991; Bhadania et al., 2005). However, the majority of the data are within the range of 17-36 per cent (Choudhary et al., 2015; Lad, 2016). The findings are in accordance with Bajaj et al. (2013) who reported moisture content in the market khoa samples in Nanded city to be 20.90 to 28.64 per cent. The Food Safety and Standards Authority of India (FSSAI) established guidelines in 2011 that specify minimum allowable total solids content levels of 55 per cent or maximum allowable moisture content levels of 45 per cent for khoa samples. Values of moisture content in all market khoa samples were below 45 per cent.

A wide variation was observed in fat content amongst the market khoa samples with values ranging from 19.65 to 26.38 per cent. These data are in collaboration with previous studies.

Aggarwal et al.(2019) prepared khoa from buffalo milk and lactose-hydrolysed buffalo milk, and reported the fat content as 35.24±0.41% and 35.02±0.55%, respectively. Prasad and Shah (2025) have reported moisture content in cow and buffalo milk khoa as 22.40±1.01 and 29.03±1.65. Bajaj et al.(2013) observed the fat content in market khoa samples from Nanded city in the range of 19.65 per cent and 26.38 per cent. Kumar and Srinivasan (1982) reported average fat content (%) in lab-made cow milk khoa, buffalo milk khoa and market khoa samples as 22.00, 32.19 and 24.58, respectively. Wanjari et al. (2016) reported in mean fat per cent in the khoa collected from East, West, North, and South regions of the district as 24.70, 26.06, 23.84 and 30.53, respectively, in Bhandara district of Maharashtra.

The protein content of market samples of khoa observed in our study is in alignment with the reported observations of Bajaj et al.(2013), with the protein content in market khoa samples from Nanded city ranging between 17.03 per cent and 23.44 per cent. Similarly, Kumar and Srinivasan (1982) reported that the average protein content as 19.12 per cent in lab-made cow milk Khoa, 17.73 per cent in buffalo milk khoa, and 19.04 per cent in market samples. Pal and Raju (2007) reported that the protein per cent of market sample khoa was 16 to 26 per cent. Wanjari et al. (2016) reported protein content in market khoa as 16.24, 16.88, 18.77, 17.98 per cent. The values of crude protein content in khoa are reported to vary from 11.3 per cent (Patel, 1982; Gothwal & Bhavdasan, 1992; Bhadania et al., 2005) and 23.39 per cent (Narain & Singh, 1981). However, majority of the data are within the range of 11 and 25 per cent (Choudhary et al., 2015; Lad, 2016). The average protein level of market khoa was slightly lower as compared to control samples that is 21.85 per cent range of 17.03 to 23.44 per cent. Aggarwal et al. (2019) prepared khoa from buffalo milk and lactose-hydrolysed buffalo milk, and reported the protein content as 17.60±0.10% and 17.96±0.08%, respectively; while Prasad and Shah (2025) have reported protein content in cow and buffalo milk khoa as 16.93±0.17 and 13.57±0.50.

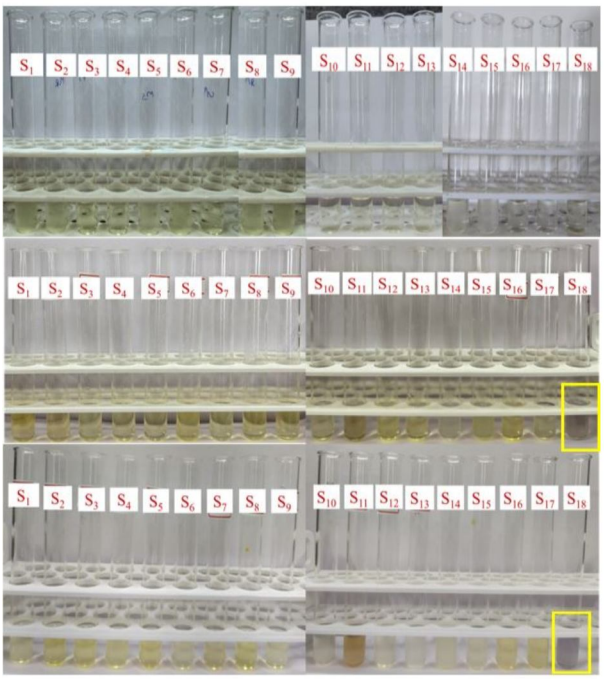


Fig. 1. Presence of starch in khoa sample

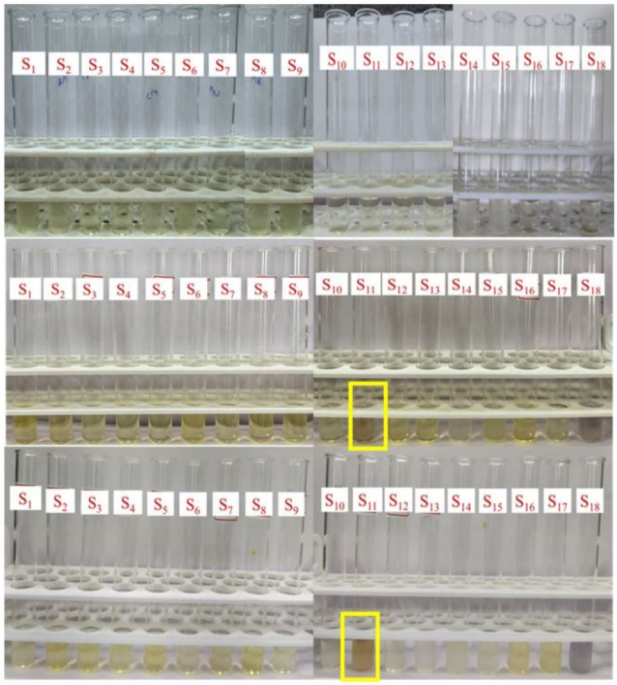


Fig. 2. Presence of maltodextrin in khoa sample

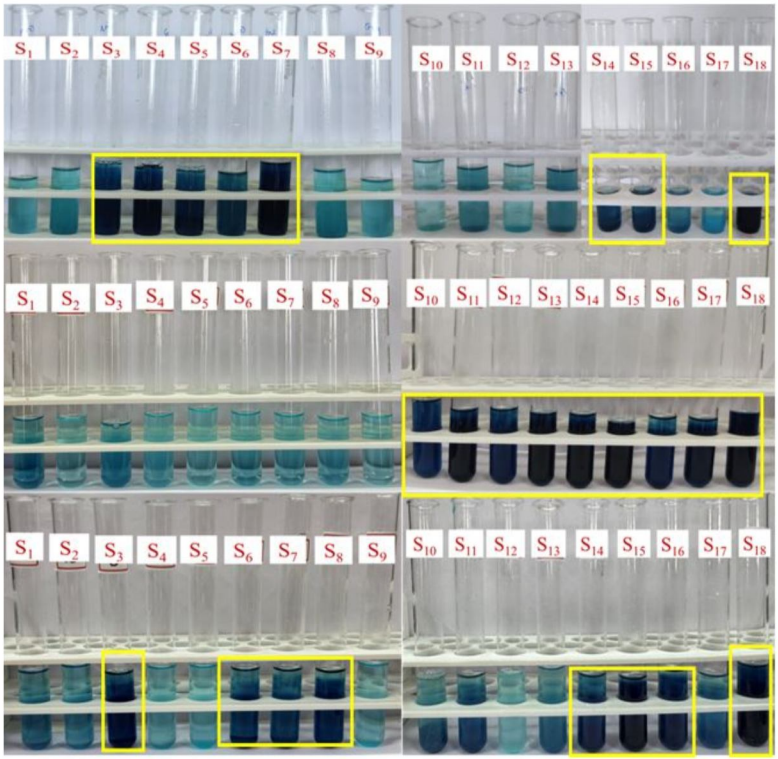


Fig. 3. Presence of glucose in khoa sample

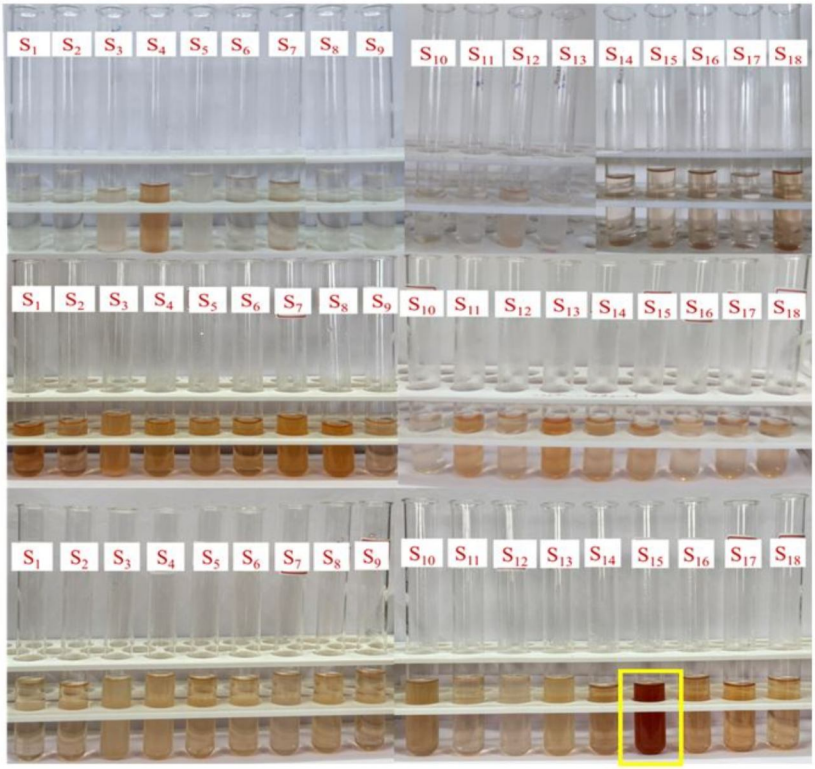


Fig. 4. Presence of sucrose in khoa sample

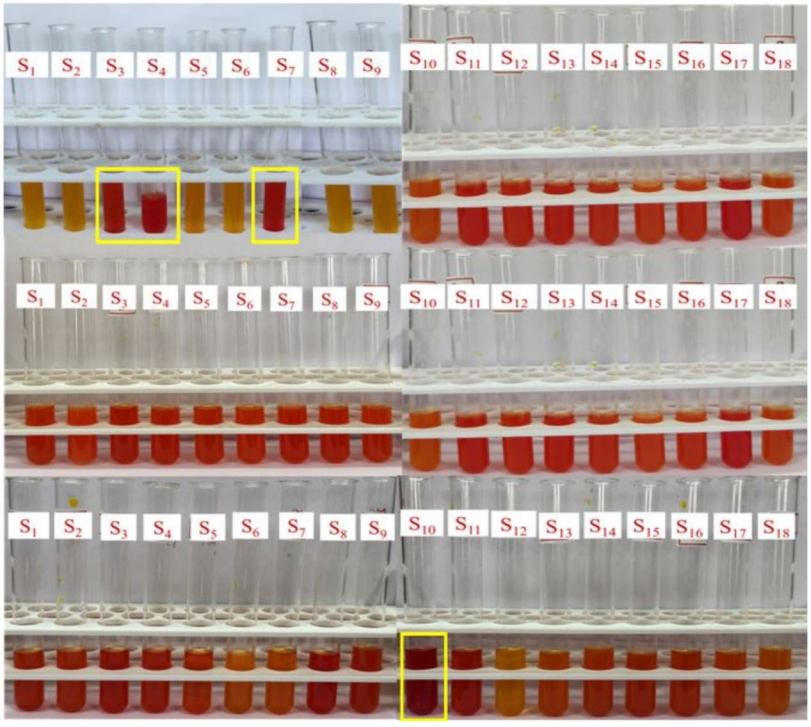


Fig. 5. Presence of neutralizer in khoa sample

Considerable variation in the carbohydrate content of the market khoa sample in our study was observed (10.36-26.63 per cent). This variation in carbohydrate content may be due to different types of milk used as well as the moisture content of the khoa. The findings of this study align with those of the values of carbohydrate content in Khoa are reported to vary from 18.8 per cent (Patel, 1982; Sapre & Deodhar, 1991) and 36.2 per cent (Srinivasan & Anantakrishnan, 1964; Narain & Singh, 1981). However, the majority of the data are within the range of 18.3 and 36 per cent (Choudhary et al., 2015; Lad, 2016). Aggarwal et al. (2019) prepared khoa from buffalo milk and lactose-hydrolysed buffalo milk, and reported the lactose content as 21.13±0.06% and 3.63±0.05%, respectively. Prasad and Shah (2025) have reported lactose content in cow and buffalo milk khoa as 26.80±0.27 and 21.32±0.78, respectively.

The values of ash content in khoa are reported to vary from 2.92 per cent (SaiPrakash, 1981; Patel, 1982) and 4.84 per cent (Narain & Singh, 1981; Hemavathy & Prabhakar, 1983; Miyani, 1988). However, the majority of the data are within the range of 2.9 and 4.85 per cent (Choudhary et al., 2015; Lad, 2016). Aggarwal et al. (2019) prepared khoa from buffalo milk and lactose-hydrolysed buffalo milk, and reported the ash content as 2.74±0.05% and 2.87±0.21%, respectively. However, Prasad and Shah (2025) have reported ash content in cow and buffalo milk khoa as 4.64±0.06 and 3.88±0.14.

Bajaj et al. (2013) analysed Khoa samples from Nanded city and found titratable acidity levels ranging from 0.24 to 0.87 per cent. Similar studies by Kumar and Srinivasan (1982) reported average acidity values of 0.52 per cent for laboratory-prepared cow milk Khoa, 0.35 per cent for buffalo milk Khoa, and 0.50 per cent for market samples. Wanjari et al. (2016) also reported comparable results, with average acidity values of 0.68, 0.68, 0.59, and 0.70 per cent in khoa samples collected from four different sources in Bhandara district. According to FSSR (2011) khoa should not contain more than 0.9 per cent titratable acidity in the finished product. All the samples surveyed in our study met with this requirement.

Mineral content in khoa: There is not published work related to analysis of khoa for mineral analysis. However, our results were in accordance with Boghra (1988), who reported that the concentrations (mg/100 g) of calcium, magnesium, phosphorus, citrate, sodium, potassium, chloride, copper, iron, zinc in market Khoa samples were 686.50, 70.43, 491.69, 623.05, 279.66, 466.22, 490.74, 0.17, 0.66, 2.14 respectively in cow milk Khoa and 704.62, 72.63, 520.50, 593.50, 259.07, 396.65, 258.20, 0.17, 0.61, 3.01 respectively in buffalo milk Khoa. Boghra and Mathur (1991) reported that the average values for calcium, sodium, potassium, copper and iron in market khoa samples were found to range between 6125 to 6300, 1715 to 1900, 3738 to 3840, 1.3 to 1.9 and 19.6 to 30.2 ppm, respectively.

Presence of selected adulterants in khoa: During festive seasons, the demand for market khoa increases significantly (Bajaj et al., 2013). This surge in demand has led to a rise in the intentional addition of both edible and non-edible adulterants in khoa. Since the khoa market operates largely in an unorganized sector and the product commands a high price, it becomes vulnerable to adulteration aimed at maximizing profits. Glucose, sucrose, starch, maltodextrin and neutralizer are reported as the most common adulterants in khoa. Therefore, in the present study attempts were made to evaluate selected adulterants in market khoa samples.

Starch, sucrose, and maltodextrin are generally indicated to be a common adulterants; however, our result doesn't indicate so. This is possibly indicative of a changing profile of adulteration in khoa. Glucose and neutralizer were found in a significant number of khoa samples. One of the reasons for widespread glucose adulteration in khoa might be the easy availability of cheap glucose. There are scanty publications citing the presence of glucose in the market samples of khoa. This may be due to attempts by producers to achieve higher profits during the festive season or possibly due to a shortage of milk and an increase in khoa production. A spot survey conducted by FSSAI in Delhi khoa market some samples were observed to be substandard with respect to the presence of starch, added sugar, urea, detergent, neutralizers. However, they have not indicated the number of samples found to be adulterated and the adulterant.

Khoa samples from the middle region of the Gujarat state were found to have considerable variation in the quality parameters. The variation in the compositional parameters in various khoa samples might be attributed to methods of khoa making and the type of milk used (i.e. cow, buffalo or a combination thereof). Many of the khoa samples did not meet the FSS regulations for fat content. The prevalence of traditionally reported adulterants i.e. starch, maltodextrin and sucrose was not found in the khoa samples; however, glucose and neutralizer were present in several khoa samples. In order to safeguard the consumers, regular monitoring of the khoa quality is the need of the hour. The results

of the study emphasizes the need for stringent regulatory control in the khoa manufacture to safeguard consumer interest.

Conflict of interest: The authors have no conflict of interest in this study.

Author's contribution: FAP, UK, JP: Investigation and data generation; AIS: Supervision of the study; AIS, JMM: Preparation of manuscript; SCP: Engaged in data curation.

Data availability statement: Data will be provided upon request to the corresponding author.

Ethical approval: Not required for this study.

Use of artificial intelligence tools: AI tools were not used in the preparation of the manuscript and study.

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