



Development and Nutritional Evaluation of Khoa Fortified with Jamun Seed (*Syzygium cumini* L.) Powder

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The current study, "Development and nutritional evaluation of khoa fortified with jamun seed (*Syzygium cumini* L.) Powder," was carried out in Vadodara, Gujarat, India during the year 2022 in the Product Development Laboratory of the Department of Food Technology, Parul Institute of Applied Sciences, Parul University. Khoa is an Indian traditional dairy product which is fortified with jamun seed powder. The nutritional evaluation of khoa fortified with jamun seed is done by analyzing nutrient content. Jamun seed powder is a popular detoxifying herb because it contains ash, moisture, crude protein, fat and fiber. The average proximate constituents such as moisture, carbohydrate, protein, fat, fiber and ash content were determined in khoa as follows (45.8%), (75.15%), (17.2%), (2.81%), (1.84%) and (3%) respectively. The minerals determined were calcium (40.87mg), iron (0.65mg), magnesium (10.38mg) and zinc (< 2.0mg) respectively. The Fourier transform infrared spectroscopy (FT-IR) of khoa showed the presence of spectra 2858.52 cm⁻¹

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which represents Carbonyl group, 1743.30 cm^{-1} which represents Hydrocarbon group, 1542.79 cm^{-1} which represents presence of CONH group and 1029.13 cm^{-1} which represents OH group. Minerals such as calcium, magnesium, iron and zinc of khoa were evaluated. The total energy value of khoa was observed as 310.01 Kcal/100gm. Then the khoa was packed in polyethylene pouches (PEP) and stored under ambient ($25\text{-}28\text{ }^{\circ}\text{C}$) and refrigerated (4°C) temperature conditions for 7 days and it was observed that during the storage study of khoa, at ambient temperature the overall increase in moisture content of khoa ranged from (45.8%) to (47.1%) whereas, the overall decrease in protein, fat and ash ranged from (17.2%) to (16.1%), (2.81%) to (2.58%) and (3%) to (2.3%), respectively. During the storage study of khoa at refrigeration temperature we observed that the overall increase in moisture content of khoa ranged from (45.8%) to (46.4%) whereas, the overall decrease in protein, ash and fat ranged from (17.2%) to (16.3%), (3%) to (2.6%) and (2.81%) to (2.75%), respectively. The Moisture increases more at ambient temperature as compared to refrigeration temperature. Whereas the overall decrease in protein, ash and fat is more in ambient temperature compare to refrigeration temperature. Thus, the developed khoa have improved nutritional value and is suggested to diabetic patients.

Keywords: Jamun seed; FT-IR; fortification; khoa; antidiabetic; antioxidant activity.

1. INTRODUCTION

Worldwide, human nutrition is mostly dependent on milk and milk products. At least (25%) of a man's daily nutrient intake is estimated to be made up of dairy products [1]. Khoa is a term used to describe a partially dehydrated whole milk product that is made by continuously heating milk over a direct flame while stirring and scraping the mixture until it has a semi-solid consistency [2]. Khoa includes fat-soluble vitamins and high amounts of proteins, minerals, fat and lactose [3]. The core ingredient khoa is extensively used to make a variety of native sweets, including peda, burfi, gulabjamun, and kalakand [4]. Also, the Bureau of Indian Standards (BIS) has specified the specifications for three varieties of khoa, Pindi, Danedar and Dhap, in terms of total solids, fat, ash, acidity, coliforms and yeast and mould counts [5]. A high-quality khoa has a smooth, firm texture, a pleasant flavor and a white or light-yellow appearance [4]. According to estimations, (7%) of India's total milk output is used to make khoa, which is utilized to prepare sweets [6].

Fruits and vegetables belong to an Important class of foods that supply human diet with nutritive requirements including vitamins and minerals which are essential for normal body health and function. *Syzygium cumini* L., popularly known as black jamun, is a significant indigenous plant from the Myrtaceae family that was first cultivated in India and Indonesia. The fruit's seeds are astringent and sour but the flesh is palatable. In herbal medicine the pulp and seeds are used to treat diarrhea, ringworm and diabetes [7]. The jamun fruits are

only obtainable once a year, in the months of June and July [8]. The jamun fruit is comprised of fleshy berries which are oval in appearance and have a single dark brown seed in the centre that is enriched with a variety of bioactive substances [9]. Jambul fruits, leaves, seeds, and bark have traditionally been utilized in herbal remedies. Jamun seeds contain a glycoside called Jamboline, which aids in the maintenance of balanced glucose levels [10]. Anthocyanins, chlorophyll, phytosterols, amino acids, vitamin C, vitamin B complexes, essential minerals and trace elements (calcium, iron, sodium, magnesium, zinc, phosphorus, chromium, vanadium, and potassium), essential oil, albumin, and fats are abundantly present in the seeds [11-15].

Food fortification is the procedure of adding one or even more essential nutrients to food, no matter if they are present naturally, in order to eliminate the nutrient deficiency [16]. The World Bank, WHO, UNICEF, MI and GAIN, all have identified food fortification to be among the most cost-effective health interventions. Fortification of staple foods with micronutrients is indeed a popular strategy in many developing countries [17]. Food fortification has been used for a very long time to successfully regulate the deficiency of a number of B vitamins, including thiamine, riboflavin, and niacin, as well as iodine and iron [18].

2. MATERIALS AND METHODS

The present investigation entitled "Development and nutritional evaluation of khoa fortified with jamun seed (*Syzygium cumini* L.) powder" was

conducted in the Department of Food Technology, Parul University, Vadodara, Gujarat, India during the year 2022.

2.1 Procurement of Raw Materials

The jamun seeds and milk was procured from the local market of Vadodara, Gujarat and bought to product development laboratory of Department of food technology, Parul University, Vadodara, Gujarat. The jamun seed powder was then used for preparation of functional khoa.

2.2 Preparation of Product

Pasteurized homogenized toned milk of fat (3.0%) and SNF (8.5%) was taken. Further the milk was clarified and then was poured in a kadhai and was kept for boiling. After that continuous heating and stirring was carried out. Continuous stirring and desiccation was carried out till viscous product reaches a pasty consistency and begins to dry up. When thick consistency was achieved; than jamun seed

powder was added to it. Mixing was carried till the khoa was ready. The prepared khoa was collected and stored in polyethylene pouches.

The standardization was done using 9-point hedonic scale which provides the score on the basis of color, texture and taste. The overall acceptability is marked with score between 9-1. For the optimization of recipe, a total of 20 different combinations of treatments were carried out. After analysis of all the score cards, Treatment -7 was selected as the best treatment.

2.3 Chemical Analysis

Moisture, Ash, Fiber and carbohydrate were determined as per the method explained by [19]. Protein and fat were determined according to the procedure mentioned in [20]. Energy value was measured by bomb calorimeter. Mineral content was determined by Kshisagar et al. [21], Ghosh et al. [22] and Sharma et al. [23]. Fourier Transform-Infrared Spectroscopy was determined as per method of [24].

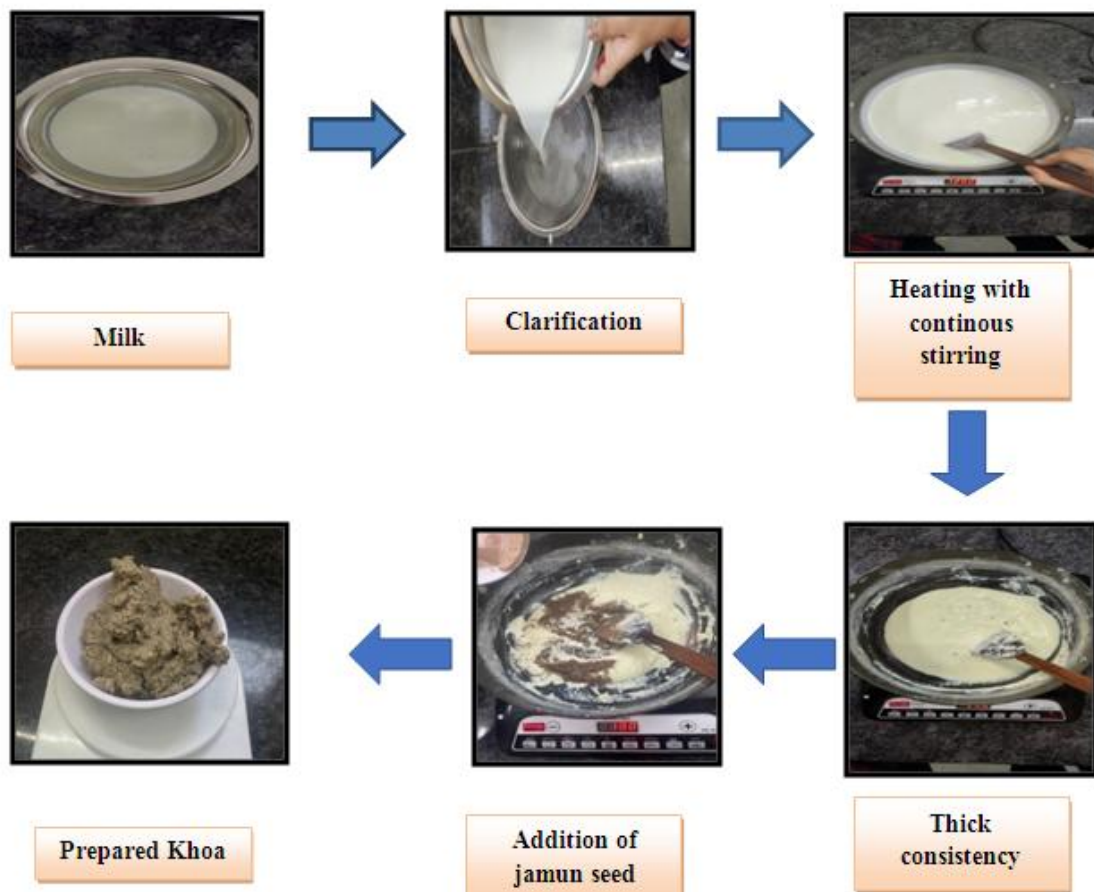


Fig. 1. Unit Operations for Preparation of Khoa Fortified with Jamun Seed Powder

Table 1. Standardization of treatment blends

Treatments	Milk(ml)	Jamun Seed Powder(gm)
T ₀	1000	0
T ₁	1000	1
T ₂	1000	2
T ₃	1000	3
T ₄	1000	4
T ₅	1000	5
T ₆	1000	6
T ₇	1000	7
T ₈	1000	8
T ₉	1000	9
T ₁₀	1000	10
T ₁₁	1000	11
T ₁₂	1000	12
T ₁₃	1000	13
T ₁₄	1000	14
T ₁₅	1000	15
T ₁₆	1000	16
T ₁₇	1000	17
T ₁₈	1000	18
T ₁₉	1000	19
T ₂₀	1000	20

2.4 Sensory Evaluation

Nine-point Hedonic scale method as given by Amerine et al. [25] was followed for conducting the sensory evaluation of sample.

2.5 Cost of Production of Functional Khoa

Cost incurred for the purchase of raw materials like jamun seed powder, milk and polyethylene pouches and other materials were considered. Over-head expenditure, manufacturing cost on equipment etc. was included for the calculation of unit cost on product sale price of functional khoa was calculated.

3. RESULTS AND DISCUSSION

The present study entitled “Development and nutritional evaluation of khoa fortified with jamun seed (*Syzygium cumini* L.) Powder” was

conducted under different experiments in the Department of Food Technology, Parul Institute of Applied Sciences, Parul University, Vadodara, Gujarat, India during the years 2023. From the above treatments (Table 1), treatment-7 was selected as the best treatment on the basis of sensory evaluation. The results of the study are presented below:

3.1 Chemical Analysis

The data showed the proximate composition and mineral content of developed khoa and the chemical parameters of developed khoa is presented and discussed in Table 2.

Table 2 represents that developed khoa has (17.2%) protein, (2.81%) fat, (1.84%) fibre, (75.15%) carbohydrate, (45.8%) moisture and (6.6%) ash respectively. The value obtained was closely resembled to the findings of Ahmadi et al. [26].

Table 2. Proximate composition of developed khoa

Sr. no	Parameters	Amount (%)
1	Protein	17.2
2	Fat	2.81
3	Fibre	1.84
4	Carbohydrate	75.15
5	Moisture	45.8
6	Ash	3

Table 3. Mineral composition of developed khoa

Sr. no	Minerals	Amount(mg/100g)
1	Calcium	40.87
2	Magnesium	10.38
3	Iron	0.65
4	Zinc	< 2.0

According to Table 3 developed khoa had 40.87 mg/100gm calcium, 0.65 mg/gm Iron, < 2.0 mg/gm Zinc and 10.38 mg/gm magnesium respectively. Kshirsagar *et.al* 2019, Ghosh *et.al* 2017 and Sharma *et al.* 2022 reported similar range of minerals content in jamun seed.

3.2 Total Energy Value of Developed Khoa

Total energy obtained in developed khoa was 310.01 Kcal/ 100gm.

3.3 Fourier Transform – Infrared Spectroscopy (FT-IR) Analysis

Fourier Transform - Infrared Spectroscopy (FT-IR) is a spectral measurement technique with long-wave infrared radiation that captures absorbance in a time field and converts it to a frequency field using the Fourier transform algorithm. Because of its ability to identify

functional groups of chemical compounds like carbohydrates, esters, and chemical bonds between atoms, FT-IR has been used to examine a wide range of samples.

3.3.1 FT-IR analysis of jamun seed powder

The results obtained in Fig. 2 shows FT-IR spectra 3626.63 cm⁻¹ and 3680.60 cm⁻¹ both represent OH group, 2039.67 cm⁻¹ represents Alkynes, 1446.98 cm⁻¹ represents presence of Methylene CH- Bond 1011.73 cm⁻¹ represents CH-Bond [24].

3.3.2 FT-IR analysis of developed khoa

The results obtained in Fig. 3 FT-IR spectra 2858.52 cm⁻¹ represents Carbonyl group, 1743.30 cm⁻¹ represents Hydrocarbon group, 1542.79 cm⁻¹ represents presence of CONH group and 1029.13 cm⁻¹ represents OH group [27].

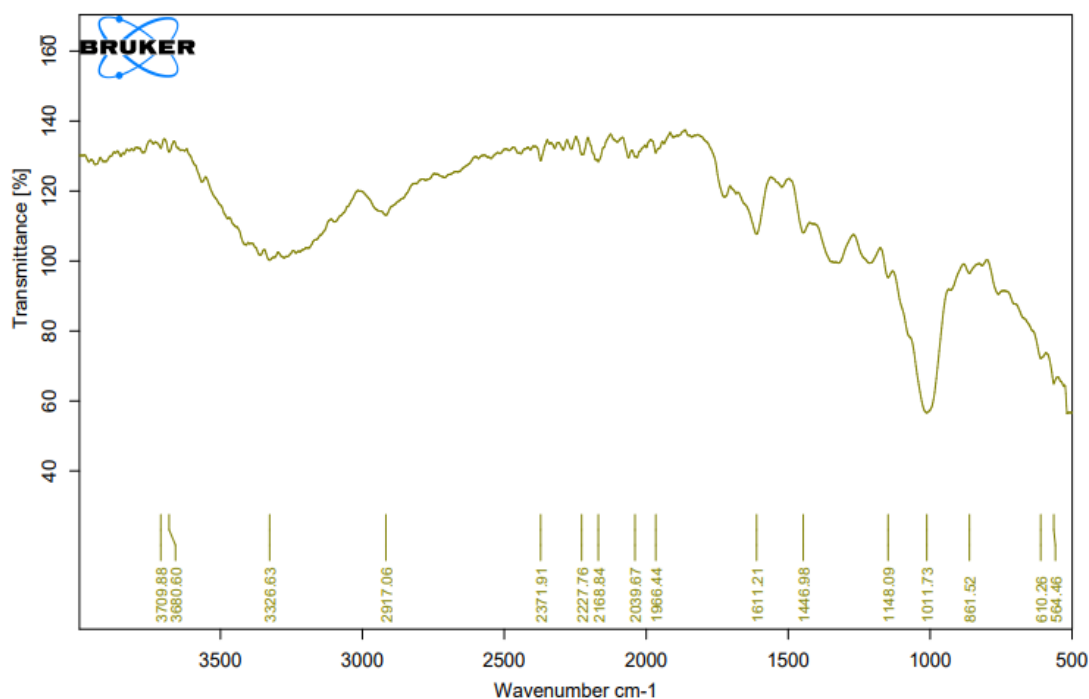


Fig. 2. FT-IR analysis of jamun seed powder

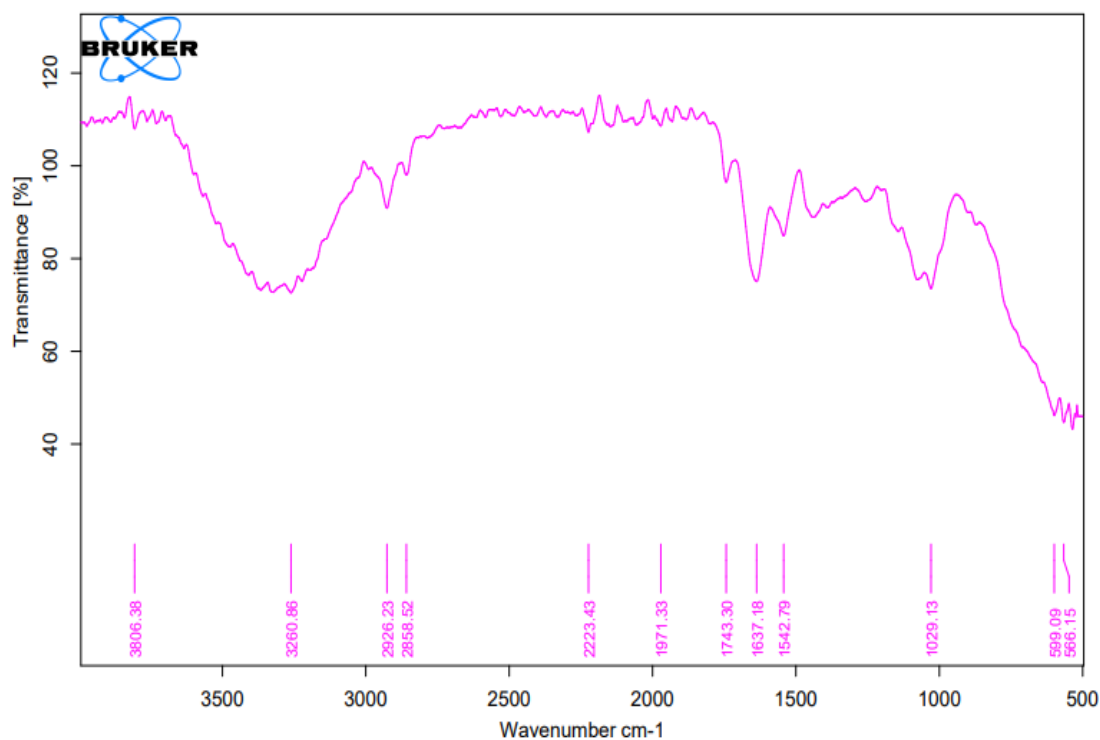


Fig. 3. FT-IR analysis of jamun seed powder

3.4 Storage Evaluation

3.4.1 Storage study of developed khoa at ambient temperature and refrigeration temperature

The developed khoa was packed in polyethylene pouches and were stored for 7 days at refrigeration (4°C) and ambient (25-28°C) condition.

Data in Table 4 and Table 5 revealed that there was general increasing in moisture content of developed khoa during entire storage period of 7 days at ambient and refrigeration temperature respectively. The overall effect of storage period indicates that moisture content in khoa increased from 45.8 to 47.1 at ambient temperature and 45.8 to 46.4 at refrigeration temperature. The lowest moisture content of khoa stored was recorded at refrigeration condition and highest at

ambient condition. The ash content during storage indicates that there was general decreasing trend in ash content of khoa during entire storage period of 7 days at both temperatures. The overall effect of storage period indicated that ash content in khoa decreased from 3 to 2.3 at ambient temperature and 3 to 2.6 at refrigeration temperature. There was general decreasing trend of protein content in khoa from 17.2 to 16.1 and from 17.2 to 16.3 for both ambient and refrigeration temperature respectively during entire storage period of 7 days. There was general decrease in fat content of khoa during entire storage period of 7 days at ambient and refrigeration temperature respectively. The overall effect of storage period indicated that fat content in khoa decreased from 2.81 to 2.58 at ambient temperature and 2.81 to 2.75 at refrigeration temperature. Similar results were found by Kshirsagar 2019, Ghosh 2017 and Sharma.

Table 4. Storage study at ambient temperature (25-28°C)

Sr. no.	0 day	2 days	4 days	7 days
Moisture	45.8	46.2	46.9	47.1
Ash	3	2.9	2.6	2.3
Protein	17.2	16.9	16.7	16.1
Fat	2.81	2.75	2.67	2.58

Table 5. Storage study at refrigeration temperature (4°C)

Sr. no.	0 th day	2 nd day	4 th day	7 th day
Moisture	45.8	46	46.2	46.4
Ash	3	2.9	2.7	2.6
Protein	17.2	16.9	16.6	16.3
Fat	2.81	2.79	2.77	2.75

3.5 Microbial Evaluation

Initially microbial growth was absent. But as storage period time increased, microbial growth was recorded and total plate count (TPC) of functional khoa obtained was 5000 cfu/g.

3.6 Cost of Production

Ingredients	Rate/100 g/ml	Quantity required(g/ml)	Amount (₹)
Milk	5	1000	50
Jamun seed powder	54.44	7	3.81
Additional charges	-	-	10
Processing charges	@10% of total cost		6.38
Total cost = ₹70.19			

The prices of all ingredients were considered while calculating the expense incurred in the production of functional khoa. The total price includes the processing fee as well as additional costs. The selling price was calculated after adding a 10 per cent profit margin. The sale price per 100 g of the product was calculated after adding (10%) processing cost. The total cost of the production was found out to be ₹70.19 /100 g for developed functional khoa [28-30].

4. CONCLUSION

The present study focuses on preparation of khoa fortified with jamun seed powder. During the Experiment we found that the developed khoa recorded (45.8%) moisture, (17.2%) protein, (1.84%) fibre, (3%), ash, 75.15 carbohydrate, (2.81%) fat respectively. Further, it was found that developed khoa had 40.87 mg/100gm, 0.65mg/gm, < 2.0mg/gm and 10.38mg/gm for calcium, iron, zinc and magnesium respectively. The Fourier transform infrared spectroscopy (FT-IR) of khoa showed the presence of spectra 2858.52 cm⁻¹ which represents Carbonyl group, 1743.30 cm⁻¹ which represents Hydrocarbon group, 1542.79 cm⁻¹ which represents presence of CONH group and 1029.13 cm⁻¹ which represents OH group. During the storage study of khoa at refrigeration temperature we observed that the overall increase in moisture content of khoa ranged from (45.8%) to (46.4%) whereas, the overall decrease in protein, ash and fat ranged from

(17.2%) to (16.3%), (3%) to (2.6%) and (2.81%) to (2.75%), respectively. The Moisture increases more at ambient temperature as compared to refrigeration temperature. Hence, it's concluded that the prepared khoa has good nutritional profile and is beneficial for health.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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