Original Research Article

Development and nutritional evaluation of khoa fortified with jamun seed (*Syzygium cumini L.*) powder

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} 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 (25-28 ^{o} C) and refrigerated (4^{o}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 (Bureau of Indian Standards). 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 (De S). Khoa includes fat-soluble vitamins and high amounts of proteins, minerals, fat and lactose (Aneja *et al* 2002). The core ingredient khoa is extensively used to make a variety of native sweets, including peda, burfi, gulabjamun, and kalakand (Patel, 1977). 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 (IS: 4883, 1980). A high-quality khoa has a smooth, firm texture, a pleasant flavor and a white or light-yellow appearance (Patel, 1977). According to estimations, (7%) of India's total milk output is used to make khoa, which is utilized to prepare sweets (Kurian, 1991).

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 (Benherlal and Arumughan, 2007). The jamun fruits are only obtainable once a year, in the months of June and July (Shrivastava and Kumar, 1953). 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 (Usda-Ars, 2008). 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 (Kalse *et al*, 2016). 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 (Singh *et.al* 2022, Kannan and Puraikalan 2015, Priyanka 2015, Qamar *et.al* 2022 and Venu et.al 2017).

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 (Anonymous, 1991). 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 (Darnton and Nalubola, 2002). 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 (Burgi *et al.* 1990).

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 tonned 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 beings 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.

Milk

Clarification

Heating with continous stirring

Thick consistency

Addition of jamun seed

Prepared Khoa

Figure 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

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.

2.4. Chemical analysis

Moisture, Ash, Fiber and carbohydrate were determined as per the method explained by (Ranganna 2009). Protein and fat were determined according to the procedure mentioned in (AOAC 2012). Energy value was measured by bomb calorimeter. Mineral content was determined by Kshisagar *et.al* 2019, Ghosh *et.al* 2017 and Sharma *et.al* 2022. Fourier Transform-Infrared Spectroscopy was determined as per method of (Stuart 2004).

2.5. Sensory evaluation

Nine-point Hedonic scale method as given by Amerine *et al*. (1965) was followed for conducting the sensory evaluation of sample.

2.6. 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. Result 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 below:

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 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.* (2014).

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 figure 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 (Stuart B, 2004).

3.3.2. FT-IR analysis of developed khoa

The results obtained in figure 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 (Luinge *et al*.1993).

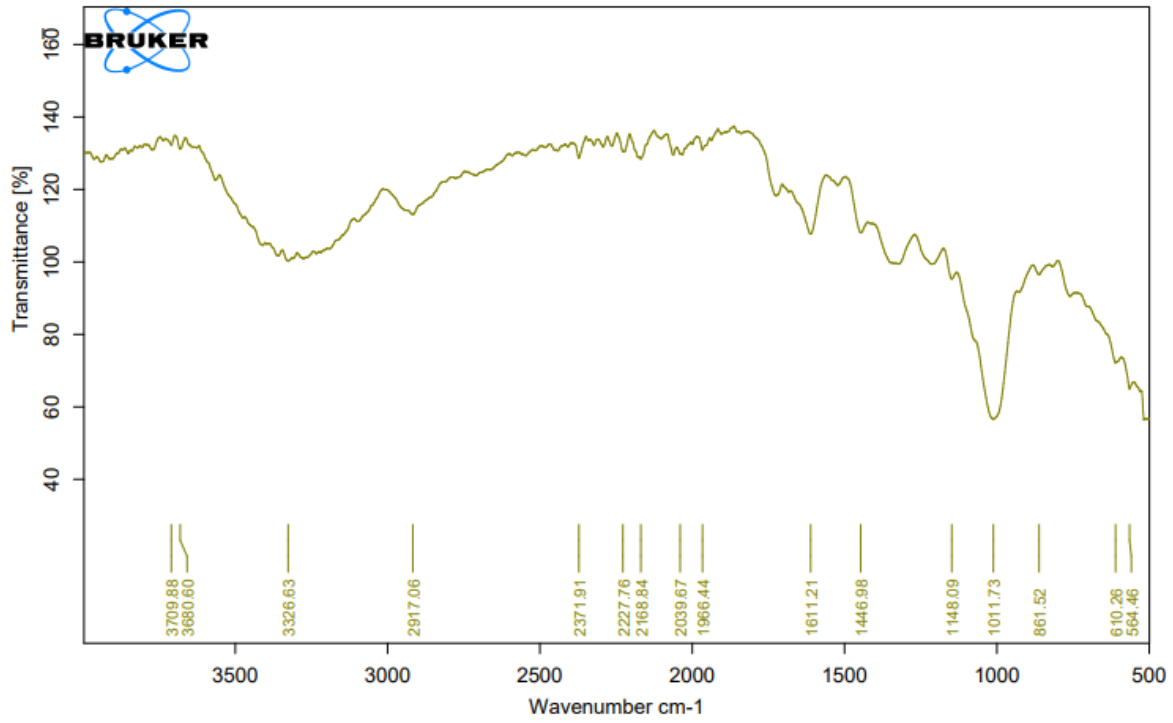

Figure 2: FT-IR analysis of jamun seed powder

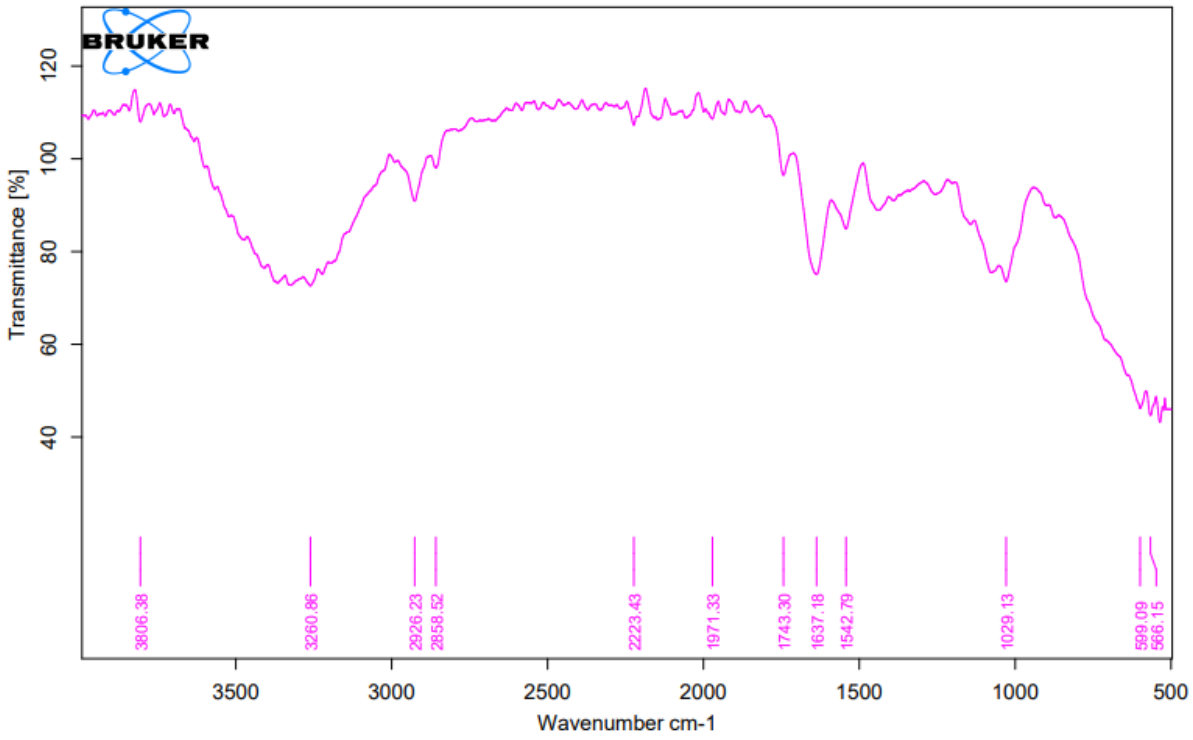

Figure 3: FT-IR analysis of jamun seed powder

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 (4^0C) and ambient ($25\text{-}28^0$C) condition.

Table 4: Storage study at ambient temperature ($25\text{-}28^0$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 (4^0C)

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

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.

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.

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.

References

Ahmadi A, Milani E, Madadlou A, Mortazavi, SA, Mokarram R and Salarbashi D. (2014). Synbiotic yogurt-ice cream produced via incorporation of microencapsulated lactobacillus acidophilus (la-5) and Fructooligosaccharide. *Journal of Food Science and Technology*, *51*, 1568-1574.

Amerine M A, Roessler E B and Ough, C S. (1965). Acids and the acid taste. The effect of pH and titratable acidity. *American Journal of Enology and viticulture*, *16*(1), 29-37.

Aneja, R P., Mathur, B N, Chandan R C and Banerjee A K. (2002). *Technology of indian milk products: handbook on process technology modernization for professionals, entrepreneurs and scientists*. Dairy India Yearbook.

Anonymous, (1991), Codex Alimentarius Commission, General Principles for the Addition of Essential Nutrients to Foods – CAC/GL 09-1987.

AOAC, (2012), *Official Methods of analysis of AOAC International* 19thed. Gaitherburg.

Benherlal PS and Arumughan C. (2007). Chemical composition and in vitro antioxidant studies on Syzygium cumini fruit. *Journal of the Science of Food and Agriculture*, *87*(14), 2560-2569.

Bureau of Indian Standards, Hand Book of Food Analysis, XI: Dairy Products, 21, Bureau of Indian Standards, New Delhi, 1981.

Bürgi H, Supersaxo Z and Selz B. (1990). Iodine deficiency diseases in Switzerland one hundred years after Theodor Kocher's survey: a historical review with some new goitre prevalence data. *European Journal of Endocrinology*, *123*(6), 577-590.

Darnton-Hill I and Nalubola R. (2002). Fortification strategies to meet micronutrient needs: successes and failures. *Proceedings of the nutrition society*, *61*(2), 231-241.

De Sukumar. (1980). Outlines of dairy technology.

De Bona, K S, Bonfanti G,Bitencourt PE R., da Silva T P,Borges, R M, Boligon A and Moretto M B.(2016). Protective effect of gallic acid and Syzygium cumini extract against oxidative stress-induced cellular injury in human lymphocytes. *Drug and chemical toxicology*, *39*(3), 256-263.

Ghosh P, Pradhan, R C, Mishra S, Patel A S and Kar A. (2017). Physicochemical and nutritional characterization of jamun (Syzygium cuminii). *Current Research in Nutrition and Food Science Journal*, *5*(1), 25-35.

IS: 4883 (1980) Indian Standard Specification for Khoa. Bureau of Indian Standards, pp 3–8. New Delhi: Indian Standards Institution.

Janick J and Paul, RE. (Eds.). (2008). *The encyclopedia of fruit and nuts*. CABI.

Kalse S B, Swami S B, Sawant A and Thakor N J. (2016). Development and quality evaluation of jamun seed powder fortified biscuit using finger millet. *Journal of Food Processing and Technology*, *7*(11), 1-3.

Kannan A and Puraikalan Y D. (2015). Development and effects of Jamun seed powder incorporated cookies. *International Journal of Pharmacognosy and Phytochemical Research*, *5*, 1934-1935.

Kshirsagar R B, Desai G B, Sawate A R and Deshmukh N M. (2019). Physico-chemical and nutritional properties of jamun (Syzygium cumini) seed. *Journal of Pharmacognosy and Phytochemistry*, *8*(2), 211-213.

Kurian K, Indigenous Milk Products of India, Present and Future Market Share, *Indian Dairyman*, 1991; 43: 106.

Luinge HJ, Hop.E Lutz, Hemert van JA Jong de E A M, (1993), *Analytica Chimica Acta*, 284:419.

Patel AA and De S, Production and storage of dried khoa, Indian Dairyman, 1977; 31(2): 79-83.

Priyanka A M and Mishra A A. (2015). Development and quality evaluation of Jamun powder fortified biscuits using natural sweeteners. *International Journal of Science, Engineering and Technology*, *3*(3), 796-801.

Qamar M., Akhtar S, Ismail T, Wahid M, Abbas M W, Mubarak M S and Esatbeyoglu, T. (2022). Phytochemical Profile, Biological Properties and Food Applications of the Medicinal Plant Syzygium cumini. *Foods*, *11*(3), 378.

Ranganna S, (2009), Handbook of analysis and quality control of fruits and vegetables.

Sehwag S and Das M. (2016). Composition and functionality of whole jamun based functional confection. *Journal of food science and technology*, *53*, 2569-2579.

Sharma S, Sharma S, Bharti A S, Tiwari M K and Uttam K N. (2022) Non-destructive assessment of the nutrient profile of underutilized seeds using spectroscopic probes. Analytical Letters. 1–17.

Singh S, Singh A K, Mishra D S, Singh G P and Sharma B D. (2022). Advances in research in jamun (Syzygium cuminii): A review. *Current Horticulture*, *10*(1), 8-13.

Srivastava HC 1953. Paper chromatography of fruit juices. *Journal of Science and Industrial Research*, *12*, 363-365.

Stuart B H. (2004,) Spectral analysis, Infrared spectroscopy: fundamentals and applications, 45-70.

Usda-Ars. (2008). Germplasm resources information network (GRIN). Online database. Beltsville, Maryland, USA: National Germplasm Resources Laboratory.

Venu Gopal K S and Anu-Appaiah, K. A. (2017). Seed incorporation during vinification and its impact on chemical and organoleptic properties in Syzygium cumini wine. *Food Chemistry*, *237*, 693-700.