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NOVELTY IN THE MANUFACTURING OF KHOA

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ABSTRACT

Khoa, a heat-desiccated indigenous Indian dairy product, is the primary ingredient used in the manufacturing of khoa based sweet. In India, approximately 7 percent milk produced is converted to khoa. Khoa is known by a variety of names, including khoya, kava, and mawa. Khoa-based sweets include gulabjamun, kalajamun, kalakand, burfi, and others. There are several traditional techniques for producing khoa, and the majority of it is produced in an unorganised manner. However, commercialization has led to development of novel ways for mechanised khoa manufacturing, such as the Inclined Scrapped Surface Heat Exchanger (ISSHE) and the Thin Film Scrapped Surface Heat Exchanger (TFSSHE) (TSSHE). Various modifications methods include roller drying, membrane technology, and reverse osmosis.

Keywords: Khoa, Mechanization, Traditional Milk Products, Novelty.

I. INTRODUCTION

Khoa is a dehydrated Indian dairy product that is used as a base for a variety of sweets such as burfi, peda, and gulabjamun [1]. FSSR (2011) Definition of khoa (As amended in 2018) Khoa by whatever name it is sold such as Khoa or Mawa or any other region specific popular name means the product obtained by partial removal of water from any variant of milk with or without added milk solids by heating under controlled conditions [2].

Table1. FSSR (2011) Composition of khoa [2]

Characteristic	Percentage
Total solid, min, %(m/m)	55
Milk fat, min, %(m/m) dry basis	30
Total ash, maximum%	6.0
Titratable acidity (as %lactic acid), max%	0.9

Classification of Khoa:

Pindi, danedar, and dhap are the three main types of khoa. The following are the features of each khoa variety [2]:

- **Pindi**: It has a smooth, homogenous body and texture and is shaped like a circular ball with a hemispherical pat. There should be no burnt particles or browning defects in the product. It should have a distinct cooked flavour, with no objectionable odours or a sour (acidic) taste.
- **Danedar**: It has a grainy texture and a slightly uneven body. The size of the grains is determined by the amount of coagulant used, which is commonly citric acid, as well as the amount of milk utilised. This form of khoa is used to make kalakand and other dishes.
- **Dhap:** It is characterized by a loose, sticky body and a smooth texture. It has higher moisture content than Pindi or the Danedar type. It is preferred for making gulabjamun because after frying and soaking in sugar syrup, it creates homogenous balls with the appropriate rheological qualities. The price of the product is influenced by the quality of the khoa made. Pindi, Dhap, and Danedar, three forms of khoa, are available in the market at various rates. Production processes determine the quality of a product of the same type. Pindi has a higher price than Dhap and Danedar. Each of these kinds is in high demand and is necessary for a specific type of confection.

Table 2. BIS standards for three khoa varieties [2]

Characteristic	Pindi	Danedar	Dhap
Total solids percent by mass, Minimum	65	60	55

Fat, percent by mass (on dry basis), Minimum	37	37	37
Total ash, percent by mass (on dry basis), Maximum	6.0	6.0	6.0
Titratable acidity, (as lactic acid) percent by mass basis, Maximum	0.8	0.9	0.6
Coliform count per gram, Maximum	50	50	50
Yeast and Mould count per gram, Maximum	90	90	90

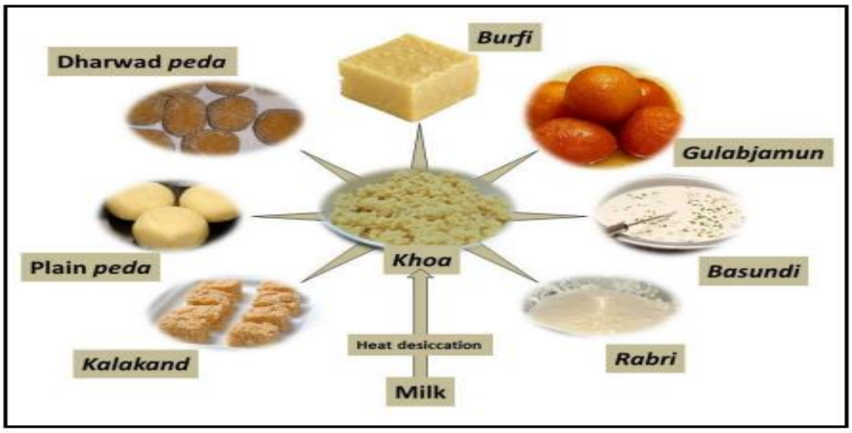

Figure 1: An illustration showing a variety of heat desiccated (khoa-based) sweets of Indian sub-continent [3]

II. LITERATURE REVIEW

Small batches of milk (no more than 5-7 litres each batch) are boiled in an open pan with 1/4 to 1/5 of the total capacity over a vigorous, non-smoky heat. A ladle is used to stir the milk vigorously and continuously in a circular motion. To prevent the burning of milk solids on the pan's surface, all surfaces of the pan with which milk comes into touch are lightly scraped throughout this procedure. Moisture evaporates at a constant rate, and the milk thickens over time. Heat coagulation of milk proteins begins at a particular concentration (2.8 for cow milk and 2.5 for buffalo milk), and the concentrates become increasingly insoluble in water. A rapid change in colour characterises this stage. After that, the heating is maintained with more precision, and the speed of stirring and scraping is increased. The viscous mixture soon dries up and becomes semi-solid or pasty in consistency. The final stage is given special care. When the final product starts to scrape away from the pan's bottom and sides and stick together, it's ready. The pan should be taken from the heat at this point, and the khoa should be distributed to the side of the pan and allowed to cool slowly before forming into a pat. The finished product is placed in aluminium containers, which are usually 1 kg in size. The khoa operation is completed in about 15-20 minutes [2].

Technological innovations in khoa making:

The traditional method of manufacturing khoa in mild steel shallow open pans over an open fire with vigorous mixing with a wooden or steel ladle has been scaled up by various semi-continuous and continuous machines that are employed in regions where the quantity of milk is sufficient for khoa making. The first continuous khoa-making machine has a capacity of 50 litres per hour [4]. A steam jacketed cylinder with rotary scrappers was used in the process, which was followed by a final concentration in an open-cascading steam jacketed pan with mechanical scrapping agitators. Following that, the procedure was standardised, with a few improvements suggested [5].

The equipment for making khoa in rural areas [6] includes a semi-jacketed, shallow open pan that is stirred with a swinging hanger type scraper throughout the desiccation process. Water is poured into two-thirds of the pan, which is then put over the furnace. A safety valve controls the pressure and temperature of steam generated inside the jacket. Inside the jacket, the steam pressure ranges from 0 to 4 kg/cm^2. They developed a semi-mechanized batch type method for khoa manufacture based on the principle of scrapped surface heat

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exchanger [7], which comprised of a jacketed drum with vapour exhaust and scrapper assembly. [8, 9, 10] the mechanisation of khoa using steam jacketed cylinders with several modifications.

The National Dairy Development Board designed the Inclined Scraped Surface Heat Exchanger (ISSHE) for continuous khoa production. Milk concentrate (40-45 percent TS at 50°C) is poured into the ISSHE inlet at the optimum flow rate by regulating the feed pump's capacity. The inclination of ISSHE at the start of the operation allows for the production of a pool of boiling milk, which is essential for the development of the desired flavour in khoa. Following that, fresh concentrated feed is added to the boiling concentrated milk pool, while an equivalent mass is continually removed as a semi-solid mass.

The scraper is used to remove coagulated particles from the heat transfer surface and mix them back into the heated milk pool. The milk absorbs the coagulated particles, causing agglomeration and the development of the khoa texture. The scraper's slant produces an interaction between metal, milk, and air, which enhances protein heat coagulation. Traditional methods are used in the open pan to make khoa, and these processes are replicated in the ISSHE. The screw conveyer propels the moist coagulated particles forward. By adjusting the inclination, flow rate, heating jacket pressure, scraper/screw speed, and total solids and temperature of the feed, the capacity, residence time, as well as the product characteristics can be varied. At the end of the process run, the concentrate milk is stopped by diverting the water supply [2].

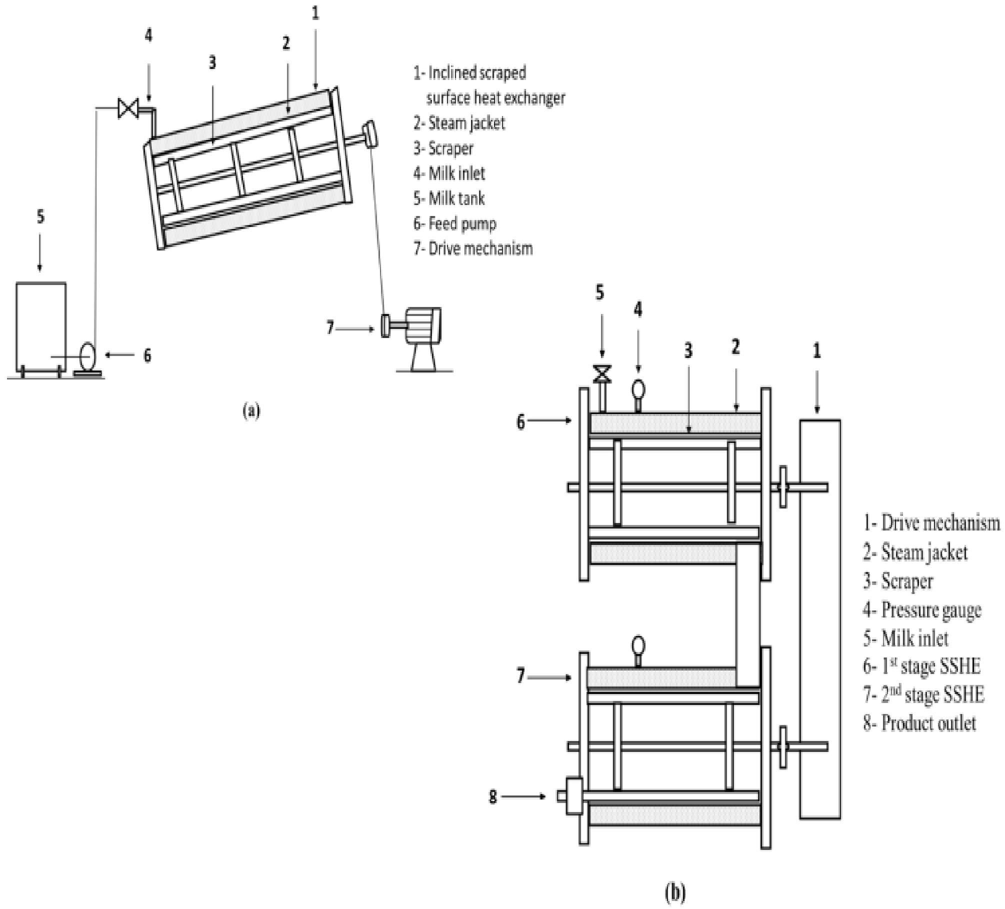


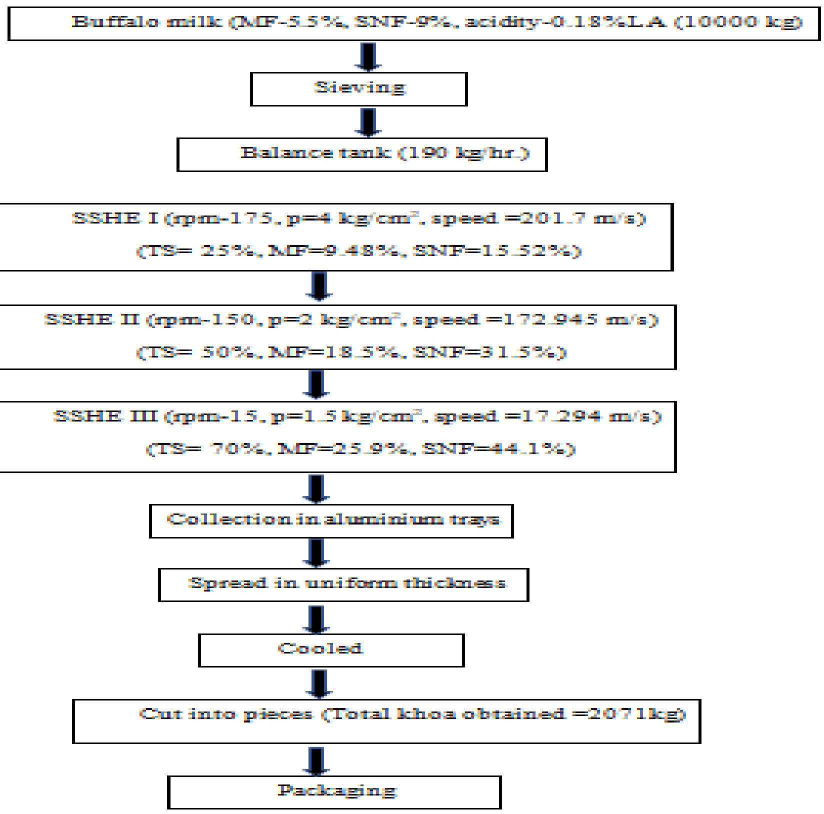
Figure 2: A mechanised processes for the manufacture of khoa (a) An inclined scraped surface heat exchanger and (b) A two-stage scraped surface heat exchanger [11].

The National Dairy Research Institute (NDRI), Karnal, India, has developed a thin film scrapped surface heat exchanger (TSSHE) for continuous khoa production based on the scrapped surface heat exchanger principle (SSHE). In this, two SSHEs are arranged in a cascade fashion. The first SSHE's rotor has variable clearance blades and runs at 3.3 rps (200 rpm). This SSHE has a concentrated the whole milk in the range of 40-45 percent TS. The concentrated milk is then pumped into a second SSHE with a different rotor design. It features two helical blades and two variable clearance blades that spin at 140-150 rpm. Both SSHEs have a steam supply line, a pressure gauge, and a vapour outlet, and are double jacketed. The cylinders in this unit are arranged horizontally, one after the other, in contrast to the ISSHE. A centrifugal pump feeds the milk into the first SSHE, while the concentrated milk is transported by gravity from the first SSHE to the second SSHE. It has a capacity of 40 kg khoa per hour [2]. The energy requirements of SSHE during khoa production were analyzed, and it was determined that three-stage SSHE may be employed successfully for continuous khoa production. The amount of steam required to make khoa ranges between 1.28 and 1.62 kg per kg of water evaporated depending on the process [12].

Table 3. Quality of khoa prepared from different mechanized systems [13]

Characteristics	ISSHE	Conical vat	Contherm-convap	Roller Process
Total solild (%)	65.6	63.1	63.8	70.9
Fat (%)	21.9	21.2	21.5	27.7
Free fat (% of total fat)	35.0	43.5	58.4	51.1
Acidity (%)	0.5	0.5	0.6	0.6
Colour (Lovibond tintometer readings)	1.61 Y	1.68Y+0.3R	2.03Y+0.5R	1.5Y
Hardness (mN)	47.5	58.1	52.01	89.7
Cohesiveness	0.5	0.5	0.4	0.4
Adhesiveness(mN)	0.3	0.7	0.8	0.5
Springiness(mN)	4.8	7.3	8.0	6.2
Gumminess(mN)	29.3	26.0	22.6	36.4
Chewiness(mm.mN)	116.4	191.2	181.1	223.9

Daneder khoa production via three-stage SSHE [14]



Alternative methods for khoa manufacturing

Alternative strategies for khoa manufacturing have also been utilised to aid in the development of mechanised operations. The viability of employing a roller dryer for khoa manufacturing was evaluated. It was observed that the khoa was extremely energy-intensive, and the khoa was flaky, dry, and lacked the necessary consistency [15]. Evaluated the use of membrane technology in the manufacturing of traditional dairy product [16]. In numerous previously examined mechanised khoa production procedures, the use of pre-concentrated milk has been considered. The reverse osmosis technology was used to preconcentrate cow milk 2-fold [17] and buffalo milk 1.5-fold [18].

Using the RO procedure

Reverse osmosis, as an energy-efficient method for pre-concentrating milk before making khoa, has a lot of potential in India. The atmospheric boiling of RO retentates in a steam kettle had been used to manufacture khoa from cow and buffalo milk. Continuous generation of khoa from RO milk retentate via SSHE is possible with this method. In the early concentration of milk, such a technique offers significant energy savings. The energy consumed in RO concentration was calculated to be around 80 kcal/kg of milk for batch processing and 25 kcal/kg for continuous processing, resulting in a net energy savings of 335 to 430 kcal/kg of milk [19].

Table 4. Comparison between Various Equipment and Processes

Characteristics	Steam jacketed kettle	Scraped surface heat exchanger	Reverse osmosis
Energy/steam consumption	1.2-1.35 kg / kg of khoa produced [20]	Low than the conventional methods [21]	Half of the normal evaporation process [22]

III. CONCLUSION

The preservation of milk solids at room temperature for longer periods of time and the production of heat-desiccated dairy products add value to milk while also creating significant work opportunities. Due to its use in the creation of a range of indigenous sweets, khoa is a commercially important item in this category. Significant study has been conducted on the mechanisation of khoa technology, and it has been concluded that TSSHE and ISSHE equipment have significant industrial potential. The majority of heat-desiccated dairy products are well-characterized, and their manufacturing processes have been standardised utilising automated or semi-automated systems. Given India's privileged position.

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