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Preparation of Khoa by Traditional and Mechanical Methods

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Authors' contributions

This work was carried out in collaboration among all authors. Authors BB, EM and RS designed the study, wrote the protocol, collected data, performed the statistical analysis, managed the literature searches, wrote the first draft of the manuscript and managed the field investigation. Authors CSR and BM read, corrected, approved the final manuscript and supported financially this study. All authors read and approved the final manuscript

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ABSTRACT

Khoa is a rich source of calcium which helps in strengthening of bones and teeth. It is helpful in osteoporosis and abundance of riboflavin in khoa helps to maintain healthy immune system. . The traditional method of khoa making has a number of drawbacks: It has a limited capacity due to batch operation which results in non-uniform product quality and thus not suitable for large volume production, inefficient use of energy and low heat transfer coefficient results in bulky equipment, large spillage losses, it requires more manual labor and sometimes burning of the product occurs which lowers its quality. In the present study a comparison between preparation of khoa by traditional method as well as mechanical method using steam jacketed khoa pan was carried out. Khoa was prepared by traditional method by stirring the raw milk continuously in a pan over a flame until the raw milk was converted into semi solid stage. The drawbacks such as vary in temperature during the experiment because of non-uniform distribution of flame and burn out of milk solids were

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identified in this method. This leads to burnt flavour and discolouration of khoa. To overcome these drawbacks of traditional method, khoa was made in a steam jacketed khoa pan installed at Dairy and Food Processing Pilot Plant, College of Agricultural Engineeering, Madakasira at a uniform pressure of about 1.5 kg/cm^2. In this mechanical method, the khoa was prepared in less time as well as it has good appearance, flavour, texture etc. compared to khoa prepared by traditional method. In traditional method, about 0.242 kg of of khoa was obtained from 0.94 kg of raw milk with addition of 0.0925 kg of sugar while 11.50 kg of khoa was obtained from 40 litres of raw milk with addition of about 4 kg of sugar when khoa was made in steam jacketed khoa pan. In this mechanical method, the khoa was prepared in less time as well as it has good appearance, flavour, texture etc. compared to khoa prepared by traditional method.

Keywords: Milk; khoa; conventional method; khoa pan; value addition of milk; milk products.

1. INTRODUCTION

India is the world's largest producer of milk and dairy products, accounting for about 13% of world's total milk production. Major portion of India's economy is based on agriculture and animal husbandry where in milk production plays vital role. India ranks first in production of milk in the world followed by United States, China and Germany. Milk Production in India was around 146 million tonnes in 2014-15 according to NDDB. Moreover, with change in consumer demands along with raw milk, value added milk products became the need of the hour. Now-a-days value added milk products like khoa, ice cream, flavoured milk, butter milk *etc.* are in peak demand.

khoa or Mawa is an important indigenous heat coagulated, partially dehydrated milk product which is very popular in large section of population throughout the country. It is obtained by heat desiccation of whole milk to 65 to 70 per cent milk solids without the use of any foreign ingredients [1].

According to Prevention of Food Adulteration Act, khoa is the product obtained from cow or buffalo milk or a combination thereof by rapid drying containing milk fat content not less than 30 per cent on dry weight basis of the final product [1], (Gupta and Gupta 2013).

For khoa making, generally traditional method is followed in which milk is heated in an open pan and continuously stirred and scraped with the help of a scraper to avoid milk solids sticking to the pan. It is estimated that about 6 lakh tonnes of khoa is produced annually, which is equivalent to seven per cent of India's total milk production [2]. Depending on the end use and the quality of milk used, mainly three commercial types of khoa are identified namely pindi, dhap and danedar which differs in composition, texture and quality [3]. Khoa is of great commercial importance due to its use for the preparation of a variety of indigenous sweets like burfi, peda, gulab jamun etc. The traditional method of khoa making has a number of drawbacks: It has a limited capacity due to batch operation which results in non-uniform product quality and thus not suitable for large volume production, inefficient use of energy and low heat transfer coefficient results in bulky equipment, large spillage losses, it requires more manual labor and sometimes burning of the product occurs which lowers its quality [4,5].

In order to overcome the above mentioned drawbacks, many attempts have been made by various researchers towards mechanization of khoa making machine. Hence the objectives of the research were prepare the khoa in a mechanical method and compare the quality of khoa obtained in traditional method.

2. MATERIALS AND METHODS

2.1 Equipments Used in Dairy Processing Plant

Equipments used in dairy processing plant were softner, steam boiler and khoa pan.

2.1.1 Softener

Softner eliminates the salts responsible for hardness from water,namely calcium and magnesium. In the softener there are millions of tiny polymer beads (resin) which carry a sodium ion charge. As the water flows over this resin,sodium ion thereby softens the water. The capacity of the softner (Fig. 1) is about 100 liters.

2.1.2 Steam boiler

The steam boiler (Model-TCEW-015) was used for the purpose of steam generation. Table 1 shows the specifications of boilers such as its maximum rated heat output, thermal efficiency, fuel consumption, dry weight as well as its height, width and diameter. Fig. 2 shows setup of steam boiler andsoftener.

Fig. 1. Softener installed at dairy and food processing pilot plant

Table 1. Specifications of boiler

Maximum rated heat output	**150 kg/hr**
Thermal efficiency	65% $\pm$ 2%
Fuel consumption	24.0 kg/hr
Dry weight	600 kgs
Overall dimensions	
Height	1000 mm
Width	800 mm
Diameter	1000 mm

Fig. 2. Setup of steam boiler and softener

2.1.3 Steam jacketed khoa pan

Steam jacketed khoa pan made of stainless steel was installed at dairy and food processing pilot plant, CAE, Madakaisra. The Khoa pan was semi-mechamixed with manual stirrer arrangement to scrap the sides of pan during khoa preparation. It has steam inlet, condensate outlet and pressure relief valve for releasing excess steam during the operation. It also has a pressure gauge which indicates the pressure during the operation. Uniform pressure of 1.5 kg/cm^2 should be maintained during the operation. Fig. 3 shows the steam jacketed khoa pan installed in the plant.

2.2 Determination of Volume of Khoa Pan

The volume of Khoa pan was calculated theoretically as well as experimentally.

2.2.1 Theoretical determination of volume of khoa pan

The volume of khoa pan was determined by considering the pan as a hemi sphere as shown in Fig. 4 and it was calculated by using eqn 1.

$$V = \frac{1}{3}\pi\, h^2\, (3r - h) \qquad \text{------------(1)}$$

V = Volume of khoa pan, m^3
h = depth of pan at the centre, m
r = radius of the pan, m

2.2.2 Experimental determination of volume of khoa pan

Experimentally, the volume of khoa pan was calculated by filling the pan with water using a glass measuring jar of one litre up to the mark where it starts over flowing.

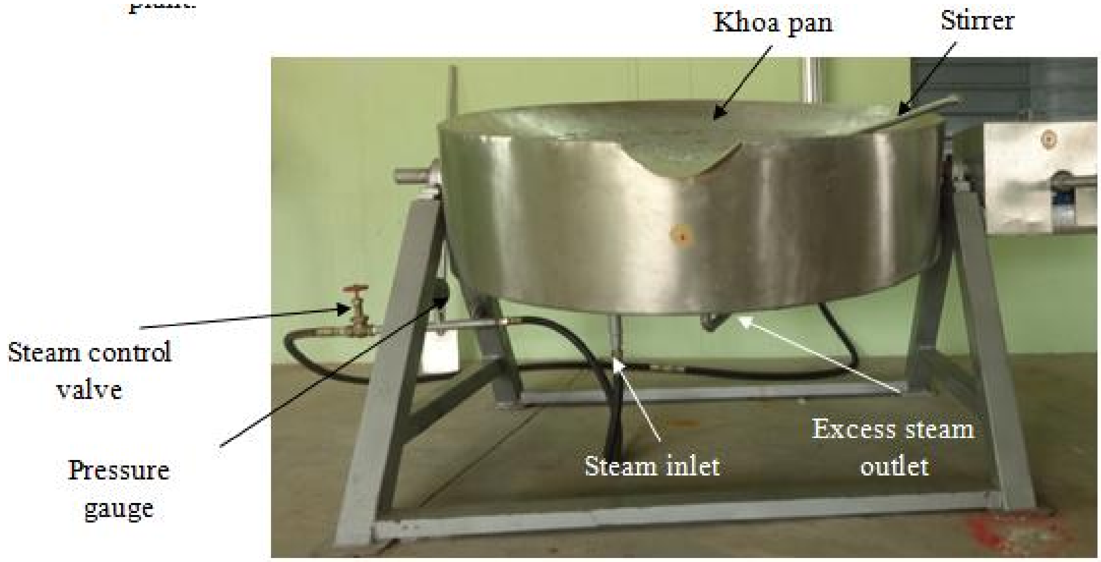

Fig. 3. Steam jacketed khoa pan installed at dairy and food processing pilot plant, CAE, Madakasira

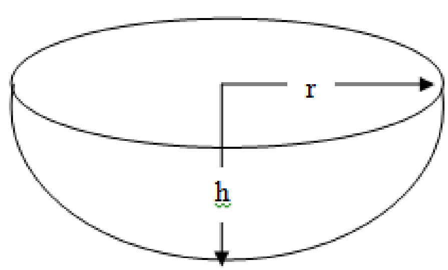

Fig. 4. Geometrical view of khoa pan

2.3 Materials

Fresh milk (cow and buffalo) was obtained from dairy farm and refined cane sugar was used for preparation ofkhoa.

2.4 Traditional Method

For preparation of khoa traditionally, 0.925 litres milk was taken and the following procedure was followed.

- The initial temperature of milk was measured by Infrared thermometer.
- Total soluble solids (TSS) of milk were calculated by taking five iterations through Refractometer.
- When the milk starts boiling the temperature was measured for every five minutes of interval.
- Ten percentage of sugar was added for one litre of milk when it reached the desired consistency and a pinch of cardamom powder was added [4].

When the desired product was obtained the moisture content was determined by oven drying method and amount of khoa produced was recorded. Flow chart for preparation of khoa was shown in Fig. 5.

2.5 Preparation of KHOA in Steam Jacketed Pan

A stainless steel double jacketed steam heated pan or evaporator was used to provide greater control of the heating process and to ensure non smoky heating. About 40litres of cow milk with 4% fat was taken and the milk was allowed to boil in the pan. During boiling, the surface of the pan was scraped and milk was stirred vigorously by a stainless steel stirrer to avoid burning of milk solids. About 1.5 kg/cm² of pressure was maintained. When the milk attained a rabri stage,

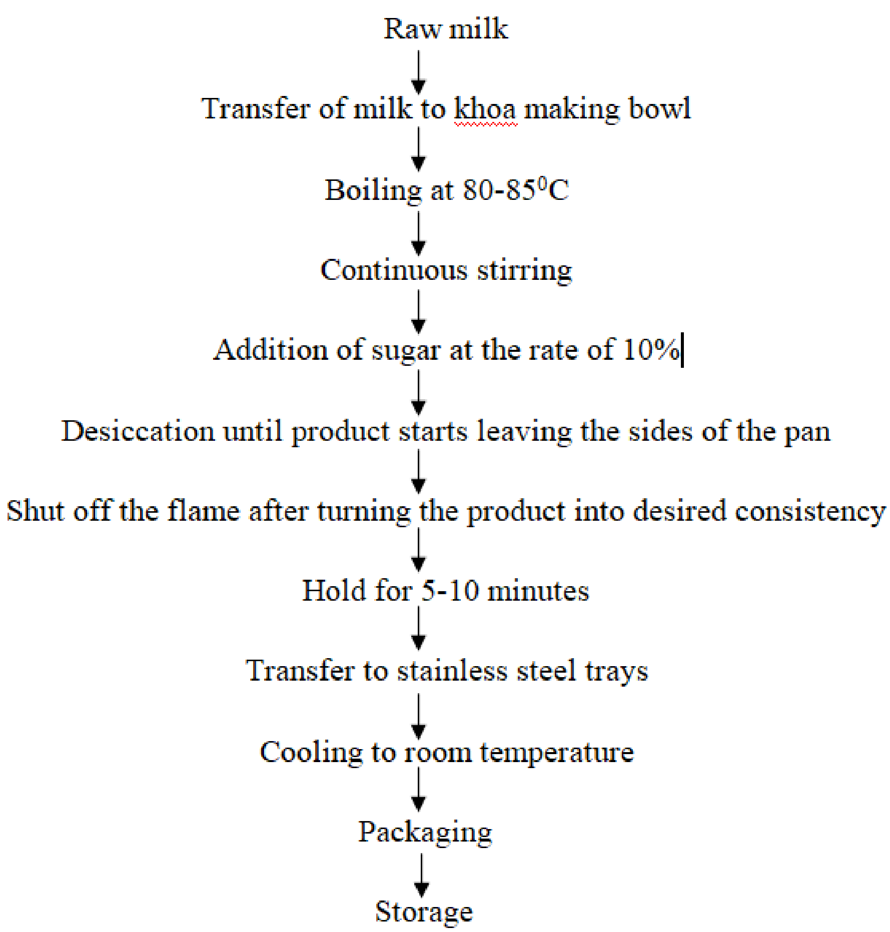

Fig. 5. Steps followed in preparation of khoa

heating was slowed down by reducing the pressure to 1.2 kg/cm^2 to prevent burning of solids on the surface, discoloration of the product, development of burnt flavour, hard body and coarse texture. The rate of stirring was increased during last stage to obtain good quality product. As soon as the product showed signs of leaving the sides of the pan, heating was stopped [2].

2.6 Mass and Material Balance

Mass and material balance are based on law of conservation of mass. The quantities of different materials passing through processing operations can be calculated by mass and material balance equation. Any processing operation can be represented diagrammatically using process flow diagrams along with the mass and fractions of different materials flowing in and out. In general the mass and material balance can be written as [6].

Mass in = Mass out + accumulation (Batch Process) .... (2)

= Mass out + losses (continuous process under steady state condition)

Raw Materials = Products + water vapour + stored material .... (3)

The steps followed in material balance in food engineering are:

- Make the process flow diagram with floe streams, mass and composition.
- Select a basis (1 kg, 10 kg, 100 kg etc).
- Make overall mass balance around a process or set of process.
- Make the component or material balance for single or set of process.
- Check the calculation.

3. RESULTS AND DISCUSSION

3.1 Volume of Steam Jacketed Khoa Pan

The volume of khoa pan was determined experimentally as well as theoretically. Experimentally it was found that khoa pan can accommodate liquid feed up to 126 litres

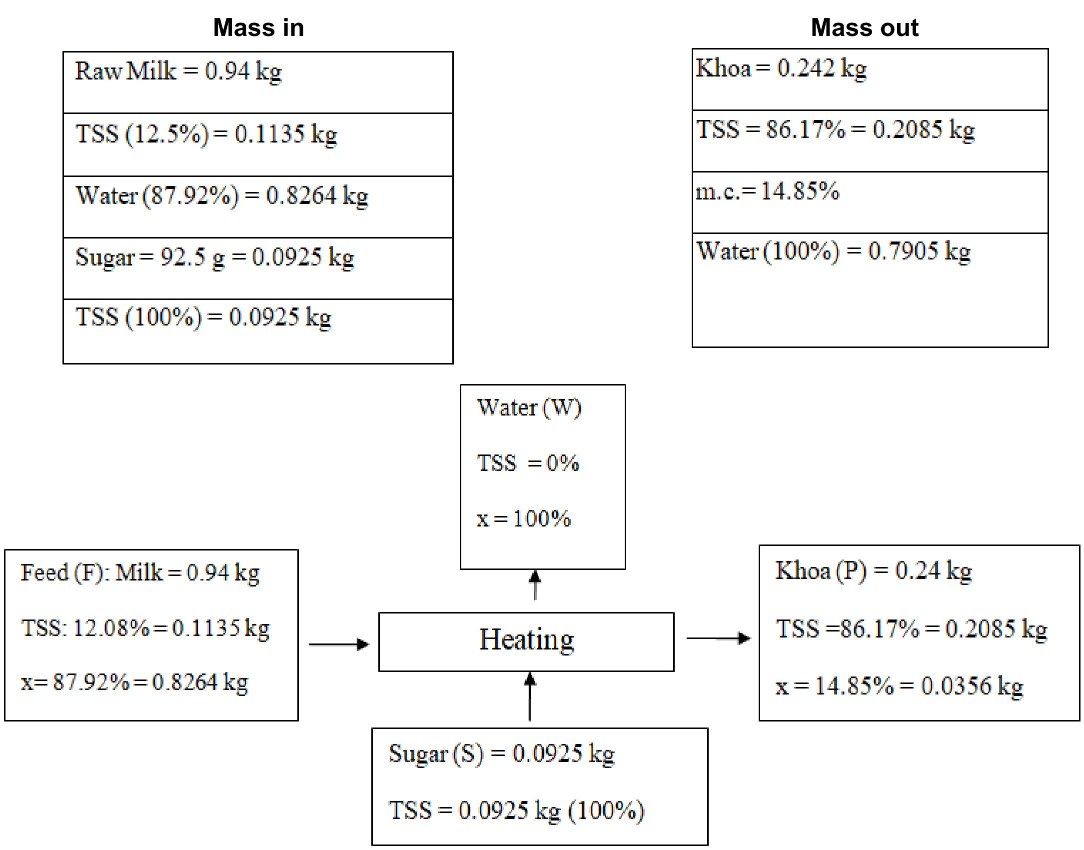

Fig. 6 Flow. sheet for mass and material balance for traditional method

whereas theoretically its volume came out to be 130.25 litres. The experimental decrease in volume may be due to presence of chute outlet discharging the khoa. Because of the presence of this chute outlet, the pan was not filled up to its full volume.

3.2 Mass and Material Balance

3.2.1 Traditional method

In this method from 0.94 kg of milk 0.242 kg of khoa was obtained and 0.7905 kg of water was evaporated. TSS in Khoa was 86.17% (0.2085kg) and about 1 hour 25 min was taken for preparation of khoa by this method. More et al., [7] also got the similar quantity i.e., 0.35 kg of khoa from one liter of milk. The following calculations were carried out to find out the quantity of different materials used during the process.

Mass Balance

Feed (F) + Sugar (S) = Product (P) + Water (W)

$$0.94 + 0.0925 = 0.242 + \text{water (W)} \quad \text{----} \quad \text{(i)}$$

Water evaporated = 0.7905 kg

Material Balance

Moisture Balance (x)

$$Fx_1 + Sx_2 = Px_3 + Wx_4$$

$$(0.94 \times 87.92) + 0 = (0.242 \times X_3) + (0.7905 \times 100)$$

$$X_3 = 14.85\%$$

Solid Balance (s)

$$Fs_1 + Ss_2 = Ps_3 + Ws_4$$

$$(0.94 \times 12.08) + (0.0925 \times 100) = (0.242 \times S_3) + 0$$

$$11.35 + 9.25 = 0.242\ S_3$$

$$S_3 = 86.17\%$$

3.2.2 Mechanical method

In this method from 40 kg of milk 11.5 kg of khoa was obtained and 32.5 kg of water was evaporated. TSS in Khoa was 76.8% (0.2085 kg). About 1 hour 15 min was taken to prepare the khoa by this method. Prakash et al., [8] got the similar quantity of khoa and time for preparation of khoa. 13 kg of khoa was obtained from 50 kg of milk and about 1 hour 40 min time was taken to prepare khoa in his work. The calculations for mass and material balance are given below.

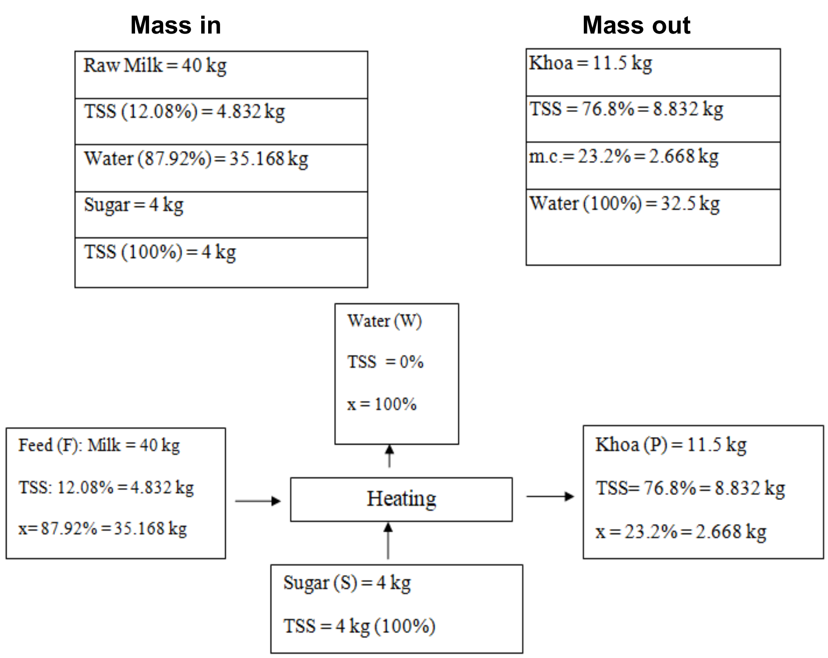

Fig. 7. Flow Sheet for Mass and Material Balance in mechanical method

Mass Balance

Feed (F) + Sugar (S) = Product (P) + Water (W)

40 + 4 = 11.5+ water (W) ---- (i)

Water evaporated = 32.5 kg

Material Balance

Moisture Balance (x)

$Fx_1 + Sx_2 = Px_3 + Wx_4$

$(40 \times 87.92) + 0 = (11.5 \times X_3) + (32.5 \times 100)$

$X_3 = 23.2\%$

Solid Balance (s)

$Fs_1 + Ss_2 = Ps_3 + Ws_4$

$(40 \times 12.08) + (4 \times 100) = (11.5 \times S_3) + 0$

$S_3 = 76.8\%$

4. CONCLUSION

Khoa occupies an important place among indigenous milk products. Khoa has considerable economic, dietary and commercial significance to the Indian population. It forms an important base for preparation of variety of milk sweets which are an integral part of the Indian food heritage. It has been observed that practically the volume accounts for 126 L whereas when calculated by theoretical method it accounts for 130.25 L. From the mass and material balances it was observed thatfor the conversion of raw milk (0.94 kg) with the addition of 0.0925 kg of sugar to Khoa (0.242 kg) by traditional method took about 1hr 25 minutes and Khoa prepared in open pan evaporator takes 1 hour 15 min and 11.50 kg of khoa was obtained from 40 litres of milk. In this mechanical method, the khoa was prepared in less time as well as it has good appearance, flavour, texture etc. compared to khoa prepared by traditional method.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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