"UTILIZATION OF NON-CONVENTIONAL; SOLAR ENERGY FOR KHOA PREPARATION"

BY

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1996

AFFECTIONATELY DEDICATED

TO MY

BELOVED PARENTS

CANDIDATE'S DECLARATION

I , hereby declare that the dissertation or part there of has not been previously submitted by me for degree of any University.

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Shri. SANJAY SURESHRAO SHAHANE has satisfactorily prosecuted his course of research for a period of not less than one academic year and that dissertation entitled , " **UTILIZATION OF NON-CONVENTIONAL SOLAR ENERGY FOR KHOA PREPARATION**", submitted by him is the result of original research work and is of sufficiently high standard to warrent its presentation to the examination. I also certify that dissertation or part there-of has not been previously submitted by him for a degree of any University.

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DATE - 17/07/1996

(P.M. PATEL)
Research Guide

CERTIFICATE II

This is to certify that the dissertation entitled " UTILIZATION OF NON-CONVENTIONAL , SOLAR ENERGY FOR KHOA PREPARATION ". submitted by Shri. SANJAY SURESHRAO SHAHANE to the Marathwada Agricultural University, in partial fulfil-ment of the requirements for the degree of MASTER OF SCIENCE (Agriculture) in the subject of DAIRY SCIENCE has been approved by the students advisory commitee after oral examination in collaboration with the external examiner.

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CHAPTER - I

INTRODUCTION

Milk is perishable in nature, so for improveing keeping quality, it can be converted into milk products. Milk can be preserved by dehydration. The indigenous heat concentrated mik products are, Rabari, basundi , kurchan and khoa.

In India khoa production exists as cottage industry. As production is unorganized it suffers from several short commings such as production in small and scattered units , lack of specilized collection, processing and marketing facilities . In our country khoa is used as base material for the prepration of various sweet products like Peda , burfi , Gulabjamun etc. According to prevention of Food adulteration rule (1976) Khoa is the product obtained from cow or buffalo (or goat or sheep) milk or combination there of , by rapid drying. The milk fat contain should not be less than 20 percent of the finished product.

The milk production of India in 1995 was 64 million tonnes(Vyas and Sodhi -1996). The production of Khoa and condensed milk products was 7.45 lakh tonnes per year which ammounted to 6.5 per cent of total milk products. (Chatterjee and Acharya 1992) so its production on commercial scale is very important.

Khoa refers to heat coagulated milk product prepared by rapid dehydration. Indigenous heat concentrated products are produced in cottage industry as traditional practice without any consideration given to quality of milk and final product. Hence, there is need to improve the method of production to ensure quality product. In rural area cowdung-cake, wooden planks, etc. are used as sourses of energy for heat processing of milk . This leads to de-forestation and loss of precious cow dung whcih can otherwise be used as a good source of manure.

In city, kerosine, coal, gas are used as sources of energy. Similarly for large scale production of these products heat exchangers, vapourizer, etc.are used which utilizes huge ammount of electric energy for their operation . Fossil fuel being non-renewable source of energy,is going to be vanished gradually. In rural area khoa obtained is of poor quality.

Taking in to consideration all above points, it can be said that solar energy is the only way of eternal energy . It is also non-conventional , non polutant, available in enormous quantity , do not require transportation, is omnipresent in day time and almost freely available in nature. Nawle (1992) found that

product obtained by utilization of solar energy was superior in quality than any other method of Khoa making. It also minimises the nutriant losses and labour required during desiccation of milk.

The maximum evaporation rate of 21.87 (ml/hr) for 7 mm column of milk was reported by Barbole (1994) .The present study is the further investigation in deciding the column height and utilization of such column of milk for large scale khoa production.

Review of Literature

CHAPTER - II

REVIEW OF LITERATURE

In order to produce a superior quality Khoa on large scale many efforts were made in the past to improve the technic of Khoa production. This was aimed at the advantage in order to save the time, energy and overall economy in the production of Khoa.

2.1 Technology for manufacture of Khoa

De and Ray (1952) reported that , inorder to obtain best textured Khoa , milk should be boiled till it reached a pasty consistancy and then temperature was lowered down to 80-88^{o}C. A continuous heating at a high temperature at later stage of Khoa making resulted in an undesirable coarse texture. It was stated further that , it was desirable to stirr the milk at a medium to high speed (94 to 100 and 150 to 160 circular stirrings per minute) during desiccation to get product of desirable texture. They also recommended that milk fat levels of 4 per cent in cow milk and 5 per cent fat in buffalo milk were desirable for preparation of good quality khoa.

De and Srinivasan (1967) utilized white butter or ghee and roller dried skim milk powder for the preparation of Khoa . The melted fat was mixed in the

reconstituted dried milk and the mixture was boiled vigorously with rapid stirring and scraping. It was found that the resultant product was having acceptable flavour, texture and desired composition though the colour was slightly caramelized.

Banerjee et al (1968) designed a pilot plant for the continuous manufacture of Khoa in order to over come the traditional system of Khoa making. The investigation was based on simple principle of heat exchanger. This method consisted of continuously heating milk, in a steam jacketed drum heater where the milk was partially concentrated, followed by further heating and concentrating the milk in an open steam jacketed pan. Over heating was prevented by scraping with power driven scrapers provided in the drum heater and in the open steam jacketed pan till the total solid contents reached to 70-75 per cent . It was claimed that Khoa could be prepared by employing this method on a large scale at the rate of 50 liters per hour.

Rajorhia (1971) used double jacketed steam heated stainless steel kettle for preparation of Khoa from 20 litres of milk by semi commercial process. He found that, this method was useful to prepare Khoa of good flavour , colour and texture.

Mulay and Ladkani (1973) utilized homogenized cow milk for Khoa production. It was reported that Khoa made from homogenized cow milk was light brown, softer in texture without appearance of free fat as compared to the Khoa made from unhomogenized cow milk.

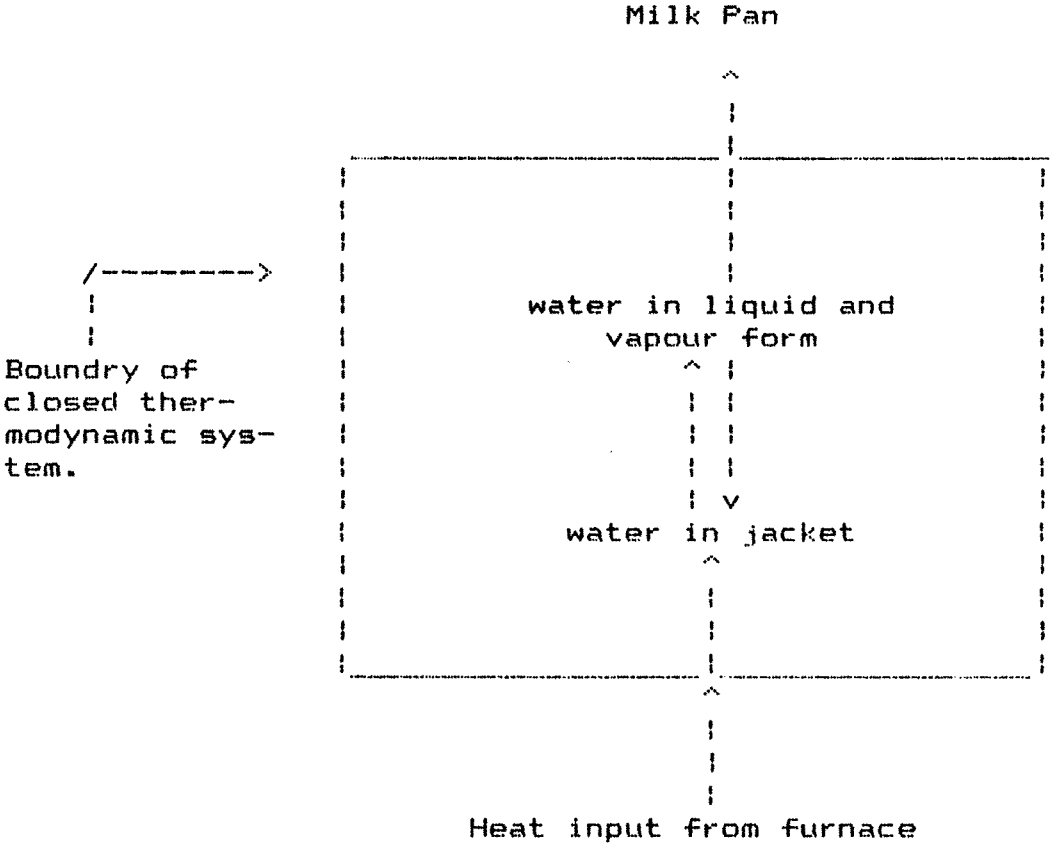
Patel and De (1977) developed method for the production of dried Khoa. The buffalo milk standardized to 5 per cent milk fat was preheated at 65-70^{o}C and homogenized . The homogenized buffalo milk was desiccated up to formation of Khoa concentrate (3:1 concentration). In this concentrated milk or Khoa concentrate calculated ammount of water was added to obtain a slurry. The slurry was micropulverized and then dried by using drum dryer. The average per cent chemical composition of dried khoa was: moisture, 3.1 , fat, 33.8 , protein, 27.2 , lactose, 30.6 and ash, 5.3 .

Anap and Bikram Kumar (1980) developed a furnace working on paddy husk and dung cake for boiling milk. The furnace was provided with chimney. It consisted of the jacketed vessel with dished bottom placed on the fire of furnace. The gasses passed through lower part of chimney were reutilized for the heating of surroundings of milk and thus economy in fuel was achieved . The milk was boiled in furnace to produce good quality khoa.

Waghmare et al (1980) studied on the preservation of milk by solar drying. Dehydration was carried out in the petri plates in direct sunlight . Maximum temp of 45^{o}C was achieved to produce the milk powder. The defects observed were the collection of milk powder was difficult . It was very difficult to spread 4 g of milk in a 62.6 square centimeter area . The milk powder obtained had pleasant flavour and sweet taste . The milk powder was quite loose and yellowish white in colour.

Sawhney et al (1981) developed a jacketed closed thermodynamic pan. The milk pan was having jacket which consisted of water. As the heat from furnace to milk followed through the water medium, heat flow could be regulated by maintaining the desired water steam pressure in the jacket . Due to even temperature profile of heat transfer, a superior quality of khoa was obtained in respect of flavour, body and texture. The capacity of khoa pan was to convert 2.5 liters of milk into khoa within 8 minutes with final moisture content of 38 per cent (wet basis).

A schematic diagram of heat flow in milk pan



(Sawhney*et al* 1981)

Prajapati *et al* (1982) observed that khoa from homogenized milk of cow and buffalo produced softer body in contrast to unhomogenized milk. They fruther reported that there was lower fat leakage ,less browning and reduced patting tendancy from khoa of homogenised milk.

More (1983) developed an equipment which consisted of double jacketed drum with inside rotating blades for stirring and scraping. The equipment required varying steam pressures at different stages of khoa making and could be maintained in the jacket by adjusting steam valve. It was claimed that the total time required per kg of milk handled for khoa making was about 7.5 minutes and over all evaporation rate was 112.69 g of water per minute.

Kherde (1985) reported that the khoa of superior quality in respect of colour, physical makeup and taste could be prepared from 15 and 20 litres of milk in ghee boiler of 285 litres capacity by foam dehydration. Further 25 litres of milk also did yield good quality khoa by this method.

Bhadania et al (1986) obtained khoa on industrial scale by roller dryer method. The milk was concentrated to 50-55 per cent total solids in a double jacketed stainless steel steam kettle with continuous stirring. The partially dried material having khoa like consistency was obtained and the material was worked to get pat form product. The flavour and taste scores of khoa prepared by roller dryer were significantly lower than that of conventional method. Colour of khoa samples was not significantly different from each other by

roller dryer and conventional method. However homogenization of milk improved the colour, appearance, body, texture and reduced free fat contents.

Agrawala et al (1987) manufactured khoa in a conical stainless steel vat consisting of a scraper with a top drive, the milk distributer, balance tank and product pumps . In each batch only about 40 kg of concentrated milk or 80 kg of whole milk was drawn in a single batch. The yield of khoa obtained was 17.60 kg from 80 kg of whole milk. For each batch 14 minutes time was required at a steam pressure of 1.5 kg/cm^2.

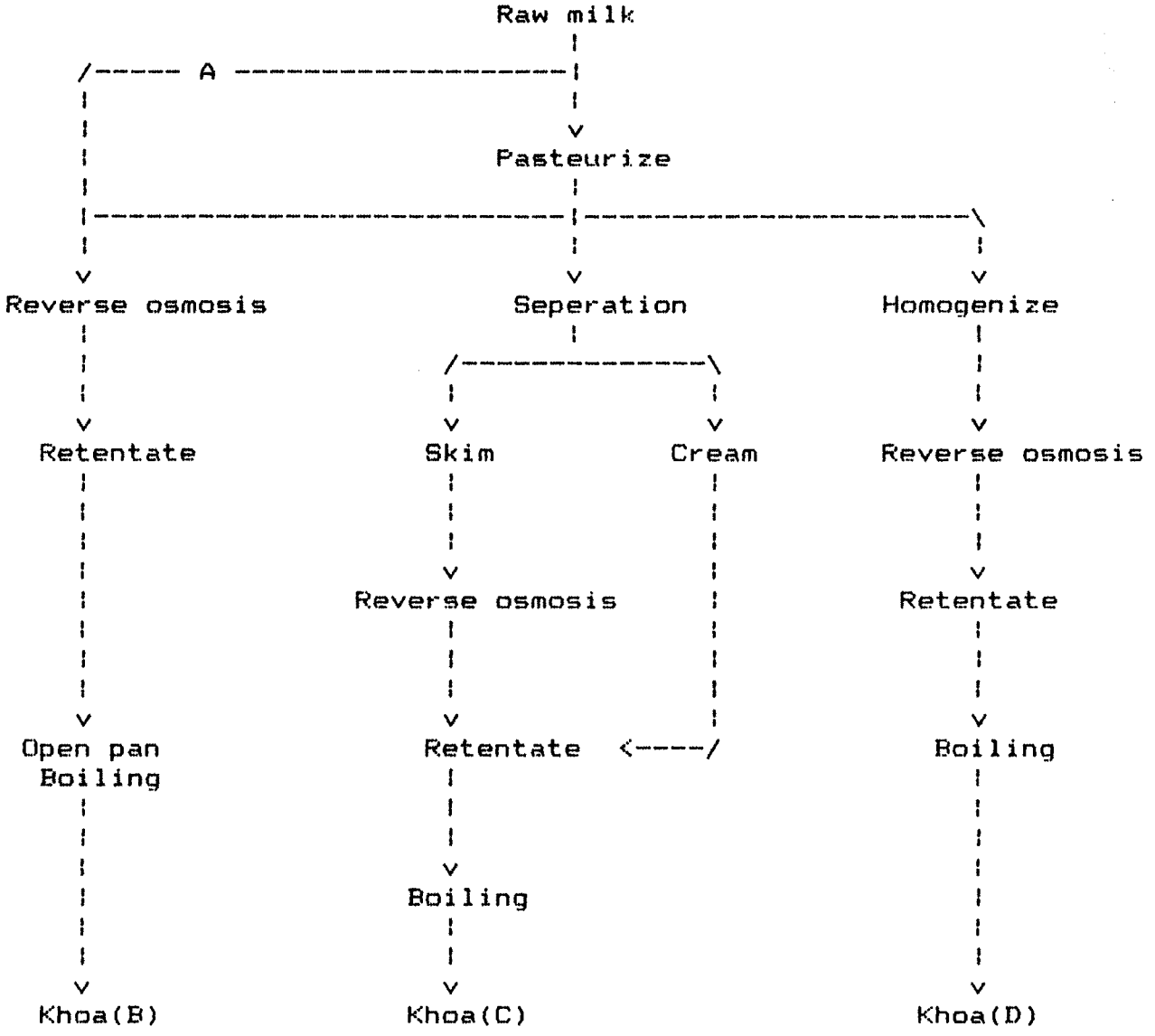
Joshi (1987) used rock bed solar heater for dehydration of milk. The milk was kept in alluminium trays in a dryer. Custard powder was added in order to reduce the time of dehydration. The trials were also taken with the addition of rice powder. It was observed that rice powder posses more water holding capacity. It was noticed that within 270 minutes time of dehydration from 110 ml milk 16.13 g of khoa was obtained .

The sugar added milk product showed more total solid content while custard powder added milk product showed a product with higher protein content. At 10 g sugar, 0.4 g rice powder and 0.4 g custard powder per 100 ml of milk superior quality product was obtained.

More(1987) developed khoa making equipment . In this method dehydration of milk was done at 121^{o} C with scraper speed of about 28 RPM. The equipment consisted of a drum with rotating scraper . The electrical energy consumed per kg of milk handled was 0.093 KWH. The yield of khoa obtained was 15.8 per cent to 22.3 per cent.

Pal and Cheriyan (1987) developed process for manufacture of khoa by using principle of reverse osmosis. The cow milk was pre concentrated from 12.5 T.S. to 31 T.S. . The khoa prepared by this method had a typical flavour and texture as compared to traditional open pan boiler method. Time required for prepration of khoa by reverse osmosis was half of the time required in traditional method. The khoa obtained by reverse osmosis method contained higher moisture and fat content over traditional method. But protein content showed no differences.

Schematic diagram of reverse osmosis process for the manufacture of khoa.

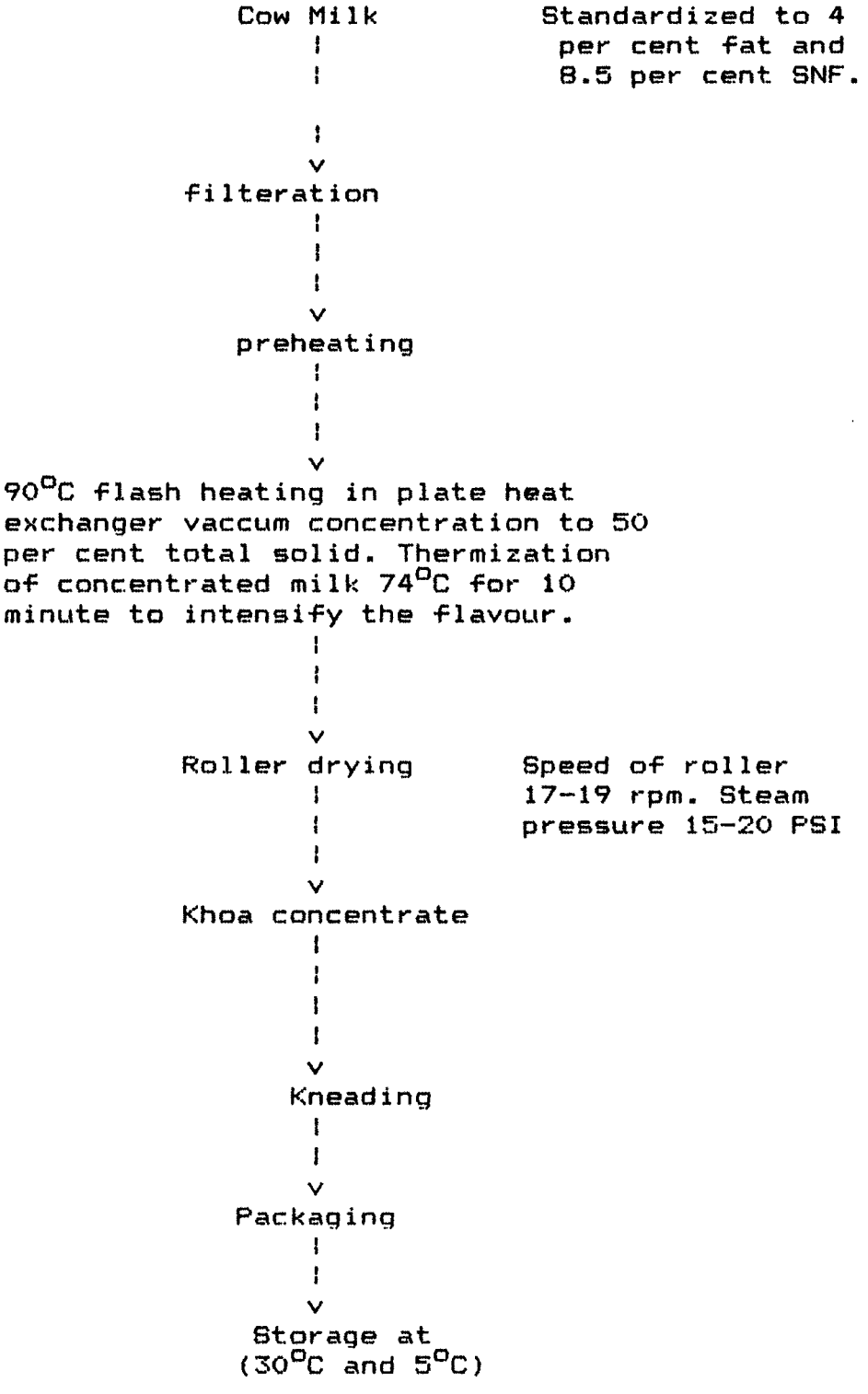


Christie and Shah(1988) developed prototype of horizontal heat exchangers of mild steel for khoa making. Per hour per batch machine could convert 50 kg of milk into khoa .

Murale(1989) reported that khoa prepared by dehydration of milk at low temp had superior in quality and less nutrient losses observed. The dehydration was carried out at a temperature of 73.9^{o}C. The specific benefit of this method is that khoa could be prepared with high protein content and less metal contamination as compared to the conventional method.

Singh and Rajorhia (1989) devised a standard method of khoa production by roller drying process. Standardized cow milk having 4 per cent fat and 8.5 per cent SNF was used. The total solids were raised to 50 per cent after vaccum concentration. Khoa prepared with roller dryer was comparatively well in flavour, texture and chemical composition to traditional method. Roller drier can be employed successfully for large scale production.

A schematic flow diagram for manufacture of khoa by roller drier method.



(Singh and Rajorhia, 1989)

Verma and Lal (1989) estimated the energy required for manufacture of khoa. Average gross energy for processing of khoa was 825.23 kcal/kg of milk in steam jacketed vat. The total thermal loss was 32.93 per cent. The energy saved by reutilization of condensate was 8.32 k.cal.

Jadhav et al (1990) prepared khoa by heat induced foam method . Excellent quality product in respect of taste , colour and physical make up was prepared by heat induced foam over the conventional method.

Punjarath et al. (1990) developed an inclined scraped surface heat exchanger for the manufacture of khoa as a continuous process. The equipment consisted of a balance tank, a positive displacement pump and an inclined scrape surface heat exhanger. By this method product obtained was of a very high quality with negligible product losses.

Rajorhia et al (1990) reported that khoa obtained from sour milk having more than 0.25 per cent acidity showed acidic smell and large grain formation in khoa. Such khoa showed hardness, springiness, guminess and chewiness. Good quality khoa can be prepared from fresh and slightly sour milk (upto 0.2 per cent acidity.) . Neutralization of sour milk with 20 per cent

sodium bicarbonate solution improved the flavour and smoothness of khoa.

Dodeja et al. (1990) worked on a horizontal thin film scraped surface heat exhanger (SSHE) for continuous khoa making. In this unit for 100 rpm rotar speed maximum steam temperature of 152^{o}C was obtained. The product of excellent colour , flavour and texture was obtained at 100 - 150 rpm rotar speed. The rotar speed of 150 rpm was considered as optimum speed.

Rajorhia et al (1991) reported performance of four mechanised system for khoa making viz conical vat, roller drier, contherm convap heat exchanger and inclined scraped surface heat echanger (ISSHE). Khoa prepared by ISSHE was similar to that of traditional product where as khoa prepared by other methods was found to be of inferior in quality as compared to traditional khoa.

Christie and Shah (1992) developed a three stage continuous khoa making machine. The khoa prepared by this method was superior over conventional method in respect of colour ,flavour and appearance. The machine has three jacketed cylinders placed in a cascade arrangement which facilitated easy transefer of milk from one cylinder into other which worked as heat

exhanger. The machine converts 50 kg of milk in to khoa per hour.

Dodeja et al. (1992) studies on designing operation and performance of continuous khoa making system. In this machine there were two scraped surface heat exchangers (SSHE) arranged in cascade fashion. The machine having four clearance blades. The milk was concentrated upto 40-45 per cent total solids. The first SSHE which was operated at 3.3 revolution per second and second SSHE operating at 2.5 revolution per second. Buffalo milk was standardized for solids not fat to fat ratio at 1.4 : 1 . The milk was filled in feed tank the pressure was adjusted to 250 kpa . The flow of milk was kept constant at the rate of 150 kg/hr . The score obtained for continuous system which was little lower for flavour and body but higher for texture as compared to conventional method of khoa making . A uniform quality product and economy in energy utilization were the most important attributes of SSHE khoa making system.

Nawle (1992) used solar energy for khoa production. Different thickness of skim milk column was kept in alluminium vessel inside the domestic solar cooker for dehydration. In this concentrated milk, cream was added and then such milk was worked in kadhai. It

was reported that the maximum total moisture removed at 1.26 cm thickness of milk film in 7.33 hours and evaporation rate 22.23 ml/hr was obsereved. The maximum moisture removed ($ml/cm^2/hr$) was 0.0959 at 1.52 cm thickness of milk film. The highest per cent of moisture removed was 69.80 at 0.63 cm thickness of milk film in 7 hours. The solar khoa had less caramelized flavour and slight salty taste but over all acceptability was observed to be more in solar khoa as compared to conventional one.

Surinder kumar and Dharm Pal (1994) studied on production of khoa , concentrating buffalo milk by reverse osmosis . The buffalo milk was standardized to 6 per cent milk fat.

This milk was preheated to $60^{o}C$ and then cooled to $50^{o}C$. By the help of reverse osmosis this milk was concentrated to (i) 1.5 and (ii) 2.0 fold concentration. The khoa prepared up to 1.5 concentration was similer to that of control khoa and superior over khoa prepared by keeping 2 fold cocentration . The body and texture of both the khoa were inferior to that of conventional one. But there were no significant differences in colour and appearance . It is concluded that khoa of acceptable quality can be made from milk concentrated to 1.5 fold by reverse osmosis.

Barbole (1994) worked on solar energy for khoa preparation. Experiment was conducted in two phases. In first phase seven different thickness of milk column (film) were taken as 1,2,3,4,5,6 and 7 mm. In first phase maximum evaporation rate ml/cm^2 was observed at 7mm thickness (21.87). In second phase by keeping 7mm thickness of milk column constant volume of milk was increased to double and quadruple times of the original volume.

The evaporation rate was maximum at quadruple (71.99) and lower in double(40.98). The yield of khoa obtained on per litre basis (g) was maximum in solar method which was 189.38 for treatment quadruple . Solar dehydration method was superior over conventional method in respect of energy saving , maximum per cent recovery, superior-sensory attributes and uniform quality product.

2.2 The chemical composition of Khoa

The chemical compostion of khoa was reported by various workers is as follows :

The Chemical Composition of Khoa. (Per cent)

Author	Species of milk	Moisture	Total solid	Fat	Protein	Lactose	Ash	Acidity	Cane sugar
Srinivasan and Anantkrishnan (1964)	cow (215)	25.6	--	25.9	19.2	25.6	3.7	---	----
	Buffalo (215)	19.3	--	37.1	17.8	22.1	3.7	---	----
Anonymous (1966)	----- (620)	----	67.8 to90.1	13.5 to34.0	6.0 to20.0	10.5 to20.3	---	0.3 to0.6	10.1 to49.6
Ghodekar et al (1974)	cow (245)	19.26 to28.41	71.0 to76.0	25.0 to28.8	15.0 to23.1	23.5 to27.2	3.0 to5.0	----	----
Kumar and Srinivasan (1982)	Cow (90)	30.6 to31.1	68.8 to69.4	21.9 to22.2	19.1 to19.2	24.1 to24.3	3.7 to3.8	0.5 to0.6	----
Jadhav et al (1990)	cow (28)	24.84	75.16	24.63	19.2	-----	3.72	-----	-----
Nawle (1992)	cow (32)								
	solar khoa	24.08	74.56	23.55	16.23	------	3.45	0.54	-----
	conventional khoa	24.18	74.38	23.32	16.20	------	3.44	0.51	-----
Barbole (1994)	cow (40)								
	solar khoa	25.66	74.33	-----	-----	-----	-----	-----	-----
	conventional khoa	26.00	74.00	------	-----	------	-----	-----	-----

Number of sample evaluated are shown in bracket.

2.3 Use of solar energy in other food products.

Kalra and Bhardwaj (1981) used the simple solar dehydrator for drying of fruit and vegetables. The maximum temperature obtained was 70^{o}C in 12 hours period. The moisture was reduced to 7 per cent in 8 hours in mango slices while in open atmosphere within a period of 9 hours the final moisture of 8 per cent was attained. In case of fruits the moisture was reduced from 83 to 25 per cent within 12 hours period. In vegetables like green peas moisture was reduced from 75 to 5 per cent in 9 hours period. Below this level of moisture the quality of peas was deteriorated.

Maini et al (1984) discussed the use of solar cooker for dehydration of potato chips which were pretreated with hydrochloric acid. It was reported that the temperature achieved was in range of 45 to 90^{o}C in the solar cooker. The concentration of HCL used was 2 per cent, to dehydrate that strach in less than 5 hours.

Borade (1986) worked on solar dryig of grapes. The experiment was conducted by using the five types of solar dehydrators. The initial moisture level of 78 per cent reduced to 20.2 per cent during the formation of raisin. The time required was 40 hours in rockbed type air heater, 42 hours in air heater with iron foils and 75 hours in cabinet dryer. The superior quality raisins were obtained by cabinet dehydrator.

Pawar et al (1988) worked on solar drying of onion flakes using four different types of dehydrator and air heaters. In solar cabinet dehydrator time required was 14.5 hours for sulphited samples, the maximum temperature obtained was 57^{o}C in it. In a solar heater the maximum temperature obtained was 84^{o}C within the chamber in 12 hours. The initial moisture of onion flakes at 87.2 per cent reduced to 5.18 per cent . A superior quality in respect of texture , reduced browing and better overall acceptability was obtained by the cabinet type of solar dryer.

Rai (1990) observed the dehydration of tomato by using three types of solar dryer. viz Rockbed solar dryer, cabinet solar dryer and sundrying . The average temperature recorded as 50.5^{o}C , 36^{o}C and 30^{o}C in rockbed, cabinet solar dryer and sun drying respectively. The moisture was reduced from 93.2 to 93.8 per cent to 8.2, 12.5 and 10.2 per cent within 14 , 21 and 19 hours in respective drying methods.

Mukherjee et al (1990) discussed on solar dryer for fish drying. In this dryer the maximum temperature rise over the ambient temperature was 18 to 24^{o}C during 11.00 to 15.00 hours during the months of September to April. The drying was continued for 2 to 3

days within a duration of 6 to 7 hours each day. The moisture was reduced from 73.40 per cent to 61.46 per cent in first day, 46.72 for second day 32.91 per cent for third day in the month of february. The dryer had capacity 56 kg of fish per batch.

Patel(1994) worked on dehydration of vegetables by use of solar cooker. Fenugreek , brinjal , cluster beans and lady-finger were subjected to dehydration in direct sun rays and by using solar cooker under two conditions (covering with black cloth and without covering). Evaporation rate per hour and per square centimeter surface area was found highest in solar cooker when vegetables were dried under covered condition. The rate of moisture removed was maximum at initial stage of dyring period in all selected vegetables .In covered condition fenugreek was found to be dried at (97.33^{o}C) within 60 minute. In dried fenugreek the moisture retained was 1.65 per cent , the same pattern was found for brinjal with 100^{o}C temperature , 105 minute with , 1.65 final moisture content , For cluster beans at 101.7^{o}C temperature ,135 minute required for drying with 1.52 per cent moisture retained. The lady-finger was dried at 92.69^{o}C in 105 min with 1.65 per cent final moisture.

Materials and Methods

CHAPTER - III

MATERIALS AND METHODS

The details of investigation carried out for the preparation of Khoa by using solar energy are described below.

3.1 Milk

Cow milk was used for preparation of Khoa . The milk was collected from Dairy farm, college of Agriculture ,Marathwada Agricultural University,Parbhani.

3.2 Solar cooker

The experiment was conducted in two phases.In first phase dehydration of milk was done by using domestic solar cooker with reflector. It had dimentions of 56x49x19cm^3(Fig.A). The solar cooker consist of rectangular enclosure insulated on the bottom and sides having two glass cover and reflector on the top.The cooker consist of four vessels.

The second phase, dehydration of milk was done by using community solar cooker with reflector. It had dimensions of 168x49x19cm^3 (Fig.B). The cooker consist of rectangular enclosure insulated on bottom and sides having seperate glass covers for three seperate compartments. The cooker consist of three vessels.In both solar cooker solar radiation enters through the top and heats up the enclosures in which milk is to be dehydrated in shallow vessels.The dimensions of vessels used in present investigation were as below.

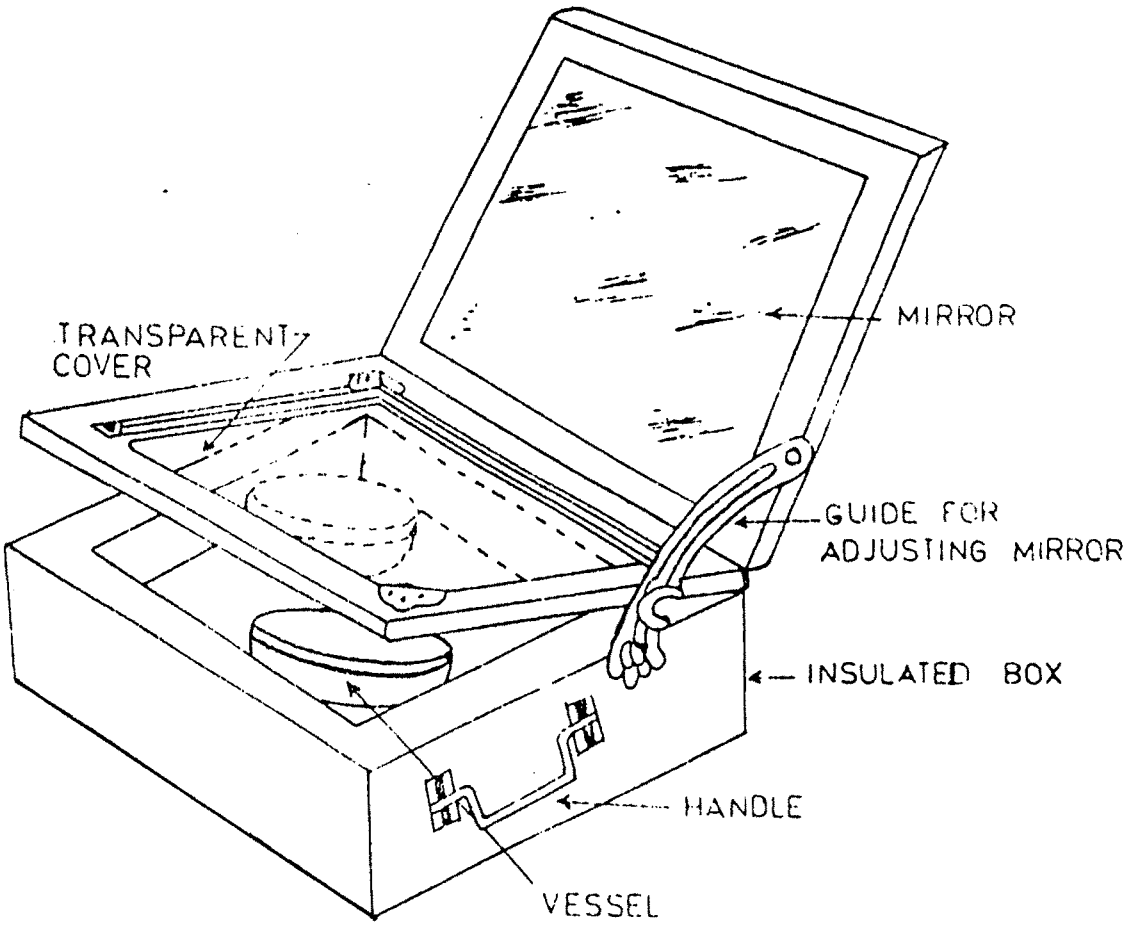


FIG. — A DOMESTIC SOLAR COOKER

PHASE NO.	DIAMETER OF VESSEL (cm)	SURFACE AREA (cm^2)	NUMBER OF VESSELS
PHASE I	19.5	298.76	4
PHASE II	27.6	598.52	3
	39.0	1195.07	3

3.3 kadhai

Iron kadhai was used for preparation of Khoa by conventional method. Dimensions were: top diameter 54 cm and depth at center 16 cm.

3.4 Ulthane (khunti)

Iron stirrer/ulthane was used for final working of the product. Dimensions were, lenth 59 cm and width at flat end 7 cm.

3.5 Solar dehydration for preparation of khoa.

In first phase six different hights of milk columns (film) were taken as 8, 9, 10, 11, 12 and 13 mm. From these such a treatment was selected which shows the highest evaporation rate ($ml/cm^2/hr$) and taken for second phase.

In second phase for this selected height of milk column the volume of milk was aimed to be increased to double and quadruple times of the original volume. The milk was seperated by using electrically operated

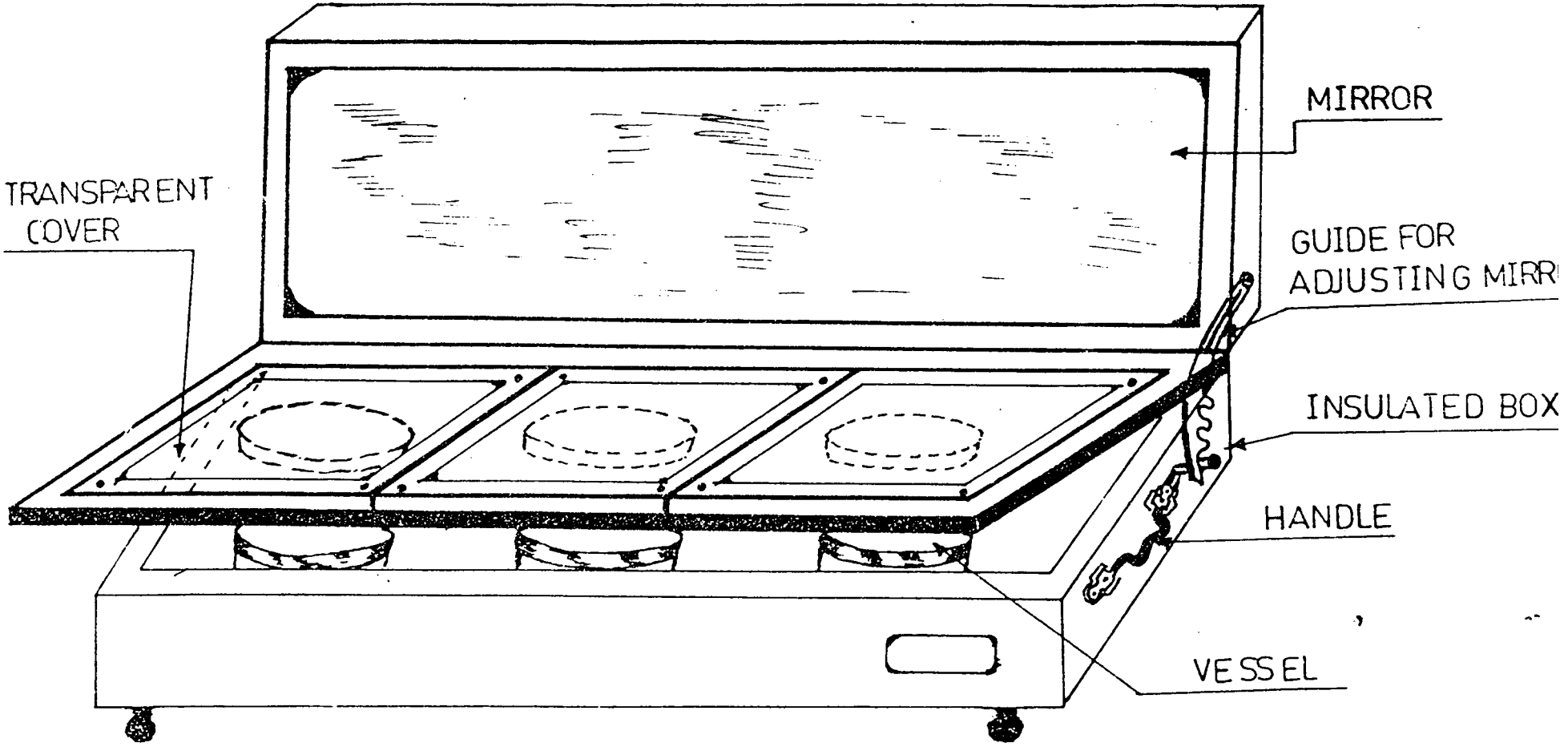


Fig-B Community Solar Cooker

cream seperator. The required quantity of skim milk was transfered to each vessel as per treatments indicated below.

Phase No.	Treat-ment	Height of milk column (mm)	Load (ml/cm^2)	Initial qty.of skim milk kept in each vessel(ml)	Total qty. kept in solar cooker (ml)
Phase I	T_1	8	0.8	239.0	956.00
	T_2	9	0.9	268.9	1075.00
	T_3	10	1.0	298.8	1195.20
	T_4	11	1.1	328.6	1314.40
	T_5	12	1.2	358.5	1434.00
	T_6	13	1.3	388.4	1553.60
Phase II	T_{6A}	13	1.3	776.8	2330.40
	T_{6B}	13	1.3	1553.6	4660.80

Seperation of milk avoids formation of skin above the milk surface, which facilitate evaporation. The vessels containing milk was transferred to solar cooker in morning at 8.30 a.m. and kept upto 4.00 p.m.

Spirit level was used to level cooker in order to obtain uniform height of milk column . Small glass rods were kept in between vessels and lid to facilitate the removal of vapours. Glass cover of solar cooker was so closed as to keep small vent in order to

avoid over heating of skim milk, as well as to give a vent for vapours produced in solar cooker.

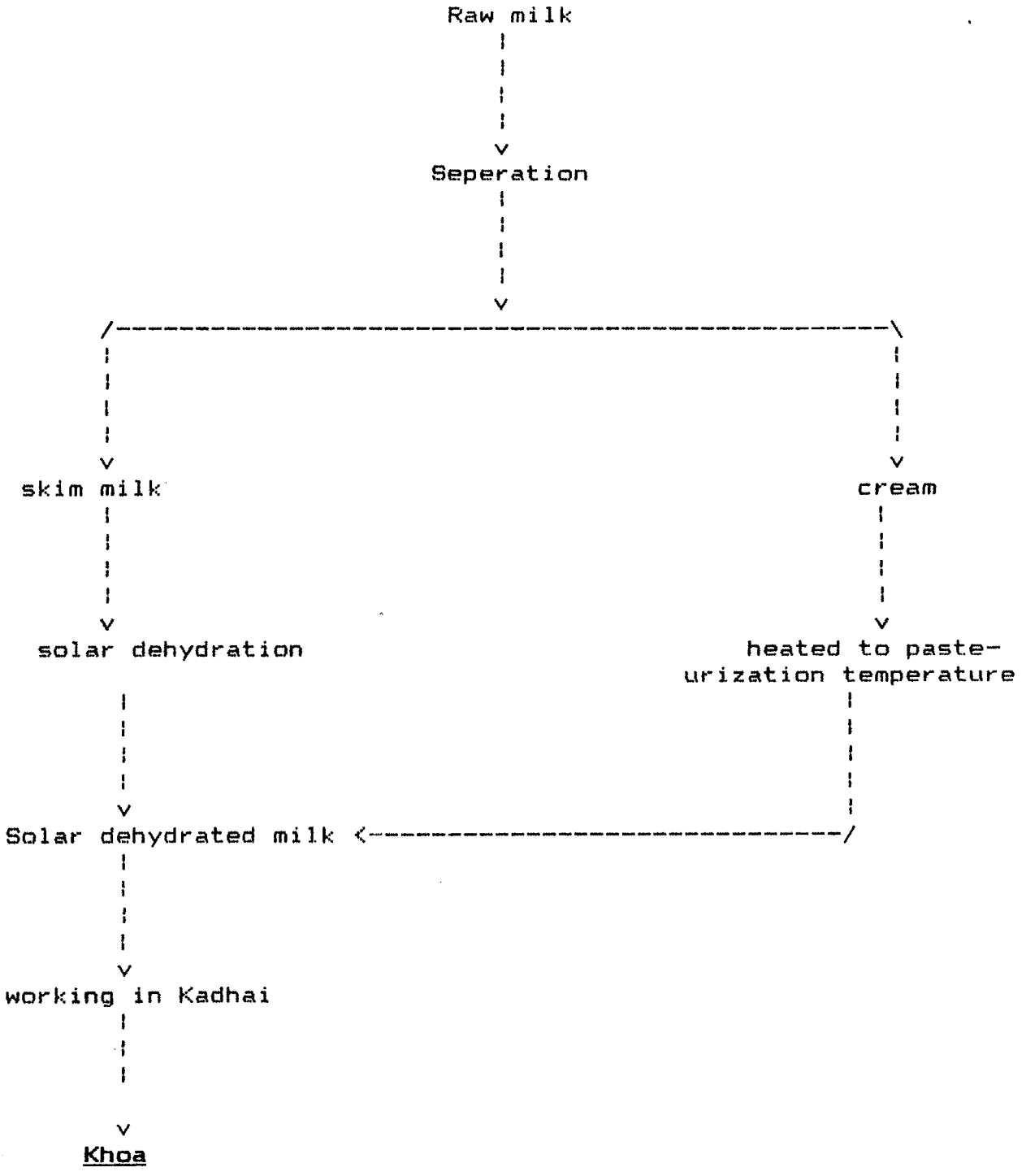
The solar cooker protect the inside milk from the insect and dust particles. the vessels are painted with black colour only on outer sides which absorbs heat efficiently from sun-rays.

Finally solar cooker was setup by adjusting mirror with sunrays falling on the vesels. The position of solar cooker was changed from time to time so as to face the sun .

Thermometer was kept inside the cooker for recording temperature. At the end of period dehydrated milk from each vessel was weighed seperately and then mixed together in kadhai. At the same time calculated quantity of Pasteurized cream was added to simulate whole milk.

Final working of the product was carried out on kerosine stove. The time required for working was recorded . The observation in respect of time required for dehydration, moisture evaporation, yield of final product, time required for final working was recorded.

Schematic flow diagram of solar dehydration process for manufacture of khoa



3.6 Conventional method

The khoa prepared by conventional method was used as control over treatments of solor method.The Khoa of all trials was collected on parchment paper . All the observations were recorded as in case of solar method.

3.7 Evaluation of Khoa

The Khoa samples were evaluated for physical ,chemical and organolyptic parameters .

3.7.1 Chemical analysis

The Khoa prepared by solar and conventional method were subjected to chemical analysis, viz. moisture,total slids, fat,protein and lactose.(Appen. I)

3.7.1.1 Determination of moisture

Moisture was determined by the method of Chaudhari (1959). For moisture 3 g of Khoa sample was weighed in evaporating dish and heated in oven at 100^{o}c. The process of heating continued till constant weight was obtained .

$$\text{Moisture } \% = \frac{\text{Losss in weight}}{\text{Weight of sample}} \times 100$$

(29)

3.7.1.2 Determination of total solids

Total solids were determined by deduction method .

% Total solids = 100 - % moisture

3.7.1.3 Determination of Fat

Fat was determined by the method of Chaudhari (1959). For fat 1.690 g of Khoa sample was wighed accurately . 10 ml of H_2So_4 (1.825 sp.gr.) was added into Gerber's milk butyrometer . Then 10 ml of distilled water along with 1.690 of khoa added in butyrometer and then 1 ml of amyl alcohol was poured in it . Shaken after fitting the stopper until the sample was disolved . Centrifuged for 5 minutes . Butyrometer was put in water bath at temp. of 67.7^{o}c and centrifuged again for 3 minutes.The reading of fat column was taken.

$$\% \text{ Fat in khoa} = \frac{\text{Reading} \times 11.25}{1.69} \times 100$$

3.7.1.4 Determination of protein

Protein was determined by the method of Chaudhari (1959). Well mixed 2 g. khoa sample was taken into clean Kjeldahl's flask. About 25 ml. of nitrogen free

sulfuric acid was added in it and then flask content was gently heated in fume chamber. At the time when fumes appear, about 10 g of Potassium sulphate and 1 g of copper sulphate was added.Then strongly heated. The flask was occasionally rotated to wash down any carbonacious matter remaining on the sides of the flask above the liquid. When the contents became colourless, it was allowed to cool,diluted with water and transfered to distillation flask.From graduated cylinder 80 ml of 40 % of NaOH solution was added in to distillation flask so as to form a seperate layer at the bottom. Accurately 50 ml of 0.1 N. H_2So_4 was taken into beaker . The beaker was placed below the condenser in such a way that the tip of condenser should be emersed in 0.1 N H_2So_4 solution. Start distillation.

When about 200 ml distilate had been distilled ,the condensing flask was disconnected.The tip of condensing tube was washed with distilled water. The distillate was titrated with 0.1 N NaOH using methyl red indicator. At the end point the colour changed from red to yellow.

$$\text{\% Nitrogen in Sample} = \frac{\text{No.of ml of 0.1 N } H_2So_4 \text{ neutralized} \times 0.0014}{\text{Weight of khoa taken}} \times 100$$

The percent of Protein = % of Nitrogen in Khoa x 6.38

3.7.1.5 Determination of lactose

Lactose Content of Khoa was determined by the procedure described in laboratory manual (1962). Well mixed 10 g of khoa sample was weihged in a 100 ml volumetic flask. To this 1-2 ml of 10 percent acetic acid was added and diluted with 90 ml distilled water. The content of flask was warmed slowly to boiling point. Then it was removed from flame and cooled. The volume was made to 100 ml by adding distilled water shaken well. The flask content was filtered into beaker. The filtrate was filled in a burette. This was titrated against 10 ml quantitative benedicts solution in a conical flask with 1 gram of sodium bicorbonate. The titration was done in boiling condition. The titration was continued till the blue colour disappeared.

$$\% \text{ of lactose} = \frac{100 \times 0.0268}{\text{Burette reading}} \times 100$$

3.7.2 Organolyptic evaluation

The extent of acceptability of the products prepared under different treatments were decided by organolyptic evaluations viz. colour, flavour, physical

makeup. The product was served to judging panel consisting of nine judges . The judges were not aware about the treatment details.

In first phase each trial was repeated for 4 times hence 36 observations of each comparative method (i.e. solar and conventional) were obtained from judges.

In second phase each trial was repeated for 6 times hence 54 observations of each comparartive method (i.e. solar and conventional method) were obtained from judges. Every judge was supplied with score card comprising "nine" point hedonic scale. For colour, flavour , physical makeup and overall acceptability developed by quarter master, food and container institute, U.S.A.(Gupta 1976).

The numerical values for colour, Flavour , Physical makeup and overall acceptability were given below :

9 Liked extremely

8 Liked very much

7 Liked moderately

6 Liked slightly

5 Neither liked nor disliked

4 Disliked slightly

3 Disliked moderately

2 Disliked very much

1 Disliked extremely

3.8 Energy Studies

The calorific value of kerosine is 9600 kcal/lit (Jagdishwar Sahay 1992). The one litre of cow milk was converted in to khoa by conventional method on kerosine stove. The average time required was 30.33 minutes with 133.5 ml of kerosine consumed. Hence, average gross energy required for preparation of khoa was 1281.6 kcal/lit of milk and 42.25 kcal/min . In present study energy was estimated on these estimated units. (Appen. II).

3.9 Statistical analysis

The data were analised by completly randomized design for all the parameters and factorial completly randomized design for comparative study.

Results and Discussion

CHAPTER - IV

RESULTS AND DISCUSSION

The maximum evaporation rate of 21.87 (ml/hr) for 7mm column of milk was reported by Barbole (1994). The present study is the further investigation in deciding the column height and utilization of such column of milk for large scale khoa preparation.

The studies were catagorised into following headings.

4.1 I Dehydration characters ofkhoa prepared by solar method.

II Dehydration characters of khoa prepared by solar method in scale-up studies.

4.2 I Recovery characters of khoa prepared by solar method.

II Recovery characters of khoa prepared by solar method in scale-up studies.

4.3 I Recovery characters of khoa prepared by conventional method.

II Recovery characters of khoa prepared by conventional method in scale-up studies.

4.4 I Comparative studies on recovery characters of khoa prepared by solar and conventional method.

II Comparative studies on recovery characters of khoa prepared by solar and conventional method in scale-up studies.

4.5 I Energy studies of solar khoa.

II Energy studies of solar khoa in scale-up studies.

4.6 I Comparative studies on chemical composition of solar and conventional khoa.

II Comparative studies on chemical composition of solar and conventional khoa in scale-up studies.

4.7 I Comparative studies on sensory characters of solar and conventional khoa.

II Comparative studies on sensory characters of solar and conventional khoa in scale-up studies.

4.1 Dehydration characters of khoa prepared by solar method.

It is interesting to note from the Table No.1A that , the treatments for solar dehydration were nominated according to the height of milk column (mm) from T_1 to T_6. For all these treatments dehydration was carried out by using domestic solar cooker. The volume of milk was taken according to the height of milk

Table No. 1 A : Dehydration characters of khoa prepared by solar method.

Treatment No.	Initial quantity (ml)	Height of milk column (mm)	Load (ml/cm^2)	Total moisture removed (ml)	% Mositure removed	Time (hrs)	Evaporation rate (ml/hr)	Moisture removed ml/cm^2	Evaporation rate ($ml/cm_2/hr$)
T_1	239	8	0.8	138.95	58.14	6.27	22.16	0.465	0.0742
T_2	268.90	9	0.9	152.59	56.75	6.645	22.96	0.511	0.0769
T_3	298.80	10	1.0	163.96	54.87	6.98	23.50	0.549	0.0787
T_4	328.60	11	1.1	171.68	52.24	7.15	24.00	0.575	0.0804
T_5	358.50	12	1.2	185.63	51.78	7.29	25.46	0.6215	0.0853
T_6	388.40	13	1.3	197.63	50.88	7.50	26.35	0.661	0.0882
			SE +	0.769	0.249	0.0311	0.0668	0.00259	0.00023
			CD	2.347	0.762	0.0948	0.2043	0.00790	0.00070

column. In case of treatment T_1 the height of milk column was 0.8 ml/cm^2 which was gradually increased up to 1.3 ml/cm^2 in case of T_6.

1.Total moisture removed.(ml)

All the treatments T_1, T_2, T_3, T_4 T_5 and T_6 were significantly different. With increase in column of milk the values of total moisture removed increased from T_1 i.e. 138.95 ml to T_6 i.e. 197.63 ml respectively. Total moisture removed in treatment T_6 was significantly higher than rest of the treatments.

It is clear from this table that, with increase in quantity of milk, as well as height of milk column, total moisture removed was increased.

2. Per cent moisture removed.

All the treatments T_1 T_2 T_3 T_4 T_5 and T_6 were significantly different except T_4T_5 which were at Par. The per cent moisture removed maximum in case of T_1 i.e. 58.14 and lowest in case of T_6 i.e. 50.88 .

Therefore, it can be asserted that, per cent moisture removed depends upon height of milk column.

3.Time (hrs.)

All the treatments T_1 T_2 T_3 T_4 T_5 and T_6 were significantly different. The evaporation time

varied from 6.27 hours in case of T_1 to the 7.50 hours in case of treatment T_6.

Therefore, it can be asserted that, the initial height of milk column was the deciding factor of evaporation rate.

4.Evaporation rate (ml/hr)

All the treatments T_1 T_2 T_3 T_4 T_5 and T_6 were significantly different. The trend observed was numerical increase in evaporation rate (ml/hr) from T_1 i.e. 22.16 to T_6 i.e. 26.35 which was significantly higher than rest of the treatments.

From this it is clear that, evaporation rate (ml/hr) depends upon initial height of milk column.

5. Moisture removed (ml/cm^2)

There were significant difference observed in all the treatments T_1 T_2 T_3 T_4 T_5 and T_6 . The significantly higher value for moisture removed was observed in treatment T_6 i.e. 0.661 and lowest in treatment T_1 0.465.

Moisture removed was increased with increase in height of milk column.

6.Evaporation rate ($ml/cm^2/hr$)

All the treatments T_1 T_2 T_3 T_4 T_5 and T_6 were significantly different. The trend for

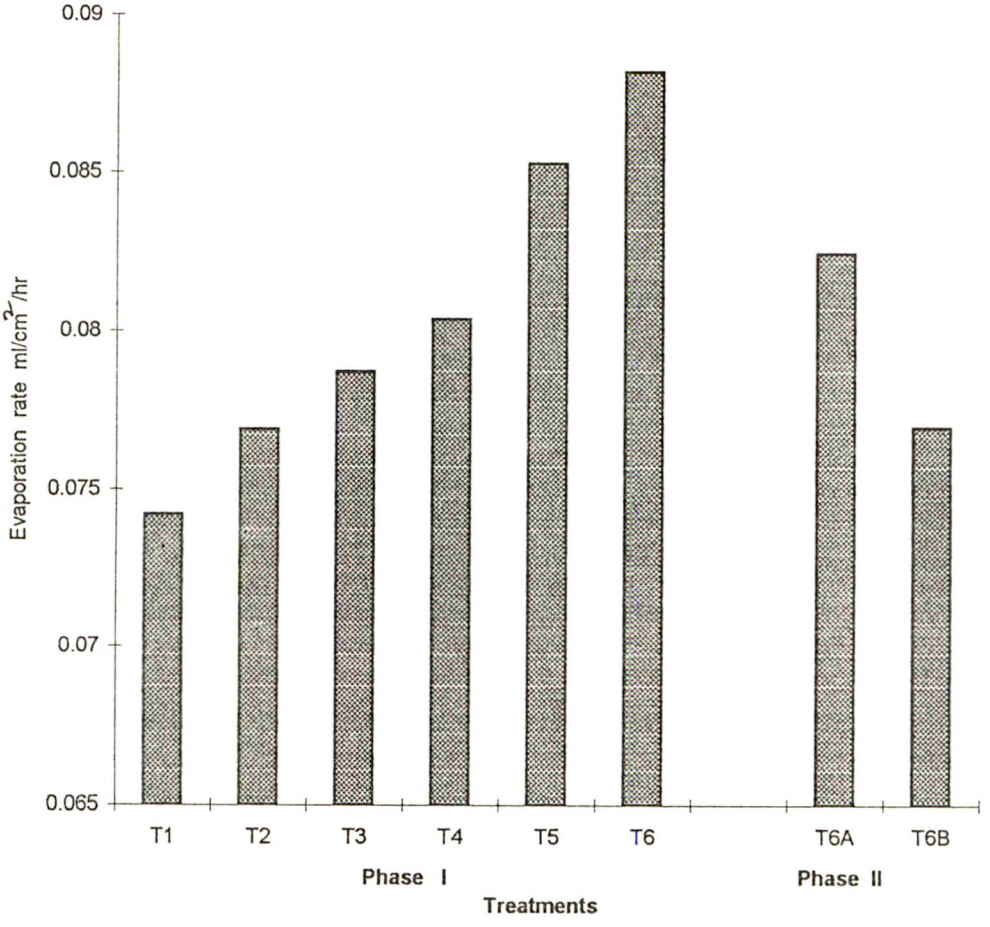


Fig. 1 The evaporation rate ml/cm²/hr in Ist & IInd phase.

evaporation rate (ml/cm^2/hr) was gradual increased from T_1 i.e. 0.0742 to T_6 i.e. 0.0882 .(Tab. 1) and (Fig.1).

Therefore, it can be concluded that evaporation rate (ml/cm^2/hr) depends upon height of milk column.

4.1 II Dehydration characters of khoa prepared by solar method in scale-up studies

The treatment which showed highest evaporation rate (ml/cm^2/hr) was T_6 in phase-I. The scaling -up of this treatment was conducted by employing community solar cooker as indicated in (Fig.B).The results obtained for this perticular type of work are presented in Table No. 1B. The treatments T_{6A},T_{6B} consisted of double (776.8 ml) and quadruple (1553.6 ml) quantity of milk of T_6 respectively.

1.Total moisture removed (ml)

Both the treatments $\underline{T_{6A}}\underline{T_{6B}}$ were significantly different. The maximum total moisture removed was observed in treatment T_{6B} i.e. 713.46 ml and minimum in treatment T_{6A} i.e. 382.46 ml with the same height of milk column .

From this it is clear that, total moisture removed increases with increase in quantity of milk , at same height of milk column .

Table No. 1 B : Dehydration characters of khoa prepared by solar method in scale up studies :

Treatment No.	Initial quantity (ml)	Height of milk column (mm)	Load (ml/cm^2)	Total moisture removed (ml)	% Moisture removed (ml)	Time (hrs)	Evaporation rate (ml/hr)	Moisture removed (ml/cm_2)	Evaporation rate (ml/cm_2/hr)
T_{6A}	776.8	13	1.3	382.46	49.23	7.75	49.34	0.640	0.0825
T_{6B}	1553.6	13	1.3	713.46	45.92	7.75	92.06	0.597	0.0770
			SE +	2.631	0.251	0.00	0.339	0.0032	0.00041
			CD	7.969	0.760	0.00	1.028	0.0098	0.00125

2.Per cent moisture removed

Both the treatments T_{6A} and T_{6B} were significantly different. Maximum per cent moisture removed was observed in treatment T_{6A} i.e. 49.23 and lowest in treatment T_{6B} i.e. 45.92.

From this it would be clear that, there is significant drop in per cent moisture removed with increase in volume of milk at constant height of milk column.

3.Evaporation rate (ml/hr)

The treatments T_{6A} and T_{6B} were significantly different. The maximum evaporation rate was observed for treatment T_{6B} i.e.92.06 and the minimum for treatment T_{6A} i.e. 49.34 ml.

From this it can be concluded that,the evaporation rate depends upon initial volume of milk.

4.Moisture removed (ml/cm^2)

The significant difference was observed in both the treatments T_{6A} and T_{6B}. The maximum moisture removed was observed in treatment T_{6A} i.e. 0.640 and that of lowest in treatment T_{6B} i.e. 0.597 ml.

The results show that the moisture removed depends upon the initial volume of milk. With increase in volume of milk at constant milk column there was decrease in moisture removed.

5.Evaporation rate (ml/cm^2/hr)

Both the treatments T_{6A} and T_{6B} were significant different.The maximum evaporation rate was observed for treatment T_{6A} i.e.0.0825 (Tab. 1B) and (Fig. 1).

From this it can be concluded that with increase in volume of milk at constant height of milk column there is significant decrease in evaporation rate.

All the presented results of dehydration characters confirm the results reported by Nawle(1992) and Barbole(1994).

4.2 I Recovery characters of khoa prepared by solar method

It is encouraging to note from Table No. 2 A that, the concentration obtained from the milk by solar treatment varied according to initial height of milk column. All the treatment T_1 T_2 T_3 T_4 T_5 and T_6 were significantly different. The lowest quantity of dehydrated milk was recorded for treatment T_1 i.e. 500.27 g.

The yield of khoa significantly increased from T_1 i.e. 177.98 g to 290.69 g at T_6. All the treatments T_1 T_2 T_3 T_4 T_5 and T_6 were significantly different. With increase in the quantity of milk, there was significant increase in the yield of khoa. There was

Table No. 2 A : Recovery characters of khoa prepared by solar method.

Treatment No.	Initial quantity (ml)	* Quantity after solar dehydration (g)	Yield of khoa (g)	Yield of khoa on per litre basis (g)	Per cent yield	Working time (min)	Working time on per litre basis (min)
T_1	956	500.27	177.98	186.17	18.62	7.57	7.92
T_2	1075.60	576.43	199.35	185.34	18.53	9.00	8.37
T_3	1195.20	662.90	222.22	185.93	18.59	11.00	9.20
T_4	1314.40	760.37	245.58	186.84	18.68	13.50	10.27
T_5	1434.00	839.71	267.41	186.48	18.65	15.70	10.95
T_6	1553.60	923.67	290.60	187.05	18.71	18.50	11.91
SE +		3.158	0.799	0.658	0.0658	0.259	0.2217
CD		9.634	2.436	NS	NS	0.791	0.6762

* Quantity after solar dehydration with added cream.

no significant difference observed for the yield of khoa on per litre basis. The values for yield of the khoa on per litre basis ranged between T_2 i.e. 185.34 g to T_6 i.e. 187.05 . These values are confirmed with earlier values of per litre yield of khoa reported by Nawle (1992) and Barbole(1994). There was no significant difference observed for per cent yield. The highest numerical values was recorded for T_6 i.e. 18.71. Observed results of perecent yield are in confirmation with results reported by Nawle (1992) and barbole (1994).

There was significant difference observed for working time. Treatment T_1 T_2 T_3 T_4 T_5 and T_6 were significantly different. These values of time ranged from 7.57 to 18.50 min. for T_1 to T_6 respectively. Working time on per litre basis for treatment T_1 T_2 T_3 T_4 T_5 and T_6 were significantly different except T_1T_2 which were at Par. With increase in intial quantity of milk , there was significant increase in working time on per litre basis of solar khoa. It may be due to reduction in per cent moisture removed with increase in initial quantity of milk as reported by Nawle (1992).

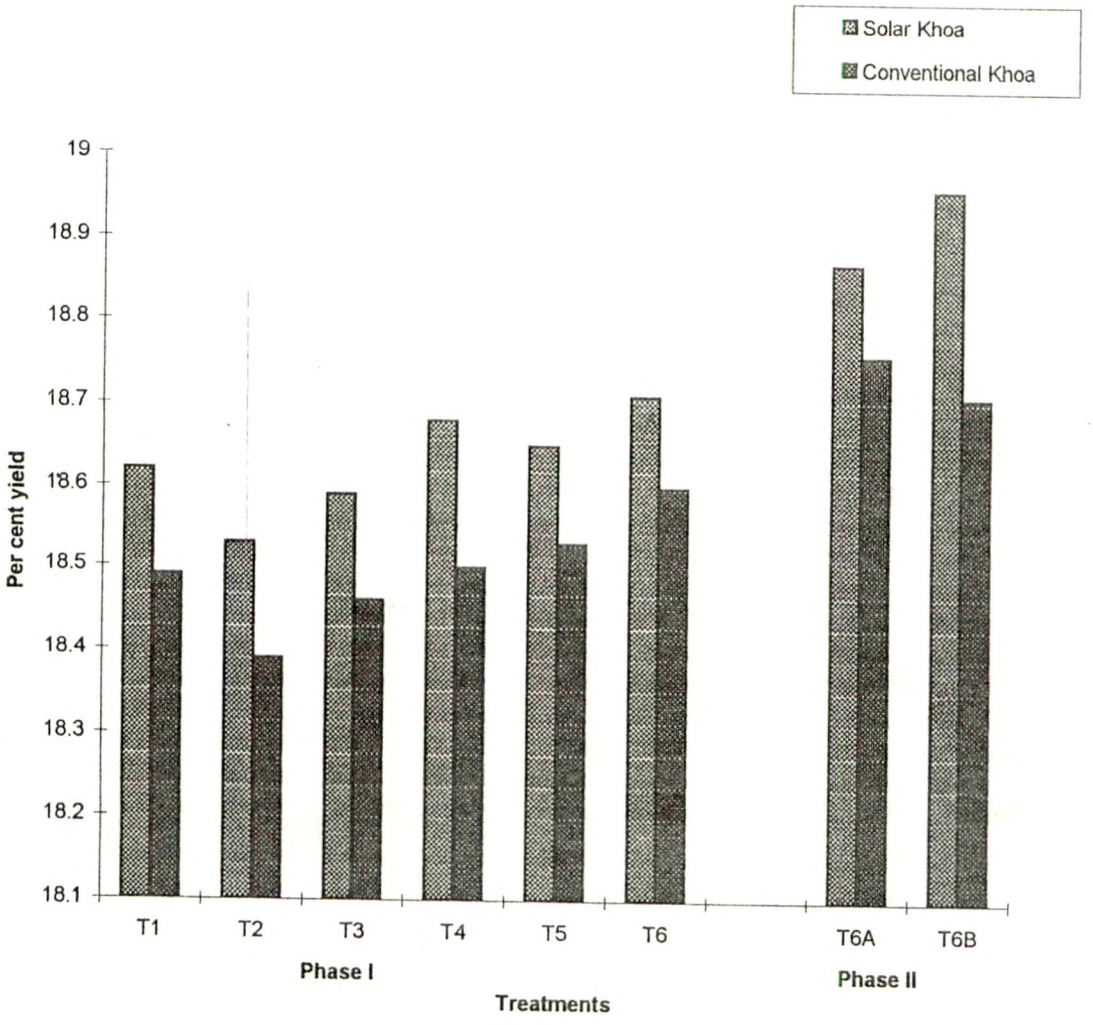


Fig. 2 : The per cent yield of khoa by solar and conventional method

Table No. 2 B : Recovery characters of khoa prepared by conventional method.

Treatment No.	Initial quantity (ml)	Yield of khoa (g)	Yield of khoa on per litre basis (g)	Per cent yield	Working time (min)	Working time on per litre basis (min)
T_1	956	176.76	184.90	18.49	29.00	30.33
T_2	1075.60	197.80	183.90	18.39	32.30	30.03
T_3	1195.20	220.63	184.60	18.46	35.50	29.70
T_4	1314.40	243.18	185.01	18.50	39.00	29.67
T_5	1434.00	265.72	185.30	18.53	42.00	29.29
T_6	1553.60	288.97	186.00	18.60	45.00	28.96
SE +		0.809	0.659	0.0658	0.510	0.4179
CD		2.468	NS	NS	1.557	NS

4.3 I Recovery characters of khoa prepared by conventional method

The yield of khoa obtained by conventional method on volume basis changed significantly from 176.76 g. to 288.97 g. in case of T_1 and T_6 treatment respectively (Table 2B) . For yield of the khoa all the treatment T_1 T_2 T_3 T_4 T_5 and T_6 were significantly different. The yield of the khoa on per litre basis obtained by this method had non significant differences. The lowest per cent yield was obtained in case of T_3 i.e. 184.60 g and that of T_6 i.e. 186.00 g. which was higher than rest of the treatments. In conventional method for per cent yield obtained , all the treatments were at par. The per cent yield ranged from 18.39 for T_2 to 18.60 at T_6 . The figures observed are indicative enough to arrive the optimum level for initial quantity of milk at T_6 which was recorded the maximum per cent yield.

The working time required for all the treatments viz. T_1 T_2 T_3 T_4 T_5 and T_6 of conventional khoa preparation had significant variation. The lowest time was recorded for treatment T_1 i.e. 29 minute and highest for treatment T_6 i.e. 45 minutes. It is interesting to note that, the working time on per litre basis decreased from T_1 ie. 30.33

minute to t_6 ie 28.96 minute. Barbole (1994) also reported that, appriciable reduction in working time on per litre basis with increase in intial quantity of milk as the intial time required for heating to vessel (kadhi) remains constant and losses due to radiation, convection and conduction of heat will not be constantly increased.

4.2 II Recovery characters of khoa prepared by solar method in scale up studies.

The results obtained for recovery characters of khoa prepared by solar method in scale -up studies are presented in Table No. 3A . Yield after solar dehydration recorded significant differences between the treatments. Maximum quantity of dehydrated milk was obtained in treatment T_6 ie 3002.20 g . There is significant difference in the yield of khoa . As initial quantity of milk doubled the yield of khoa also corrospondingly increased in quantity. The yield of khoa on per litre basis also showed significant differences T_{6A} and T_{6B}. The higher yield on per litre basis was obtained in treatment T_{6B} ie. 189.60 g. The observed result of yield on per litre basis are in confirmation with result of Barbole (1994).There was no significant difference observed for per cent yield . The highest

Table No. 3 A : Recovery characters of khoa prepared by solar method in scale up studies.

Treatment No.	Initial quantity (ml)	* Quantity after solar dehydration (g)	Yield of khoa (g)	Yield of khoa on per litre basis (g)	Per cent yield	Working time (min)	Working time on per litre basis (min)
T_{6A}	2330.40	1418.30	439.75	188.70	18.87	27.98	12.00
T_{6B}	4660.80	3002.20	883.69	189.60	18.96	58.10	12.46
SE +		7.89	0.657	0.191	0.0228	0.231	0.0576
CD		23.91	1.992	0.580	NS	0.702	0.1746

* Quantity after solar dehydration with added cream.

value was observed for treatment T_{6B} ie. 18.96 per cent. Hence, it could be concluded that, the level of T_{6B} can be used for large scale khoa preparation.

The working time also proportionately increased with increase in quantity of dehydrated milk with added cream. The maximum working time was observed for treatment T_{6B} ie. 58.10 min . In respect of working time on per litre basis there was also significant difference observed for T_{6A} and T_{6B}. The highest working time on per litre basis was observed for treatment T_{6B} ie. 12.46 min. With increase in moisture content in dehydrated milk or with decrease in per cent moisture removed there is increase in per litre working time. The observed result of working time on per litre basis is in confirmation with result of Barbole (1994).

4.3 II Recovery characters of khoa prepared by conventional method in scale up studies.

The results obtained for recovery characters of khoa prepared by conventional method in scale up studies are presented in Table No. 3B. Both the treatments T_{6A} and T_{6B} showed siginficant differences for yield of khoa . The maximum yield obtained in treatment T_{6B} ie. 872.03 g while that of mimimum in treatment T_{6A} ie. 437.18 g . There no significant

Table No. 3 B : Recovery characters of khoa prepared by conventional method in scale up studies.

Treatment No.	Initial quantity (ml)	Yield of khoa (g)	Yield of khoa on per litre basis (g)	Per cent yield	Working time (min)	Working time on per litre basis (min)
T_{6A}	2330.40	437.18	187.60	18.76	67.41	28.92
T_{6B}	4660.80	872.03	187.10	18.71	134.93	28.95
SE +		0.926	0.257	0.0250	0.945	0.268
CD		2.804	NS	NS	2.863	NS

difference observed for per litre yield of khoa. The maximum per litre yield obtained at T_{6A} treatment level was 187.60 g . The per cent yield also do not show significant differences. The maximum per cent yield was obtained in treatment T_{6B} ie. 18.76.

The working time was significantly increased with increase in initial quanitity of milk. There was significant difference observed between the treatment T_{6A} and T_{6B} . The minimum working time was observed for treatment T_{6A} ie. 67.41 min. The working time on per litre basis did not show significant difference. The maximum working time on per litre basis was oberved for treatment T_{6B} ie. 28.95 minute.

4.4 I Comparative studies on recovery characters of khoa prepared by solar and conventional method.

The results obtained for recovery characters like yield of khoa, yield on per litre basis, working time , working time on per litre basis and per cent yeild for solar and conventional khoa making methods were compared to study the effect of method of manufacture .

It is revealed from Table No. 4A & Fig. No. 2 that, the yield obtained by solar method was numerically more than conentional one but the difference was not

Table No. 4 A : Comparative studies on recovery characters of khoa prepared by solar and conventional method.

Treatment No.	Initial quantity (ml)	Method	Yield of khoa (g)	Yield of khoa on per litre basis (g)	Per cent yield	Working time (min)	Working time on per litre basis (min)
T_1	956	S	177.98	186.17	18.62	7.57	7.92
		C	176.76	184.90	18.49	29.00	30.33
T_2	1075.60	S	199.35	185.34	18.53	9.00	8.37
		C	197.80	183.90	18.39	32.30	30.03
T_3	1195.20	S	222.22	185.93	18.59	11.00	9.20
		C	220.63	184.60	18.46	35.50	29.70
T_4	1314.40	S	245.58	186.84	18.68	13.50	10.27
		C	243.18	185.01	18.50	39.00	29.67
T_5	1434.00	S	267.41	186.48	18.65	15.70	10.95
		C	265.72	185.30	18.53	42.00	29.29
T_6	1553.60	S	290.60	187.05	18.71	18.50	11.91
		C	288.97	186.00	18.60	45.00	28.96
		SE +	0.804	0.6589	0.0658	0.4050	0.3345
		CD	NS	NS	NS	1.1679	0.9646

S= Solar khoa C= Conventional khoa

The data were statistically analised by factorial completly randomized design.
The given SE and CD's are of interaction between treatment and method of manufacture.

statistically significant . In respect of yield on per litre basis also no significant differences were observed. There was no significant difference observed for per cent yield.

There was significant difference observed for working time for all the treatments, except T_3T_4 and $T_4T_5T_6$ which were at par. Working time on per litre basis also showed significant difference , except T_1T_2 which were at par.

4.4 II Comparative studies on recovery characters of khoa prepared by solar and conventional method in scale up studies.

The comparative results obtained for recovery characters of solar and conventional khoa making in scale-up studies are presented in Table No.4B and Fig.2. Significant difference was observed for yield of khoa in treatments T_{6A} and T_{6B}. The T_{6B} was significantly higher than T_{6A}. The per litre yield also showed significant difference in T_{6A} and T_{6B} treatments. The T_{6A} was significantly higher than T_{6B}. In respect of per cent yield significant difference was observed these two treatments. The T_{6A} was significantly higher than T_{6B}.

Table No. 4 B : Comparative studies on recovery characters of khoa prepared by solar and conventional method in scale up studies.

Treatment No.	Initial quantity (ml)	Method	Yield of khoa (g)	Yield of khoa on per litre basis (g)	Per cent yield	Working time (min)	Working time on per litre basis (min)
T_{6A}	2330.40	S	439.75	188.70	18.87	27.98	12.00
		C	437.18	187.60	18.76	67.41	28.92
T_{6B}	4660.80	S	883.69	189.60	18.96	58.10	12.46
		C	872.03	187.10	18.71	134.93	28.95
		SE +	0.803	0.226	0.0238	0.688	0.194
		CD	2.352	0.664	0.0699	2.015	NS

S= Solar khoa C= Conventional khoa

The data were statistically analised by factorial completly randomized design.
The given SE and CD's are of interaction between treatment and method of manufacture.

In respect of working time also significant difference observed between T_{6A} and T_{6B} treatments. The T_{6B} was significantly higher than T_{6A} but the working time on per litre basis did not show significant difference.

4.5 I Energy studies of solar khoa.

In present study the average gross erengy required for perparation of khoa by conventional method on kerosine stove was 1281.6 kcal/litre of milk. The average time required for preparation of khoa from 1 lit. of milk was 30.33 minutes. That means 42.25 kcal energy required per minute and from it energy saved was estimated.

It may observed from the Table No. 5A and Fig. 3 that the time required for working was increased proportinatly with increase in quantity of milk in conventional as well as in solar method. All the treatments T_1 T_2 T_3 T_4 T_5 and T_6 were significantly different . For conventional method working time ranged between 29.00 for treatment T_1 to 45.00 minute for treatment T_6. The working time for solar khoa ranged from 7.57 to 18.50 respectively. In respect of time saved also shown significant differences execpt following treatments which were at par T_2T_3 T_3T_4 and $T_4T_5T_6$.

Table No. 5 A : Energy studies of solar khoa.

Treatment No	Inital quantity (ml)	Working time (minute)			Energy saved (kcal)	Per cent energy saved
		Conventional	Solar	Time saved		
T_1	956.00	29.00	7.57	21.43	905.42	94.71
T_2	1075.60	32.30	9.00	23.30	984.43	91.52
T_3	1195.20	35.50	11.00	24.50	1035.12	86.61
T_4	1314.40	39.00	13.50	25.50	1077.38	81.96
T_5	1434.00	42.00	15.70	26.30	1111.18	77.49
T_6	1553.60	45.00	18.50	26.50	1119.62	72.07
	SE +	0.510	0.259	0.617	22.39	1.83
	CD	1.520	0.769	1.832	68.30	5.58

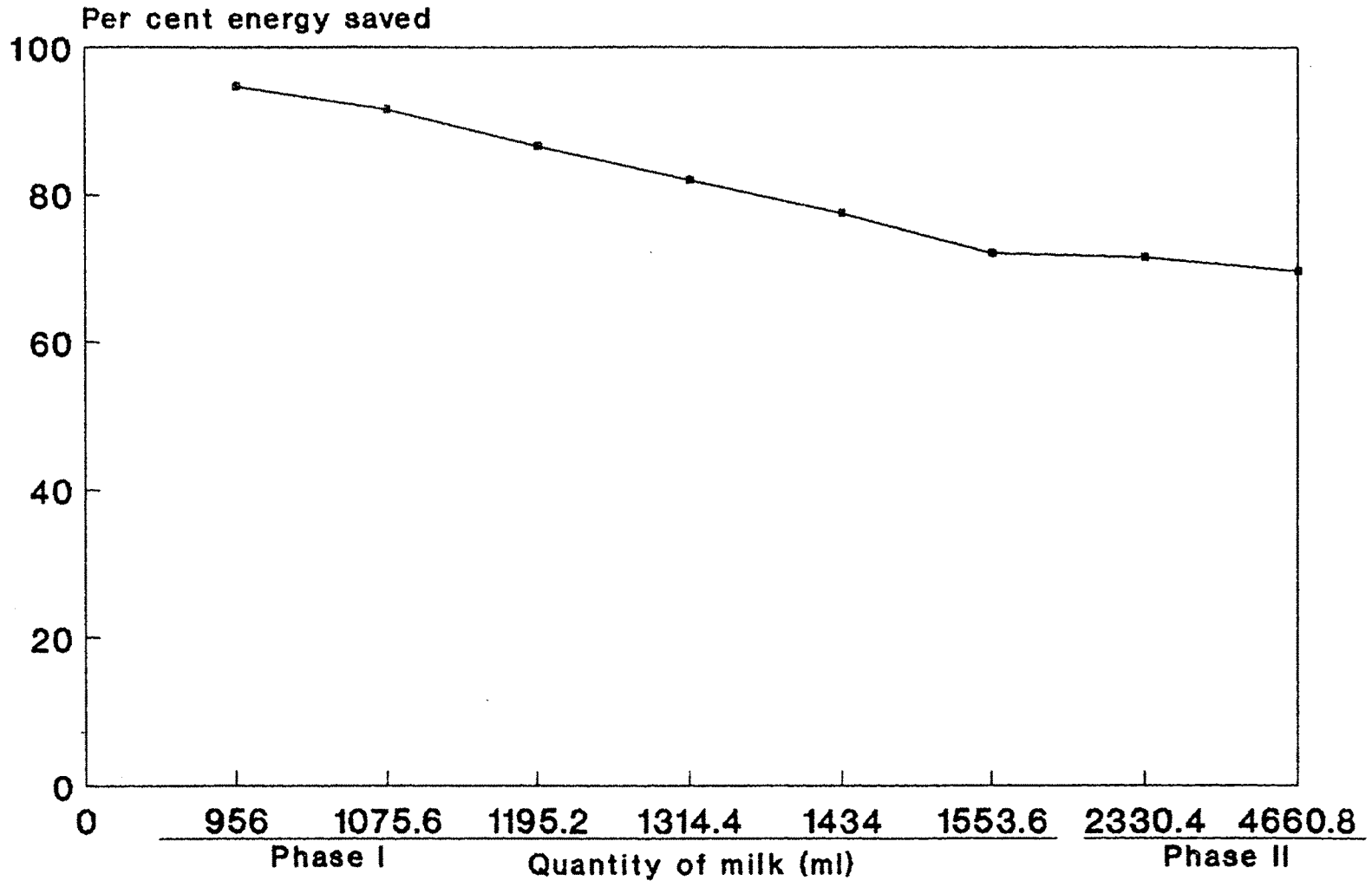


Fig. 3. Energy studies in solar *Khoa*

In respect of energy saved also showed significant difference except following treatments T_2T_3 T_3T_4 and T_4 T_5 T_6 which were at par. In respect of per cent energy saved also significant differences recorded except, T_1T_2 T_2T_3 T_3T_4 T_4T_5 and T_5T_6 which were at par.

From this table it is interasting to note that time saved by solar method over conentional method increases with increase in quantity of milk Barbole (1994). With increase in initial quantity of milk the energy saved (kcal) also increases but there is decrease in per cent energy saved (Fig.3). The maximum per cent energy saved was observed in treatment T_1 which was 94.71 while that of mimimum 72.07 in treatment T_6.

This minimum level of 72.07 per cent energy saved also important from the energy crisis point of view.

4.5 II Energy studies of solar khoa in scale up studies.

It may be observed from Table No.5B & Fig.3 that, the working time by conventional and solar method show significant difference between T_{6A} and T_{6B}. The values for working time of conventional khoa were 67.41 and 134.43 minute for T_{6A} and T_{6B} respectively. That of solar khoa was 27.98 and 58.10 minute. In respect of

No. 5 B : Energy studies of solar khoa in scale up studies.

Treatment No	Inital quantity (ml)	Working time (minute)			Energy saved (kcal)	Per cent energy saved
		Conventional	Solar	Time saved		
T_{6A}	2330.40	67.41	27.98	39.43	1665.92	71.49
T_{6B}	4660.80	134.93	58.10	76.83	3246.07	69.65
	SE +	0.945	0.231	0.974	40.96	1.081
	CD	2.920	0.715	3.010	142.05	3.748

time saved also showed significant difference between T_{6A} and T_{6B} treatments. In case of T_{6B} time saved was 76.43 minute which amounted approximately double to the T_{6A}.

Hence, energy saved recorded significant difference between T_{6A} and T_{6B} treatments. The maximum energy saving was observed at T_{6B} treatment level which amounted to 3246.07 kcal. This value was approximately double over T_{6A} . There fore, the optimum level of milk for khoa making by solar method may be adjusted at 4660.80 ml.

The per cent energy saved by two respective treatments were 71.49 and 69.65 . The Per cent energy saved also showed significant difference between T_{6A} and T_{6B} treatments. From the result obtained it is worthwhile to suggest that, in order to obtain more efficient per ent energy saving the amount of initial quantity of milk may be adjusted between these two treatments.

4.6 I Comparative studies on chemical composition of solar and conventional khoa.

Comparative per cent chemical composition of both types of khoa is presented in Table No. 6A. There was no significant difference among all the treatments. But the maximum scores for total solid, fat, protein and

Table No. 6 A : Comparative studies on chemical composition of solar and conventional khoa.

Treatment No.	Method	Moisture %	Total solid %	Fat %	Protein %	Lactose %
T_1	S	28.13	71.87	23.77	18.37	25.93
	C	28.47	71.32	23.66	18.29	25.82
T_2	S	27.79	72.19	23.88	18.45	26.05
	C	28.15	71.73	23.73	18.33	25.88
T_3	S	28.03	71.93	23.78	18.38	25.94
	C	28.13	71.50	23.65	18.28	25.81
T_4	S	28.12	71.75	23.75	18.36	25.90
	C	28.51	71.35	23.60	18.24	25.75
T_5	S	28.10	71.71	23.73	18.33	25.88
	C	28.65	71.17	23.54	18.19	25.69
T_6	S	28.09	71.74	23.74	18.34	25.89
	C	28.37	71.48	23.65	18.27	25.80
SE +		0.267	0.260	0.0879	0.0675	0.0956
CD		NS	NS	NS	NS	NS

S= Solar khoa C= Conventional khoa

The data were statistically analised by factorial completly randomized design. The given SE and CD's are of interaction between treatment and per cent chemical composition.

lactose were observed in solar khoa. The per cent moisture content was higher in conventional khoa than that of solar khoa.

The moisture content of solar khoa ranged between 28.13 to 28.60 per cent in case of T_3 and T_6, total solid ranged between 71.71 to 72.19 per cent, fat, 23.73 to 23.88 per cent and protein, 18.33 to 18.45 per cent. These values are comparable with the results obtained for conventional khoa in present studies and result of Anonymous (1966). The lactose content ranged between 25.88 to 26.05 per cent for solar khoa . These results for lactose content are comparable with results obtained for conventional khoa in present studies and result of Ghodekar et al (1974).

4.6 II Comparative studies on chemical composition of solar and conventional khoa in scale up studies.

The Table No. 6B shows that there was no significant difference between both the treatments. But the numerically higher values were obtained in solar khoa.

The moisture content of solar khoa ranged between 27.85 to 27.94 per cent, total solid, 71.83 to 71.97 per cemt, Fat 23.77 to 23.81 per cent and protein, 18.36 to 18.40. These values are comparable with the

Table No. 6 B : Comparative studies on chemical composition of solar and conventional khoa in scale up studies.

Treatment No.	Method	Moisture %	Total solid %	Fat %	Protein %	Lactose %
T_{6A}	S	27.94	71.83	23.77	18.36	25.92
	C	28.15	71.17	23.71	18.32	25.86
T_{6B}	S	27.85	71.97	23.81	18.40	25.97
	C	27.99	71.82	23.76	18.36	25.92
	SE +	0.087	0.076	0.0256	0.0198	0.0276
	CD	NS	NS	NS	NS	NS

S= Solar khoa C= Conventional khoa

The data were statistically analised by factorial completly randomized design. The given SE and CD's are of interaction between treatment and per cent chemical composition.

result obtained for conventional khoa in present studies and result of Anonymous (1966).

The lactose content ranged between 25.92 to 25.97 per cent in case of solar khoa. These values are comparable with result obtained for conventional khoa in present studies and result of Ghodekar et al (1974).

4.7 I Comparative studies on sensory characters of solar and conventional khoa.

The scores of sensory attributes like colour, flavour, physical make-up and over all acceptability were recorded in Table No. 7A for solar and conventional khoa.

In respect of colour no significant difference was observed but the scores obtained for solar khoa were numerically more than conventional one. The score of colour for solar khoa was ranged between 8.03 to 8.52 in T_2 to T_6 respectively. The maximum score regarding colour was observed for treatment T_6.

There was significant difference observed for flavour except $\underline{T_2T_1T_3}$ $\underline{T_1T_3T_4}$ $\underline{T_3T_4T_5}$ and $\underline{T_4T_5T_6}$ which were at par. In case of solar khoa the score obtained for flavour were numerically greater than conventional khoa except T_2. The maximum score for flavour was obtained for treatment T_6 which was 8.39.

Table No. 7 A : Comparative studies on sensory characters of solar and conventional khoa.

Treatment No.	Method	Colour	Flavour (taste,odour, mouth feel)	Physical make-up (body and texture)	Over-all accepta-bility
T_1	S	8.03	7.95	7.65	8.00
	C	7.62	7.94	7.99	7.95
T_2	S	8.28	8.05	8.06	8.23
	C	7.77	8.11	8.07	7.92
T_3	S	8.18	8.13	8.00	8.02
	C	7.90	7.97	7.98	7.82
T_4	S	8.23	8.09	7.95	8.28
	C	7.96	7.76	7.82	7.71
T_5	S	8.52	8.28	8.03	8.39
	C	7.77	7.87	7.78	7.63
T_6	S	8.52	8.39	8.25	8.42
	C	7.97	7.71	7.85	7.81
	SE +	0.0900	0.1285	0.1535	0.1139
	CD	NS	0.3712	NS	NS

S= Solar khoa C= Conventional khoa

The data were statistically analised by factorial completly randomized design.

The given SE and CD's are of interaction between treatment and sensory characters.

In case of physical make up no significant difference was observed. The values of physical make up for solar khoa ranged between 7.65 to 8.25 in respective treatments from T_1 to T_6. The maximum score was obtained for treatment T_6 ie. 8.25.

In case of over all acceptability also there was no significant difference observed. The values of overall acceptability for solar khoa ranged between 8.00 to 8.42 . These values are numerically greater than that of conventional khoa . The maximum overall acceptability of the product 8.42 was obtained for T_6 of solar treatment.

From this table it would be concluded that, T_6 treatment level is best suitable to obtain khoa of good colour, flavour, physical make up and overall acceptable quality.

4.7 II Comparative studies on sensory characters of solar and conventional khoa in scale up studies.

It may be observed from the Table No. 7B that the values for colour in solar khoa were 8.62 and 8.31 in the respective treatment of T_{6A} and T_{6B}. Both the treatments T_{6A} and T_{6B} were significantly different. The higher values for colour were obtained in solar khoa.

Table No. 7 B : Comparative studies on sensory characters of solar and conventional khoa in scale up studies.

Treatment No.	Method	Colour	Flavour (taste,odour, mouth feel)	Physical make-up (body and texture)	Over-all acceptability
T_{6A}	S	8.62	8.42	8.37	8.46
	C	8.31	7.86	7.98	8.08
T_{6B}	S	8.31	8.39	8.21	8.27
	C	8.27	7.84	8.01	8.12
	SE +	0.0349	0.0586	0.0692	0.0557
	CD	0.1022	NS	NS	0.1632

S= Solar khoa C= Conventional khoa

The data were statistically analised by factorial completly randomized design.
The given SE and CD's are of interaction between treatment and sensory characters.

In respect of flavour both the treatments were at par. The values for flavour of solar khoa were 8.42 and 8.39 in respective T_{6B} and T_{6B} treatments. The score for flavour in solar khoa was numerically greater than conventional one.

In respect of physical make-up also no significant difference was observed . The values for physical make-up of solar khoa were 8.37 and 8.21 for T_{6A} and T_{6B} treatments respectively.

The over all acceptability of khoa made in treatments T_{6A} and T_{6B} differd significantly . The values for overall acceptablity of solar khoa were 8.46 and 8.27 for treatments T_{6A} and T_{6B} respectively.

It can be asserted from this table that, the optimum level of milk for khoa making by solar method was 2330.40 ml (T_6). But the score obtained for solar khoa at T_{6B}(4660.80 ml) treatment level was also greater than that of conventional one . So both the levels are suitable for large scale khoa prodction by solar dehydration method.

Summary and Conclusion

Chapter - V

SUMMARY AND CONCLUSION

In present study dehydration of milk was carried out by using solar energy in order to obtain better quality khoa economically on large scale. The khoa obtained was compared with conventional khoa. The result of present study are summarized as under .

The milk was tested with 8 mm to 13 mm heights of milk column for solar dehydration. The total removal of moisture at T_6 treatment level was 197.63 ml which was the maximum and minimum found at T_1 treatment level was 138.95 ml. The per cent moisture removed gradually decresed with increase in height of milk column. The maximum per cent moisture removed was observed in treatment T_1 ie 58.14 while that of minimum in treatment T_6 ie. 50.88 . The time required for dehydration proportionately increased from T_1 to T_6 ie. 6.27 to 7.50 hours. The evaporation rate also gradually increased . The maximum evaporation rate observed for treatment T_6 ie. 26.35 ml/hr while that of minimum for treatment T_1 ie. 22.16 ml/hr. The maximum moisture removed was observed in treatment T_6 ie. 0.661 ml/cm^2 and the lowest value recorded in treatment T_1 ie. 0.465 ml/cm^2. The evaporation rate $ml/cm^2/hr$ was maximum at T_6 treatment level ie. 0.0882 while that of minimum recorded at T_1 ie 0.0742.

In scale up studies the total moisture removed was maximum in treatment T_{6B} ie. 713.46 ml while that of lowest in treatment T_{6A}. The maximum per cent moisture removed was observed in treatment T_{6A} ie 49.32 while mimumum in treatment T_{6B} ie. 45.92 . The evaporation rate (ml/hr) was maximum for treatment T_{6B} ie. 92.06 while that of minimum for T_{6A} ie. 49.39. The moisture removed ml/cm^2 was maximum in treatment T_{6A} ie 0.640. The evaporation rate ($ml/cm^2/hr$) was also maximum for treatment T_{6A} ie. 0.0825.

In respect of comparative recovery characters. The yield values of solar khoa ranged between 177.98 to 290.60 g while that of in conventional method 176.76 to 288.97g from T_1 to T_6. Yield per litre for solar khoa ranged between 185.34 to 187.05 g which was maximum for all the treatments. While that of conventional khoa ranged between 183.90 to 186.00 g from T_2 to T_6.The per cent yield in solar khoa was also numerically greater than conventional one. The value of per cent yield for solar khoa ranged between 18.53 to 18.71 at T_2 to T_6 respectively .

The final working time required for solar method was much less than the conventional one, ranging between 7.57 to 18.50 min from T_1 to T_6 while that of in conventional method ranged from 29.00 to 45.00 min which was maximum for all the treatments . The per

litre working time was also more in conventional method. Which ranged between 28.96 to 30.33 min. from T_6 to T_1, while that of for solar method ranged between 7.92 to 11.91 min .

In scale up studies the maximum yield was obtained in treatment T_{6B} for solar khoa ie. 883.69 g. The yield on per litre basis was also maximum at T_{6B} level ie. 189.60g. The per cent yield was maximum in treatment T_{6A} ie. 18.96. Working time and working time on per litre basis was minimum for treatment T_{6A} the values recorded were 27.98 and 12.00 respectively.

Energy saved in kcal was maximum for treatment T_6 ie. 1119.62 and minimum for treatment T_1 ie 905.42. The per cent energy saved was maximum in treatment T_1 ie. 94.71 that of minimum in treatment T_6 ie 72.07 . In scale up studies the maximum energy saved was observed in treatment T_{6B} ie 3246.07 kcal. while that of minimum in treatment T_{6A} ie. 1665.92 . The per cent energy saved was maximum in treatment T_{6A} ie 71.49.

The chemical composition of solar and conventional khoa did not show significant difference, but the values for fat, protein and lactose were numerically greater in solar khoa than conventional one. The moisture content was more in conventional khoa than solar one. The value of fat for solar khoa ranged between 23.73 to 23.88 per cent in treatment T_5 and T_2

respectively. In case of protein the maximum protein content was obsereved in treatment T_2 ie. 18.45 and maximum lactose content of 26.05 per cent.

In scale up studies maximum, fat, protein and lactose were obtained in treatment T_{6B} ie. 23.81 , 18.40 and 25.97 per cent respectively.

In respect of sensory character the flavour of solar khoa was significantly better over conventional khoa with the score ranging from 7.95 to 8.39 at T_1 to T_6 respectively. The other parameters like colour, physical makeup also scored numerically greater than that of conventional khoa. Maximum score for colour of solar khoa was obtained for treatment T_5 and T_6 ie 8.52 while that of minimum was obtained for treatment T_1 ie 8.03 . The maximum score for physical make up was obtained for treatment T_6 ie 8.25 . The over all acceptability for solar khoa ranged between 8.00 to 8.42 which was maximum . In scale up studies significant improvement in colour and over all acceptability was observed over conventional khoa . The maximum score for colour was obtained for treatment T_{6A} ie 8.62. Flavour, physical makeup and over all acceptability was also observed maximum at T_{6A} treatment level . Maximum score for flavour, physical makeup and over all acceptability were 8.42,8.37 and 8.46 respectively.

CONCLUSION

It is concluded from the present study that,

1. The T_6 ie 13 mm height of milk column was proved to be the best in solar dehydration in the solar cooker recording maximum evaporation rate ml/cm^2/hr and per cent yield of khoa compared to conventional one.

2. There was no significant difference recorded for per cent chemical composition viz. moisture, total solid, fat , protein and lactose in both the methods.

3. Solar khoa recorded improved flavour over conventional Khoa.

4. Per cent energy saved in solar method of khoa making using 8-13 mm height of milk column was recorded as 94 to 72 per cent over conventional method.

5. At 13 mm height of milk column when quantity of milk increased to double and quadruple the trend of results were similar for all parameters. Though numerically double quantity was slightly better.

SUGGESTION FOR FUTURE RESEARCH

Experiment may be conducted for ;

1. To find out optimum height of milk column in order to prepare Khoa on large scale.
2. To achieve optimum evaporation rate.
3. To reduce time of solar dehydration for Khoa preparation.
4. Drying of various dairy products by using solar energy (as chhana, khoa, etc.).
5. To find out the extent of energy saved by solar method.

Literature Cited

LITERATURE CITED

Agrawala,S.P., Sawhney, I.K. and Bikram Kumar (1987). "National Seminar on recent advances in Dairy processing." Dairy India, 1987 :26-27.

Anap, G.R. and Bikram Kumar (1980). Developement of villege level processing unit. Indian dairy-man,32(6) : 477 - 478.

Anonymous (1962). A laboratory manual of Dairy Science, Andhra Vet. College , Tirupati : 18.

Anonymous (1966). Survey of Bombay market for khoa quality. Annual Report of N.D.R.I.,Karnal.

Banerjee, A.K., Verma, I.S. and Bagchi, B. (1968). Pilot plant for continuous manufacture of khoa Indian Dairyman,20(3) : 81 - 86.

Barbole, S.L. (1994). Solar energy utilization for khoa preparation. M.Sc.(Agri),dissertation submitted to M.A.U.,Parbhani.

Bhadania, A.G.,Patel, S.J. and Shah, U.S. (1986). Use of roller dryer for manufacture of khoa J.Fd. Sci. Technol, 23(4) :295 - 296.

Borade, R.S.(1986). Studies on solar drying of grapes M.Sc.(Agri), dissertation submitted to M.A.U., Parbhani.

Chatterjee, A.K. and Acharya, R.M.(1992). Heading for 21st century. Dairy India,1992 : 4

Chaudhari, A.C. (1959). A practical manual of dairy science, Scientific Book Agency, Calcutta. 150-153.

Christie, N. and Shah, B.T. (1988). Prototype of horizontal heat exchanger of mild steel for khoa making . Indian J. Dairy Sci., 64(2) : 84-88.

Christie, I.S. and Shah, U.S. (1992). Developement of three stage continuous khoa making machine. Indian dairyman, 64 (1) : 1-4

De,S. and Ray, S. C. (1952). Studies on indigenous method of khoa making. Indian Dairyman, 5 (3) : 142.

De,S. and Srinivasan, M. R. (1967) Utilization of aged atmospheric roller dried skim milk powder and

white butter for khoa making.Indian dairyman, 19(5) : 151 - 155 and 170.

De, S (1990). Prevention of food adulteration rule (1976). Outlines of Dairy Technology. Oxford University Press, New Delhi. pp. 386 .

Dodeja, A.K., Abhichandani, H. Sharma, S.C.,Dharam Pal and Verma , R.D. (1990). Performance of thin film scraped surface heat exchanger for continuous manufacture of khoa . Indian J. Dairy Sci., 43(4) : 625-627.

Dodeja, A.K.; Abichandani, H, Sharma, S.C. and Dharam Pal (1992). Continuous khoa making system design , operation and performance. Indian J. Dairy Sci., 45(12) : 671-674.

Ghodekar, D.R., Dudani, A.J. and Ranganathan , B.(1974). Microbiological quality of Indian milk products. J. milk Fd. Technol., 37(3) :119 -122.

Gupta, S.K. (1976). Sensory evaluation in food industry. Indian dairyman, 28(7) : 293 - 295.

Gyanendra kumar and Sriniavasan, M.R. (1982). A comparative study on the chemical quality of three types of khoa. Indian J. Dairy Sci., 35(1): 56 - 60.

Jadhav, N.S. , Waghmare, P.S. and Zanjad, P.N. (1990). Observations on the dehydration of heat induced milk foam for khoa making. Indian J. Dairy Sci., 43(2) : 185 - 189.

Jagdishwar Sahay (1992). Elements of Agricultural Engineering . Agro Book Agency, New Chitragupta nagar, Patana 20 : pp-14

Joshi, S.D. (1987). Studies on the use of solar energy for dehydration of milk. M.Sc. (Agri) dissertation submitted to M.A.U., Parbhani.

Kalra, S.K. and Bharadwaj, K.C. (1981). Use of simple solar dehydrator for drying of fruit and vegetable products . J. Fd. Sci. Technol., 18(1): 23-26.

Kherde, R.K. (1985). Standardization of manufacturing technique using jacketed kettle for production of khoa by dehydration of heat induced foam. M.Sc.(Agri) dissertation sumitted to M.A.U. , Parbhani.

Maini, S.B.; Divan ,B. Bhawalkar, R.H. and Anand J.C. (1984). Utilization of solar enegry for acid hydrolysis of strach . Indian food packer, 38(2) : 64-66

More, G.R. (1983). Khoa making equipment for rural area Science Reporter, 20(4) : 243.

More, G.R. (1987). Development of semi mechanised khoa making equipment . Indian J. Dairy Sci., 40(2) 246-248.

Mukherjee, S.; Bandyopadhyay, S. and Bose, A.N. (1990). An improved solar dryer for fish drying in the costal belt. J.Fd. Sci. Technol., 27 (03) : 175 -177

Mulay, C.A. and Ladkani , B.G. (1973). Comparative assesment of quality of khoa their products from homogenized and unhomogenized milk J.Fd.Sci. Technol., 10(10) : 110-111.

Murale, R. V. (1989). Studies on use of low temperature (less than boiling point) for partial dehydration of milk to prepare khoa. M.Sc.(Agri) dissertation submitted to M.A.U., Parbhani.

Nawle, E.M.(1992). Solar heat utilization for khoa production. M.Sc.(Agri) dissertation sumitted to M.A.U. Parbhani.

Pal, D. and Cheryan, M.(1987). Application of reverse osmosis in the manufacture of khoa. Process optimization and product quality . J.Fd.Sci. Technol., 24 (5) : 235-238.

Patel , A.A. and De, S.(1977) . Production and storage of dried khoa. Indian J. Dairy Sci., 30 (4) : 325 - 330.

Patel, S.P. (1994). Feasibility of solar cooker for dehydration of selected vegetables. M.Sc.(Home Sci.) dissertation submitted to M.A.U., Parbhani.

Pawar V.N., Singh, N.I.,Kulkarni D.K., and Ingle V.M.(1988) Solar drying of white onion flakes. Indian food packer, 42(1) : 15 - 28.

Prajapati, P.S., Thakkar, P.N. and Vyas, S.H.(1982). Rheology of milk and milk products as influenced by homogenization process. Dairy guide, 4(7):24-29.

Punjarath, J.S, Veerajaneyulu, V., Muthunni, M.T., Samul, S.K. and Aneja, R. P. (1990). Inclind scraped surface heat exhanger for continuous khoa making . Indian J. Dairy Sci., 43(2) : 225 - 230.

Rai, K.R. (1990).Use of solar dryer for drying of Tomato B.Tech.(Food Sci.) dissertation submitted to M.A.U., Parbhani.

Rajorhia, G.S.(1971). Studies on yield and chemical quality of khoa. Indian J.Animal Res., 5(1) :25.

Rajorhia, G.S.,Dharam Pal, Garg F.C. and Patel R.S. (1990). Effect of quality of milk on chemical sensory and rheological properties of khoa . Indian J. Dairy Sci., 43 (2) : 220 - 224.

Rajorhia, G.S.,Dharma Pal, Garg F.C. and Patel R.S.(1991). Evaluation of quality of khoa prepared from different mechanised systems . Indian J. Dairy Sci. 44(2) 181-187.

Sawhney, I.K., Kumar,B. and Sharma, S.C. (1981). Improved dairy processing equipments for rural application. Indian Dairyman, 33(7) : 441 - 443.

Singh, S.K. and Rajorhia, G.S.(1989). Adoption of roller drying process for khoa making . Indian J. Dairy Sci., 42(2) : 321-325.

Srinivasan, M.R. and AnantKrishnan, C.P. (1964). Milk products of India . I.C.A.R. publication. New Delhi - 5.

Surinder Kumar and Dharma Pal (1994). Production of khoa from buffalo milk concentrated by reverse osmosis process. Indian J. Dairy Sci., 47(3) : 211-214.

Verma, R.D. and Lal G.(1989). Energy analysis in Indian dairy processing . Indian J. Dairy Sci., 42(3) : 608 - 610.

Vyas, B.M. and Sodhi, R.S. (1996). Indian Dairy Industry Marketing Strategy 2000 A.D. Indian Dairyman, 68 (2):134

Waghmare, P.S., Lembhe, A.F. and Khedkar D.M. (1980-81). Studies on preservation of milk and in-digenous milk products (Dahi, Chakka, Channa and Khoa) by sun drying. Annual report of research work in Animal sci.M.A.U., Parbhani. 1980-81 : 104.

Appendix

APPENDIX - I

Chemical composition of cow milk

	Constituents	Per cent
1.	Moisture	86.70
2.	Total solids	13.30
3.	Fat	4.40
4.	Protein	3.40
5.	Lactose	4.80

APPENDIX - II

Estimation Of Solar Eenergy

Treatment No.	Energy required (kcal)		Energy saved (kcal)
	Conventional	Solar	
T_1	1225.25	319.83	905.42
T_2	1364.68	380.25	984.43
T_3	1499.87	464.75	1035.12
T_4	1647.75	570.37	1077.38
T_5	1774.50	663.32	1111.18
T_6	1901.25	781.63	1119.62
T_{6A}	2848.07	1182.15	1665.92
T_{6B}	5700.79	2454.72	3246.07

APPENDIX - III

Meteorological data

Date	Temperature ^{o}C		Wind Velocity	Humidity(%)	
	Max.	Min.	km/hr	7.30am	2.30pm
1	2	3	4	5	6
16-03-96	39.8	23.5	5.8	47	17
21-03-96	38.8	20.5	4.0	46	21
22-03-96	39.5	22.8	4.4	39	19
25-03-96	39.3	20.5	4.5	46	10
26-03-96	40.5	18.8	3.7	39	15
27-03-96	41.0	17.8	4.3	36	9
29-03-96	40.8	20.8	5.6	43	15
30-03-96	41.7	19.5	5.2	33	13
02-04-96	38.0	15.2	6.4	42	08
03-04-96	38.4	16.8	4.1	42	11
04-04-96	40.0	24.5	4.2	33	22
06-04-96	38.5	22.0	5.6	45	15
10-04-96	39.0	17.8	3.4	33	19
11-04-96	39.5	17.5	4.5	46	11
12-04-96	39.5	20.2	4.3	40	28
15-04-96	35.0	20.0	6.4	58	32
16-04-96	36.0	19.5	8.8	75	33

1	2	3	4	5	6
17-04-96	36.0	20.2	3.4	60	27
18-04-96	38.6	20.5	3.0	56	21
20-04-96	39.6	23.5	6.7	55	23
22-04-96	38.6	20.5	5.8	51	24
23-04-96	40.4	23.5	6.5	51	20
24-04-96	41.4	23.8	6.0	47	23
25-04-96	41.0	23.5	5.7	61	23
15-05-96	40.0	26.2	11.5	48	26
16-05-96	40.4	27.2	7.6	42	19
17-05-96	41.0	28.0	8.5	36	16
20-05-96	39.5	20.0	5.7	42	24
21-05-96	39.5	22.5	5.5	35	20
22-05-96	40.8	26.2	6.0	38	21
23-05-96	41.8	27.8	8.7	41	15
24-05-96	42.5	30.2	10.5	39	20
27-05-96	42.8	28.5	7.2	43	17
28-05-96	42.8	26.2	12.3	46	16
30-05-96	40.5	28.0	8.8	40	17
31-05-96	43.0	31.0	7.1	33	17

VITA

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