ADOPTION OF ROLLER DRYING PROCESS FOR KHOA MAKING

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This is to certify that the work reported in this dissertation entitled "Adoption of Roller Drying Process for Khoa Making" was carried out by Mr. Shreekeshwar Singh under my guidance in partial fulfilment of the requirements for the degree of Master of Science in Dairying (Dairy Technology) of the Kurukshetra University. Help and assistance given by individuals as well as Institutions in the prosecution of the work has been suitably acknowledged.

(G.S. Rajorhia)

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CHAPTER – 1

INTRODUCTION

INTRODUCTION

Khoa (Mawa) is an important Indian indigenous milk product which is used as a base and filler material for the preparation of various milk sweets. The latest available data on the utilization of milk in India as reported by the National Commission on Agriculture (1976) show that in 1966 nearly 5% of the gross production was used in the manufacture of khoa. Rajorhia and Srinivasan (1976) estimated an increased production of khoa to about 7% of the total milk production in India.

The traditional method of khoa manufacture was essentially standardized to meet the needs of cottage scale situation. In this process, the whole milk is continuously boiled and stirred in an open pan till it attains a viscous consistency, thereafter, heat is curtailed and stirring is continued until the whole mass assumes a dough shape.

The production of khoa is scattered over small units since this continues to be the business of small and unorganized khoa makers in localities where milk does not find remunerative prices. The product is handled under unhygienic conditions and exposed to the stress of environment leading to post processing contamination and short shelf life.

The market for khoa is usually located at far off places and by the time it reaches the intermediate processors i.e. sweet makers, the microbiological quality of the product gets deteriorated to a considerable extent. The product continues to be in great demands for the manufacture of sweets and for this reason alone whatever quantity and quality are made available to the sweet makers, the same are converted into sweets.

In view of the growing market for khoa and khoa based sweets, the organized dairy plants have planned to manufacture khoa on large scale. The mechanised processes developed for khoa have not gained wide acceptance in the industry partly because the prototypes were not designed for continuous production at commercial scale. The available indigenously developed technology does not permit mass production of khoa for sale.

Currently, the utilization of surplus milk in the manufacture of indigenous milk products has been considered to be a feasible and economic proposition. Until such time a new technology for commercial manufacture of khoa is developed, attempts to use the existing machineries available in the modern dairy plants should be exploited. This would help in securing the benefits of product diversification by providing alternate use of seasonal and regional surpluses of milk solids in khoa making. In order

to provide a suitable technology for the manufacture of khoa, use of atmospheric roller driers could be conceived as a possibility for preparing a product with similar characteristics as those of khoa. Khoa powder prepared from whole milk could be considered as an alternate approach for solving the problem of shelf life and availability during lean season. The present investigation was, therefore, undertaken to study the feasibility of manufacturing khoa and khoa powder on the roller drier by altering some technological process so that the dairy plants possessing the roller drier facility could also manufacture khoa and similar products with longer shelf life.

CHAPTER – 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The traditional methods for khoa making were developed to suit the small scale village technology of conserving small quantities of surplus milk. Except for few attempts made to mechanize khoa making to put this product on sound industrial footing, no tangible progress could be made on commercialization of khoa making. The works related to the manufacture, packaging and storage of khoa are reviewed here.

2.1 Methods of manufacture of khoa

De and Srinivasan (1967) standardized a method for preparing khoa from white butter or ghee and roller dried skim milk. The product so made was of acceptable flavour, texture and composition, but colour was caramelized. The reconstitution of milk solids was necessary for production of khoa. They mentioned that reconstitution time of one hour and sufficient stirring were the conditions to maintain the particles in suspension. Subsequently, in 1968, both these researchers made limited attempts for utilizing vacuum concentrated milk with 31 and 37% total solids in the manufacture of khoa. They used plain standardized milk of 3.5% fat which did not yield the product with 20% fat. This product was criticized for lack of flavour.

Rajorhia (1971) attempted a semi-commercial process for preparation of khoa in a double-jacketed steam-heated, stainless steel kettle, using 20 litres of milk at a time. The contents were allowed to boil and stirred continuously with the help of a built-in-stirrer. Since milk sticks to the side of the pan and it was difficult to scrap the contents, a hand driven scraper was also used to avoid browning and burning of milk solids.

Banerjee, Bagchi and Verma (1968) developed a continuous khoa making machine. In this unit, milk is gradually concentrated in a steam jacketed drum heater and two cascading open pans which are provided with scrapers. Owing to the absence of control for regulated supply of milk and proportionate discharge of khoa, the plant did not work very efficiently. Moreover, the prototype was constructed from mild steel which usually got rusted overnight and caused the problem of oxidation of khoa.

De and Singh (1970) standardized the production of khoa by the continuous machine. The resultant product was having a soggy body. Several improvements in the design and operation of the continuous khoa plant were suggested. Based on extensive trials, Rajorhia and Srinivasan (1975) made many alterations in the design of this plant and got it fabricated in stainless steel.

Beghra (1979) used concentrated milk (31% and 40% TS) and whole milk powder (roller and spray dried) reconstituted with water to 15, 31, 40 and 65% TS for khoa making and obtained good quality khoa from both cow's and buffalo's vacuum concentrated milk with 31% TS. The product was comparable to conventionally prepared khoa both in respect of chemical composition and sensory evaluation. Khoa samples prepared from both concentrated milk having 40% TS and spray dried milk were sticky and scored low flavour ratings. Khoa samples prepared from roller dried powder (cow's and buffalo's) were quite satisfactory.

Patel (1977) attempted to develop a technology for the production of khoa powder from standardized, homogenized open pan concentrated buffalo milk. Prior to roller drying the product was mixed with water to make a slurry with 16-18% solids. The process so developed was cumbersome and offered little advantage. Problems such as difficult reconstitution or rehydration due to hardened granules and development of an off flavour (because of the product's prolonged contact with air at elevated temperatures) were noted. He suggested that obstacles like the lack of typical flavour and texture characteristics would have to be overcome by developing appropriate technology if milk preserved in powder form has to be utilized directly for sweet making either at the plant or at home.

Thompkinson and De (1978) developed a process for the manufacture of khoa powder using the technique of Patel (1977). Standardized milk was concentrated to 21-28% TS in a khoa pan at atmospheric pressure, pulverized and dried. Antioxidant was added in concentrated milk before drying. Khoa powder from cow milk had mild khoa flavour and the buffalo milk powder having cooked, sweetish flavour. Although satisfactory quality Gulab-jamun were prepared from cow khoa powder, the buffalo khoa powder did not compare satisfactorily with control samples. The product was found to possess a after-taste.

2.2 Shelf life

The spoilage of khoa is due to grouth of various types of micro-organisms. Molds cover the entire surface of the product and produce abnormal colour, flavour and appearance changes.

Bhat et al (1948) did steaming of khoa for 15 to 20 minutes, but storage of khoa beyond 48 hours resulted in rancid odour, brown discolouration and grainy appearance.

Sethna and Bhat (1949) used ultra-violet radiation to improve the keeping quality of khoa by 25 days. Irradiation of samples decreased moisture by 7 per cent. It is not clear whether the improved keeping quality was due to the bacteriological effects of irradiation or to the reduced moisture level. De and Ray (1953) studied that khoa could last upto 24 days at refrigeration temperature.

Ghodekar (1969) found that laboratory prepared samples remained in good condition for 14 days at refrigeration temperature. The laboratory samples of khoa stored for 14 days developed a total lactic acidity of 0.3% as against 0.56% in the market samples.

Jalil, Pandit and Singh (1963) reported the spoilage of khoa after 15 days at room temperature and 20 days at $4\pm1^{\circ}C$.

Rajorhia (1965) prolonged the shelf life of khoa by seven days at $28\pm1^{\circ}C$ by packaging khoa in waxed butterpaper.

Rudreshappa and De (1971) and Rajorhia and Srinivasan (1974) found no improvement in keeping quality of khoa by adding potassium sorbate and butylated hydroxyanisole in khoa, but Ghodeker (1969) found an improvement in the shelf life of khoa from 2 to 4 days at room temperature. Jha, Singh and Singh (1977) found benefits of adding potassium sorbate on the shelf life of khoa. It had more effect on the yeast and mold count. The shelf life of khoa could be increased upto 10-11 days at $30^{\circ}C$ and 40 days at $5^{\circ}C$. Addition of nisaplin and antioxidants like ascorbic acid, propyl gallate and lecithin did not improve the keeping quality of khoa. Kumar *et al* (1975) reported that khoa packed in parchment paper and polyethylene remained acceptable upto five days at $37^{\circ}C$ and upto 14 days at $8\pm1^{\circ}C$, while five days at $37^{\circ}C$ and 30 days at $8\pm1^{\circ}C$ in laminate packets. Four ply aluminium coated laminates proved to be the best for packaging of khoa followed by two ply packs,

high density polyethylene and parchment paper in descending order.

Rudreshappa and De (1971) tried khoa packaging in sterilized tins and increased the shelf life of khoa upto 14 days at 37±1°C with initial moisture of 20-25%. Jalil, et al (1963) concluded that greater resistance to deterioration was offered by stainless steel, next in order being aluminium, brass, tinned brass and iron, the life of the product being 6, 5, 4 and 3 days in different cans respectively at room temperature.

In conclusion it can be stated that khoa has a very short life which provides a field for further research.

Patel (1977) reported the shelf life of gas-packed khoa powder as 75 days at 37°C and 105 days at room temperature (16-30°C). The air-packed khoa powder did keep for 90 days.

Thompkinson and De (1978) studied the shelf life of khoa powder from cow and buffalo milk with gas packed, air packed and with BHA (CAO-3) as an antioxidant. They found the shelf-life of cow milk khoa powder as 115, 40 and 160 days at room temperature in gas-packed, air packed and antioxidant treated lots and at 37°C, the shelf life was 63 days for gas packed and 93 days in case of antioxidant treated product. In case of buffalo milk at room temperature, the shelf life was 105, 33, 150 in respective packages and at 37°C, 60 days in gas packed and 90 days with the help of antioxidant.

2.3 Flavour in khoa

The typical flavour of khoa is described as intense cooked with richness and sweetness. Sulphydryl compounds are greatly responsible for development of cooked flavour. The intensity of cooked flavour increases with increasing heat treatment (Ghuchlova, 1970).

Hemavathy and Prabhakar (1973) were the first to observe the production of carbonyl compounds in khoa. The major carbonyls found in khoa were methyl ketones and saturated aldehydes. Khoa was rich in lower carbon chain methyl ketones.

Arora (1976) found a gradual and considerable increase in level of total carbonyls during khoa making. Rajorhia (1978) found that there was an increase in the total steam volatile flavour compounds at successive stages of khoa making. Although many unidentified peaks appeared on the chromatograms of the varian Aerograph, peptan-2-one was the most predominant flavouring compound both in cow's and buffalo's milk. Pentanone continued to be maximum throughout heating, except that a fall in the quantity was noticed at the pat formation stage in samples from both cow's and buffalo's milk. Heptone was the second major flavouring compound in cow's milk at all stages of heating. Other identified flavouring compounds includes octanone, acetaldehyde, propionaldehyde, nonanont and benzaldehyde. The quantity of each of the flavouring compounds varied with heating in different

types of milk. The author also stated that there was a progressive release of Sulphydryl compounds during khoa making. At boiling stage, the reducing capacities increased from the initial value. Sulphydryls also increased at the pat formation stage in both types of milk.

Patel (1977) reported that product stored at 37°C had the satisfactory flavour upto 75 days. The product kept at room temperature had no change in the flavour upto 45 days. The off flavour developed upto 105 days was not objected in gas-packed khoa powder and 90 days for air packed products. The off flavour developed was rancid, coconut like, stale or slightly burnt. The score obtained for flavour at gas-packed product was 8.0-3.0 at 37°C and 8.5-5.0 at room temperature for 0-20 days. The air-packed product had the score of 8.5-3.5 at room temperature. The evaluation of flavour was done out of a maximum score of 10.

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CHAPTER – 3

SCOPE AND PLAN OF WORK

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3.1 Scope of work

The dairy plants in India are getting interested in the manufacture of khoa in view of the assured market. The non-availability of a suitable machanized process for large scale production of khoa has been responsible for its slow adoption by the dairy plants. Systematic attempts should therefore be made to adopt existing dairy processes and equipments for khoa making. This investigation was planned to study the possibilities of using the roller drying process for the manufacture of khoa with typical caramel flavour. Adaptation of this new method may become useful in the large scale production of khoa to meet the ever growing demand of public. The problem of the shelf-life of khoa could also be solved by reducing its moisture content upto powder level. The cost of transportation and refrigeration could also be minimized. The present studies were directed towards the following objectives:

3.1.1 To standardize a process for the manufacture of khoa and khoa powder using a roller drier for large scale production.

3.1.2 To study the shelf life of the product obtained from roller drier using flexible polyethylene packages and tins.

3.2 Plan of work

The plan of work is outlined as follows:

3.2.1 Standardizing the manufacturing procedure

3.2.1.1 To find out a suitable total solids concentration in milk for the manufacture of khoa and dried khoa.

3.2.1.2 Type of milk:

(i) Cow milk (4% Fat, 8.5% SNF)

(ii) Buffalo milk (5% Fat, 9% SNF)

3.2.1.3 Levels of concentration achieved using a single effect vacuum pan:

(i) 30%

(ii) 40%

(iii) 50%

3.2.2 Studies on the shelf life of the product

3.2.2.1 Storage temperatures and periods

(a) At $5^{o}C$

(i) Khoa - 0, 5, 15 days

(ii) Khoa nodules - 0, 30, 60, 90, 120, 150 days

(iii) Khoa powder - 0, 30, 50, 70, 90, 110 etc. days

(b) At $30^{o}C$

(i) Khoa - 0, 5 days

(ii) Khoa nodules - 0, 5 , 10, 20, 30 days

(iii) Khoa pouder - 0, 15, 30, 45, 60, 75, 90, 105, 120 and 135 days.

3.2.3 Methods of examination

3.2.3.1 Sensory evaluation

a) Colour
b) Body and Texture
c) Flavour

3.2.3.2 Chemical tests

a) Moisture
b) Fat
c) Acidity (as % lactic acidity)
d) Free fatty acidity
e) Free fat
f) Peroxide value
g) p-DMAB reactivity (Zero day only)
h) 5-HMF value (Zero day only)

3.2.3.3 Microbiological tests

a) Presumptive coliform test
b) Viable counts
c) Yeast and mold counts

The experiments were replicated two times.

CHAPTER - 4

MATERIALS AND METHODS

MATERIALS AND METHODS

The first part of this chapter deals with the methods of manufacture of the product while the second part deals with the analytical procedures adopted in the examination of milk, khoa, khoa nodules and khoa powder.

4.1 Methods of manufacture

4.1.1 Preparation of concentrated milk

The fresh, chilled milk was obtained from the Experimental Dairy of the Institute. Cow's milk was standardized to 4.0% fat and buffalo's milk to 5.0% fat. Milk was preheated to 90±2°C through a "Silkeborg" plate heat exchanger. At a time 500 litres milk was taken for concentration in the single effect vacuum pan. Milk was concentrated to 30, 40 and 50% total solids. As soon as the concentration was reached to 30% total solids, the vacuum was released and 40 litres of concentrated milk was drawn from the vacuum pan into a sterile aluminium can. The vacuum was again brought to 25 inches Hg and remaining milk was concentrated to 40%. A portion of this milk having 40% concentration was collected in a 40 litre can. The last portion of the milk was concentrated to 50% total solids and the whole lot was collected into cans.

4.1.2 Preparation of roller dried products

The 'Richard Simon' top fed atmospheric double drum drier was used with the following specifications:

Length of the roller	= 18 inches
Diameter of the roller	= 16 inches
Speed of the roller	= 17 to 19 rpm
Rate of water evaporation	= 44 lb/hr
Steam pressure	= 74 - 78 psi

4.1.2.1 Production of khoa

The concentrated milk with 30% total solids was heated to 74°C for 10 minutes and divided into two parts. From one part khoa was prepared on the rollers by reducing the steam pressure to 15-20 psi and rate of flow of milk. The distance between the drum and the knives was also manipulated. A very thin paste was collected in the tray. This paste lacked the typical flavour, body and texture of khoa.

Khoa of desired quality could not be prepared at 15-20 psi from 40% total solids also.

A portion of the concentrated milk with 50% solids was heated to 74°C for 10 minutes. Khoa of desired flavour at 15-20 psi was obtained. Thus, a total solids concentration of 50% was selected for further studies on khoa making.

4.1.2.2 Production of khoa powder

Khoa pouder with 30% total solids concentrated milk was prepared at 40 psi which did not possess the characteristic khoa flavour.

Khoa powder from 40% total solids concentrated milk was manufactured at 68 psi. The product had a mild flavour.

The second portion of concentrated milk with 50% total solids was heated to 56°C and fed to roller drier for manufacture of khoa powder. Khoa powder was made at 74-78 psi.

The third portion of 50% total solids concentrated milk was heated to 74°C for 10 minutes at atmospheric pressure for intensifying the cooked flavour before feeding to roller drier. By varying rate of flow and distance between roller and the knives, khoa powder was obtained at 74-78 psi.

4.1.2.3 Production of khoa nodules

By increasing the milk flow, at 25-30 psi khoa rolls (nodules) were obtained with 50% total solids concentrated milk. Khoa nodules were collected in the trays closely mounted to the rollers. The khoa nodules prepared with 30% and 40% total solids did not have the satisfactory khoa flavour. Therefore, they were rejected for further studies.

4.1.3 Packaging of the products

The sterilized polyethylene bags (250 gm capacity) were used for packaging of khoa and khoa nodules. Khoa powder was packaged in sterilized tin containers (250 gm capacity). The polyethylene bags were sterilized by

Ultraviolet rays and tins in hot air oven at 160°C for three hours.

4.1.4.0 Storage of packed products

The samples of polyethylene packed khoa and khoa nodules and tin packed khoa powder were stored at 5±1°C and 30±1°C temperatures. Samples were opened and examined at predetermined durations as enumerated in Section 3.2.2.1.

4.1.5.0 Judging of the products

The samples of khoa, khoa nodules and khoa powder prepared from cow, buffalo heated and unheated concentrated milk were served to judges for sensory evaluation. The products for their colour, flavour, body and texture were evaluated on a maximum score of 10 for each characteristics. The grading was done as follows:

Excellent	9 - 10
Good	6 - 8
Fair	4 - 6
Poor	1 - 3

The judging panel consisted of 5-7 judges selected from the staff members of Dairy Technology Division.

4.2 Methods of Examination

4.2.1 Chemical Examination of milk

4.2.1.1 Fat

The fat per cent in milk was determined by the Gerber method described in IS (1958).

4.2.1.2 Total Solids

The "dry and weigh" method was used for estimating the total solids and SNF per cent in milk.

4.2.2 Chemical Examination of concentrated milk

4.2.2.1 Fat

Fat per cent in concentrated milk was determined according to the method described in the Laboratory Manual (1959) of U.S. Milk Industry Foundation.

4.2.2.2 Total solids

The extent of concentration during condensing were tested by 'Baush and Lomb' Refractometer. Later on the Mojonnier's gravimetric method was used for exact determination of total solids.

4.2.2.3 Lactic acidity

The lactic acidity was determined according to IS (1960) by suitable dilution with distilled water.

4.2.3 Chemical examination of khoa, khoa nodules and khoa powder

4.2.3.1 Moisture in Khoa

The moisture per cent in khoa was determined by adopting the method described for cheese in IS (1964).

4.2.3.2 Fat of Khoa

The method for determination of fat in cheese as described in IS (1964) was used.

4.2.3.3 Acidity of Khoa

The acidity of khoa and khoa nodules was determined by indirect method which is given as follows:

Two gm of khoa was weighed into a porcelain dish. The product was made into a fine paste in a pestle and morter by adding 3 ml of hot distilled water and diluting by another 17 ml of hot distilled water washing off the adherants from the pestle. Later 10 ml of 0.1 N sodium hydroxide (A.R. Grade) was added. After adding 1 ml of 0.5 per cent phenolphthalein indicator, the contents were titrated against 0.1 N hydrochloric acid with continuous stirring till the pink colour completely disappeared. Acidity was expressed as lactic acid per 100 gm of khoa

$$\% \text{ L.A.} = \frac{10 - V}{W} \times 0.9$$

Where V = Volume of 0.1 N HCl required for titration

W = Weight of sample of khoa (2 gm)

4.2.3.4 Moisture per cent in khoa powder

The moisture in khoa powder was found out by the method described in IS (1967).

4.2.3.5 Fat % in khoa powder

Fat in khoa powder was determined according to the method described in Laboratory Manual (1959) of U.S. Milk Industry Foundation for whole milk powder.

4.2.3.6 Acidity determination of khoa powder

The lactic acidity of khoa pouder was determined according to IS (1967).

4.2.3.7 Free fat

The free fat content in all the three products was determined by the method given by Hall and Hedrick (1971).

4.2.3.8 Hydroxy Methyl Furfural value for brouning

The method of Keeney and Bassette (1959) as adopted by Craig, ACeto and Della Monica (1961) was used for estimating the free as well as total HMF for browning intermediates in all the three types of products.

4.2.3.9 p-Dimethyl Amino Benzaldehyde Reactivity

The method of Kumar and Hansen (1972) was used for measuring the p-Dimethyl Amino Benzaldehyde (p-DMAB) reactivity for all the three types of product.

4.2.3.10 Free fatty acidity

Free fatty acidity of all the three types of product was determined by titration method given in IS (1966) for ghee. The fat was extracted from the product with the help of petroleum ether and solvent ether.

4.2.3.11 Peroxide value

Peroxide value of fat extracted from the three types of product was determined by the method of Stin et al (1954).

4.2.4 Microbiological methods of khoa, khoa nodules and khoa powder

The surface portions of khoa and khoa nodules were scraped with the help of a sterile spatula to remove the surface contaminants. The stored samples of khoa and khoa nodules were opened by Schematic random procedure in an inoculation chamber sterilized by ultra-violet radiation. All aseptic precautions were observed during the sampling and preparation of samples.

4.2.4.1 Preparation of sample

In the ultra-violet rays sterilized chamber, the glass mortar and pestle were sterilized by flaming with two ml of alcohol in the mortar and stirring with the pestle till the flame disappeared. The mortar and the pestle were allowed to cool down for some time. The previously weighed watch glass was sterilized with igniting alcohol and cooling it down for a while. One gram of the sample was weighed on the sterilized glass and transferred to the sterilized mortor. Two ml of warm starile solution of 20% sodium citrate was put in the mortar and ground thoroughly with the sterile pestle. Eight ml of warm (maintained at $45^{o}C$) sterile normal saline solution was poured to the ground sample and stirred to give a dilution 1:10 free from lumps. Further dilutions of 1:100, 1:1000 etc. were prepared accordingly.

4.2.4.2 Presumptive coliform test

One ml of 1:10 dilution of the sample prepared was inoculated in duplicate into MacConkey's borth tubes (Chalmers, 1962). The inoculated tubes were incubated at 37°C for 24-48 hours. The formation of acid and gas indicated the presence of coliforms.

4.2.4.3 Viable bacterial counts

The Tryptone dextrose agar for viable bacterial counts was prepared according to IS (1962). The plates were incubated at 37±1°C for 24-48 hours. The colonies were counted according to the Standard Methods for the Examination of Dairy products as published by American Public Health Association (A.P.H.A.) 1967.

4.2.4.4 Yeast and mold counts

Potato-dextrose agar medium was used for enumerating yeasts and molds in the sample. The medium was prepared according to the composition given by Chalmers (1962) as follows:

200 gm of potato infusion	=	1 lit of water
Dextrose	=	20 gm
Agar	=	15 gm
Distilled water	=	1 litre

The medium was sterilized in an autoclave at 15 psi for 15 minutes. The pH of the medium was adjusted to 3.5 at the time of pouring the plates by using 10% sterile tartaric acid.

Required number of serial dilutions were made from 1:10 dilution of the suspension of the sample and the plates were poured in duplicates. The plates were incubated at 24±1°C for 3 to 5 days and the colonies of yeasts and molds were counted.

CHAPTER - 5

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

This chapter deals with the techniques employed in the standardisation of processes for the manufacture of (i) khoa, (ii) khoa nodules and (iii) khoa powder using a laboratory type roller drier. The products were also subjected to shelf life studies at 30°C and 5°C in polyethylene and tin containers. The data collected in respect of chemical, microbiological and sensory properties during standardization and storage are tabulated and discussed.

5.1 Manufacture of khoa using a roller drier

5.1.1 Standardization of khoa making process

As enumerated in section 4.1.1, the cow's and buffalo's milks were separately concentrated in a single effect vacuum pan upto 30%, 40% and 50% total solids. Figure 1 represents the operations involved in the manufacture of the products. In the first instance, standardized buffalo milk was concentrated to 30% total solids and fed to the roller drier in such a manner as to allow maximum retention of moisture in the semi-dried product. In routine operation for powder manufacture, a steam pressure of 50 - 75 psi is maintained but in this case the steam pressure was reduced to 15-20 psi.

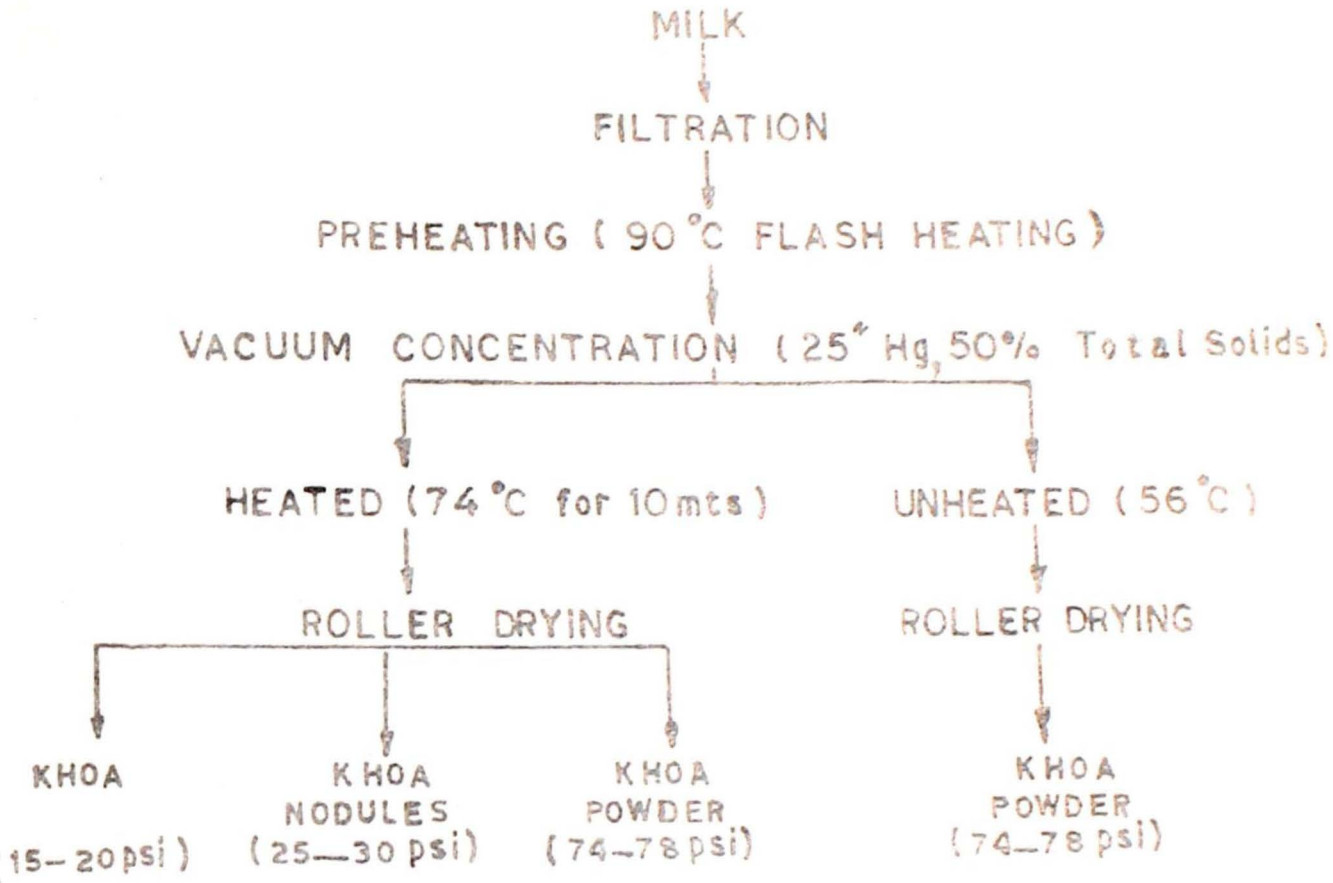

FIG. 1 FLOW DIAGRAM FOR MANUFACTURE OF KHOA, KHOA NODULES AND KHOA POWDER.

The resultant product, contained high percentage of moisture and did not resemble to any of the textural and body characteristics of khoa. Increasing the pressure of steam or reducing the feed rate did not help in the improvement of any characteristics of the resultant product.

The second attempt was made using buffalo concentrated milk with 40% total solids. By manipulating the feed rate of milk and distance between the two rotating drums and scraping knives and maintaining the pressure at 15-20 psi, it was possible to obtain a product which closely resembled khoa in appearance and texture. The product, however, lacked the typical khoa flavour. Similar difficulties were experienced in converting cow's concentrated milk into khoa which was previously concentrated to 30% and 40% total solids.

Further attempts were made to convert concentrated buffalo milk with 50% total solids into khoa. To intensify khoa flavour, the concentrated milk was heated to 74°C for 10 minutes before transferring into the roller trough. The feed rate of concentrated milk was controlled with the help of a faucet fixted to a milk delivery can. The product manufactured at a steam pressure of 15-20 psi contained desirable flavour, body and texture. The product was analysed for various chemical, sensory and microbiological properties. Data collected on these aspects have been presented in Table 1.

Table 1 : Chemical, microbiological and sensory evaluation properties of khoa.

(Average of two trials)

	Constituents	Cow	Buffalo
1.	Moisture (%)	30.06	31.55
2.	Fat (%)	22.25	21.50
3.	Free fat		
	(a) % by weight in khoa	12.87	17.65
	(b) % of fat in khoa	57.71	82.09
4.	Acidity (% L.A.)	0.67	0.76
5.	Free fatty acidity (% oleic acid)	0.21	0.28
6.	Peroxide value (meq O_2/kg fat)	0.45	0.62
7.	p-DMAB reactivity (absorbance at 545 nm/gm of milk)	0.311	0.293
8.	5-HMF value (umoles/100gm of total solids)		
	(a) Free	0.41	0.57
	(b) Mean	13.92	13.21
9.	Average sensory value	7.56	7.50
10.	Viable counts (/gm)	80	100

All the samples were negative to presumptive coliform test and yeast and mold counts.

It may be observed that both cow and buffalo concentrated milk with 50% total solids produced acceptable quality of khoa which contained 30% and 31.5% moisture respectively. Both the samples of khoa manufactured on roller drier had 22.25% and 21.50% fat in cow and buffalo khoa. The P.F.A. rules have prescribed a minimum of 20% fat in khoa on "as it is" basis. Thus, khoa prepared from cow's and buffaloe's milk previously concentrated to 50% total solids met the minimum legal requirement. Jailkhani and De (1978) suggested that the release of free fat controls the textural properties of khoa. The heat treatments cumulatively given to milk resulted in the release of 12.8% and 17.6% free fat in cow's and buffaloes khoa. It may be seen that about 58% of the total fat in cow's khoa and 82% in buffalo's khoa were in free state. Boghra (1979) also observed the presence of 66-77% free fat in the total fat of khoa prepared by batch process using vacuum concentrated milk. The per cent lactic acidity and free fatty acidity in the two products were also very close to those obtained in batch process of khoa making. The peroxide value of the product was somewhat higher as compared with the product manufactured by Kumar et al (1975). The formation of high quantity peroxides may be attributed to increased free fat formation due to prolonged boiling even at low temperature obtainable in the vacuum pan and subsequent heating of concentrated milk before feeding to roller drier. The extent to which khoa was subjected to heat treatment was

Fig.9 KHOA prepared on the roller drier

measured by p-DMAB reactivity and production of 5-HMF. The values for measuring the heat effects in the present experiment both for cou's and buffalo's khoa are somewhat higher than those reported by Boghra (1979) and Rajorhia (1978) since these workers used batch method for khoa making using small quantities of milk at a time.

The products from both cou's and buffalo's milk were tested for the presence of coliform organisms and yeast and mold counts which were negative. The total viable counts ranged from 80-100/gm of khoa. This would indicate that the product was hygienically sound.

5.1.2 Studies on the shelf life of khoa prepared on the roller drier

Khoa samples were packaged in sterilized polyethylene containers. The effects of storage on the chemical and sensory attributes of khoa are presented in Table 2. It may be observed that as the days of storage increased, the moisture % decreased in both cou's and buffalo's milk khoa. The rate of decrease of moisture was more at 30°C than at 5°C. Polyethylene has got poor moisture barrier properties. Similar results were reported by Kumar et al (1975). They found that moisture was reduced to 28.5% from an initial value of 32% at 37°C in 5-10 days.

There was a simultaneous increase in the fat content in khoa samples as a result of evaporation of moisture during storage.

Table 2 : Chemical changes during storage of khoa prepared on roller drier
(Average of 2 trials)

Constituents	Cou's milk khoa				Buffalo's milk khoa			
	Days of storage				Days of storage			
	30°C		5°C		30°C		5°C	
	0	5	10	15	0	5	10	15
1. Moisture (%)	30.06	26.67	28.26	27.23	31.55	26.87	29.32	27.54
2. Fat (%)	22.25	23.57	22.82	23.15	21.50	22.97	22.20	22.76
3. Free fat (a) % by weight in khoa	12.87	13.74	13.21	13.42	17.65	19.12	18.27	18.78
(b) % of fat in khoa	57.71	58.46	57.88	57.96	82.09	83.63	82.31	82.53
4. Lactic acidity (%)	0.67	0.89	0.73	0.74	0.76	0.96	0.85	0.86
5. Free fatty acidity (% oleic acid)	0.210	0.307	0.205	0.213	0.280	0.300	0.285	0.290
6. Peroxide value (meq. O_2 /kg fat)	0.45	1.71	0.48	0.50	0.62	0.73	0.64	0.66
7. Average sensory scores	7.56	4.0	7.16	3.0	7.5	3.0	7.5	2.6

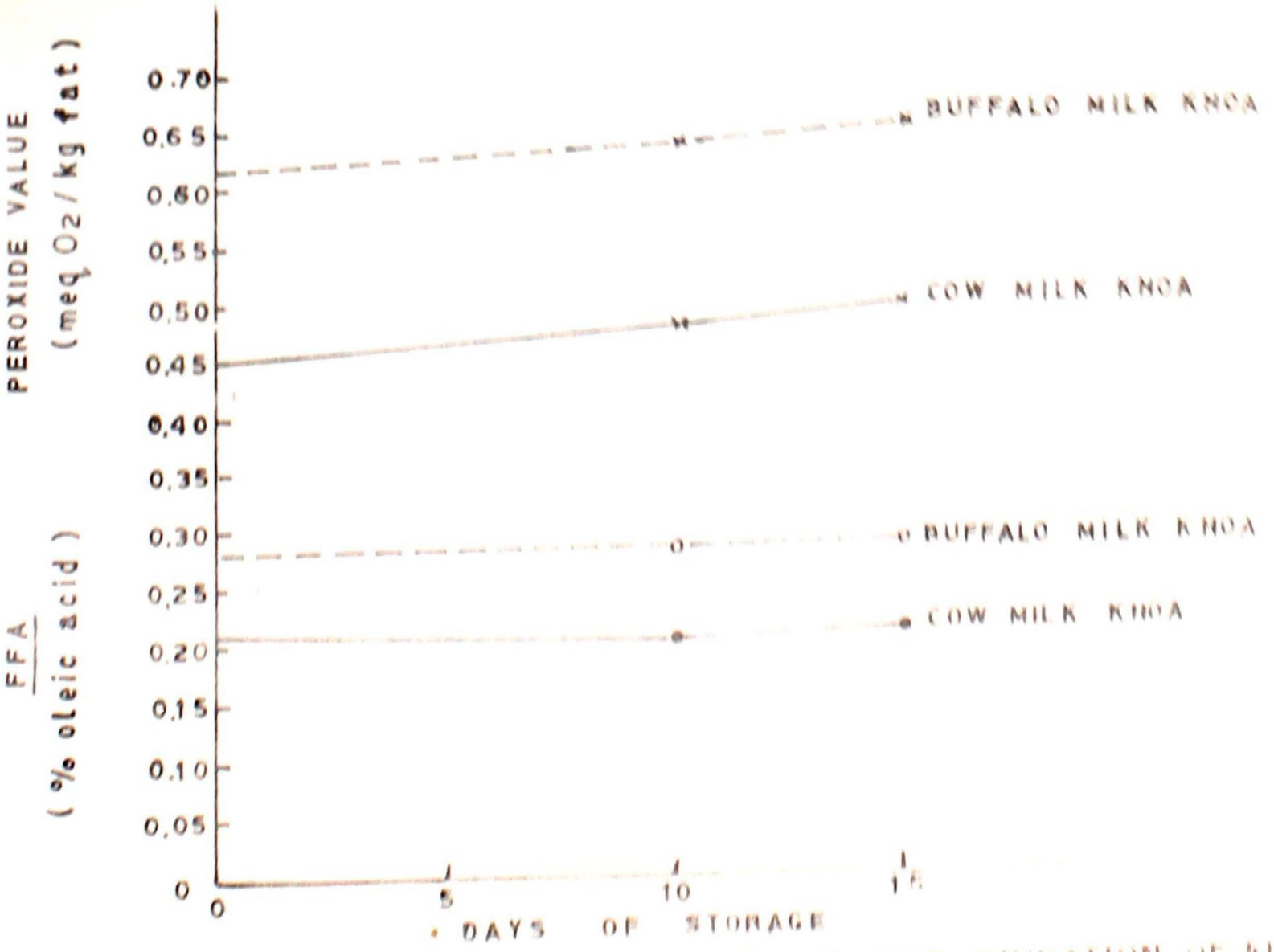

FIG. 2 EFFECT OF STORAGE AT 5°C ON FAT OXIDATION OF KNOA

Free fat % in khoa from both cow's and buffalo's milk got slowly increased during storage. Buffalo's khoa had more free fat than cow's khoa. The release of free fat during storage was more in buffalo's khoa than that of cow's.

The increase in Lactic acidity during storage of cow's khoa was less than buffalo's khoa.

The initial free fatty acidity was higher in buffalo's khoa than cow's khoa and it increased during storage. The increase was higher at 30°C than at 5°C (Figure 2).

The peroxide value of fat was found to be higher in buffalo's khoa than in cow's khoa and the values increased during storage. The increase was higher at 30°C than at 5°C. Kumar *et al* (1975) found an increase of peroxide value from 0.12 to 0.32-0.78 in 5-10 days storage at 37°C.

The microbiological changes during storage of khoa at 5° and 30°C are tabulated in Table 3. It may be seen that all the samples of khoa were negative to presumptive coliform test.

Buffalo's khoa had slightly higher viable counts than cow's khoa. After 5 days storage the viable counts increased to 9,450 and 11,250 million/gm at 30°C in cow's and buffalo's khoa. The viable counts in millions per gm of khoa at 5°C were 5.0, 7.0 and 65.0, 76.0 on 10th and 15th day in cow's and buffalo's respectively.

Table 3 : Microbiological changes during storage of khoa from heated concentrated milk (50% T.S.).

(Average of two trials)

Microbiological tests	Storage days			
	30°C		5°C	
	0	5	10	15
		Cow khoa		
1. Viable counts (per gm)	80	9450×10^6	5.0×10^6	65×10^6
2. Yeast and mold counts (per gm)	Nil	4500	100	3500
		Buffalo Khoa		
1. Viable counts (per gm)	100	11250×10^6	7.0×10^6	76.0×10^6
2. Yeast and mold counts (per gm)	Nil	4700	120	4500

The samples were negative to presumptive coliform test.

The yeasts and molds at zero day were not present in both cow's and buffalo's khoa. But there was rapid increase in their counts after 5, 10 and 15 days. This may be due to atmospheric contamination of the product during handling and packaging. These results are in close agreement with those of Ghodeker (1969) for laboratory samples of khoa.

5.2 Studies on the manufacture of khoa nodules

5.2.1 Standardisation of the process for manufacture of khoa nodules

The nodules of khoa were manufactured at 25-30 psi from 50% concentrated milks using cow's and buffalo's milk seperately. The concentrated milk was heated at 74°C for 10 mts to increase the intensity of flavour. Concentrated milk was uniformly spread in the trough of the roller drier and distributed to the rollers in such a way that the dried product in the form of strips rolled over in the form of nodules. These nodules were collected in the trays (Fig. 10).

The chemical, microbiological and organoleptic properties of the khoa nodules are presented in Table 4. It may be seen that khoa nodules prepared on the roller drier from cow's and buffalo's concentrated milk carried 16.4% and 17% moisture respectively. Most of the moisture got enveloped within the internal strips of the nodules. The outer surface of the nodules was comparatively drier and crisp which was expected to provide better protection against microbial spoilage.

Fig.10 KHOA NODULES

Table 4 : Chemical, microbiological and sensory properties of khoa nodules

(Average of two trials)

	Constituents	Cow	Buffalo
1.	Moisture (%)	16.40	17.07
2.	Fat (%)	24.26	25.33
3.	Free fat		
	(a) % by wt. of khoa	14.25	16.85
	(b) % of fat in khoa	58.73	66.50
4.	Lactic acidity (%)	0.68	0.72
5.	Free fatty acidity (% oleic acid)	0.25	0.20
6.	Peroxide value (meq. O_2/kg fat)	0.52	0.61
7.	p-DMAB reactivity (absorbance at 545 nm/gm of milk)	0.312	0.301
8.	5-HMF value (u moles/100 gm of total solids)		
	(a) Free	0.39	0.55
	(b) Total	14.22	13.50
9.	Presumptive coliform test	-ve	-ve
10.	Viable counts (x1000/gm)	8.0	9.75
11.	Yeast and mold counts (x1000/gm)	0.01	0.01
12.	Average sensory scores	8.16	8.3

The fat content in the khoa nodules prepared from buffalo milk was 25.53% which was more than the cow's khoa nodules (24.26%). The free fat content in khoa nodules of buffalo milk was 66.5% and that of cow's 58.73%. The amount of free fat in the nodules was less than the khoa prepared on roller drier. The extent to which khoa nodules were exposed to heating was less than khoa. The lactic acidity was higher in buffalo's khoa nodules (0.72%) than cow's khoa nodules (0.68%). The lactic acidity of khoa nodules and khoa powder was almost the same.

The free fatty acidity which is the measure of hydrolysis of fat was higher in cow's khoa nodules than buffalo's khoa nodules (0.2% oleic) and khoa tested higher oleic acidity than khoa nodules in both the species. In order to verify whether adequate heat treatment has been given during the manufacture of khoa nodules to ensure the formation of required quantity of flavouring compounds, the p-DMAB reactivity was measured. It was found that cow's khoa nodules show higher reactivity (0.312) than buffalo's khoa nodules (0.301). Boghra (1979) reported p-DMAB reactivity as 0.27, 0.26 and 0.28, 0.27 for cow's and buffalo's khoa from 30% and 40% concentrated milk. The p-DMAB reactivity of khoa and khoa nodules was not different in the present experiment.

Release of free HMF as an intermediate product of browning was found to be 0.55 and 0.39 u moles/100 gm total solids in buffalo's khoa nodules and cow's khoa nodules respectively, but total HMF value was more in cow's khoa nodules (14.22 u moles/100 gm) total solids. Boghra (1979) reported the HMF values as 18.30, 15.76 and 15.44, 14.66 u moles/100 gm total solids in cow's and buffalo's khoa from 31% and 40% concentrated milk.

Khoa nodules were found negative to coliform test. The yeasts and molds were less than 10/g. The viable counts were 8,000 and 9,750/gm in nodules obtained from cow's and buffalo's concentrated milk.

5.2.2 Chemical, microbiological and sensory changes during storage of khoa nodules

Khoa nodules from cow's and buffalo's heated concentrated milk were packaged in polyethylene bags and stored upto 30 days at 30°C for 120 days at 5±1°C. The chemical and sensory values of cow's khoa nodules and buffalo's khoa nodules are tabulated in Table 5. The following changes were noticed.

In both types of khoa nodules, moisture for first five days decreased rapidly and then slowly. At refrigeration temperature, the decrease in moisture was rapid during first one month. The moisture percentage, thereafter, got stabilized around 11% from an initial value of 16.4%.

Constituents	Days of storage								
	30°C					5°C			
	0	5	10	20	30	30	60	90	120
	Cow milk khoa nodules								
Moisture (%)	16.40	13.62	12.21	11.30	10.26	11.56	11.21	10.82	10.41
Fat (%)	24.26	25.06	25.47	25.74	26.04	25.66	25.76	25.88	25.99
Acidity (% L.A.)	0.68	0.75	0.78	0.86	0.96	0.68	0.685	0.69	0.72
Free fat – (a) % of khoa	14.25	14.82	15.22	15.53	15.82	15.23	15.33	15.51	15.70
(b) % of fat in khoa nodules	58.73	59.13	59.75	60.33	69.75	59.35	59.51	59.93	60.42
Free fatty acidity (% as oleic acid)	0.26	0.28	0.29	0.31	0.34	0.32	0.34	0.35	0.37
Peroxide value (meq. O_2/kg fat)	0.52	0.57	0.58	0.60	0.65	0.60	0.65	0.71	0.83
Average sensory scores	8.16	7.6	6.5	5.5	2.8	7.6	7.3	7.3	7.3
	Buffalo milk khoa nodules								
Moisture (%)	17.07	14.75	13.62	12.25	11.23	12.52	11.31	10.62	10.21
Fat (%)	25.33	26.03	26.38	26.79	27.11	26.72	27.08	27.30	27.62
Lactic acidity (%)	0.72	0.75	0.78	0.81	0.85	0.77	0.79	0.81	0.85
Free fat % (a) of khoa	16.85	17.40	17.76	18.20	18.61	17.87	18.28	18.54	18.87
(b) of fat in khoa nodules	66.50	66.85	67.32	67.94	68.67	66.91	67.53	67.94	68.33
Free fatty acidity (% oleic acid)	0.20	0.24	0.26	0.28	0.31	0.25	0.28	0.30	0.31
Peroxide value (m.eq. O_2/kg fat)	0.61	0.65	0.68	0.72	0.76	0.65	0.69	0.73	1.07
Average sensory scores	8.3	7.6	6.3	5.5	2.8	7.5	7.3	7.5	7.5

There was a corresponding increase in the fat content of the nodules with progressive evaporation of moisture during storage. The increase in the lactic acidity in both cow's and buffalo's khoa nodules was slow at both the temperature of storage. In cow's khoa nodules lactic acidity at 30°C storage increased from the initial value of 0.68% to 0.96% after 30 days storage while in buffalo's khoa nodules the increase was upto 0.85% from an initial lactic acidity of 0.72%. The increase in lactic acidity was insignificant at 5±1°C. The free fat % was found to increase during storage both at 5°C and 30°C. Initially buffalo's khoa nodules had more free fat than cow's khoa nodules. In cow's khoa nodules free fat increased from the original value of 58.73% to final percentage of 60.75%. In buffalo's khoa nodules the increase was only 1.3% i.e. 66.5% increased to 68.67% of the total fat.

The free fatty acidity (0.26%) in cow's khoa nodules at zero day increased to 0.34 (% oleic acid) after 30 days storage at 30°C and to 0.37 in 120 days storage at 5°C. The corresponding values for buffalo's khoa nodules were 0.31% at 30°C after 30 days and 0.31% at 5°C in 120 days. The initial value was 0.2%.

The peroxide value in cow's khoa nodules and buffalo's khoa nodules was 0.52 and 0.61 meq O_2/kg fat respectively which increased during storage. The rate of fat oxidation was slower in khoa nodules than khoa. The peroxide value in cow's khoa nodules after 30 days increased to 0.83 at 30°C. The increase was higher in khoa nodules of buffalo. It appears that free fat plays a dominant role in the formation of peroxides.

The average sensory scores were quite satisfactory on zero day. Khoa nodules were organoleptically acceptable after 20 days storage at 30°C. The acceptability was suddenly reduced on 30th day of storage. It may be inferred that khoa nodules can be stored safely upto less than 4 weeks. Khoa nodules at refrigeration temperature continued to be acceptable to the judges upto 120 days of storage. The shelf life of khoa nodules can be predicted upto 5-6 months.

The microbiological changes during storage are presented in Table 6. It is interesting to note that all the samples of khoa nodules were free from coliform organisms. The initial vieble counts in cow's and buffalo's khoa nodules ranged from 8.0 - 9.75 thousand/gm which decreased during storage. Yeast and mold counts showed an increasing trend during the storage at both the temperatures. The yeast and mold counts in stored samples ranged from 10 to 2,000/gm.

Table 6 : Microbiological changes during storage of roller dried khoa nodules (Average of two trials)

Constituents	Days of storage								
	30°C					5°C			
	0	5	10	20	30	30	60	90	120
	Khoa nodules from cow milk								
1. Viable counts (thousand/gm)	8.0	6.65	5.2	4.3	2.9	3.2	2.1	1.5	0.75
2. Yeast and mold counts (thousand/gm)	0.01	0.10	0.20	0.40	1.0	0.20	0.50	1.0	1.20
	Khoa nodules from buffalo milk								
1. Viable counts (thousand/gm)	9.75	7.00	6.20	5.40	3.45	5.92	4.65	3.40	1.05
2. Yeast and mold counts (thousand/gm)	0.01	0.20	0.40	0.70	1.2	0.50	0.80	1.5	2.00

All the samples were found to be negative to presumptive coliform.

5.3 Manufacture of khoa powder from concentrated milk

5.3.1 Standardization of the method for manufacture of khoa pouder

The cow's and buffalo's milks were concentrated to 30%, 40% and 50% total solids in the single effect vacuum evaporator. Each type of concentrated milk was equally divided in two parts. The first portions were heated to 56°C and the second portions to 74°C for 10 mts before drying. This heating became necessary for producing cooked flavour in the powder. It was possible to manufacture khoa powder from all the 3 x 2 types of concentrated milks by adjusting the steam pressures in the roller driers.

The steam pressures used for drying of 30%, 40% and 50% concentrated milks were 40, 68 and 74-78 psi respectively.

All the samples of khoa powders were examined for sensory properties by a panel of judges and the highest average scores were awarded to the powder made from 50% concentrated milk previously heated to 74°C for 10 mts. followed by 50% concentrated milk warmed to 56°C. The mean sensory scores for buffalo and cow concentrated milks for high heat treated and low heat treated khoa powders were 8.3, 8.2, 7.9 and 7.8 respectively, the lower figures being associated with those of the cow's (Table 7).

Fig.11 KHOA POWDER

The sensory characteristics of khoa powder manufactured from 30% total solids were criticised for lack of flavour, although product from 40% total solids got a satisfactory scoring provided it was prepared from concentrated milk after heating to 74°C for 10 mts. Heating to 56°C before roller drying did not improve the flavour in both these cases and the powder resembled to that of the ordinary whole milk powder.

All the batches of powders were examined for various chemical, microbiological and sensory properties and their values are reported in Table 7.

The moisture contents in powder from cow's concentrated (56°C) and heated concentrated (74°C for 10 mts) milk were 3.42% and 3.17% whereas in buffalo's the corresponding values were 4.25% and 4.12%. According to the Prevention of Food Adulteration rules, the maximum moisture in whole milk powder by roller drying process should not exceed 5%. The moisture contents in the present experiment were less than this limit. The fat content in both cow's and buffalo's khoa powder on gross weight basis were 30.76 to 30.84% and 30.33 to 30.42% respectively.

The lactic acidity in khoa powder from buffalo's milk warmed and heated was 1.02% and 1.04% and in cow's 0.99 and 1.03%. The I.S.I. have prescribed that whole

Table 7: Chemical, microbiological and sensory properties of khoa powder.

(Average of two trials)

Constituents	Cow		Buffalo	
	Concentrated	Heated concentrated	Concentrated	Heated concentrated
1. Moisture (%)	3.42	3.17	4.25	4.12
2. Fat (%)	30.76	30.84	30.33	30.42
3. Free fat (% by wt. of khoa pouder)	20.12	21.32	23.43	25.59
4. Acidity (%)	0.99	1.03	1.02	1.04
5. Free fatty acidity (% oleic acid)	0.11	0.11	0.062	0.064
6. Peroxide value (meq. O_2/kg fat)	0.42	0.41	0.50	0.55
7. p-DMAB reactivity (absorbance at 545 nm/gm of milk)	0.315	0.326	0.281	0.312
8. 5-HMF value (u moles/100 gm of total solids)				
(a) Free	0.40	0.56	0.38	0.53
(b) Total	13.99	14.54	13.42	13.64
9. Average sensory scores	7.8	8.25	7.9	8.3
10. Presumptive coliform test	-ve	-ve	-ve	-ve
11. Viable counts (x1000/gm)	4.20	3.37	5.28	4.74
12. Yeast and mold counts (x 1000/gm)	0.0	0.0	0.01	0.01

milk powder should not contain more than 1.2% lactic acidity. Khoa powders fall well below this limit in their lactic acidity. The free fatty acidity of buffalo's khoa powder (0.11, 0.11% oleic acid) was less than cow's khoa powder (0.062, 0.064% oleic acid) in warmed and heated sample. The corresponding peroxide values in buffalo's khoa powder (0.42, 0.41 meq O_2/kg fat) were higher than cow's. P-DMAB reactivity and total HMF values were slightly more in cow's milk khoa powder (0.40, 0.56 umoles/100 gm of total solids) than buffalo's. When compared to khoa prepared by conventional or roller drying processes, the p-DMAB reactivity and 5-HMF values were almost the same. This would indicate that adequate heat treatment was given to milk solids in the process for khoa powder.

Khoa powders from cow's and buffalo's milk were found negative to coliform organisms. The total bacterial counts were higher in buffalo's khoa powder (5.28 and 4.74 thousand/gm) than cow's powder (4.20 and 3.37 thousand/gm). Yeasts and molds were absent in cow's milk khoa powder but in buffalo's khoa they were present in less than 10 per gm.

In order to assess the suitability of khoa powder for the preparation of sweets reconstitution was done with the calculated amount of milk and water separately to obtain a moisture level of about 30% as in case of khoa. The reconstitution was accomplished by sprinkling calculated quantity of water to khoa powder, soaking for 10 mts,

mixing, heating and stirring in a double jacketed pan. The same procedure was also adopted with hot milk soaking. Reconstituted khoa obtained with water had flat flavour khoa obtained from reconstitution with milk had normal flavour. Khoa powder reconstituted well into khoa with smooth texture and uniform body. These body characteristics are required for the preparation of sweets such as burfi and gulabjamun. Khoa with grainy texture was not obtained by the process of reconstitution. Thus, the preparation of Kalakand, and milk cake may not be possible from khoa powder unless some citric acid is added along with milk for grain formation.

5.3.2 Chemical changes during storage of khoa powder

Khoa powders prepared from both concentrated and heated concentrated milks were packaged in 250 gm sterilized tins, sealed and stored at 30°C and 5°C for 120 days. The changes observed during storage have been presented in Table 8, 9, 10 and 11. The discussion have been arranged on different parameters that were examined during the course of this investigation.

5.3.2.1 Moisture

The moisture percent in cow's and buffalo's concentrated khoa powder did not change significantly. Tins proved good barrier against moisture transmission.

5.3.2.2 Acidity

The percent lactic acidity in cow's and buffalo's powder prepared from unheated and heated concentrated milks

Table 8 : Chemical changes during storage of roller dried khoa prepared from buffalo concentrated milk.

(Average of two trials)

Days	Moisture %	Acidity (% L.A.)	Free fat (% by wt. of khoa powder)	Free fatty acidity (% oleic acid)	Peroxide value (meq. O_2/kg fat)	Average Sensory scores
			30°C			
0	4.25	1.02	23.43	0.062	0.50	7.9
15	4.26	1.02	23.65	0.080	0.68	8.16
30	4.25	1.02	23.86	0.109	0.93	8.3
45	4.25	1.02	24.11	0.130	1.36	7.8
60	4.26	1.02	24.34	0.151	1.66	7.6
75	4.25	1.02	24.58	0.168	1.85	7.6
90	4.26	1.021	24.79	0.190	2.12	7.6
105	4.26	1.022	24.98	0.234	2.43	7.5
120	4.27	1.021	25.21	0.251	2.71	7.6
			5°C			
30	4.26	1.02	23.45	0.080	0.67	8.0
50	4.26	1.02	23.46	0.090	0.71	7.8
70	4.25	1.021	23.48	0.105	0.77	7.8
90	4.26	1.021	23.53	0.120	0.85	7.8
120	4.26	1.021	23.58	0.142	0.95	7.5

Fat % in khoa powder = 30.33

Table 9 : Chemical changes during storage of Roller dried khoa prepared from buffalo heated concentrated milk.

(Average of two trials)

Days	Moisture (%)	Acidity (% L.A.)	Free fat (% by wt. of khoa powder)	Free fatty acidity (% oleic acid)	Peroxide value (meq. O_2/kg fat^2)	Average sensory scores
			30^0C			
0	4.12	1.04	25.59	0.064	0.55	8.3
15	4.12	1.04	25.81	0.081	0.70	8.5
30	4.13	1.041	26.10	0.11	0.97	8.1
45	4.13	1.04	26.32	0.136	1.33	7.8
60	4.13	1.04	26.67	0.152	1.68	8.0
75	4.12	1.041	26.89	0.170	1.96	8.3
90	4.12	1.042	27.12	0.230	2.16	8.3
105	4.12	1.041	27.35	0.242	2.57	8.0
120	4.13	1.041	27.58	0.256	2.83	7.8
			5^0C			
30	4.13	1.04	25.61	0.082	0.71	7.8
50	4.12	1.041	25.63	0.091	0.721	8.0
70	4.13	1.041	25.64	0.106	0.802	8.0
90	4.13	1.041	25.66	0.140	0.88	8.5
120	4.13	1.042	25.69	0.144	1.23	8.2

Fat % in khoa powder = 30.42

remained almost constant during storage. All types of powders from buffalo had higher initial acidity than cow's powder. Similar results were reported by Planine and Milohnoja (1969), and Pijanowski and Kolanecka (1970) who observed slight increase in acidity of spray-dried whole milk. Valent (1977) reported that titratable acidity remained virtually unchanged during storage of dried whole milk. Dried whole milk powder was packaged in polyethylene bags and stored at 20°C and 60-65% R.H. at 37°C and 30% R.H. and examined after storage for 2, 4, 6, 7 and 9 months. Korhonen et al (1976) found no detectable changes in lactic acid of spray-dried whole milk and skim milk powder.

5.3.2.3 Free fat

Free fat content increased at 30°C and 5°C as the days of storage advanced but the increases were more pronounced at 30°C in all types of khoa powders. Buffalo's khoa powder had higher free fat content than both types of cow's khoa powders (Table 8, 9). Tran The Truyen (1975) did experiments on three samples of dried whole milk stored at various temperatures (7, 20 and 30°C) and in air of various R.H.(40, 60 and 80%) and showed that storage at higher R.H. values and at high temperature significantly increased the free fat. Valent (1977) studied three samples of dried whole milk (drying procedure not stated).

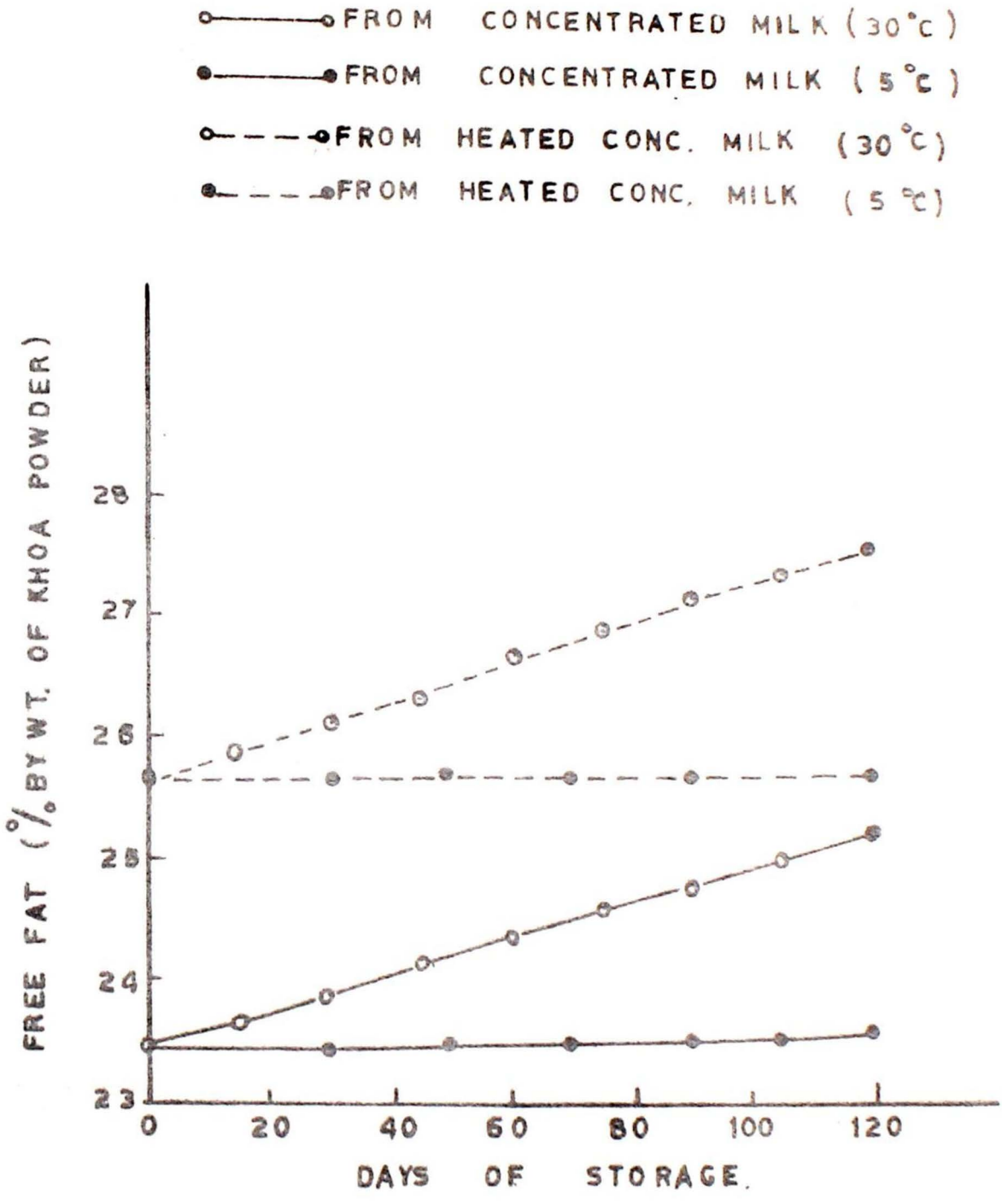

FIG. 3 CHANGES IN FREE FAT CONTENT OF KHOA POWDER FROM BUFFALO'S CONC. MILK.

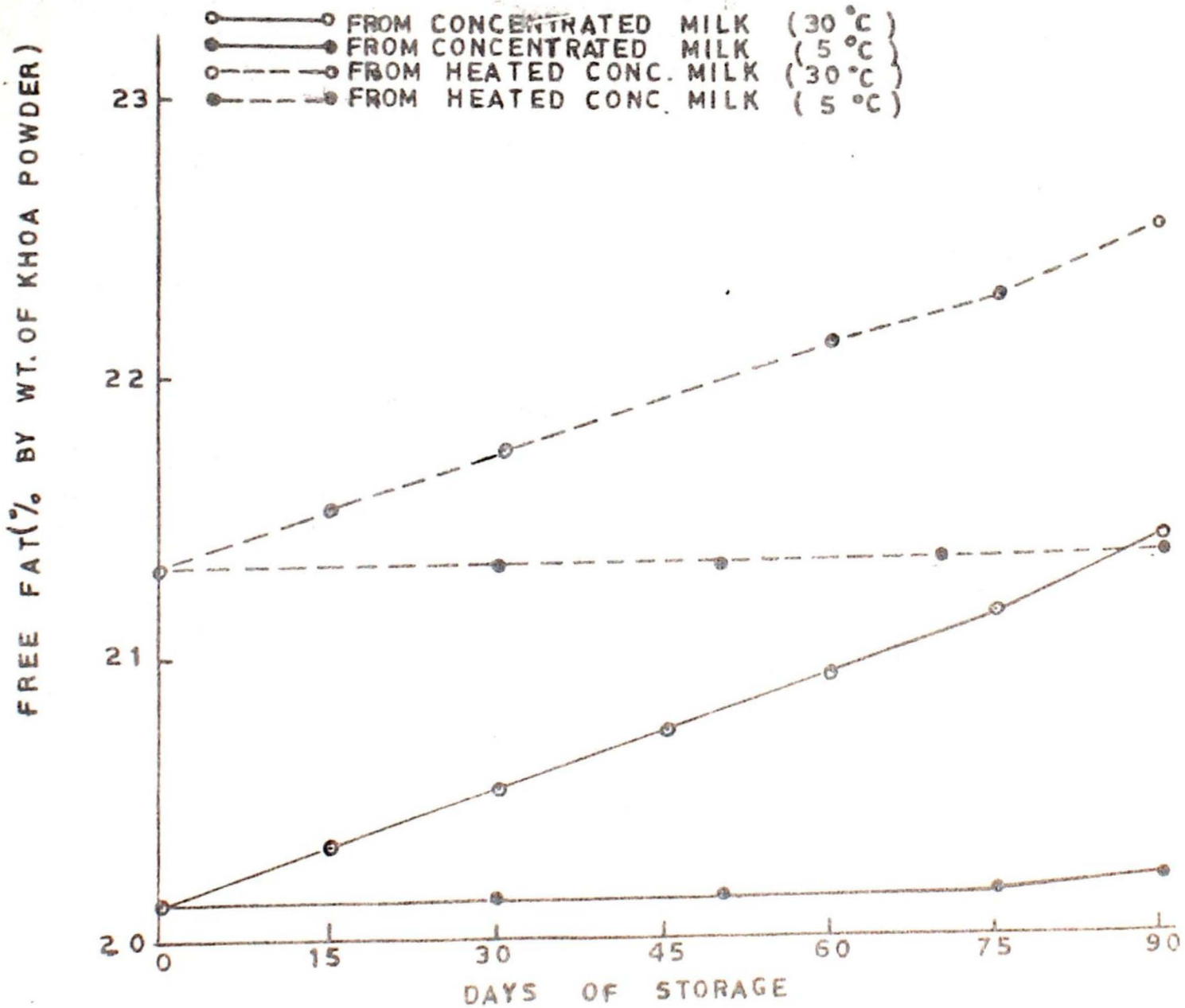

FIG. 4 CHANGES IN FREE FAT CONTENT OF KHOA POWDER FROM COW'S CONC. MILK

The samples were directly examined after manufacture and 200-g portions were stored in polyethylene bags at approx. 20°C and 60 - 65% R.H. or at 37°C and 30% R.H. and examined after 2, 4, 6, 7 and 9 months of storage. During storage free fat content increased from 34.6 - 36.6 to 34.8 - 36.8 and 36.2 - 38.9 at 20°C and 37°C, respectively.

5.3.24 Free fatty acidity

There was 4 times increase in free fatty acidity of buffalo's khoa powder during 120 days storage at 30°C. At 5°C the free fatty acidity increased by about 1.7 times in buffalo's khoa powder. Khoa powders had slightly higher FFA released during storage from heated concentrated milks (Table 9, 10). Loney and Bassette (1971) studied the changes in free fatty acids in sterile concentrated milk during storage. They found linear increase in free fatty acids at 37°C and 55°C but no detectable lipid hydrolysis was found during storage at 4°C.

5.3.2.5 Peroxide value

There was about 5.4 fold increase in the peroxide value of khoa powder from buffalo concentrated milk (unheated) after 120 days of storage at 30°C. At 5°C, the peroxide value was raised by 1.9 times from an initial value of 0.50 (Table 8). Similar results were obtained on powders prepared from buffalo's heated concentrated milk (Table 9). Cow milk khoa powder showed an increase of 4.5 and 4.7 folds after 90 days storage at 30°C. At 5°C, these increases were 2.2 and 2.17 folds during 90 days storage (Table 10, 11). The increases in peroxide value did not materially influence the sensory

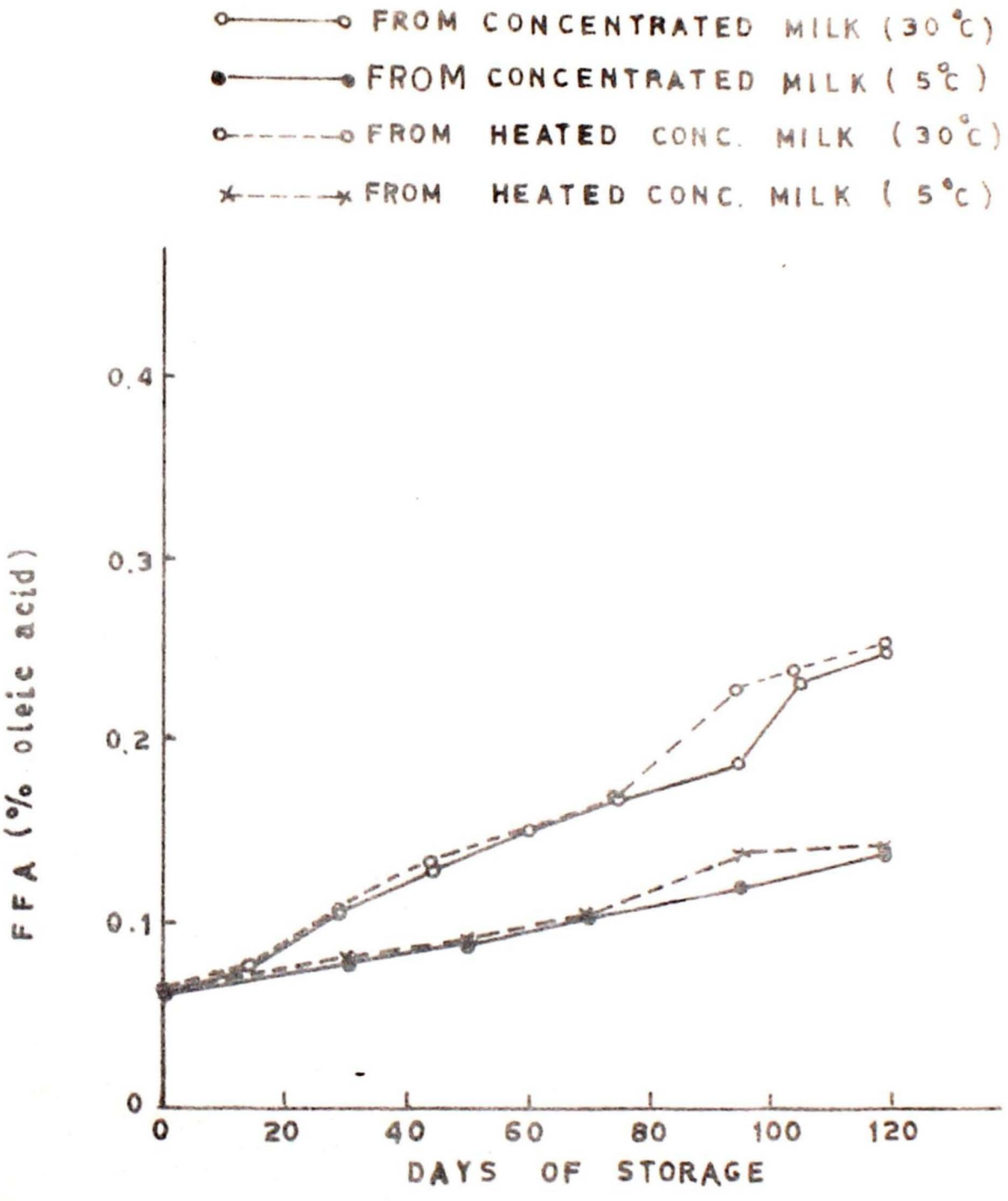

FIG. 5 CHANGES IN FREE FATTY ACIDITY OF KHOA POWDER FROM BUFFALO'S CONC. MILK.

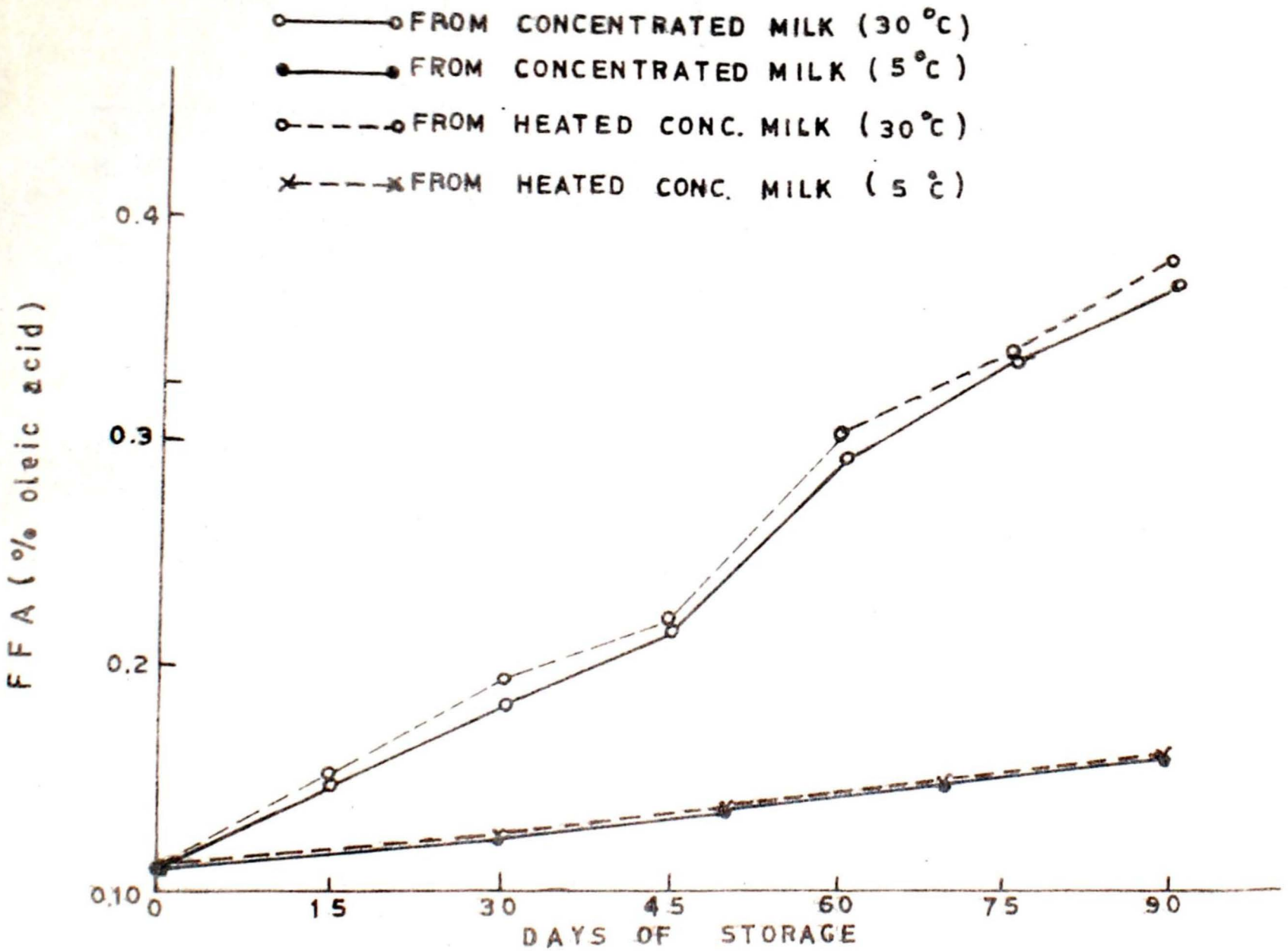

FIG. 6 CHANGES IN FREE FATTY ACIDITY OF KHOA POWDER FROM COW'S CONC. MILK.

Table 10 : Chemical changes during storage of roller dried khoa prepared from cow concentrated milk.

(Average of two trials)

Days	Moisture (%)	Acidity (% L.A.)	Free fat (% by wt. of khoa powder)	Free fatty acidity (% oleic acid)	Peroxide value (meq. O_2/kg fat)	Average Sensory scores
			30°C			
0	3.42	0.990	20.12	0.110	0.42	7.9
15	3.42	1.010	20.33	0.147	0.61	8.0
30	3.43	1.012	20.54	0.182	0.82	7.7
45	3.42	1.011	20.73	0.213	1.20	7.8
60	3.41	1.010	20.94	0.292	1.43	7.9
75	3.41	1.010	21.16	0.337	1.65	7.5
90	3.42	1.011	21.45	0.372	1.89	7.5
			5°C			
30	3.42	1.010	20.14	0.123	0.58	7.9
50	3.41	1.010	20.15	0.136	0.68	7.8
70	3.42	1.011	20.17	0.147	0.80	7.9
90	3.42	1.011	20.21	0.158	0.92	7.6

Fat % in khoa powder = 30.76

Table 11 : Chemical changes during storage of Roller dried khoa prepared from cow heated concentrated milk (Average of two trials)

Days	Moisture (%)	Acidity (% L.A.)	Free fat (% by wt. of khoa powder)	Free fatty acidity (% oleic acid)	Peroxide value (meq. O_2/kg fat)	Average sensory scores
			30°C			
0	3.17	1.030	21.32	0.110	0.41	8.2
15	3.18	1.031	21.53	0.152	0.63	8.3
30	3.18	1.032	21.74	0.193	0.81	7.9
45	3.17	1.032	21.95	0.221	1.22	8.3
60	3.17	1.030	22.14	0.305	1.46	8.1
75	3.17	1.030	22.31	0.342	1.67	7.9
90	3.18	1.031	22.56	0.385	1.92	7.6
			5°C			
30	3.17	1.030	21.34	0.124	0.56	8.1
50	3.18	1.030	21.35	0.138	0.67	8.2
70	3.18	1.031	21.37	0.148	0.79	8.0
90	3.17	1.031	21.39	0.160	0.89	7.6

Fat % in khoa powder = 30.84

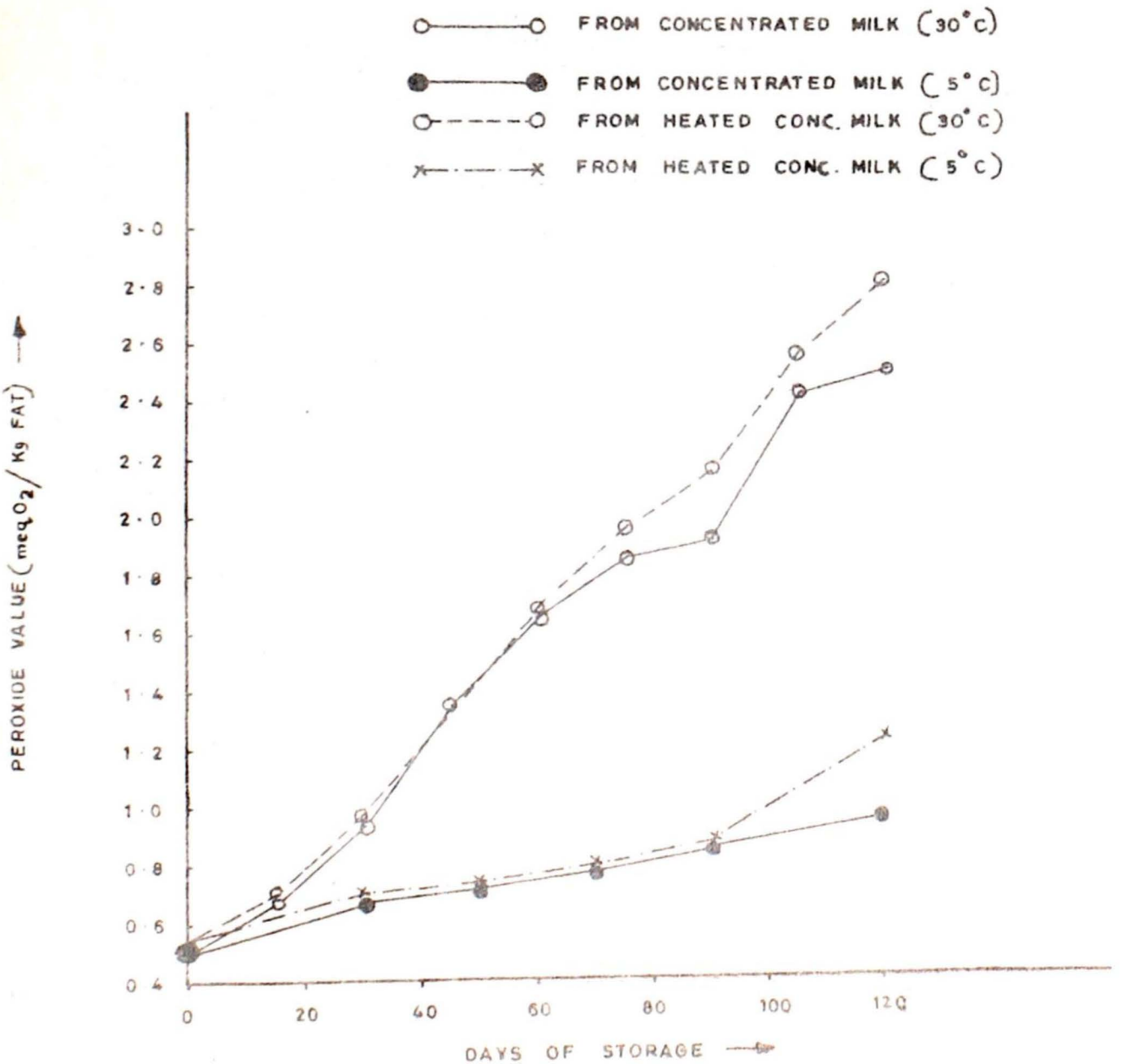

FIG. 7 CHANGES IN PEROXIDE VALUE OF KHOA POWDER FROM BUFFALO'S CONC. MILK.

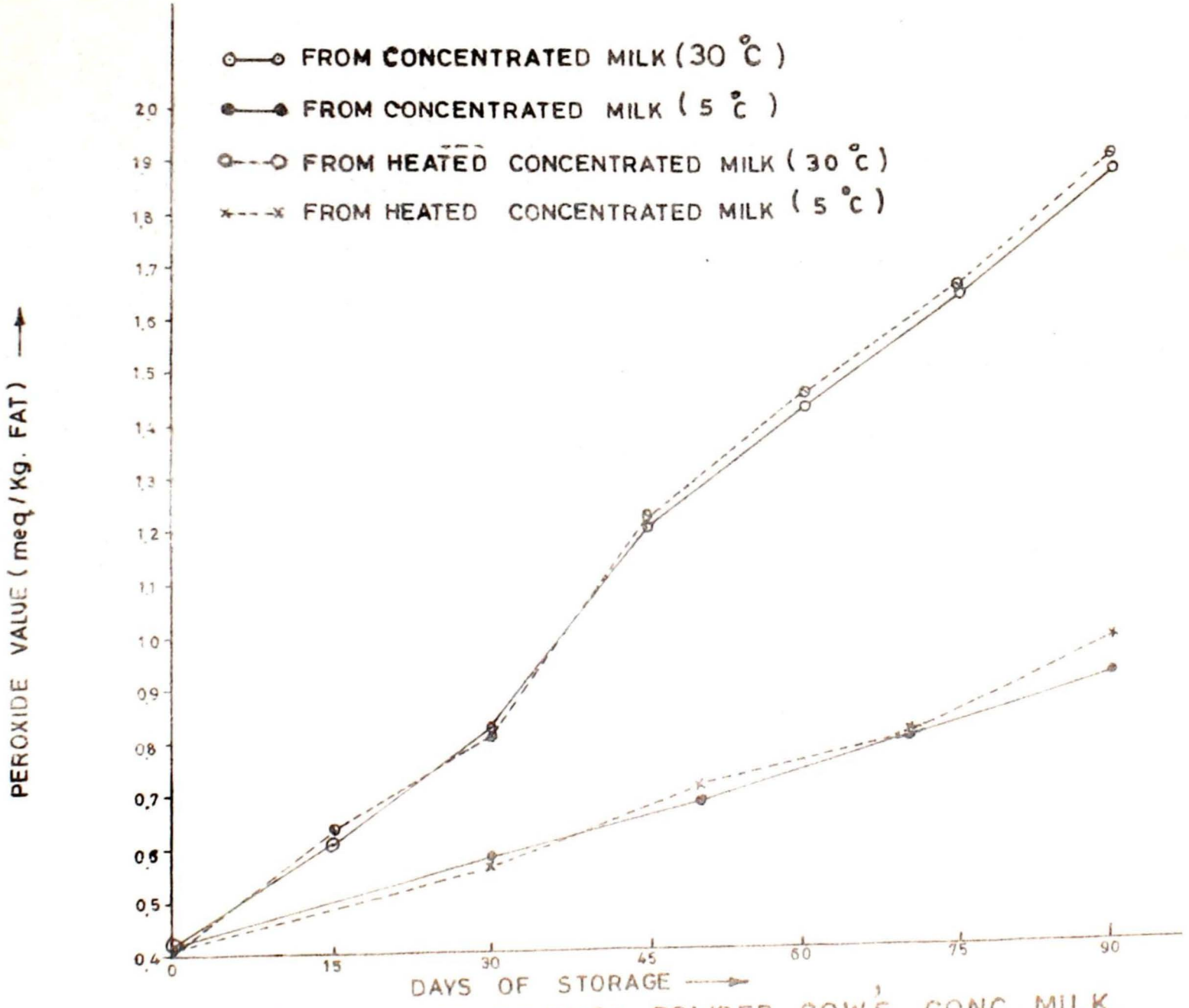

FIG. 3 CHANGES IN PEROXIDE VALUE OF KHOA POWDER COW'S CONC. MILK.

properties of khoa powders during storage. Pijanouski and Kolanecka (1970) found increased peroxide value from 3.90 to 7.77 meq. O_2/kg fat in spray dried whole milk stored during 112 days storage.

5.3.3 Microbiological changes during storage

All the samples of khoa powder from concentrated and heated concentrated milk (cow and buffalo) were found negative to presumptive coliform test (Table 12, 13).

The initial viable counts in khoa powder from buffalo's concentrated milks were found to be 5.28 and 4.74 thousand/gm whereas khoa powder samples from cow's concentrated and heated concentrated milk were having 4.20 and 3.37 thousand/gm. As the storage time increased, viable counts decreased. Nichols (1939) found that stored samples of milk powder had less than 10% of the initial counts. Higher storage temperature had remarkable effect on the decrease in the viable counts. Higginbottom (1944) showed a decrease in the number of bacteria and decreases were slightly more in roller drier powders than in the corresponding spray dried powders.

Planine and Milohnoja (1969) examined the microbial population of 47 samples of dried milk over a period of 12 weeks storage at 18-25°C and R.H. at 60-75%. There was decrease in bacterial numbers. The coliform bacteria could be isolated from only one sample. Korhonen et al (1976) examined spray dried whole milk pader packaged in polyethylene bag for 94 days at -5°C to 30°C and 43-84% R.H. and observed a little change in viable counts. Yeasts and molds occured in small numbers (1-7/gm). The counts of coliforms and yeasts and molds didnot change during storage.

Table 12 : Microbiological changes during storage of roller dried khoa from buffalo concentrated milk.

(Average of two trials)

Days	Viable counts (Thousand/gm)	
	Heat concentrated milk	Concentrated milk
	30°C	
0	4.74	5.28
15	2.13	2.56
30	0.80	1.20
45	0.64	0.83
60	0.40	0.52
75	0.36	0.39
90	0.32	0.25
105	0.25	0.20
120	0.20	0.15
	5°C	
30	4.00	3.20
50	3.03	2.50
70	2.50	1.80
90	0.80	0.70
120	0.40	0.30

Note: 1. All the samples were found to be negative to presumptive coliform test.

2. Yeast and mold counts during storage periods were found less than 10/gm.

Table 13 : Microbiological changes during storage of roller dried khoa from cow concentrated milk.

(Average of two trials)

Days	Viable counts (Thousand/gm)	
	Heat concentrated milk	Concentrated milk
	30°C	
0	3.37	4.20
15	2.50	3.00
30	1.45	2.10
45	0.82	1.25
60	0.40	0.64
75	0.34	0.54
90	0.30	0.42
	5°C	
30	2.50	3.27
50	1.20	1.55
70	0.72	0.86
90	0.50	0.60

Note: 1. All the samples were found to be negative to presumptive coliform test.

2. Yeast and mold counts during storage period were found less than 10/gm.

Yeast and mold counts throughout storage of both types of khoa powder remained less than 10/gm.

From the foregoing discussion it can be inferred that khoa powder prepared from concentrated milk with 50% total solids was stored without using any chemical, microbiological and sensory properties at 30°C when packed in sterilized tin containers. This storage study was not conducted beyond 120 days. On the basis of the results the shelf life of the khoa powder can be predicted for about six months at room temperatur and about one year in the cold store.

CHAPTER – 6

SUMMARY

SUMMARY

The traditional method of khoa making in the past was essentially developed for small scale production. [illegible] of khoa making still remains to be the problem of [illegible]. The present study was planned to develop a new technology for large scale production of khoa using the existing machineries available in the plants. [illegible] roller driers are used for drying of milk in many dairy plants of India. It was, therefore, decided to examine the feasibility of manufacturing khoa on the roller drier by manipulating the process parameters such as steam pressure, level of concentration of milk, adjusting the distance between scraping blades and the rollers and rate of feeding of milk. The shelf life of the product manufactured on the roller drier was [illegible] polyethylene packages and kept at 30°C and 5°C.

The cow's and buffalo's milk [illegible] and 5% fat respectively [illegible] 30%, 40% and 50% [illegible]

The selection of a suitable concentration of milk for product manufacture was found out on the basis of chemical and sensory properties of the concerned product.

Milk with 50% total concentration heated to 74°C for 10 mts was found most suitable for khoa manufacture on the roller drier at 15-20 psi. Khoa nodules were best prepared at 25-30 psi and khoa powder at 74-78 psi using milk with 50% total solids concentration.

Khoa powder manufactured from 50% total solids concentration and heated to 56°C before drying had good cooked flavour but khoa powder prepared from concentrated milk with 50% total solids and heated to 74°C for 10 mts had pronounced cooked flavour. Both these alternatives are available to the industry for khoa powder making depending upon the end usages.

Khoa powder was reconstituted into khoa with calculated amount of water and milk separately. The steps for reconstitution involved uniform mixing, soaking for 10 mts, heating and stirring till the desired body and texture were reached. Khoa reconstituted with water had flat taste but the one with milk was found to be of satisfactory quality in flavour, body and texture.

Khoa, khoa nodules and khoa powder were analysed for colour, flavour body and texture, moisture, fat, lactic acidity, free fatty acidity, free fat, peroxide value, para dimethyl aminobenzaldehyde-reactivity, 5-HMF value, presumptive coliform test, viable counts and for the presence of yeasts and molds.

Khoa prepared on roller drier with 50% total solids concentrated milk was compared well in flavour, body and texture with khoa prepared by conventional method. This khoa had almost same percentages of moisture, fat and free fat as that of conventionally prepared khoa. Peroxide value were slightly higher and the free fatty acidity lesser than conventional product. P-DMAB reactivity was slightly higher in cow's milk khoa than buffalo's. Free HMF values were higher in buffalo's khoa but total HMF was found to be more in cow's khoa.

The shelf life studies of khoa prepared on roller drier were conducted after packaging in polyethylene bags at 30°C and 5°C. The product remained for 5 days at 30°C and 15 days at 5°C. The moisture content during storage at 30°C decreased in both cow's and buffalo's khoa. Free fat, lactic acidity, free fatty acidity, peroxide value, viable counts and yeasts and molds increased with the days of storage. The coliform organisms were absent.

Khoa nodules were tested to 16-17% moisture and 24-25% fat. The free fat content in khoa nodules from buffalo's and cow's were 16.85% and 14.25% respectively. The lactic acidity of buffalo's and cow's khoa nodules was 0.72% and 0.68% respectively. Free fatty acidity in cow's khoa nodules was higher (0.26%) than cow's (0.20%). Peroxide value was lesser in cow's khoa nodules (0.52 u moles/kg fat) than buffalo's (0.61 u moles/kg fat). P-DMAB reactivity and total HMF were almost the same as in khoa prepared by roller and conventional processes. Microbiologically the nodules were better than khoa because of lower moisture contents.

During storage of khoa nodules, there was faster moisture loss in the first five days followed by gradual decrease afterwards. Lactic acidity, free fat, free fatty acidity, peroxide value were increased at both the temperatures in both types of nodules. The increase in free fat was very slow at both the temperatures. Viable bacteria decreased and yeasts and molds increased. Coliforms were absent during all the days of storage.

Khoa powders prepared from concentrated and heated concentrated cow's and buffalo's milk were found to have 3.42, 3.17 and 4.25, 4.12% moisture respectively. Free fat, lactic acidity and peroxide value were higher in buffalo's than cow's khoa. P-OMAB reactivity and 5-HMF value (free and total) were higher in cow's milk khoa powder. Viable counts in thousand/gm were found to be ranging from 5.28 to 3.37. Yeasts and molds were absent in cow's khoa powder and were less than 10/gm in buffalo's khoa powder. Coliforms were absent in both cow's and buffalo's khoa powders.

Storage studies on buffalo's khoa powder were conducted for 120 days and on cow's khoa powder for 90 days. During storage of khoa powders in Tin containers there was no significant change in moisture and lactic acidity but free fat, and free fatty acids, peroxide values increased in all types of powder. These increases were faster at 30°C than at 5°C temperature of storage. Bacterial population decreased during 120 days of storage. Yeasts and molds

remained almost constant and never exceeded 10/gm. Coliforms were negative in all the samples. All the samples of khoa powders were found acceptable to chemical and sensory characteristics upto 120 days.

CHAPTER – 7

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CHAPTER – 8

APPENDICES

APPENDIX - I

Organoleptic changes during storage of khoa prepared from roller drier
(Average of two trials)

Organoleptic tests	Cow's milk khoa				Buffalo's milk khoa			
	Days of storage				Days of storage			
	30°C		5°C		30°C		5°C	
	0	5	10	15	0	5	10	15
Colour	8.0	4.0	8.0	2.5	8.0	4.0	7.5	3.0
Body and Texture	7.2	5.5	6.5	4.5	7.0	3.0	8.0	3.0
Flavour	7.5	2.5	7.0	2.0	7.5	2.0	7.0	2.0
Average Sensory Score	7.6	4.0	7.2	3.0	7.5	3.0	7.5	2.6

APPENDIX - II

Organoleptic changes during storage of khoa nodules prepared from roller drier

(Average of two trials)

Organoleptic tests	Days of storage								
	30°C					5°C			
	0	5	10	20	30	30	60	90	120
	Cow concentrated milk (Heated)								
Colour	8.5	8.5	6.5	8.0	2.5	8.5	8.0	8.0	8.0
Body and Texture	8.0	7.5	5.0	6.0	3.0	7.0	7.0	7.0	7.5
Flavour	8.0	7.0	5.0	5.5	3.0	7.5	7.0	7.0	7.0
Average Sensory score	8.16	7.6	5.5	6.5	2.8	7.6	7.3	7.3	7.5
	Buffalo concentrated milk (Heated)								
Colour	9.0	8.5	7.0	6.0	3.0	8.5	8.0	8.0	8.0
Body and Texture	8.0	7.5	7.0	6.5	3.5	7.5	7.0	7.5	7.5
Flavour	8.0	7.0	5.0	4.0	2.0	7.5	7.0	7.0	7.0
Average Sensory Score	8.3	7.6	6.3	5.5	2.8	7.8	7.3	7.5	7.5

APPENDIX - III

Organoleptic changes during storage of roller dried khoa prepared from buffalo milk

(Average of two trials)

Days of storage	Colour		Body and Texture		Flavour		Average sensor score	
	A	B	A	B	A	B	A	B
				$30^{o}C$				
0	8.0	8.5	8.2	8.5	7.5	8.0	7.9	8.3
15	8.5	9.0	8.0	8.0	8.0	8.5	8.2	8.5
30	9.0	8.5	8.0	7.5	8.0	8.5	8.3	8.1
45	8.8	8.0	7.5	7.5	8.0	8.0	7.8	7.8
60	8.0	8.5	7.5	7.5	7.5	8.0	7.7	8.0
75	7.5	9.0	7.5	8.0	8.0	8.0	7.6	8.3
90	8.0	8.5	7.5	8.0	7.5	8.5	7.6	8.3
105	8.0	8.5	7.0	7.5	7.5	8.0	7.5	8.0
120	8.0	8.5	7.5	7.5	7.5	7.5	7.6	7.8
				$5^{o}C$				
30	8.5	8.0	7.5	7.5	8.0	8.0	8.0	7.8
50	8.0	8.5	7.0	7.5	8.0	8.0	7.8	8.0
70	8.0	8.5	8.0	7.5	7.5	8.0	7.8	8.0
90	8.0	9.0	7.5	8.0	8.0	8.5	7.8	8.5
120	8.0	8.5	7.0	8.0	7.5	8.0	7.5	8.2

A = Khoa pouder from concentrated milk

B = Khoa pouder from heated concentrated milk

APPENDIX - IV

Organoleptic changes during storage of roller dried khoa prepared from cow concentrated milk.
(Average of two trials)

Organoleptic tests	Days of storage										
	30°C							5°C			
	0	15	30	45	60	75	90	30	50	70	90
	Khoa powder from concentrated milk										
Colour	8.0	8.0	7.5	8.0	8.2	8.0	8.0	8.3	8.0	8.2	8.0
Body and texture	8.5	8.5	8.2	8.0	7.7	7.5	7.5	8.0	8.0	8.0	7.5
Flavour	7.0	7.5	7.5	7.5	8.0	7.0	7.0	7.5	7.5	7.5	7.5
Average sensory score	7.8	8.0	7.7	7.8	7.9	7.5	7.5	7.9	7.8	7.9	7.6
	Khoa powder from heated concentrated milk										
Colour	8.0	8.5	8.3	8.5	8.3	8.2	8.0	8.3	8.5	8.5	8.5
Body and texture	8.5	8.5	8.0	8.5	8.0	7.5	7.5	8.0	8.0	7.6	7.0
Flavour	7.5	8.0	7.5	8.0	8.0	8.0	7.5	8.0	8.0	8.0	7.5
Average sensory score	8.2	8.3	7.9	8.3	8.1	7.9	7.6	8.1	8.2	8.0	7.6

VERIFIED