STUDIES ON THE MANUFACTURE OF BASUNDI USING CONICAL PROCESS VAT

THESIS SUBMITTED TO THE NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL (DEEMED UNIVERSITY) IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF

MASTER OF TECHNOLOGY IN DAIRYING (DAIRY TECHNOLOGY) BY

RANJEET KUMAR


REGN. NO. 2030105
Dedicated

to

My Parents,
brothers & Gudia
STUDIES ON THE MANUFACTURE OF BASUNDI USING CONICAL PROCESS VAT

BY

RANJEET KUMAR

THESIS SUBMITTED TO THE NATIONAL DAIRY RESEARCH INSTITUTE (DEEMED UNIVERSITY) KARNAL (HARYANA) IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF

MASTER OF TECHNOLOGY IN DAIRYING (DAIRY TECHNOLOGY)

Approved By

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Dated: June 17, 2003

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Dated: June 2003.

(Ranjeet Kumar)
ABSTRACT

India is the top milk producers in the world with an average annual production of 84 MT. It is estimated that about 50-55% of the Indian total milk production annually is a converted into traditional milk products. The traditional milk products provide a means of preserving precious milk solids for a comparatively longer time thereby improving the shelf life. Basundi is the most popular delicious sweets in Maharashtra and Gujarat and some parts of southern India. It is mainly prepared in small scale at different occasions and hence production is very less. It is estimated that about 300 tons Basundi is produced annually in India.

The increasing demand of Burundi presents a great opportunity for the organized dairies as well as private dairies to mechanize its production. But only limited studies have been reportedly carried out on its mechanization. The innovation of conical process vat for large scale production and continuous production has opened the door for mechanization of large scale production of Basundi at industrial level.

Basundi has an appearance like plain condensed milk, light brown colour, thick and smooth texture with the presence of soft and very minute suspended flakes and pleasant, caramel and nutty flavour. The traditional method for Basundi preparation is more time consuming and energy intensive. Basundi prepared by traditional method has low shelf-life and poor quality.

So far improving the shelf life and microbiological quality of Basundi we used the mechanized system for the production of Basundi by using conical process vat.
सारांश

भारत 84 मिट्रिक टन दुध उत्पादन के साथ विश्व में अग्रणी स्थान पर है। एक अनुमान के अनुसार भारत में दुध के कुल उत्पादन का 50-55 प्रतिशत दुध पदार्थों में परिवर्तित किया जाता है। देशीय दुध पदार्थ, दूध के कीमती तत्वों को लम्बे समय तक सुरक्षित रखने का साधन है। बासुन्दी, महाराष्ट्र, गुजरात व दक्षिण भारत के कुछ हिस्सों में एक प्रसिद्ध देशीय दुध पदार्थ है। क्योंकि यह विभिन्न मौसमों पर छोटे स्तर पर बनाया जाता है, इसलिए इसका उत्पादन कम होता है। प्रतिवर्ष लगभग 300 टन बासुन्दी का उत्पादन होने का अनुमान है।

इसकी बढ़ती हुई मांग को देखते हुए इसके संचरित व निजी क्षेत्रों की झूठीयों में गजीनकृत उत्पादन के बढ़त अवसर है। परंतु इसके मजीनकृत उत्पादन के सिमित अध्ययन की ही रफ्त मिलती है। कोनिकल प्रोजेस वेट के नवनिर्माण का इसके अधिक व निरंतर स्तर के गजीनकृत उत्पादन की दिशायें खोल दी है।

बासुन्दी देखने में एक प्लेन संसाधित दुध की तरह हरे भूरे रंग में, गाढ़ा व मुलायम टैक्सचर वाला पदार्थ होता है जिसमें बहुत छोटे व मुलायम फलेंक्स उपस्थित होते हैं। इसकी सुगन्ध बहुत सुहावनी, कीर्तमल व मेमो जैसी होती है। बासुन्दी के देशीय उत्पादन का तरीके से ज्यादा समय लगाने वाला व ऊर्जा स्वप्न वाला है। इस तरीके से तैयार बासुन्दी क्रम समय तक सुरक्षित रहती है और इसकी गुणवत्ता भी कम होती है।

अतः इसकी लम्बे समय तक सुरक्षित रखने के लिए ल इसकी सूक्ष्मजीवाणु गुणवत्ता बढ़ाने के लिए इसका गजीनकरण उत्पादन का अध्ययन किया गया जिसमें कोनिकल प्रोजेस वेट का उपयोग किया गया।
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1. INTRODUCTION

The importance and completeness of milk as a human food was realized prior to 'Vedic' times itself. This recognition of the socio-economic eminence of milk in human nutriment instinctively led ancient Indians to conserve such nutrients into more stable products under the tropical climatic conditions. The concerted efforts towards such accomplishment included concentration, fermentation, acid coagulation, use of preservatives (such as sugar) and filler (like flour, rice) etc., which resulted into introduction of an array of products, some of which are peculiar to Indian (Prakash, 1961, Mathur, 1991).

A major portion of the Indian confection depends on added sugar for preservation. Such indigenous dairy products, which even today account for nearly 60 percent of the total milk produced, are prepared by taking recourse to heating/desiccation. The use of a diverse range of heat desiccated milk products has been mentioned in the early 'Vedic' literature (Mathur, 1991). In the present context also, their place in the dietary regime as well as socio-economic connotations remains significant through cultural heritage. It goes without saying that in India, no festival or marriage is complete without serving milk based delicious sweets growing trend and interest in exporting traditional milk-based sweets (Goyal, 1991).

The methods being employed over the years for the production of indigenous dairy products are essentially suitable for the scale of operations, which involved in ancient times. The equipment, which was being employed, was very simple in design and easy to fabricate. The technologies for their manufacture on small scale have been developed through the experiences gained over a long period (Mathur, 1991).
Now-a-days, with rapid expansion of urban and semi-urban areas, the demand for traditional dairy products is increasing at a fast pace. Inspite of the fact that the dairy industry has made rapid strides in the last 3-4 decades, the methods of manufacture of the traditional products have remained essentially unchanged. The small-scale producers find it difficult to cope up with the increasing demand. Therefore, in recent times, attention is being focussed either to scale-up the operation or to modify the technology so as to make it amenable to mechanization and continuous operation. These, innovations can best be made by adopting suitable technologies that are already existing. Findings of researches on other similar types of foods and use of membrane processes need to be explored for their judicious application under the Indian conditions. Moreover, in modern times, packaging has been identified as an integral part of processing in the food industry. Exploitation of combination of some of these areas could be advantageously used to enhance the shelf-life of the product manufactured.

Any attempt on these lines should produce products matching in taste, texture and overall quality with the product traditionally produced by the unorganized sector (Baxi, 1991). The high price commanded by the traditional trade for its products, because of its 'freshness' provides an opportunity to concentrate on the quality of the products which can also improve the viability of the dairy industry. This can be understood from the fact that the cost of raw materials, including milk and sugar, accounts for over two-third of the sale price of western type dairy products, whereas for traditional milk based products, it is only about one-third of the sale price (Aneja, 1991). Looking to above facts, a stride which can enable the organized sector to launch the indigenous milk products on industrial scale can have far reaching impact on the dairy industry as well as on socio-economic condition of milk producers in the country.
The indigenous milk products, which are very popular in India, are Khoa and Khoa-based sweets, Chhana and Chhana-based sweets and Paneer. The other popular indigenous milk products are region specific. They are Rabri in northern parts, Shrikhand and Basundi in western and some southern parts, Kheer and Palpayasum in central and other parts and many other products in one or the other parts of the country. These products enjoy the preference of consumers and hence have high economic importance.

Basundhi is one of such confections of importance. In the 'First Indian Dairy Year Book', It has been termed as 'Basundhi' and is defined as "a preparation of boiled and sugared milk, used mostly in western India. According to this book, Basundi can be classified in the condensed milk group alongwith Rabri, Khoa-Mithai, Kheer and can be considered similar to sweetened condensed whole milk (Raghavan, 1960).

Basundi, available in market varies considerably in its physico-chemical and organoleptic characteristics. So far, limited studies have been conducted on this product and published information is almost non-existent. The trade of this products is also restricted to small local manufacturers viz., 'halwais'. This product, though very popular in western India, particularly in the state of Gujarat and Maharashtra, has received little attention both by the research and the PFA authorities culminating in almost complete absence of scientific know-how on the subject as well as lack of promulgated quality standards for the product. Therefore, tremendous scope exists for growth and expansion of the market for this product, provided the quality and safety are ensured and shelf life is extended to facilitate distribution over distant areas.

Recently, an organized dairy sector has shown keen interest in production technology for indigenous milk products, which is reflected from the fact that an indigenous products specific plant has
been set up by a cooperative dairy organization in the state of Gujarat. Hence, an attempt has been made to mechanize an indigenous method of *Basundi* preparation in the conical vat, during present investigation.
2. REVIEW OF LITERATURE

Milk is almost a perfect food both for man and microbes. Consequently, as a commodity of commercial significance, it is quite vulnerable to spoilage if not cared for. Therefore, man through passing of civilization, has learnt the art of conserving nature’s best gift to mankind by applying different modes such as fermentation, heat desiccation, sugar and/or salt addition, etc. for its preservation for future use. Application of such methods has resulted in development of an array of dairy products, many of which have by now become globally popular whereas others have still remained country and/or region specific. Indigenous milk products belong to the latter category.

In India, we have an array of traditional dairy products which are prepared by employing principles of fermentation (e.g. Dahi and Chakka based products), heat desiccation and sugar addition (e.g. Khoa and Khoa based sweets, as well as sweetened liquid dairy products like Basundi, Rabri and Kheer), heat-cum acid coagulation (e.g. Chhana, Paneer) etc. Many of these products such as Khoa, Chhana ,Paneer, Srihhand have been well documented and studied in detail by the research scientists, whereas others, for example Basundi are yet to be thoroughly studies. Consequently, there is very scanty published information available on various technological aspects for such products.

Since very little published information is available on Basundi, the literature on closely related heat desiccated traditional dairy products such as Rabri, Kheer, Kunda, etc. has also been included in this chapter. The review of literature covered in the following
write-up also includes the effects of heating concomitant with the concentration of milk which has been extensively studied for the similar western dairy products like sweetened condensed milk (SCM) and evaporated milk. Some of the manufacturing steps for such products are almost similar to the ones used in the manufacture of Basundi.

2.1 HEAT DESICCATED MILK PRODUCTS

The advent of concentrated milk has been towards the close of the eighteenth century. In 1796 Nicolas Appert, a French research worker, experimented on the possibilities of preserving milk in concentrated form. He was successful in standardizing the method by condensing milk in a hot water bath to about two-thirds of its original volume. Shortly after Appert’s discovery, several other investigators experimented on different methods to preserve milk and were successful in initiating the commercially viable condensed milk industry (Hunziker, 1949). On the other hand, inspite of popularity of Basundi, no standardized procedure has been evolved and reported so far.

2.1.1 BASUNDI

2.1.1.1 Evolution

The preservation of milk by thermal concentration has resulted in creation of a large number of milk-based delicacies. Raghavan (1960) in the ‘First Indian Dairy Year Book’ has grouped the traditional concentrated milk products in the following four categories.

I. Rabri

II. Khoa-Mithai
III Sweetened condensed, unsweetened condensed and evaporated whole milk, and

IV Kheer

The exact origin of Basundi is not known, but it has been traditionally prepared for centuries in the western parts of India as a dessert and served on special occasions like wedding etc. (Aneja, 1992).

2.1.1.2 Characteristics

Basundi or Basundhi is referred as a preparation of boiled and sugared milk (cow or buffalo), used mostly in western and southern parts of India (Raghavan, 1960). The International Dairy Federation defined the product as a confectionery based on concentrated milk (Anon, 1983).

Recently, the characteristics of Basundi have been defined by Pagote (2003). He stated that the Basundi is an indigenous concentrated and sweetened milk product, with a specific type of pleasant aroma. Its body is similar to plain condensed milk but less viscous and easy to pour. It has smooth texture with or without the presence of soft and very minute flakes. The light brown color of this product is preferable. It has very pleasant caramel and nutty flavour with desirable level of sweetness.

2.1.1.3 Composition

*Basundi* has been reported to have 18-22 per cent fat, 20-22 percent sucrose and 28-32 percent TS (Aneja, 1992).

Recently Patel and Upadhaya (2001) reported the composition of Basundi manufactured in three cities of Gujrat. They found wide variation in the composition. Further it was reported that Basundi
contains an average 11.52 % fat, 18.67 % SNF, 7.7 % protein, 9.64 % lactose, 1.33 % ash, 16.43 % sucrose and 46.62 % total solids.

2.1.1.4 Method of Preparation

Traditionally, whole buffalo milk is preferred for its preparation. The milk is kept on open fire in shallow pan. Then evaporation is continued till to achieve the concentration of about two-fold by slow boiling with continuous agitation and scrapping to avoid burning. If, the film of milk constituents is formed on the milk-air interface, it is stirred back into milk. It gives typical soft-textured flakes, which remains uniformly suspended in thickened milk. After reaching to the desired concentration followed by addition of cardamom or nutmeg powder and dry fruits. The product is then cooled and served as a special and delicious sweet dish. It can be consumed as such like Kheer or along with specially prepared four-folded chapatti (Pagote, 2003).

2.1.2 RABRI

Rabri also referred to as Rabbri is a heat desiccated thickened whole milk sweet, containing several layers of clotted particles in a viscous mass and prepared preferably from buffalo milk.

2.1.2.1 Characteristics

Rabri has a white to pale yellow/creamish colour with caramelized clots, a creamy consistency and sweet caramel flavour. The finished product consists of non-homogeneous flakes, partly covered by and partly floating in SCM. The product is a favoured dessert both in urban and rural areas of central and north India (Davies, 1948; Bandyopadhyay and Mathur, 1987).
2.1.2.2 Composition

The average composition of Rabri is comprised of 65-70 per cent total solids, 20 percent fat, 10-13 percent protein, 16-17 percent lactose, 15-30 percent sugar and 3-3.5 per cent ash which results in a more homogeneous, chewy-textured mass (Davies, 1948; Warner, 1951, Khurody, 1957; Rangappa and Achaya, 1974; Bandyopadhyay and Mathur, 1987; Rajorhia, 1987; Mahadevan, 1991; Mathur, 1991; Aneja, 1992; Thompkinson, 1995).

Gayen and Pal (1991), however reported the product to contain 51.80 per cent total solids, 16.10 per cent fat, 10.01 per cent protein, 10.80 per cent lactose, 11.90 per cent sugar, 1.88 per cent ash and 0.31 per cent acidity.

Rabri has also been made by condensing milk to a viscous consistency while adding sugar from time to time with vigorous stirring. The milk film of requisite thickness adhering to the sides of the vessel is scrapped off and left in the condensed milk (Itzerott, 1960).

2.1.2.3 Method of Preparation

The process of manufacture of Rabri as standardized by Gayen and Pal (1991) involved (i) standardization of buffalo milk to 6 per cent fat, (ii) continuous heating of milk between 90-95° C and repeated removal of clotted cream (malai) equal to about 1/10th of the initial volume of milk, (iii) concentration of remaining milk portion to 3-fold, followed by addition of sugar at the rate of 6 percent of concentrated milk, and finally, (iv) remixing of malai to the concentrated mass.

2.1.2.4 Shelf-life
*Rabri* has a shelf life of about 5-7 days at refrigeration temperature (Bandyopadhyay and Mathur, 1987; Mahadevan, 1991; Mathur, 1991; Aneja, 1992).

*Rabri* packaged in polystyrene cups had a shelf life of 18 h at 30°C and 20 days at 5°C (Gayen and Pal, 1991).

### 2.1.2.5 Microbiological Quality

Sharma *et al.* (1969) reported coliform count of $1.25 \times 10^5$/g of *Rabri*. The count tended to be lower when total solids and sugar content were high. The yeast and mould count of the same samples was 395 per g. On the other hand Singh *et al.* (1975) reported an average mould count of 8500/g, mucor being the predominant group. The spore formers comprised of 2-4 per cent of the total bacterial count present.

### 2.1.3 KHEER

*Kheer* is quite popular amongst the northern, western and central Indian population. It is used as a sweet dish on all occasions. The product is usually consumed soon after preparation. It resembles the rice pudding commonly consumed in the west. A similar product quite popular in South India is *Payasam* (Warner, 1951; Itzerott, 1960; Mathur, 1991; Aneja, 1992; Thompkinson, 1995).

### 2.1.3.1 Characteristics

*Kheer* is a partially desiccated indigenous milk product. It has a ratio of concentration of about 3-4 times. It is usually sweetened before consumption and resembles SCM. Although there is some evidence of lactose crystals formation, the length of storage is not enough for the sugar crystals to grow appreciably in size (Rangappa and Achaya, 1974).
2.1.3.2 Composition

*Kheer* has been reported to contain 31.00 – 38.29 per cent TS, 6.38 – 12.20 per cent fat, 5.44 – 6.90 per cent protein, 6.49 – 11.30 per cent lactose, 0.74 – 1.41 per cent ash, 14.00 – 15.25 per cent sucrose and 4.45 – 8.95 per cent other carbohydrates (Balasubramanian and Basu, 1955; De et al., 1976; Bandyopadhyay, 1985; Chaudhary, 1989).

2.1.3.3 Existing Technology

*Kheer* is prepared by concentrating whole milk (cow or buffalo milk or its admixture) in an open pan with constant stirring and scraping to a desirable concentration ratio, after which either crushed or steeped (30°C for 30 min) rice is added followed by sugar incorporation (De et al., 1976).

Use of standardized (4.0 – 5.0 per cent fat) cow or buffalo milk as a starting material, combining 5-8 per cent rice (Gobindobhog/Basmati variety) by weight of milk, addition of cane sugar at the rate of 5-12 per cent (w/w) of milk at a stage when about 1.2 – 1.5:1 concentration has been reached, and final simmering till a concentration of 2:1 is obtained has been found to yield good quality product (Bhargava, 1949; Warner, 1951; Bandyopadhyay, 1985; Bandyopadhyay and Mathur, 1987; Rajorhia, 1987; Chaudhary, 1989; Aneja, 1992).

During the simmering step, the rice softens up and shows signs of gelatinization leading to substantial thickening. Chopped nuts, cardamom, saffron etc. can be used as flavouring materials (Aneja, 1992).

According to De et al. (1976), use of 4 per cent fat milk, incorporation of 2.5 per cent rice and 5 per cent sugar at appropriate stages helped in obtaining a highly acceptable product.
2.1.3.4 Shelf-life

The control samples of Kheer could be stored for 2-3 days and 10-15 days respectively at 37°C and 4°C, whereas Kheer samples subjected to in-can sterilization (98°C for 20 min) had a shelf life of 3-4 days at 37°C and 60-70 days at 4°C. Use of nisin at the rate of 0.02 per cent (w/w) markedly enhanced the shelf life i.e. 8-10 days at 37°C and 100-150 days at 4°C (De et al., 1976).

Chaudhary (1989), however, observed the shelf life of Kheer to be 7-8 h at 30°C and 9 days at 5°C.

2.1.3.5 Nutritive Value

Ramachandran (1954) reported that Kheer has slightly higher content of biotin, panothenic acid and folic acid than milk.

Kheer (100 g) had the following nutrient profile: vitamin A-242 IU, vitamin B_1-118 μg, riboflavin-353 μg, folic acid-291 μg, ascorbic acid-3.4 mg, calcium-388 mg and phosphorus-237 mg (Balasubramanian and Basu, 1955).

The digestibility coefficient, biological value (BV) and protein efficiency ratio (PER) of Kheer were reported to be 97 per cent, 76 and 2.32 respectively. Kheer was found to be as effective as milk, Dahi, Khoa and Chhana in supporting good growth, reproduction and lactation in three generations of rats in a study conducted by Lily et al. (1955 a, b).

The processing method involved in Kheer manufacture causes some losses of nutrients especially vitamins such as ascorbic acid, thiamine, riboflavin, nicotinic acid and vitamin A; the casein and milk fat were least affected (Mani et al., 1955).
2.1.3.6 *Kheer* Related Products

A cereal-based product named ‘Payasam’ has a pleasing, rich caramel flavour and contains additives such as some aromatic spices and flavourings (Patel, 1991).

A ready-mix for *kheer* has been developed which involves use of 30 per cent each of roasted (145°C) wheat suji (Semolina) and powdered sugar and 40 per cent whole milk powder. Such ready-mix could be processed into *Kheer* within 5 min to have desirable taste, aroma and consistency (Singh and Shurpalekar, 1989). Shelf-life studies of such ready-mix revealed that use of polypropylene (pp) and metallized polyester polypouches enabled the product to be kept well for 120 and 150 days respectively under storage condition of 65 per cent RH and 27°C, whereas at 92 per cent RH and 38°C both the packaging materials gave a shelf life of 46 days. Equilibrium moisture content of 5.7–5.8 per cent at 44 percent RH was found to be critical, exceeding which the ready-mix tended to become lumpy (Singh *et al.*, 1990).

2.2 REFINEMENTS IN PROCESSING PARAMETERS FOR CONCENTRATED MILK PRODUCTS

The process employed by halwais/housewives, on small scale, for preparation of ‘Basundi’, and related milk products consume lot of energy and often results in poor quality product due to burning problems. The resultant product has a very short shelf-life. Many workers have attempted to overcome these limitations and have suggested refinements in the traditional process of manufacture of such indigenous milk products (Chakraborty, 1978b; Ganguli, 1979; Heldman, 1981; Gupta and Patil, 1987; Gupta *et al.* 1987; Balachandran and Rajorhia1988; Punjrath, 1991; Rajorhia, 1995). These refinements are discussed hereunder.
2.2.1. USE OF DIFFERENT EQUIPMENT/SYSTEMS FOR MILK CONCENTRATION

A simplified process has been reported for the manufacture of condensed milk for use under village conditions (Anon, 1943). In the process, milk was heated in a double jacketed deep pan to a temperature between 88-99°C until the desired consistency was reached. Uniform temperature in the pan was maintained by keeping fine sand in the space between the two jackets. The condensed milk produced was sterilized before cold storage and in case of SCM making, cane sugar was added to milk prior to heating.

Bandyopadhyay and Mathur (1987) reported use of a steam jacketed kettle for desiccating milk in the preparation of concentrated milk products.

Use of a semi-mechanized Khoa-making equipment such as scraped surface heat exchanger (SSHE) was suggested for the manufacture of concentrated milk / Basundi (More, 1987, Upadhyay et al., 1993).

For large scale production of Rabri, vacuum concentration of milk followed by blending it with required quantities of sugar and malai was attempted by Gayen and Pal (1991).

A mechanized system involving three-stage concentration of milk in a horizontal scraped heater and two-steam jacketed pans has been elaborated by Chakraborty (1978c).

Membrane processes such as ultrafiltration and reverse osmosis (RO) can also be advantageously used for the manufacture of concentrated milk products since they are energy efficient. Alvarez et al. (1979) reported the application of ultrafiltration in the production of sweetened condensed milk. Such product was free from sandiness and browning and had less risk of gelation at low
temperature storage. The process was also beneficial since the product had high calcium to phosphate ratio and had more available lysine than the conventional SCM.

RO concentrate (1.5-2 X concentration, 25-33 per cent TS) obtained from buffalo milk can serve as an intermediate in the preparation of the Rabri. The lipids, protein minerals and lactose in concentrated milk increased by an extent equal to the concentration factor. The process did not exert any adverse effect on the titratable acidity, pH, free fatty acids, free fat and microbial load. The sensory quality of the product was similar to that of fresh buffalo milk and at 2.0 x concentration, the size of fat globules were found to be less than 2.5μ (Gupta and Pal, 1993).

In future, in the organized sector, applications SSHE for direct conversion of milk into concentrated product in a single pass, or use of pressurized steam jacketted kettle integrated with packaging system seems quite likely to be adopted (Bandyopadhyay and Mathur, 1987). Use of RO as an intermediate process could also be used as an adjunct with the conventional method for preparing such products.

2.2.1 PRE-HEATING OF MILK

Preheating is not only of importance for the destruction of microorganisms and enzymes but also for improving the physical qualities of the finished products including viscosity and stability. The tendency of concentrated milks to age-thickening during storage can be controlled by choosing appropriate preheating temperature-time combination. To distinctly different problems of storage stability are encountered by varying the forewarming treatments (Swanson et.al. 1965; Burton, 1969; Mehta, 1980).
i) Sedimentation with use of high forewarming temperatures, and

ii) Gelatin with use of low forewarming temperatures.

Hartmar and Swanson (1962) reported that 3:1 concentrates made from milk forwarmed at 85°C for 30 min were more heat stable than those made after forewarming at 74°C for 30 min.

The heat stability characteristics may be varied by altering the preheating temperatures and/or holding time. Increasing the holding time improves heat stability but if it is extended beyond a certain point, which differs for each type of milk, a lowering of heat stability can occur. Similarly, increasing temperature above a certain level may not be fruitful (Newstead, 1977, Newstead and Baucke, 1983). The reason why one set of preheating conditions should give better stability than another is not yet understood.

In practice, preheating temperatures of 85-90°C with holding times of 10-20 min are commonly used in the manufacture of evaporated milk but use of higher temperatures with shorter holding times are more effective in obtaining a final product with sufficient viscosity and heat stability to prevent heat coagulation (Webb and Bell, 1942; Srinivasan et al., 1970; Yadav, 1971; Bhanumurthi et al., 1972; Metwally et al., 1978 a,b; Prasad and Balachandran, 1987; Ghatak and Bandopadhyay, 1991).

Newstead et al. (1977) showed that concentrated milk prepared using milk from which the whey proteins had been largely removed was heat stable, irrespective of whether the milk was preheated or not. Concentrated milks prepared from normal milk or milk with an increased whey protein content were stable only if the milks were preheated before concentration. Thus, whey proteins appear to have a highly detrimental effect on the heat stability of the caseinate system of concentrated milk which can be counteracted by heat treatment (preheating) of milk prior to concentration, forming
complexes of whey proteins (mainly β-lactoglobulin) and some precipitated calcium phosphate with k-casein. Such casein micelles coated with β-lactoglobulin and calcium phosphate might be less susceptible to dissociation (mainly of k-casein) during subsequent concentration than micelles in non-preheated milk (Trautman and Swanson, 1959; Sawyer, 1969, Newsted et al. 1977, 1979; Singh and Fox, 1987).

Prasad et al. (1988) reviewed the effects of preheating on milk stability and its constituents in the manufacture of milk concentrate.

2.2.3. HOMOGENIZATION

Homogenization is one of the important unit operations employed in the manufacture of concentrated and dried milks. Homogenization of milk or concentrate brings about profound changes in the characteristics of the resultant product. Since homogenization has been used as one of the treatments in the present study on Basundi, the pertinent literature on homogenization is briefly reviewed here below.

Homogenization of unconcentrated skim milk had little effect on its heat stability but the stability of unconcentrated whole milk is usually reduced (Sweetsur and Muir, 1983).

As in case of normal milk, homogenization reduces the heat stability of concentrated full cream milk when carried out before preheating and concentration. Concentration of milk before preheating and subsequent homogenization, or both concentration and homogenization before preheating has been found to reduce the heat stability of recombined concentrated milk (Newstead et al. 1979).

Sweetsur and Muir (1982) established the destabilizing influence of homogenization on the heat stability of concentrates and
showed marked seasonal differences on the effects of homogenization on subsequently concentrated milks prepared from non-preheated whole milk.

Homogenization leads to an increased adsorption of milk proteins on the disrupted fat globules which culminates in formation of centres of high protein concentration, now being favourable to coagulation (Prasad, 1985). Homogenization at 180-360 kg/cm$^2$ increases the viscosity of the finished product thereby promoting the stability of the fat dispersion.

Soluble salts, especially calcium rather than milk fat were shown to be the major determental factor in the heat stability of concentrated homogenized whole milks (Sweetsur and Muir, 1982).

Addition of $\beta$-lactoglobulin to concentrated milk before preheating reduced its heat stability and subsequent homogenization accentuated the destabilizing influence of $\beta$-lactoglobulin. The sulphhydryl group interactions played a vital role in the destabilization of homogenized concentrated milk on heating (Sweetsur and Muir, 1983).

The heat stability and salt-balance of buffalo milk and its concentrate (2:1) was studied by Sindhu and Tayal(1983). They observed that significant disruption in the salt equilibrium as a result of homogenization destabilized the concentrated milk.

A stable condensed milk suitable for prolonged storage was obtained when raw-milk was homogenized at 148-153 kg/cm$^2$ pressures exceeding this gave a product with excessively viscous consistency (Davidov et al. 1975; Snoeren et al. 1984).

The adverse effects of homogenization on the heat stability of concentrates can be reduced by (i) homogenizing the concentrate rather than milk prior to preheating and/or concentration, (ii)
traditional preheating (90°C for 10 min), (iii) preheating at high
temperature (120°C for 120 s or 145°C for 5 s), (iv) adopting two-
stage homogenization instead of single stage (v) employing multiple-
pass homogenization, and (vi) addition of phosphate stabilizers
(Newstead et.al. 1979; Sweetsur and Muir, 1982; Prasad and
Balachandran, 1988).

2.2.4 USE OF ADDITIVES

According to Sommer and Hart (1926) there exists a critical
equilibrium between the natural anions and cations of milk, which
ddictates its maximum heat stability. The addition of salts has a direct
effect on the stability of the casein micelles and an indirect effect by
facilitating the denaturation of whey proteins and their interactions
with casein under the influence of heat. Minerals present in milk
especially calcium magnesium, phosphates and citrates represent a
system in equilibrium where a change in concentration in the soluble
phase produces changes in the colloidal phase. Consequently, the
addition of stabilizing agents modifies the mineral composition of the
serum of milk (Blais et.al. 1985).

Several chemical additives have been tried to improve the
heat stability and quality of concentrated milks. Prasad et.al. (1988,
1992) extensively reviewed the role of additives to improve the heat
stability of concentrated buffalo milk.

2.2.4.1 Casein Stabilizing Salts

Bovine milk, in general, is Type A milk, wherein a maximum
pH (~6.7) and a minimum pH (~6.9) is observed on heat coagulation
time (HCT) – pH curve (Rose, 1961 a,b). For a milk of this type
having its natural pH value on the acid side of the heat stability
maximum, additives such as di-sodium hydrogen phosphate,
trisodium phosphate, tri-sodium citrate or even sodium bicarbonate
could be used for stabilizing it; whereas for milk with natural pH
value on the alkaline side of the maximum acidic salts such as sodium hydrogen phosphate were found to be most beneficial in prolonging the storage life of concentrated milks (Leviton and Pallansch, 1961a,b; Wilson et.al. 1963). On the other hand, addition of orthophosphates hastened gelation. Gordon (1973) observed retardation in thickening and gelation in SCM on inclusion of 0.05-0.15 percent of tetra polyphosphate which increased the shelf life of the product by a factor of 6.

2.3 CHANGES IN MILK DUE TO HEATING AND CONCENTRATION

Severe heat treatment in preparation of concentrated milk products is expected to cause numerous changes in milk components as well as its physico-chemical characteristics. Since literature on heat induced changes during Basundi making is non-existent, the pertinent literature on concentrated milks such as SCM, evaporated milk and indigenous concentrated products (e.g. Rabri, Khoai etc.) is reviewed in the following paragraphs alongwith characteristics of buffalo milk.

Buffalo milk, owing to intrinsic differences it its components and characteristics, when used for making concentrated milks in place of cow milk, poses several problems, both during the manufacture and storage. These problems are related to viscosity (Srinivasan et.al. 1970; Bhanumurthi et.al., 1972), lactose crystallization, age thickening and discolouration (Godbersen, 1964, Dalaya and Patel, 1971). Anantakrishnan and Kothavalla (1947), Ray 1957, Bhalerao and Iya (1964), Chakraborty (1978a), Ganguli (1979), Verma and Gupta (1981), Rajorhia (1987), Prasad et.al. 1989, Sindhu (1995) and Pandya et.al. (unpublished) have reported or discussed general aspects of buffalo milk as a raw material for manufacture of concentrated milks.
Since in the present study, buffalo milk has been used as a raw material for manufacture of Basundi, pertinent literature on buffalo milk particularly influence of heat and concentration on its components and characteristics is included in the following paragraphs.

2.3.1 EFFECT ON PROTEINS

Heating causes a number of alterations in natural state of milk proteins. The hydrolytic cleavage of peptide and phosphate bonds in casein results either from enzymatic action or thermolysis at the elevated temperatures. The liberation of inorganic phosphate from skim milk occurs on heating at high temperatures (Howat and Wright, 1934 a; Pyne and McHenry, 1955; Davies and White, 1959). Casein is reported to be more resistant to heat treatment as far as its denaturation is concerned compared to whey proteins. However, casein-casein interactions have been reported by Schmidt *et al.* (1967).

Since casein has a native structure, mostly of quaternary type, temperature and pH can drastically affect casein association and result in micelle alteration. It has been observed that casein particle diameter and dynamic viscosity increases with the severity of heat treatment (Biryukova, 1968; Ramanasukas and Urbene, 1970; Youssef *et al.* 1977).

The serum proteins are the fractions most affected by heat treatment. Rowland (1937) reported that heating of milk above 75°C caused denaturuation of lactalbumin and lactoglobulin. The heat resistance of immunoglobulins, serum albumin, β-lactoglobulin and α-lactalbumin was in increasing order.

Sawyer (1968) observed that upon heating, β-lactoglobulin forms a heavier aggregate (tetramer) through two stages wherein disulphide linkage is involved in the first stage.
Heat treatment causes modification in the structure of whey proteins resulting in release of sulphydryl groups from the linkages (Larson and Jenness, 1950). An important phenomenon associated with whey proteins is the development of cooked flavour due to the generation of sulphydryl groups. The sulphydryl groups upon further heating are converted to hydrogen sulphide and subsequently liberated.

Two-fold concentration of skim milk increases the rate of dephosphorylation, while preheating at 90°C for 10 min before concentration slightly decreases the rate of dephosphorylation of milk proteins (Belec and Jenness, 1962 a,b).

The effects of heat on buffalo milk proteins have been studied by several workers (Felice and Vitagliano, 1972; Shazyl et.al. 1973; Stephen and Ganguli, 1974; Singh et.al., 1989). The intrinsic properties of buffalo milk proteins (Ganguli 1968,1969, 1973) are responsible for its poor heat stability (Dastur, 1956; Laxminarayana and Dastur, 1968; Dastur et.al. 1971). Buffalo whey proteins are more vulnerable to heat treatment that the cow whey proteins (Shazly et.al.1973; Stephen and Ganguli, 1974,1977). Increase in buffalo β-lactoglobulin concentration leads to an increase in the molecular association of the proteins (Felice and Vitagliano, 1972). When buffalo milk was subjected to pasteurization, boiling and sterilization, an increase of 0.8, 15.6 and 6.4 percent sedimentable protein (casein micelles) respectively was observed (Sabarwal and Ganguli, 1973; Morissey and O'Mahony, 1976). Metwally et.al. (1978 a) observed a decrease in heat stability of buffalo milk with increase in concentration of total solids.

Little change occurred in non-protein nitrogen (NPN) during pasteurization of unconcentrated milk but severe heat treatment increase the NPN almost linearly with time (Howat and Wright, 1934a). For instance, on heating milk at 135°C for 60 min, 10-20
percent of total nitrogen was converted to NPN. The protein-protein interactions in food systems as a result of heat/concentration have been reviewed by Howell (1991).

Saiprakash 91981) observed reduction in total N, non-casein N, total albumin-N and β-lactoglobulin N with concomitant increase in casein N and NPN fractions during the manufacture of Khoa from Buffalo milk. The soluble nitrogen (at pH 4.5) and formal titre values, on gross weight basis, increased uniformly during manufacture of Khoa (Rajorhia and Srinivasan, 1974) formation of insoluble lipid-lipid and lipid-protein complexes (King, 1955).

The effect of concentration in concentrated milk (Brunner, 1962), the changes in the properties of fat globule membrane (Cheeseman and Mabbitt, 1968) and the protein-lipid interactions is concentrated infant formula (Rowley and Richardson, 1985) have been reviewed.

The electron microscopic studies of fat-protein complex of evaporated milk revealed bulky fat-casein agglomerates mainly in top layers (Schmidt et.al. 1971).

During manufacture of Khoa from buffalo milk, Boghra (1979) and Bogra and Rajorhia (1982) observed 68.00-82.8 percent free fat (of total fat) in 31 percent TS concentrate. Slight increased in both the peroxide value and free fatty acid (FFA) were observed by Rajorhia and Srinivasan (1974). Arora and Bindal (1981) found that heat treatment involved had no influence on the levels of Phospholipids, cholesterol (total, free and esterified) and FFA at any stage during manufacture of Khoa, while the carbonyl content showed a progressive increase.
2.3.2 EFFECT ON SUGARS

Although most of the changes in lactose during heat treatment of milk are associated with the Maillard reaction, milk being a complex system of diverse components, some of these are liable to interact with lactose to produce some changes (Jenness and Patton, 1959, Burton, 1984). It is also a major source of acidity due to thermal decomposition being responsible for about half the decrease in pH (Sweetsur and White, 1975). Decomposition of lactose leads to the formation of compounds such as formic, acetic, butyric, propionic, pyruvic and lactic acids (Morr et al. 1957). The extent of Maillard type browning caused due to the interaction of lactose and proteins is related to the intensity of heat treatment and exposure time (Patton and Josephson, 1949; Ellis, 1959). The protein carbohydrate complex and its degradation products lead to the formation of several reducing and fluorescent substances (Tarassuk and Simonson, 1950; Stewart, 1951; Kumar and Hansen, 1972). Basundi being a high heat-treated product limited discolorations and cooked flavours are observed, however, in this product these characteristics are appreciated. Rajorhia and Srinivasan (1974) noticed the loss of lactose accompanied by development of coloration, browning and cooked flavour, during Khoa manufacture.

2.3.4 EFFECT ON MILK SALTS

The practical importance of milk salts arises largely from their marked influence on the condition and stability of the milk proteins particularly on the heat treatment to which milk is subjected during the manufacture of concentrated milks.

Heat treatment reduces the concentration of soluble phosphate and of both soluble and ionic calcium. Ultrafiltrates prepared from milk heated at 94°C showed that total ultrafiltrable calcium and phosphate concentrations were reduced by 50 and 18
percent respectively, whereas ionic calcium was reduced by 60 percent (Rose and Tessier, 1959). On heating, the soluble calcium phosphate precipitates as colloidal calcium phosphate (CCP), which differs from the indigenous CCP. On subsequent cooling, some of the original calcium phosphate dissolves to restore the content of soluble calcium and phosphate to nearly the original levels found in the raw milks (Khannan and Jenness, 1961).

These studies are related to unconcentrated milk only and the heat-induced changes in milk salts in concentrated systems are not well understood. Kreveld and Minnen (1955) showed that the activities of both Ca++ and Mg ++ increases during concentration but at a lower rate than those of Na + and K + suggesting the formation of insoluble or undissolved salts of Ca and Mg with increasing milk solids.

Preheating milk at 90°C for 10 min reduced the concentration of soluble components by only 7-9 percent, but during concentration a greater proportion of soluble calcium and phosphate precipitated. These changes are undoubtedly involved in the coagulation of concentrated milk. Since some of these changes are reversible, measurement of milk salts equilibrium at elevated temperature is critical (Hardy et al. 1984).

High concentration of minerals, particularly calcium was found to be responsible for poor heat stability of buffalo milk (Laxminarayan and Dastur, 1968). The basic difference of cow and buffalo milk in its mineral balance has been studied by Ganguli and Menon (1971), Sindhu and Roy (1973) and Yadav and Singh (1973).

During manufacture of Khoa from buffalo milk, Rajorhia (1978) observed a remarkable reduction in the total as well as soluble calcium, magnesium and phosphorus whereas Bhoghra and Mathur (1996) found marked increase in soluble calcium, phosphorus,
magnesium, zinc, citrate, sodium, potassium, chloride, copper and iron up to the coagulation stage.

### 2.3.5 EFFECT ON pH

During concentration, a shift in the ionic-equilibrium takes place, which can be easily ascertained from the hydrogen ion concentration. The concentrated milk products always exhibit lower pH values than the original milk.

Concentration of milk leads to precipitation of calcium and phosphate, which causes a significant decrease in pH (Fox, 1982). The pH of milk decreases almost linearly up on concentration in the total milk solids range of 9 to 40 percent. This decrease in pH upon concentration may contribute to the greater heat sensitivity of concentrated milks compared to normal milks, sometimes leading to coagulation (Pyne, 1958; Rajorhia and Srinivasan, 1974; Fox, 1981). Under prolonged heat treatment at elevated temperature, additional acidity is developed as a result of further changes in the milk (Howat and Wright, 1934 b).

At low pH (~ 6.3), coagulation of concentrated milk appears to be due to the joining of micelles through some bridging materials, while at higher pH (~7.0) the formation of a gel matrix of protein probably is derived from whey proteins (Singh et.al. 1989; Omar, 1990).

### 2.3.5 EFFECT ON VISCOSITY

The fluidity of concentrated milk is very important from the point of view of its technical evaluation. The viscosity can also be used as a criteria to monitor the consistency of concentrated milks to a level which is most acceptable to the consumers (De and Gupta, 1971; Kohli et.al., 1980; Verma and Gupta, 1981).
Concentration of milk causes closer packing of the casein micelles and leads to higher concentration of fat globules, whey proteins, lactose and soluble and colloidal salts. As a result, viscosity increases with concentration. This is supported by Sawhney et.al. (1985) who observed a progressive decrease in flow behaviour index (η) with increase in concentration of total solids leading to coagulation at a concentration ratio of 2.48 in case of buffalo milk (De and Ray, 1952).

Eilers (1947) studied the behaviour of skim milk during concentration, with or without addition of sugar. He observed a progressive rise in viscosity with increase in the total solid content of the milk evaporated at 30°C to a product containing 30 percent dry matter. The viscosity of evaporated pasteurized milk was found to be higher than that obtained from raw product even though the final total solids content was same. The viscosity was also higher if the milk as subjected to heat treatment of 95°C for 15 min followed by 75°C for 30 min, prior to condensing.

The viscosity of SCM increased so considerably with the solids content that even a logarithmic curve scale for the viscosity gave a highly curved line. The thickening exhibited by condensed milk during storage depended on the mode of pasteurization of the original milk. A condensed product made from milk pasteurized at 75°C showed lower tendency to stiffen than a similar product made from milk previously heated to 95°C, indicating great difference in the heat stability of the condensed product made from sweetened or unsweetened milks (Eilers, 1947).

The higher viscosity of milk pasteurized at higher temperature before concentration has been attributed to the greater voluminosity of the denaturable proteins of the milk and the closer packing of such particles (courts, 1976). The thickening of the sugared product
is reported to be caused by gradual precipitation of the whey proteins during storage (Leighten and Mudge, 1923).

Extensive work has been reported on the viscosity of milk and concentrated milk systems. The studies include, interactions between the major milk constituents in model milk system (Roy and Yadav, 1978, 1979), of milk (Horne, 1993), the flow properties (Randhahn, 1973), effect of homogenization and concentration (Snoeren et al. 1982 a, b, 1983) and effect of factors such as TS and protein content, preheating conditions and holding time (Puri et al. 1963, Bloore and Boag, 1981).

For achieving satisfactory viscosity in evaporated milk, Herrmann et al. (1983) stabilized raw milk using suitable stabilizing salts along with high pre-warming temperature.

2.3.6 EFFECT ON FLAVOUR PROFILE

During the manufacture of concentrated milks, depending upon the process protocol used, the undesirable flavour may develop because of the interaction between lactose, sugar and milk proteins and the multitude of secondary products resulting from these interactions.

The concentrated milk contains a number of potential flavour producing compounds. Such flavour producing compounds identified in concentrated milk products are 2-pentanone, 2-heptanone and acetaldehyde (Dutra et al., 1959; Rajorhia, 1978), acetone (Wong et al. 1958); δ-decalactone and δ-dodecalactone (Keeney and Patton, 1956, Patton 1961; Cobb and Patton, 1962) 2-nonanone, 2-undecanone, 2-tridecanone, caproic acid, caprylic acid, capric acid, lauric acid, myristic acid and palmitic acid (Muck et al., 1963) and caronyls (Arora, 1978).
During Khoa making from buffalo milk, at a point just prior to the coagulation stage, there was a progressive release of sulphydryl compounds and a marked increase in the total steam volatile flavour compounds (Rajorhia, 1978).

Emundson et al. (1959) observed that more cooked flavour is imparted in a product by additional heating to 93°C for few minutes after concentration.

2.3.7 EFFECT ON BROWNING AND RELATED ASPECTS

Gothwal and Bhavadasan (1992) studied the browning characteristics in dairy products and the effects of Maillard reaction has been reviewed by O'Brien and Morrissey (1989). They concluded that browning, loss of available lysine and the development of off-flavours result from Maillard reaction. McGookin and Augustin (1991) harnessed the antioxidant activity of casein and Maillard reaction products by the reaction of casein with glucose or lactose.

Prasad (1985) observed an increase in 5-hydroxymethyl furfural (HMF) value with increase in TS content and storage temperature in case of sterilized buffalo milk concentrate.

2.4 CHANGES DUE TO CONCENTRATION OF MILK

The knowledge about effects of concentrating milk on the properties is far from complete, particularly if much (i.e. more than half) of the water is removed in its concentration (Walstra and Jenness, 1984). The important changes in the properties caused by concentration have been described by Walstra and Jenness (1984), the same are summarized below.
2.4.1 DISSOLVED SUBSTANCE AND SOLUTES

The concentration of all components, except water and a few volatiles increases. Therefore, the thermodynamic activity of solutes increases. The increase in activity is usually not proportional to the concentration factor, since the activity coefficient changes.

As a result of the concentration of milk, the dissolved substances become super saturated and may precipitate. However, for calcium phosphate and tricalcium citrate, there is an increase in their quantum of association with the casein micelles instead of getting precipitated. Lactose becomes saturated in concentrated milks at room temperature when the concentration factor is about 2.7. Moreover, the increase in activity coefficient causes its solubility to decrease (e.g. the solubility of lactose in SCM is only \( \approx 10 \) g water as compared to \( \approx 20 \) g per 100 g in pure water at room temperature). Most other substance (including the proteins) remain in solution and do not tend to precipitate.

2.4.2 pH

The precipitation of calcium phosphate, in part, accounts for the decrease in pH by about 0.3 and 0.5 units for a concentration factor of 2 and 3 respectively. Finally, the isoelectric pH of the milk proteins decreases (Hunzikar, 1949).

2.4.3 CONFORMATION OF PROTEIN

The conformation of proteins may change. The change in pH causes stronger internal salt bridges and a decreased electrical charge. The solvent quality also changes. Hence, the tendency of the protein molecules to attain a compact conformation is probably increased. The tendency to associate also increases leading to an increase in the size of casein micelles. The increase in casein micelles size is less if the milk has been preheated to such an extent
that most of the whey proteins have become associated with the casein (Sweetsur, 1979).

2.4.4 COLLIGATIVE AND OTHER PHYSICAL PROPERTIES

The colligative properties like osmotic pressure, freezing point depression and boiling point elevation increases in magnitude to the degree of concentration achieved. The same holds true for electrical conductivity. However, due to increase in pH, the changes are somewhat less than that expected from the concentration factor (Leviton et al., 1987).

Most physical properties gets altered upon concentration of milk. For instance, density and refractive index increases, whereas, heat conductivity and a_w decreases. A larger proportion of the water must be removed to lower the a_w appreciably. Other changes resulting from boiling are effective removal of dissolved gases (nitrogen, oxygen, carbon dioxide), reduction of some off-flavours causes by volatile compounds and considerable damage to fat globules (i.e. splitting them into smaller ones and changing their surface layers) (Hostettler, 1972).

2.5 CHANGES IN CONCENTRATED MILKS DURING STORAGE

The concentrated milks, like any other dairy products, undergo storage changes depending on factors such as quality of raw milk used, process parameters employed, final physico-chemical as well as microbial status of the product, package type and quality used, storage conditions employed etc. The types of storage changes that may occur in concentrated milks are briefly reviewed here below.

2.5.1 SEPARATION OF FAT

Fat separation in concentrated milk is not a major problem because, in normal practice, the concentrated milk is homogenized, usually after concentration. However, homogenization under high
pressure may cause fat clustering and thus fat separation. The fat separation in concentrated milks can be minimized or prevented by adopting measures such as (i) proper heat treatment, (ii) homogenization (at 100-150 kg/cm²) (iii) carrying out a second stage homogenization at a lower pressure (i.e. 50 kg/cm²), and (iv) to have a product with final SNF content of 22-23 percent to ensure optimum viscosity of concentrate (Shtal’berg et.al. 1962; Swanson et.al. 1965; Hostettler, 1972; Seehafer et.al., 1962 a).

On the basis of electron microscopic study, Sabharwal (1973) revealed that adequate fat-protein complex formation can retard the tendency of fat separation.

2.5.2 MECHANISM OF THICKENING/GELATION

The current state of knowledge is insufficient to make adequate elucidation of the mechanism of excessive viscosity/thickening/gelation in concentrated milks during storage. Various explanation of the phenomenon have been offered based on changes observed in concentrated milks during storage and on conditions that alter the thickening/gelation period. However, the explanations are mostly speculative in nature.

Several mechanisms or changes that trigger the loss of stability of the casein micelles that are hypothesized to explain the phenomenon are:-

a. Changes in pH and casein micelles (Hostettler et.al., 1957; Samel et.al.,1971).

c. Dephosphorylation of caseins (Belec and Jenness, 1962 a,b; Parry, 1974).

d. Maillard type reaction between $\varepsilon$-NH$_2$ groups of proteins and reducing groups of lactose or its degradation products (Andrews and Cheeseman, 1971,1972; Andrews, 1975; Moller et.al., 1977).

e. Non-enzymatic release of sialic acid from k-casein due to heat received during processing resulting into partial dissociation of k-casein during storage. This leads to loss of ability of k-casein to stabilize the casein micelles (Hostettler et.al. 1968; Schmidt, 1968; Samel et.al. 1971; Hostettler, 1972; Aoki and Imamura, 1974).


g. Changes in free energy (Hostettler et.al. 1968; Samel et.al., 1971; Hostettler, 1972).

It is observed that in increase in ionic strength and a drop in pH, both manifested by concentration of milk led to reduction of calcium binding to the protein, culminating in increased voluminosity and thus viscosity.

Freshly prepared condensed milk is a system in which interaction between dispersed particles is relatively slight. During age thickening, the primary phase involves increase in mass due to formation of aggregates, which not only increases the particle size but also changes the particle shape and symmetry. Continued interaction among the protein micelles tend to develop a weak network which accounts for an increase in viscosity, commonly referred to as age thickening/gelation (Upadhyay, 1998).
2.5.3 VISCOSITY CHANGES

All concentrated milks undergo changes in viscosity during storage. Its rate of change may be almost negligible to very rapid, so that after only a few weeks, the product may be too thick to pour or may be quite unfit for use. Such changes in viscosity have been reported in terms of age thickening (Seehafer et al. 1962 a,b; Morr, 1969; Hostettler, 1972; Schmidt, 1980), coagulation (Samuelsson and Holm, 1966; Snoeren et al., 1979), sweet curd formation (Kreveld, 1950), thixotropic gel formation (Swanson et al., 1965), partial gelation (Samuelsson and Holm, 1966; Hostettler, 1972) or lumpiness (Tarassuk and Tamasma, 1956).

In the initial stage of storage, there is thinning of the concentrated milk product followed by a fairly long period during which very little change in viscosity is observed. In the terminal period there is a sudden rise in viscosity culminating in gel formation within a short period (1-3 weeks). Samples that are viscous or at an early stage of gelation can be easily dispersed to a thin consistency by agitation. However, these samples revert to the viscous state within 24-48 h. When gelation/excessive viscosity occurs, the product exhibits a custard-like consistency, and the process is irreversible at this stage. The gels are characterized, in most instances, by absence of syneresis (Tarassuk and Tamasma, 1956) but on further storage, syneresis do occur (Harwalkar and Vreeman, 1978 a).

Changes in viscosity and gelation in evaporated milk during storage were first recognized by Deysher et al., (1944) and Bell et al. (1944). Thereafter, numerous workers studied changes in viscosity during storage in UHT sterilized milk (Samuelsson and Holm, 1966; Aoki and Imamura, 1974; Blanc et al., 1980), concentrated milk (Tarassuk and Tamasma, 1956; Leviton and Pallansch, 1961 a,b; Ellertson and Pearce, 1964; Snoeren et al. 1976), concentrated skim
milk (Harwalkar and Vreeman, 1978a; Snoeren et al., 1982 a,b) and SCM (Hunzikar, 1949; Samel and Muers, 1962 a,b,c; Zavarin et al., 1978; Upadhyay, 1998).

The viscosity changes in sweetened condensed full cream buffalo milk during storage have been studied by Srinivasan et al. (1970) and Bhanumurthi et al. (1970). They observed little change in viscosity during storage at 8°C upto 1 year after an initial slight decrease over the first three months. However, at ambient temperature, the viscosity fluctuated throughout the storage period of 34 weeks.

2.5.3.1 Factors Affecting Viscosity Changes

Various factors affect the degree of viscosity changes; the prominent ones among them are reviewed here below.

a) Quality and composition of milk

The variation in milk composition particularly the quality and quantity of proteins and mineral content influence the stability of milk and therefore the viscosity. Such changes are influenced by numerous factors, particularly season, feed (Zadow and Chituta, 1975; Graf and Bauer, 1976), breed (Beeby and Luftus, 1962; Dudani and Iya, 1963), health of animal (Swartling, 1968), and stage of lactation (Zadow an Chituta, 1975).

Similarly, acidity of the milk also has a marked influence on the viscosity changes in concentrated milks. Other compositional attributes like solids-not-fat (SNF) content also play a vital role (Hunzikar, 1949; Tarassuk and Tamasma, 1956; Graf and Bauer, 1976).
b)  *Fat/SNF ratio in the product*

Fat acts as a softener and diluent of protein suspension, yielding a more syrupy texture than the product made from skim milk. The latter incidentally has a pronounced tendency to age thicken than the product obtained from whole milk (Hunzikar, 1949).

c)  *SNF-in-water ratio of the product*

Since proteins, which form part of SNF of milk, are mainly involved in age thickening of SCM, their increase or decrease would simultaneously increase or decrease the age thickening tendency (Hunzikar, 1949).

d)  *Heat treatment*

Fore warming, a beneficial step in improving the stability of concentrates, when imparted at a higher temperature and for a longer period, delays gelation at the cost of sedimentation and flavour deterioration. Hence, forewarming treatment should be chosen with due consideration to stabilize raw milk (Hunzikar, 1949; Swanson *et al.* 1965; Burton, 1969; Mehta, 1980).

e)  *Homogenization and sequence of operation*

In normal commercial practice, homogenization is included as one of the processing stages in preparation of concentrated milks prepared from whole milk. However, its effect is governed by its application at a specific state of operation.

Placing the homogenization step before concentration yields a product with reduced stability against excessive viscosity (Leviton *et al.* 1963).

Holding the concentrate at 94°C to allow development of a critical viscosity is another significant step influencing excessive
viscosity/gelation behaviour. This treatment has been claimed to retard development of excessive viscosity/gelation during storage (Giroux et al. 1958; Calbert and Swanson, 1959).

\( f) \quad \text{Sugar and its stage of incorporation} \)

The increase in the sucrose-in-water ratio decreases the tendency of the product to age thickening. The beneficial effect of increased sucrose content may be through its effect on the salt equilibrium by reacting with the metals or by dissolving some otherwise insoluble calcium or magnesium salts. The dissolved sugar markedly increases the volume of dispersed medium and also tends to increase viscosity of dispersed medium leading to reduced interaction between dispersed particles (Hunzikar, 1949).

Addition of sugar to milk, prior to forewarming, is most conducive to age thickening. Forewarming of milk (65 percent concentration) and drawing the mixture into the VAT retarded the tendency to age thickening. Incorporating sugar at the end of the condensing period tends to cause age thinning, which might give rise to objectionable fat separation (Hunzikar, 1949).

2.5.3.8 DEGREE OF CONCENTRATION

A product with high concentration has a high initial viscosity and tends to hasten age thickening (Bell et al., 1944; Hunzikar, 1949; Tarassuk and Tamasma, 1956, Calbert and Swanson, 1959; Leviton et al., 1963; Ellerton and Pearce, 1964; Parry, 1974). Moreover, increased severity of heat treatment has less influence on retarding the development of excessive viscosity of concentrates containing high TS (Stewart et al., 1959).
g) **Stabilizing salts and other additives**

Extensive studies have been conducted to select additives, which would be effective in controlling the age thickening/gelation of concentrates during storage.


Other additives that delayed gelation of concentrates are polyhydric compounds like lactose, sucrose, dextrose, sorbitol (Leviton and Pallansch, 1962), Sulphhydryl blocking agents (Nakai *et al.*,1965), sodium hydroxide (Board and Bullett, 1970) and sodium carbonate (Anon, 1979).

Stabilizing effect of certain added cations such as zinc and manganese could be due to their interaction with and removal of polyvalent serum anions (e.g. phosphate and citrate) (Samel and Muers, 1962c).

Thus, adjustment of mineral balance through removal or addition of appropriate salts, in accordance with the initial salt balance of milk, is one of the practical measures which could be used to prevent development of excessive viscosity. Inclusion of 0.05-0.15 per cent of tetra polyphosphate increased the shelf-life of SCM as observed by Gordon (1973).

Addition of acid-precipitated casein, before or during concentration, in proportion of 1:8 to 1:10 (acid casein : milk) for
buffalo milk helps in preventing age-thickening during storage (Mathur and Shanbhag, 1969).

**h) Temperature of condensing**

Condensing the milk at a relatively high pan temperature tends to destabilize the finished product and augments the tendency to age thickening. However, Samel and Muers (1962b) observed the stabilizing effect when using a moderately high condensing temperature and cool storage after condensing.

**i) Temperature of storage**

The storage temperature has a marked effect on age thickening. The thickening tendency increases with increase in the storage temperature, particularly at temperatures above 20°C. It has been observed that the rate of thickening approximately doubles with a rise in storage temperature of every 5°C above – 1°C (Hunzikar, 1949). However, the extent of temperature dependence on gelation/thickening times varies (Leviton et al.; Ellertson and Pearce, 1964).

2.6 **APPROACHES TO EXTEND AGE THICKENING - FREE SHELF LIFE**

Although the fundamental understanding of the mechanisms of age thickening/gelation in concentrates is not adequate at present, there are several empirical approaches, which are useful in extending the age thickening/gelation-free shelf life of concentrated milks in practical situations:

a. Assurance of good quality raw milk.

c. Proper stage of addition of sugar and in proper form.
d. Incorporation of additives such as polyphosphates, and
e. Maintenance of lower temperature of storage.

2.7 MECHANIZATION OF INDIAN DAIRY PRODUCTS

For large-scale production of concentrated milk products a mechanized systems involving Conical Process Vat and Thin film scrapped surface heat exchanger have been elaborated by (Agarwala et.al. 2001).

2.7.1 CONICAL PROCESS VAT

Developed at NDRI, Karnal by Agarwala et al. (1987), the equipment consists of a steam-jacketed stainless steel conical vat with a cone angle of 60°. The steam jacket is partitioned into 4 segments to provide variable heating area for efficient use of thermal energy. The rotary scrapers have been devised to offer a uniform centrifugal force of scraping at all points on heat transfer surface. Agitating baffles have been attached to the scraper-shaft for continuous mixing of the contents. Mounted on the same shaft is a radial flow, a propeller for efficient discharge of the viscous products. The scraping assembly is coupled to a variable speed drive unit to offer an attractive speed control at different stages of khoa preparation, desired to obtain a better product texture.

The straight line scraping profile offered by conical vat greatly improves the scraping action upto 140-rpm, the peripheral speed not exceeding 135 m/min. There was no fouling or burning on problem. The equipment offered mechanical loading and unloading of material and could be handled easily by one operator only. On the basis of two shifts per day in a dairy plant, each shift containing 8 hours operation the processing rates would be given as (1) 300 liters of
buffalo milk into khoa, (2) two tons of pre-concentrated milk (37% TS) into khoa, and (3) 800 kg of butter/500 kg of cream into ghee.

2.7.2 THIN FILM SCRAPED SURFACE HEAT EXCHANGER (TSSHE)

Thin film scrapped surface heat exchanger was developed by Dodeja et al.1990. The equipment is based on the principle of heat and mass transfer in a horizontal thin film scrapped heat exchanger. In SSHE the heating surface is scraped continuously. By this technique, the slow moving heat transfer, is quickly removed and mixed with bulk of the liquid. Also at the same time fresh liquid is brought into contact with the surface. The scraping is achieved by a set of rotating blades. The motion of blades substantially accelerates the heat and mass transfer rates by creating turbulence and pumping action in the liquid. By the same action of blades, the product to be evaporated is formed on the heating surface in form of a thin film. The rotor is designed in such a manner that it can handle both the products i.e. ghee and Khoa.

This studies on this system revealed that it possesses following specific advantages.

a). High heat transfer co-efficient.

b). Total absence of fouling on the heat transfer surface.

c). Short residence time therefore less heat damage to the product.

d). High capacity reduction.

e). Product is confined as a thin film on the heating surface; consequently the hold-up volume is extremely small, giving compact design.
f). Improved flow-characteristics of the product inside the equipment.

g). The equipment can handle products even in a semi-solid form without causing heat damage.

h). Equipment adaptable to automation and cleaning-in-place (CIP).

i). Sanitary operation, as process take place in a completely closed system.

j). No strain on the operators. Only small valves have to be closed or opened by the operator.

k). Uniform product quality as the process is continuous.

Thus, this system offers scope to easily overcome all disadvantages and limitation of the current methods for manufacture of ghee and Khoa in the industry. In addition, it is very versatile as only a single heat exchanger is required to handle ghee and Khoa and therefore, the maintenance becomes relatively easy.

Considering the review of literature, it seems that study is required to be undertaken to mechanize the production of indigenous milk product like Basundi to scale up the production using the equipment like conical vats developed for manufacturing concentrated milk products.
3.0 SCOPE AND PLAN OF WORK

3.1 SCOPE

India’s dairy sector is expanding and the milk production in India has increased more than triple between 1970 and 2002, which representing about 16% of total world milk production. Output of this, only 18% of milk is processed industrially by organized sector at 260 dairies, while the rest is utilized locally as fluid milk for direct consumption and for converting into traditional dairy products by the unorganized sector (Nygaard, 1996). Thus, manufacture of traditional milk products including Basundi has tremendous scope, both in organized as well as unorganized sector provided that we have standard technology available which is amenable to adoption, both at large as well as small scale.

The review of literature presented in preceding chapter revealed that although Basundi is a very popular and delicious Indian recipe, almost very negligible information is available on it. Since, it is region specific traditional milk product, its manufacture is confined to housewife and limited to Halwai (in few cities only) and prepared on some special occasions. Hence, its production is very less with very widely variation in composition and quality, depending on the raw material used and skill. The fuel consumption during its production is quite high. Recently, a batch method has been standardized (Pagote, 2002) but there is further need to mechanize the method for attaining uniformity in composition and quality as well as for large scale production. It is therefore, study has made for the evaluation of newly developed process equipment i.e. conical process vat for the manufacture of Basundi with the following objectives:
1. To determine the suitability of conical process vat for the manufacture of Basundi with respect to quality.

2. To assess the cost of processing.

3.2 PLAN OF WORK

To accomplish the above stated objectives, the plan of work behind this study was drawn into following sections.

3.2.1. EVALUATION OF SUITABILITY OF CONICAL PROCESS VAT

Basundi samples were prepared in conical process vat and compared with that of control samples (which were prepared by standardized batch method (Pagote, 2002) for its quality. The parameters regarding conical process vat and quality of Basundi were studied, extensively.

3.2.1.1 Parameters Regarding Conical Process Vat

3.2.1.1.1 Variables Parameters

a. Processing Time

20, 40, 60, 80, 100 and 120 minutes

b. Steam Pressure

0.6, 0.8, 1.0 and 1.2 kg/ cm²

c. Stage of Sugar Addition

After 50% of milk solids concentration
Just after forewarning.
3.2.1.2 Constant Parameters


b. Speed of scrapper : 70 rpm

c. Re-circulation Rate. : 3.5 Kg/min.

3.2.1.2 Quality evaluation of Basundi.

The quality of Basundi samples were checked at different stages, considering following parameters:

3.2.1.2.1 Quality Evaluation During Milk Concentration:-

a. The consistency/concentration level were checked on the basis of total solids with the help of refractometer at 20 minutes interval till reaching desired total solids.

b. Brown colour development (Browning): The colour changes during milk concentration in each trial were checked at each 20 minutes interval by visual observation.

c. Overall visual quality during milk concentration and final stage, were recorded including body and texture of the final product.

3.2.1.2.2 Quality Evaluation of Final Product

The quality evaluation of final product was done by considering following sensory attributes (for organoleptic evaluation) and physico-chemical parameters.

a) Sensory Attributes

i) Colour and Appearance    ii) Flavour

ii) Body and Texture        iv) Sweetness and Overall acceptability.
b) Physico-Chemical Parameters

i) Total Solids

ii) Fat

iii) Proteins

iv) Sucrose

v) Lactose

vi) Acidity

vii) PH

viii) Specific gravity

ix) Viscosity

x) Colour reflectance

xi) HMF Value

xii) FFA Value

3.2.2 EVALUATION OF COST OF PROCESSING

The cost of processing of Basundi (including raw materials, process equipment, utilities, etc.) also worked out.
4.0 This chapter dealt with the setup of conical process vat and its operation, accessories; materials and ingredients required, method of sample preparation and analytical procedures relating to various parameters of the product.

4.1 MATERIALS

4.1.1 CONICAL PROCESS VAT

The multipurpose conical process vat developed at National Dairy Research Institute, Karnal by Agarwala et al. (1987) was used for preparation of Basundi samples during entire study. The system of conical process vat is shown in Figure 3.1. It consists the following mechanisms:

4.1.1.1 Scrapping Mechanism

The conical process vat with cone angle of 60° has a scrapping mechanism consisting of three equidistant arms supported with two shaft and each arm having three independent spring-loaded blades made up of Teflon material.

4.1.1.2 Re-circulation cum Product Spreading Mechanism

To improve mixing and thermal performance of the equipment, recirculation mechanism is provided which also spread the product on heating surface of vat through rotor positive displacement of single screw pump.

4.1.1.3 Product Discharge Mechanism

Product discharge mechanism consists of open type backward rake and three-vane impeller provided in the volute, located at the bottom of the vat for convenient discharge of viscous finished product.
4.1.1.4 Steam Control Mechanism

The jacket of conical process vat is partitioned into three segments, which provided variable heating areas by throttling individual steam valves, and which help to control the product spoilage during foaming (on account of variable product volume). For an efficient use of thermal energy, separate connections for steam-inlet, condensate-outlet and air-vent is provided to each segment of jacket, which controls heat supply and provides required heating area during different stages of processing of product. The pressure gauge is provided to monitor steam pressure.

4.1.2 ACCESSORIES / MATERIALS

4.1.2.1 Digital Thermometer

To monitor the temperature change during the production process of Basundi, a battery operated ‘digital temperature indicator’ alongwith probe (supplied by Naina Company), was used.

4.1.2.2 Pocket Refractometer

To measure the consistency of product during preparation, pocket-refractometer between the range of 60° to 90° Brix, supplied by Mercantile Engineers, New Delhi, was used.

4.1.2.3 Other Materials

Weighing balance, milk cans, plunger, trays, etc.

4.1.3 INGREDIENTS

4.1.3.1 Milk

The fresh, pooled raw buffalo milk obtained from the Experimental Dairy of the Institute, was used for present study.
4.1.3.2 Sugar

Commercial grade white crystalline sugar taken from the store of Experimental Dairy and used in all trials.

4.1.3.3 Nuts and Dry-fruits

Nuts and dry-fruits were purchased from the local market and used in Basundi.

4.2 METHODS

4.2.2 PREPARATION OF CONTROL BASUNDI SAMPLE

For the preparation of control sample, the method, which has been recently standardised by Pagote (2002) was adopted. As per method, a fresh buffalo milk was taken and standardised to fat/solids-not-fat ratio of 0.7 using skim milk (separated from same lot of buffalo milk) and/or water as needed. The milk was then poured into the shallow pan (of its about two-third volume) for slow heating on thermostatically controlled heater. It was forwarmed to 85°C for 20 minutes, and continued the evaporation (with continuous agitation and slow boiling to avoid burning) till to get two-fold milk concentration. Nutmeg powder then added at this stage to get sufficient time for flavour development, and sugar also added @ 7 per cent of standardised milk. Further concentration was continued till getting desired consistency (at about 2.25 fold concentration of milk solids). Heating was stopped and homogenised the sample at 65°C. Product was then allowed to cool, first at room temperature and then to around 20°C for examination, or stored at refrigerated temperature till taken for further study.

4.2.3 PREPARATION OF SAMPLES IN CONICAL PROCESS VAT

Mechanized conical process vat was used for the preparation of Basundi at different steam pressure (0.6, 0.8, 1.0, 1.2 kg/cm²) and processing time (40, 60, 80, 100 and 120) minutes. Sugar was added at
two different stages (i.e. after 50% of milk concentration and just after for warming). The speed of scrapper was kept constant (Sec. 3.2.1.1)

The following steps were followed to prepare Basundi samples in conical process vat.

A. A fresh buffalo milk collected from Experimental Dairy of Institute was strained, and then standardized to get fat/SNF ratio of 0.7. Then final samples were taken out from the vat.

B. Before taking milk in conical process vat, it was cleaned properly by using 1.2 % solution of caustic soda at 75°C followed by rinsing and cleaning with warm water.

C. The pre-standardized milk (40litre/batch) was taken in the vat and opened steam-valve gradually and adjusted to 0.5-0.6 Kg/cm² pressure for fore warming (at 85°C for 20 mins) and further continued heating.

D. Started the scrapper assembly and re-circulation pump.

E. After fore warming, steam pressure(s) at pre-determined level(s) was adjusted gradually by control valve, for different sample preparation.

F. Increase in milk solids’ concentration during evaporation, were checked frequently with the help of pocket refractometer at every 15-20 minutes or required time intervals, as needed.

G. When, concentration of milk solids reached to two-fold, sugar was added @ 7 percent of standardized milk along with desired amount of nut powder for flavour development. However it was also added just after forewarning to study the effect of sugar addition on Basundi.
FIG. 1: LINE DIAGRAM OF THE EXPERIMENTAL SETUP FOR BASUNDI PRODUCTION

A Drive unit
B Supporting frame
C Conical vat
D Scraper assembly
E Steam connections
F Supporting frame
G Impeller
H Re-circulation pump
I Product outlet valve
J Product spreader
K Drive link
L Central shaft
M Product supply
H. When product reaches to the desired consistency and total solids between 40° to 45° Brix, heating was stopped by closing steam valve gradually and after some times, the scrapper assembly also stopped.

I. Finally, the product samples were collected through outlet valve of conical vat.

4.2.3. ANALYTICAL PROCEDURE

4.2.3.1 Fat

The fat content of milk, skim milk and cream was determined by Gerber method as per Bureau of Indian Standard (SP:18, Part-XI, 1981). Similarly, Basundi samples were analysed for fat after diluting 2 x (w/w) with distilled water. The values of fat for Basundi were computed by using dilution factor.

4.2.3.2 Solids-not-fat (SNF)

For SNF content of milk and skim milk samples, they were tempered at ~29°C, and determined by using BIS lactometer (IS:10083, 1982). The following formula was used for calculating SNF:

\[ \text{Per cent SNF} = 0.25 \times F + \frac{\text{CLR}}{4} + 0.44 \]

Where, \( F \) = fat percent of sample and \( \text{CLR} \) = corrected lactometer reading.

4.2.3.3 Total solids (TS)

The TS of Basundi was estimated gravimetrically using Mojonnier milk tester, Model-D as per the standard procedure (Laboratory Manual, 1959).
4.2.3.4 **Total Proteins**

Total protein of *Basundi* was determined by semi-microkjeldahl method (IS:1479 - Part-II, 1961), using Kjel-plus digestion system (Model-KPS 006L, M/s Pelican Instruments, Chennai) and Kjel-plus semiautomatic distillation system (Model –Distil M, M/s Pelican instruments, Chennai) as follows:

In a digestion tube 0.5 – 1.0 g of the sample was accurately weighed and then 2.4 g of digestion mixture potassium sulphate: copper sulphate : selenium dioxide; (0.1:0.1) was added. To the tube contents, 10 ml of nitrogen-free concentrated sulphuric acid was added. The tubes were then transferred to the digestion block, where the contents were digested for about 30 min at a final temperature of 350°C.

The cooled, digested contents were loaded in the’ Kjel-plus distillation unit and after the unit was ‘ready’, a fixed volume of alkali (20 ml of 40 per cent sodium hydroxide) was added automatically to the sample. The distillation time was fixed at 3 min. The liberated ammonia was condensed and collected in 25 ml of saturated boric acid solution containing three drops of mixed indicator [equal volume of saturated solution of methyl red and 0.1 per cent methylene blue solution, both made in 95 per cent (v/v) ethanol]. The distillate in boric acid was titrated against 0.05 N sulphuric acid. A reagent blank was simultaneously run using all the above chemicals except the sample and its reading was subtracted from the experimental reading.

The per cent total nitrogen was calculated using the formula.

\[
\text{Per cent total nitrogen} = \frac{0.07 \times (\text{Burette reading} - \text{Blank reading})}{W}
\]
Where,

\[ W = \text{Weight of sample} \]

For converting the values of total nitrogen into per cent total protein, the values were multiplied by a factor of 6.38.

### 4.2.3.5 Lactose

Lactose content of Basundi samples were determined as per Bureau of Indian Standard 9SP:18-Part-XI, 1981) with slight change in the quantity of samples taken. Accordingly, in a 250 ml conical flask, 10 g of sample was weighed and 50-60 ml of hot (~75°-80°C) distilled water was added. Then neutral lead acetate solution was added drop by drop till no further precipitation occurred followed by addition of a drop of alumina cream. The content after gentle mixing was allowed to rest for 15 min and then it was made lead free using sodium oxalate solution till the cloudy appearance transformed to a clear one. The end point was judged by using potassium iodide solution. The content was then filtered through a Whatman filter paper No. 1 and the volume was made to 100 ml using distilled water.

The filtrate, which comprised of the sugar solution, was filled in the burette and titrated against a mixture of 5 ml each of Fehling-A and Fehling-B solutions using methylene blue as an indicator. The titration was carried out in boiling condition over a flame and end point was observed as clear brick red precipitates. The readings were then used to compute lactose content of the product in solution.

### 4.2.3.6 Sucrose

Sucrose content of Basundi samples was determined by the colorimetric method suggested by Pantulu et al. (1976),

In a 250 ml volumetric flask, 2.5 g of Basundi sample was weighed and distilled water, in requisite quantity (~1—ml), was added. The solution
was precipitated with 4-5 drops of 40 per cent w/v of lead acetate solution. The content was mixed gently and the volume was made to 250 ml with distilled water. The content was allowed to stand for 10-15 min and then filtered using Whatman filter paper No.1. Out of this filtrate, 1 ml was taken in a 100 ml volumetric flask and the volume made to 100 ml with distilled water. Two ml of this diluted filtrate was transferred to a test tube, to which 2 ml of 0.12 per cent resorcinol solution and 6 ml of 12 N hydrochloric acid was added. After mixing the content thoroughly, the test tube was put in a boiling water bath for 10 min for colour development.

After cooling to room temperature, the colour intensity of the solution was measured by using spectrophotometer (model-Spectronic – 20D, M/s Milton Roy Co., USA) at 490 nm. The per cent sucrose content of the sample was determined using a standard curve (Appendix VII).

4.2.3.7 **Titratable acidity**

The titratable acidity of all the samples was determined by titrating 10 g of sample against 0.1 N sodium hydroxide using phenolphthalein as an indicator and the results expressed in terms of per cent lactic acid (LA) (IS:1479 Part –1, 1960).

4.2.3.8 **pH**

pH of milk, and Basundi samples was measured by potentiometric method using Systronics Digital pH meter.

4.2.3.9 **Free Fatty Acids (FFA)**

Free Fatty acids (FFA) content of Basundi samples was determined by the method suggested by Deeth and Fitz-Gerald (1976).

Three milliliters of milk or Basundi (diluted to its original milk TS) was warmed to 30°C and taken in a test tube, stopper and mixed with 10 ml of extraction mixture (i.e. iso-propanol: petroleum ether: 4 N sulphuric acid in 40: 10:1) ratio, 6 ml of petroleum ether and 4 ml of distilled water.
The stopper test tube was then shaken vigorously for 15 mins. After allowing sufficient time (i.e. 5-10 min) for the two layers to separate, 7.5 ml aliquot of the supernatant was withdrawn and transferred to a 50 ml flask. After addition of 6 drops of 1 per cent methanolic phenolphthalein, the solution was titrated against 0.02 N methanolic potassium hydroxide solution. A blank titration using water, instead of sample was also carried out. The FFA content of Basundi, expressed in terms of micro equivalent per ml was calculated using the following formulae:

\[
\text{FFA (micro équivalent/ml)} = \frac{V \times N \times 10^3}{3P}
\]

Where, \( V \) = Net titration volume, \( N \) = Normality of KOH, and \( P \) = Part of the upper layer titrated out of total volume.

4.2.3.10 5-Hydroxy Methyl Furfural (HMF)

The quantitative method presented by Keeney and Bassette (1959) for quantifying HMF by spectrophotometric measurement of the 2-thio barbituric acid (TBA) reaction production was used to assess the extent of browning in milk and Basundi samples.

Ten milliliters of milk or Basundi (diluted to its original milk TS) was pipetted into a 50 ml test tube and to this, 5 ml of 0.3 N oxalic acid was added and mixed thoroughly. The tubes were covered with inverted 20 ml glass beaker and then placed in a boiling water bath for 1 h and then cooled to room temperature. Thereafter, 5 ml of 40 per cent trichloro acetic acid (TCA) was added, the contents mixed thoroughly and subsequently filtered through a Whatman filter paper No. 42. Four milliliters of this filtrate was pipetted into a test tube, followed by addition of 1 ml of 0.05 M TBA. The test tube was placed in water bath maintained at 40°C for 30-40 min, and subsequently cooled to room temperature.
The solution was then subjected to measurement of absorbance at 443 nm in a spectrophotometer (Spectronic –20D, M/s Milton Roy Co., USA). A blank was simultaneously prepared substituting milk/Basundi with water. The absorbance of the sample solution was measured against the blank. HMF was calculated from the absorbance which is the total of fee and potential HMF formed from browning intermediates.

The formula used was: HMF (µmol/lit) = (Absorbance - 0.055) x 87.5

4.2.3.11 **Specific Gravity**

The specific gravity of Basundi samples was determined at 25°C using a specific gravity bottle according to the method described by Ling (1956).

4.2.3.12 **Viscosity**

The viscosity of milk and Basundi sample was determined using Contrave’s RHEOMAT RM-108 E/R viscometer. Viscosity was measured by single point measurement mode with the following parameters:

- Sample temperature: 25°C
- Time Interval: 30 S
- Shear rate: 280/S
- Measuring system: 1,1
- Mode: 11
- Measuring tube: 1 (Φ= 32.54 mm)
- Measuring bob: 1 (Φ=30 mm, 1 = 45 mm)

Samples were tempered to 25°C and filled in the measuring tube. The machine was run with the above parameters and the dynamic
viscosity was noted after 30 sec. The readings were converted from Pascal second (pa.s) to centi poise (1 pa.s = 1000 centipoise)

4.2.3.13 Colour Reflectance

The colour of Basundi was measured in terms of colour reflectance using a “Reflectometer CL-28“ manufacture by Elico Pvt Ltd. Hyderabad, India.

The operating procedure consisted of setting indicator at ‘Zero’ by adjusting the screw provided in the meter. Instrument was then connected to main supply (220/440v) and switch was set to ‘on’ position with blank plate in the socket, Indicator was readjusted to ‘Zero’ with the ‘set zero’ knob. Search unit was then placed on the white standard Magnesium Oxide block and instrument adjusted to the value corresponding to the selectivity marked on the block with the aid of the sensitivity knob. Magnesium Oxide block was then replaced with black, gray and white slabs supplied with the instrument and adjustment made to ensure that the meter reading corresponds to the value marked on these slabs. When everything was in order, Basundi sample in glass bottle (rectangular) was placed before the search unit and reflectivity measured at 450 nm.

Percent size in reflectance was obtained by using formula:-

\[
\text{Colour reflectance} = \frac{\text{Reflectance of sample} - \text{Reflectance of raw milk}}{\text{Reflectance of raw milk}} \times 100
\]

4.2.4 SENSORY EVALUATION

Basundi manufactured at different stages of its manufacturing process and was evaluated for its sensory characteristics by a panel of 5 judges selected from the staff of Dairy Technology Division. The score card used for sensory evaluation of Basundi used is given in Appendix-I.
4.2.5  STATISTICAL ANALYSIS

The mean values generated from the analyses of duplicate samples, obtained in either three or four replications as the case may be, were subjected to statistical analysis using completely randomized design (CRD) as per Steel and Torrie (1980), which is illustrated as given below.

\[ Y_{ij} = \mu + T_i + E_{ij} \]

Where, \( Y_{ij} \) = Response due to \( j^{th} \) observation in the \( i^{th} \) treatment

\( \mu \) = General mean

\( T_i \) = Effect of \( i^{th} \) treatment, and

\( E_{ij} \) = Error due to \( j^{th} \) observation in the \( i^{th} \) treatment

4.2.3  COST OF PROCESSING

To ascertain the commercial and economic viability of production of Basundi, cost of processing was calculated considering appropriate assumptions, wherever necessary. The basis of cost calculations, the assumptions made and calculated cost, are discussed in see 5.5.1.
5.0 RESULTS AND DISCUSSION

The present study was undertaken to determine the suitability of Conical Process Vat for the manufacture of Basundi. The results obtained during the course of investigation are presented and discussed as follows:

5.1 EFFECT OF STEAM PRESSURE AND PROCESSING TIME ON PRODUCT CHARACTERISTICS.

With the intention to see the effect of different steam pressure (viz. 0.6, 0.8, 1.0 and 1.2 kg/cm²) on various characteristics of Basundi, standardized buffalo milk was concentrated till desired level of total solids. The sugar was added to the milk while two-fold concentration was achieved. Whereas, nut flavour (in the form of powder) was added in to the concentrated milk, about 20 minutes prior to the final-relating time of required total solids. The observation were recorded during concentration till and at different time intervals and discussed here under.

Table 1: Effect of steam pressure and processing time on body and texture of Basundi during milk concentration.

<table>
<thead>
<tr>
<th>Steam pressure (kg/ cm²)</th>
<th>Processing Time (mins.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td>0.6</td>
<td>--</td>
</tr>
<tr>
<td>0.8</td>
<td>--</td>
</tr>
<tr>
<td>1.0</td>
<td>Very thin (TS=30)</td>
</tr>
<tr>
<td>1.2</td>
<td>Thin (TS=28)</td>
</tr>
</tbody>
</table>

TS = Total Solids
The effect of steam pressure and processing time on body and texture of Basundi during milk concentration depicted in Table 1

It is evident from the tabulated values that at very low steam pressure viz. 0.6 kg/cm² the body and texture were very thin up to 60 mins of evaporation time. At 80, 100 & 120 mins of holding time the body and texture of Basundi were improved gradually and reached upto desired level within 120 minutes of Processing time.

At 0.8 kg/cm² steam pressure, the body and texture of Basundi were very thin up to 60 mins of evaporation time and after that the consistency of the product was increased fast with the increase in total solids. The optimum consistency and desired TS level were achieved within 100 minutes.

At 1.0 kg/cm² steam pressure, the body and texture of Basundi were very thin up to 40 mins of evaporation time. Beyond 40 mins of holding time, the consistency were increased very fast and reached upto the desired level within 80 minute due to fast evaporation. Where as at 1.2 kg/cm² steam pressure the body and texture were thin at 40 mins of evaporation time. The desirable body and texture were obtained after achieving the required consistency and total solids.

Table 2: Effect of steam pressure and processing time on colour and appearance of Basundi during milk concentration.

<table>
<thead>
<tr>
<th>Steam pressure (kg / cm²)</th>
<th>ProcessingTime (mins.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td>0.6</td>
<td>--</td>
</tr>
<tr>
<td>0.8</td>
<td>--</td>
</tr>
<tr>
<td>1.0</td>
<td>White</td>
</tr>
<tr>
<td>1.2</td>
<td>Very light brown</td>
</tr>
</tbody>
</table>
The effect of steam pressure and processing time, on colour and appearance of Basundi during milk concentration depicted in table 2.

There are four different steam pressures and six different processing time were tried for study the effect on colour and appearance of Basundi. It was seen that at 0.6 and 0.8 kg/cm$^2$ steam pressure, the colour as well as appearance of Basundi were not changed considerably upto 40 minutes of evaporation time. Whereas, at 1.0 kg/cm$^2$ pressure, light brown colour was obtained in the product during 60 minutes of evaporation time.

At 0.6 and 0.8 kg/cm$^2$ steam pressure, the colour of Basundi were very light brown upto 60 mins of evaporation time. At 1.2 kg/cm$^2$ steam pressure within 60 mins of evaporation time, the product became brown in colour. At 0.6 kg/cm$^2$ the optimum colour were not obtained even after 120 mins of evaporation time; because of that there are some component which are responsible for colour development were not properly heated at this steam pressure (Hunziker, 1975) Where as the colour and appearance of Basundi were achieved desirable brown at steam pressure 0.8 and 1.0 kg/cm$^2$ after 100 and 80 mins of evaporation time respectively. When the holding times were increased at 1.0 and 1.2 kg/cm$^2$ the obtained product were brown in colour.
Table 3: Effect of steam pressure and Processing Time on flavour (sweetness and pleasantness) of Basundi.

<table>
<thead>
<tr>
<th>Pressure (kg/cm²)</th>
<th>Holding Time (mins.)</th>
<th>Sweetness</th>
<th>Pleasantness</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>120</td>
<td>Optimum</td>
<td>Unpleasant</td>
</tr>
<tr>
<td>0.8</td>
<td>100</td>
<td>Optimum sweet</td>
<td>Pleasant</td>
</tr>
<tr>
<td>1.0</td>
<td>80</td>
<td>Optimum sweet</td>
<td>Pleasant</td>
</tr>
<tr>
<td>1.2</td>
<td>60</td>
<td>More</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

The effect of holding time in relation to steam pressure, on sweetness and pleasantness of Basundi is shown in Table 5.

It had been seen from the tabulated value that at 0.6 kg/cm² steam pressure the sweetness of the product was optimum but not pleasant. Due to low steam pressure and short processing time some of the flavoring compound which are responsible for flavour development are not properly heated at this pressure and processing time (Annon,1978). At 0.8 and 1.0 kg/cm² steam pressure, obtained product were optimum in sweetness and pleasantness after 100 and 80 mins. of processing time respectively. Where as at 1.2 kg/cm² steam pressure and 60 mins. of processing time the product became more sweet and hence the pleasantness was liked moderately.
Table 4: Effect of steam pressure and processing time on sensory score of Basundi.

<table>
<thead>
<tr>
<th>Pressure (kg/cm²)</th>
<th>Holding Time (mins.)</th>
<th>Sensory Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Body &amp; Texture</td>
<td>Flavour</td>
</tr>
<tr>
<td>0.6</td>
<td>120</td>
<td>6.50</td>
</tr>
<tr>
<td>0.8</td>
<td>100</td>
<td>8.75</td>
</tr>
<tr>
<td>1.0</td>
<td>80</td>
<td>8.75</td>
</tr>
<tr>
<td>1.2</td>
<td>60</td>
<td>8.75</td>
</tr>
<tr>
<td>S.Em.</td>
<td></td>
<td>0.487</td>
</tr>
<tr>
<td>C.D (0.05)</td>
<td></td>
<td>1.09</td>
</tr>
</tbody>
</table>

The effect of processing time in relation to steam pressure and sensory score of Basundi is depicted in Table 6.

According to the panel of judges, at 0.6 kg/cm² steam pressure and 120 minutes processing time the final product obtained very low sensory score. At this pressure, the body and texture of Basundi was very thin, colour was very light brown and flavour also was not optimum but that was moderately acceptable.

At 0.8, 1.0 kg/cm² steam pressure, the body and texture, flavour, colour and appearance were optimum and obtained a maximum score according to the panel of Judges.
At 1.2 kg/cm² steam pressure the body and texture of Basundi were desirable and flavour were optimum but more brown in colour as compared to control sample.

Table 5: Effect of final holding time with its corresponding pressure on physico chemical properties of Basundi.

<table>
<thead>
<tr>
<th>Pressure (kg/cm²)</th>
<th>0.6</th>
<th>0.8</th>
<th>1.0</th>
<th>1.2</th>
<th>S.Em. C.D.(0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physico-Chemical Parameters</td>
<td>Processing time (mins)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viscosity (centipoises)</td>
<td>120</td>
<td>100</td>
<td>80</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Reducing sugar (%)</td>
<td>70.05</td>
<td>74.32</td>
<td>78.30</td>
<td>80.22</td>
<td>5.85</td>
</tr>
<tr>
<td>HMF (µmol/liter)</td>
<td>69.05</td>
<td>80.20</td>
<td>76.51</td>
<td>73.32</td>
<td>4.987</td>
</tr>
<tr>
<td>FFA (ml eq. / ml)</td>
<td>1.25</td>
<td>1.38</td>
<td>1.55</td>
<td>1.97</td>
<td>0.328</td>
</tr>
<tr>
<td>PH</td>
<td>6.48</td>
<td>6.51</td>
<td>6.52</td>
<td>6.52</td>
<td>0.412</td>
</tr>
<tr>
<td>Acidity (% LA)</td>
<td>0.41</td>
<td>0.43</td>
<td>0.39</td>
<td>0.42</td>
<td>0.112</td>
</tr>
<tr>
<td>Reflectance (% size in O.D.)</td>
<td>62</td>
<td>54</td>
<td>56</td>
<td>60</td>
<td>2.895</td>
</tr>
</tbody>
</table>
The effect of final holding time with its corresponding pressure on physico-chemical properties of Basundi is depicted in Table-5.

It is apparent from the tabulated values that heat treatment had significant effect on the FFA, HMF, viscosity and invert sugar of the Basundi manufactured. The invert sugar progressively increased significantly with increase in pressure due to hydrolysis of sugar.

The viscosity of the products prepared also progressively increased significantly on successive increase in steam pressure product at low steam pressure shows lower viscosity than the higher steam pressure.

It is well known that heat treatment affects the denaturation of milk proteins and hence the viscosity. Similar increase in dynamic viscosity of milk and milk concentrates with increase in severity of heat treatment has been observed by Eilers (1947) and Biryukova (1968).

The HMF content (which is the index of browning reaction) in products, also progressively increased with increase in steam pressure in relation to holding time. It is minimum in unheated milk and maximum in heat treated milk at highest temperature indicating the influence of heat on browning reaction (Patton and Josephson, 1949).

The FFA values progressively increased significantly with increase in the steam pressure. Basundi manufactured from raw milk without pre-heat treatment had the least value, whereas the one made from forewarned milk had the highest value of FFA content. Such effect of heat treatment on FFA content is an expected live and is supported by the finding by Arora and Bindal (1981) who found in higher FFA in high heat treated milk as compared o raw milk while manufacturing Khoa.

The properties like acidity and pH were optimum.
5.2 Effect of stage of addition of sugar at different steam pressure on the product characteristics.

In this section the trails were conducted in two different stages viz.

1\textsuperscript{st} Stage - After 50\% milk evaporation, and

2\textsuperscript{nd} Stage - Just after forewarming.

And recorded the changes observed in body and texture, colour, flavour and consistency of the product during concentration.

Table 6: Effect of stage of sugar addition at different steam pressure on body and texture of \textit{Basundi}

<table>
<thead>
<tr>
<th>Steam Pressure (kg/cm\textsuperscript{2})</th>
<th>After 50% milk concentration</th>
<th>Just after forewarming</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>Slight thin body and low consistency</td>
<td>Thin body and desirable consistency</td>
</tr>
<tr>
<td>0.8</td>
<td>Desirable body and optimum consistency</td>
<td>Thick body and little more consistency</td>
</tr>
<tr>
<td>1.0</td>
<td>Desirable body and optimum consistency</td>
<td>Thick body and more consistency</td>
</tr>
<tr>
<td>1.2</td>
<td>Thick body and optimum consistency</td>
<td>Very thick body and high consistency</td>
</tr>
</tbody>
</table>
Tabler

ANOVA for effect of stage of sugar addition at different steam pressure on body and texture of Basundi.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between steam pressure</td>
<td>3</td>
<td>167.3333</td>
<td>55.77778</td>
<td>102.9744*</td>
<td>3.238867</td>
</tr>
<tr>
<td>Addition of sugar</td>
<td>1</td>
<td>32.66667</td>
<td>32.66667</td>
<td>60.30769*</td>
<td>4.493998</td>
</tr>
<tr>
<td>Interaction</td>
<td>3</td>
<td>11.33333</td>
<td>3.77778</td>
<td>6.974359*</td>
<td>3.238867</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>8.666667</td>
<td>0.541667</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>220</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant at 0.05

The effect of stage of sugar addition on body and texture of Basundi at different steam pressure during milk concentration is depicted in Table 8.

When sugar is added after 50% milk evaporation 0.6 kg/cm² steam pressure during concentration the body and texture of Basundi were slightly thin with low consistency, but on the other hand when sugar is added just after fore warming at 0.6 kg/cm² the body and texture of Basundi were thin and desirable consistency. The obtained data resulted that when sugar is added after 50% of milk evaporation at 0.8 & 1.0 Kg/cm² steam pressure during concentration, it was observed that the body and texture of final product of Basundi were thin and optimum consistency where as when sugar its added just after fore warming at this pressure the body and texture of final product of Basundi were thick and little more consistency compared to control sample. At 1.2 Kg/cm² steam pressure the body and texture were thick and optimum consistency, after 50% of milk concentration where as, when sugar is added just after fore
warming the obtained products were very thick body and high consistency.

The effect on body and texture of Basundi is due to stage of incorporation of sugar. Addition of sugar to milk just after fore warming, is most conducive to age thickening. Incorporating sugar syrup at the end of the condensing period tends to become age-thickening, which might give objectionable fat separation (Hunzikar, 1949).

Table 8: Effect of stage and sugar addition at different steam pressure on colour and appearance of Basundi.

<table>
<thead>
<tr>
<th>Steam Pressure (kg/cm²)</th>
<th>After 50% milk concentration</th>
<th>Just after forewarming</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>Very light brown</td>
<td>Slightly light brown</td>
</tr>
<tr>
<td>0.8</td>
<td>Light brown</td>
<td>Brown</td>
</tr>
<tr>
<td>1.0</td>
<td>Light brown</td>
<td>More brown</td>
</tr>
<tr>
<td>1.2</td>
<td>More brown</td>
<td>Very high brown</td>
</tr>
</tbody>
</table>
Table 9: ANOVA for effect of steam pressure and sugar addition on colour and appearance.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between steam pressure</td>
<td>3</td>
<td>2.394367</td>
<td>0.798122</td>
<td>6.595824*</td>
<td>3.238867</td>
</tr>
<tr>
<td>Between sugar addition</td>
<td>1</td>
<td>5.491267</td>
<td>5.491267</td>
<td>45.38081*</td>
<td>4.493998</td>
</tr>
<tr>
<td>Interaction</td>
<td>3</td>
<td>0.313433</td>
<td>0.104478</td>
<td>0.863423*</td>
<td>3.238867</td>
</tr>
<tr>
<td>Within</td>
<td>16</td>
<td>1.936067</td>
<td>0.121004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>10.13513</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* significant at 0.05

Effect of stage of sugar addition on colour and appearance of Basundi at different stem pressure during milk concentrations depicted in table 10.

As can be seen from the table that the colour and appearance were significantly affected on the final product. When the sugar is added at 2nd stage (just after for warming) at 0.6 kg/cm², the product obtained were slightly light brown in colour whereas when sugar addition is at the 1st stage (After 50% milk evaporation) the product obtained were very light brown in colour.

At 0.8 kg/cm² the product obtained in first stage of sugar addition, were light brown in colour and good appearance but in second stage the colour was brown.
When sugar is added after 50% milk evaporation at 1.0 kg/cm² the product obtained more light brown colour and desirable appearance where as when the sugar is added at this pressure, the product obtained were more brown and high consistency.

At 1.2 kg/ cm² steam pressure the product obtained were more brown in colour at the first stage of sugar addition. Where as in 2nd stage of sugar addition the product obtained were very high brown in colour.

It has been noticed that when sugar is added just after forewarming at lower steam pressure (0.6 kg/ cm² ) there were slight change in colour and appearance in comparison to first stage of sugar addition when the pressure were increase (0.8, 1.0) kg/ cm² the product obtained were good and diserable colour and appearance but in second stage of sugar addition the product were very more brown in colour.

So, according to judges, Basundi prepared by first stage of sugar addition were very good in colour and appearance and desirable.

Table 10: Effect of stage of sugar addition at different steam pressure on flavour (Pleasantness/sweetness) of Basundi.

<table>
<thead>
<tr>
<th>Steam Pressure (kg/cm²)</th>
<th>Stage of sugar addition</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>After 50% milk concentration</td>
<td>Just after forewarming</td>
<td></td>
</tr>
<tr>
<td>Sweetness</td>
<td>Pleasantness</td>
<td>Sweetness</td>
</tr>
<tr>
<td>0.6</td>
<td>Optimum</td>
<td>Unpleasant</td>
</tr>
<tr>
<td>0.8</td>
<td>Optimum</td>
<td>Pleasant</td>
</tr>
<tr>
<td>1.0</td>
<td>Optimum</td>
<td>Pleasant</td>
</tr>
<tr>
<td>1.2</td>
<td>More</td>
<td>Moderately</td>
</tr>
</tbody>
</table>
Effect of stage of addition of sugar on flavour (pleasantness/sweetness) is depicted in table-11.

It is evident from the tabulated value shows that when sugar is added after 50% milk evaporation the obtained products were optimum sweet but not pleasant. Where as when sugar is added just after forewarming the product had slightly less sweet and unpleasant. At 0.8 and 1.0 Kg/cm$^2$ steam pressure in both stages of sugar addition the obtained products were optimum flavour. Where as at 1.2 Kg/cm$^2$, at first stage of sugar addition the final products were more sweet and moderately accepted. It is revealed that the flavour increased significantly on increase in intensity of heat treatment. This increase in flavour might be due to the development of pleasant, cooked and nutty flavour in high heat treated milks as judges preferred this type of flavours in Basundi.

At 0.6-Kg/ cm$^2$ steam pressure in both stage of sugar addition the product obtained had not pleasant flavour.
Table 11: Effect of stage of addition of sugar at different steam pressure on sensory score of Basundi

<table>
<thead>
<tr>
<th>Steam Pressure (Kg/cm²)</th>
<th>Sensory Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Body and Texture</td>
</tr>
<tr>
<td></td>
<td>After 50% Evap.</td>
</tr>
<tr>
<td>0.6</td>
<td>6.50</td>
</tr>
<tr>
<td>0.8</td>
<td>8.75</td>
</tr>
<tr>
<td>1.0</td>
<td>8.75</td>
</tr>
<tr>
<td>1.2</td>
<td>8.75</td>
</tr>
<tr>
<td>S.Em.</td>
<td>0.487</td>
</tr>
<tr>
<td>C.D. (0.05)</td>
<td>1.09</td>
</tr>
</tbody>
</table>
Effect of stage of sugar addition on the sensory score of *Basundi*. The effect of stage of sugar addition on the sensory score of *Basundi* is depicted in Table-I.

It can be seen from the tabulated value which shows that the obtained score were minimum at 0.6 Kg/cm$^2$ steam pressure. The obtained product at this pressure had very thin body and texture, light brown in colour and appearance, unacceptable flavour and low overall acceptability. At 0.8 and 1.0 Kg/cm$^2$ the product obtained a maximum score according to the panel of judges. At this pressure, the body and texture, colour and appearance, flavour and overall acceptability were desirable. The sensory score of Basundi is significant at 5% level of significance in first stage of sugar addition.
Table 14: Effect of stage of sugar addition (just after fore warming) at different steam pressure on physico-chemical properties of *Basundi*

<table>
<thead>
<tr>
<th>Steam Pressure (Kg/cm²)</th>
<th>Processing Time (min.)</th>
<th>Stage of sugar addition (just after fore warming)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Viscosity (25°C)</td>
</tr>
<tr>
<td>0.6</td>
<td>120</td>
<td>72.13</td>
</tr>
<tr>
<td>0.8</td>
<td>100</td>
<td>78.28</td>
</tr>
<tr>
<td>1.0</td>
<td>80</td>
<td>89.63</td>
</tr>
<tr>
<td>1.2</td>
<td>60</td>
<td>94.24</td>
</tr>
<tr>
<td>S.Em.</td>
<td></td>
<td>4.397</td>
</tr>
</tbody>
</table>
The effect of stage of sugar addition at just after fore warming on Physico-chemical properties of *Basundi* in relation with steam pressure and its corresponding processing time is depicted in Table 14.

It is evident from the tabulated value that the viscosity was increased at the second stage of sugar addition (just after fore warming) corresponding to an increase in steam pressure and processing time.

The specific gravity, FFA, HMF values were also found to be significantly increased due to the severity of heat treatment.

Due to an increase in steam pressure and processing time, there were some changes in viscosity, specific gravity, HMF, FFA content, whereas acidity and pH were found optimum.

### 5.5 COST OF PROCESSING

To assess the economic feasibility of *Basundi* manufacture, an exercise was carried out wherein various technical and economic aspects were examined.

A plant producing 100 kg of *Basundi* per day was considered reasonably satisfactory for the present cost analysis.

#### 5.5.1 Raw Materials Cost

The raw materials used for manufacture of *Basundi* are buffalo milk, sugar, and condiments such as almonds, pistachio, cardamom, and saffron. The quantities of these materials required for preparing 100 kg of *Basundi* are depicted in Table 15, along with their costs.

It is observed from the tabulated values that raw materials account for Rs. 43.71 per kg.
5.5.2 Requirement of Utilities

The basis taken for calculating the heat energy requirements and thereby the steam quantity for preparing 100 kg of experimental Basundi per day has been furnished. The tabulated values show the heat energy required for processing i.e. forewarming of milk, concentration involved in the production of 100 kg of Basundi.

The electricity requirements for processing of milks well as refrigeration including coding and storage of 100 kg of Basundi.

The cleaning solution used per day has been shown in Table 16. The requirement of water has been assumed to be three times the quantity of milk handled (Tables 16).

5.5.3 Overhead Cost

The overhead cost involving direct wages to the employees for a plant producing 100 kg Basundi per day are provided in Table 16.

**Table 15: Raw Material cost for preparation of 100 kg. Basundi**

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Ingredients</th>
<th>Rate per Kg (Rs.)</th>
<th>Quantity required (kg.)</th>
<th>Cost of Ingredient (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Buffalo milk</td>
<td>14.00</td>
<td>224.98</td>
<td>3149.60</td>
</tr>
<tr>
<td>2.</td>
<td>Sugar</td>
<td>14.00</td>
<td>15.748</td>
<td>220.48</td>
</tr>
<tr>
<td>3.</td>
<td>Dry fruit and nuts</td>
<td>500.00</td>
<td>2.00</td>
<td>1000.00</td>
</tr>
<tr>
<td>3.</td>
<td>Basundi, 100 kg</td>
<td></td>
<td></td>
<td>4370.072</td>
</tr>
</tbody>
</table>

Raw material cost (Rs.) per Kg. of Basundi: Rs. 43.71, considering 1% product loss.
Table 16: Processing cost of Basundi

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>Particulars</th>
<th>Rate (Rs.)</th>
<th>Quantity/Amount</th>
<th>Cost (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Raw Material cost</td>
<td>43.71/kg</td>
<td>100kg</td>
<td>3970.07</td>
</tr>
<tr>
<td>2.</td>
<td>Works overhead cost</td>
<td>450/day</td>
<td>Rs.450.00</td>
<td>150.00</td>
</tr>
<tr>
<td></td>
<td>Supervisor-1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Labourers-2</td>
<td>100/day</td>
<td>Rs.200.00</td>
<td>200.00</td>
</tr>
<tr>
<td>3.</td>
<td>Utilities cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Steam</td>
<td>3.0/kg</td>
<td>160.86kg</td>
<td>482.59</td>
</tr>
<tr>
<td></td>
<td>-Electricity</td>
<td>5/kwh</td>
<td>40kwh</td>
<td>200.00</td>
</tr>
<tr>
<td></td>
<td>-Detergent</td>
<td>60/kg</td>
<td>2kg</td>
<td>120.00</td>
</tr>
<tr>
<td></td>
<td>-Water</td>
<td>10/500lit</td>
<td>720 liter</td>
<td>14.40</td>
</tr>
<tr>
<td></td>
<td>Total cost for 100 kg.</td>
<td></td>
<td></td>
<td>Rs.5437.06</td>
</tr>
<tr>
<td></td>
<td>Basundi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost per kg Basundi</td>
<td></td>
<td></td>
<td>Rs.54.38</td>
</tr>
</tbody>
</table>
Table 17: Physico-chemical characteristics of *Basundi* prepared in conical process vat

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Selected sample</th>
<th>S.Em.</th>
<th>Control sample</th>
<th>S.Em.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity (CP)</td>
<td>74.32</td>
<td>6.39</td>
<td>75.48</td>
<td>6.52</td>
</tr>
<tr>
<td>Reducing Sugar (%)</td>
<td>9.47</td>
<td>.985</td>
<td>8.85</td>
<td>.892</td>
</tr>
<tr>
<td>HMF (μmol/liter)</td>
<td>80.20</td>
<td>7.534</td>
<td>92</td>
<td>6.321</td>
</tr>
<tr>
<td>Reflectance (% change in OD)</td>
<td>54</td>
<td>5.345</td>
<td>49</td>
<td>4.372</td>
</tr>
<tr>
<td>FFA (ml.eq/liter)</td>
<td>1.38</td>
<td>.857</td>
<td>1.20</td>
<td>.659</td>
</tr>
<tr>
<td>PH</td>
<td>6.51</td>
<td>.402</td>
<td>6.52</td>
<td>.421</td>
</tr>
<tr>
<td>Acidity (%LA)</td>
<td>0.43</td>
<td>.102</td>
<td>0.39</td>
<td>0.231</td>
</tr>
</tbody>
</table>

Table 18 Gross composition of *Basundi* prepared in conical process vat.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Selected Sample</th>
<th>S.Em</th>
<th>Control Sample</th>
<th>S.Em.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat (%)</td>
<td>12.08</td>
<td>1.695</td>
<td>11.59</td>
<td>1.034</td>
</tr>
<tr>
<td>SNF (%)</td>
<td>24.35</td>
<td>2.654</td>
<td>21.62</td>
<td>2.654</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>9.35</td>
<td>0.962</td>
<td>8.98</td>
<td>0.853</td>
</tr>
<tr>
<td>Total solids (%)</td>
<td>44.35</td>
<td>7.325</td>
<td>45.92</td>
<td>6.254</td>
</tr>
<tr>
<td>Sucrose (%)</td>
<td>16.40</td>
<td>2.985</td>
<td>15.55</td>
<td>2.485</td>
</tr>
</tbody>
</table>
5.3 SUGGESTED PROCEDURE FOR THE MANUFACTURE OF BASUNDI

- Buffalo Milk
- Standardization (fat/SNF=0.7)
- Slow heating (85°C/20 min.)
- Concentration till half of original volume (2 times)
  - Addition of sugar & nut powder
- Concentration till required consistency (2.25 times)
- Homogenization (65°C)
  - Addition of dry fruits
- Cooling
- Packaging
6.0 SUMMARY AND CONCLUSION

The objective of the present investigation was to arrive for large-scale production of Basundi using conical process vat.

Accordingly the study was planned and conducted:

1. To evaluate the suitability of conical process vat with respect to quality.
2. Determined the cost of processing.

Basundi samples as per the need of the experimentation where evaluated for physico chemical properties (i.e. acidity, pH, FFA, HMF, Sp. Gravity, Viscosity, invert sugar), organic quality (i.e. colour and appearance, body and texture, flavour and overall acceptability) and gross chemical composition of final product (i.e. TS, Fat, SNF, Protein, Lactose, Sucrose and ash).

To evaluating the suitability of conical process vat for the manufacture of the Basundi with respect to quality, the following parameters were considered.

The variable parameters including holding time, steam pressure and stage of sugar addition were studied. However the holding volume of conical process vat and the scrapper speed were considered as constant parameters. The addition of sugar was done at two different stages, viz.

1. After two fold concentration of milk and
2. Just after forewarming

The quality evaluation of Basundi during milk concentration was done by checking total solids for consistency, browning by observing colour change and overall visual quality for body and texture of final product.
The organoleptic evaluation, chemical composition of the final product were checked. There five holding time (40, 60, 80, 100 and 120) and four steam pressure (0.6, 0.8, 1.0 and 1.2 kg/cm²) were taking for the proposed study for manufacturing of **Basundi**.

Basundi prepared in conical process vat were good body and texture colour and appearance flavour and overall acceptability at 0.8 and 1.0 kg/cm² steam pressure and 80 and 100 minutes holding time respectively, when the sugar is added after two fold milk concentration. So we have selected these two pressure and holding time for best quality of Basundi at industrial level.

**Costing of Basundi**

The economical process for manufacturing Basundi was evaluated with the consideration cost of all input and Basundi production (capacity 40 kg/batch); a cost of work out was Rs. 64.38 per kg.

Based on the result of the study, the process comprised of standardization of buffalo milk (ratio = 0.7), forewarming of milk (85 to 90°C / 10-20 minutes), partial concentration of milk 2 times of the original milk TS; Stage of sugar addition, final concentration to 2.25 times (the original milk TS inclusive of sugar) and is recommended for large scale production.

**RECOMMENDATIONS**

During investigation, it was observed that the quality of **Basundi** can be achieved successfully in conical Process Vat with longer processing time and more energy consumption (i.e. steam, electricity, etc.) which certainly increases the cost of processing. But reduction in processing cost would be possible, if adopted following recommendation made.

1. For reduction of steam consumption, the steam pressure be kept high at initial stage of milk evaporation and progressively reduced at the end.
2. Initially, steam be opened in all the section of jacket and shutting them progressively as the concentration increases.


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Nygaard, H,(1 996), India's dairy sector is expanding *Maalkeritidende;* 109 (3) 52-53. Cited in Dairy Sci. *Abstr.* 58 (6) 3636


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Appendices
Score card for sensory evaluation of BASUNDI

Name of the Judge ____________________________

Date ______________

A) Score on the basis of 9-point hedonic scale as under:

<table>
<thead>
<tr>
<th>Perception</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Like extremely</td>
<td>9</td>
</tr>
<tr>
<td>Like very much</td>
<td>8</td>
</tr>
<tr>
<td>Like moderately</td>
<td>7</td>
</tr>
<tr>
<td>Like slightly</td>
<td>6</td>
</tr>
<tr>
<td>Neither like nor dislike</td>
<td>5</td>
</tr>
<tr>
<td>Dislike slightly</td>
<td>4</td>
</tr>
<tr>
<td>Dislike moderately</td>
<td>3</td>
</tr>
<tr>
<td>Dislike very much</td>
<td>2</td>
</tr>
<tr>
<td>Dislike extremely</td>
<td>1</td>
</tr>
</tbody>
</table>

B) Score of samples:

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Sample Nos.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Flavour</td>
<td></td>
</tr>
<tr>
<td>Body &amp; Texture</td>
<td></td>
</tr>
<tr>
<td>Colour and appearance</td>
<td></td>
</tr>
<tr>
<td>Overall acceptability</td>
<td></td>
</tr>
</tbody>
</table>

C) Remarks, if any:

SIGNATURE OF JUDGE
Gross composition of basundi

composition of basundi

- fat
- snf
- sugar
- lactose
- ash
APPENDIX VII: Standard Curve for Sucrose

Concentration of Sucrose (%) vs. Absorbance O.D. at 490 nm