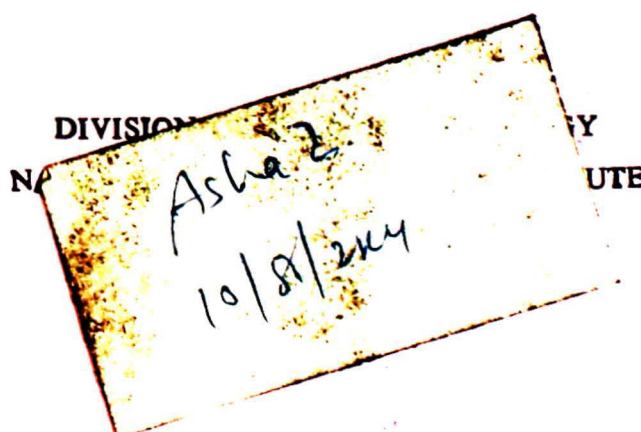


EFFECT OF DIFFERENT HEAT TREATMENT ON SOME PHYSICO-CHEMICAL PROPERTIES OF GOAT MILK

By

KANKA BORA

B.Sc. (Dairy Technology)



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NATIONAL DAIRY RESEARCH INSTITUTE
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KARNAL (Haryana) INDIA**

1981

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**EFFECT OF DIFFERENT HEAT TREATMENTS
ON SOME PHYSICO-CHEMICAL PROPERTIES
OF GOAT MILK**

A DISSERTATION

**SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE**

IN

**DAIRYING
(DAIRY TECHNOLOGY)
TO THE
KURUKSHETRA UNIVERSITY, KURUKSHETRA**

BY

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**DIVISION OF DAIRY TECHNOLOGY
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1981.

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C E R T I F I C A T E

I certify that the work reported in this dissertation entitled " EFFECT OF DIFFERENT HEAT TREATMENTS ON SOME PHYSICO-CHEMICAL PROPERTIES OF GOAT MILK" was carried out under my guidance by Shri Kanke Bora in partial fulfilment of his M.Sc. Dairying (Dairy Technology) course.


(Joginder Singh)

A C K N O W L E D G E M E N T

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Kanka Bora.
19/5/81.
(KANKA BORA)

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CHAPTER I

INTRODUCTION

Domestic goat, an important dairy species, is a compact animal which thrives well on small agricultural lands and ranks after the cow and buffalo. In India, goat is regarded as poor man's cow due to its small size and economy although its milk is considered somewhat inferior to cow's or buffalo's. Though the importance of goat is well recognised for meat production but recently its utility as milk producing animal has gained momentum in a number of tropical countries.

Goat milk has got highly nutritional characteristics as fluid milk and possesses a therapeutic value. It has been considered best for infant feeding, and for people suffering from tuberculosis, gastro-intestinal disturbances and ulcers. Besides its importance as fluid milk it has gained significance in many countries for manufacturing of various products like cheeses, yogurt and other fermented products, ice cream, frozen yoghurt, evaporated and dried milks etc.

As reported by FAO (1977), the total world production of goat milk is 1.5%. FAO (1979) reported that the world population of goats is 445,712,000 yielding 7,183,000 tonnes of milk. In less developed countries, goat milk ranks third after cow and buffalo and they produce about 52% of the total world's production of goat milk. In India, goat produces 5% of the total

milk production as against 2% in the United States. Further, India possesses about 69 million goats but only 8 to 10 millions of them are milch animals.

Studies on goat milk have become a matter of wide interest around the Globe especially to the people of United States, Europe, Middle East, India, Africa and Caribbeans. In India, importance has been given only recently for the utility of goat milk due to its potentialities in the organised sector.

In any manufacturing procedure, the main objective of subjecting milk to heat treatment is to destroy all pathogenic and non-pathogenic organisms to make it safe for human consumption. In addition, the importance of heat treatment is to destroy the bulk of the acid producing organisms in fluid milk and thus prolong its keeping quality. Heat processing is also important to facilitate mixing and blending in the case of ice cream mix and processed cheese. Other dairy products such as concentrated and dried milks gain their identity only through heat processing by removal of their moisture. In a broad way, heat treatment is important for preservation and to enhance the keeping quality of milk and its products. The properties that may be imparted to milk or its products as a result of heat treatment may be increased viscosity, reduced curd tension, resistance to oxidation, changes in flavour and color

and alteration in protein stability. In India, the heat treatment commonly utilized for milk includes pasteurization both by Holding and H.T.S.T. methods, boiling, simmering and sterilization. During these processes of heat treatment, milk is heated to varying time temperature combinations. The chemical and physical changes that occur during heating of milk depend upon the time and temperature of heating.

Before proceeding for manufacturing any milk product it is necessary to study the different physico-chemical characteristics of raw milk. Various constituents like fat, lactose, proteins, minerals etc. affect the physico-chemical characteristics of goat milk. A few characteristics viz. viscosity, curd tension, flavour and color have got a practical significance in the dairy industry. Viscosity has its importance in the manufacture of condensed and evaporated milks and ice cream making. Curd tension is important in infant nutrition and digestibility. Flavour and color are infact important from the view of consumer's acceptability and marketability of the product. Other parameters like acidity and pH of milk have their utility in determining the acceptability of milk and for subjecting it to different levels of heat treatment. The physico-chemical characteristics of goat milk as affected by heat treatment have got a practical importance for its utility in the manufacture of its products and therefore were considered desirable

to be investigated in the present study.

Some research work is in progress on goat milk in other countries though very little work has been done in India on the physico-chemical characteristics of goat milk. Almost no literature is available on physico-chemical characteristics of goat milk as affected by heat treatment under Indian conditions. Keeping this in view the present study emphasises on the effect of different heat treatments on some physico-chemical characteristics of goat milk such as viscosity, curd tension, acidity, pH, total reducing capacity and TBA values.

* * * *

CHAPTER II

REVIEW OF LITERATURE

Heat treatment results in a change in the physico-chemical properties of milk depending upon the severity of heat treatment. As the physico-chemical characteristics of milk are dependent on its composition therefore the review of literature has been dealt under two heads namely (i) Composition of goat milk and (ii) Physico-chemical characteristics of goat milk.

2.1 COMPOSITION OF GOAT MILK:

Several workers have studied the composition of goat milk with respect to fat, lactose, protein and minerals and these are briefly reviewed below.

MILK FAT:

Workers like Schultz and Chandler (1921), Apple (1935), Gamble et al (1939), Kulkarni and Dole (1958) studied the fat globule size of goat milk and they reported that goat milk possessed a poor creaming property due to a smaller size of fat globules. However, the size of globules for goat and cow milks had the same range (1-10 μm . dia). But goat milk was reported to contain proportionately more number of small globules than the cow milk which were measured microscopically or by the rate of rise. Puri et al (1952, 1961) reported that the size of fat globules in goat milk ranged 1-4 μm . in diameter in some breeds. Most of the fat globules existed in an oil-in-water type emulsion and the surface was coated with fat globule membrane.

Singh et al (1968) reported an increase in the size of fat globules and decrease in the number of globules upon heating milks of cow, ewes, goats and buffalo. Pasteurization at 61°C for 30 minutes increased the average globule size in goat milk by about 12% as a result of coalescence.

Fat globules of goat milk do not cluster when milk is cooled. Apparently goat milk lacks agglutinin which causes fat globules in bovine milk to cluster upon cooling as reported by Jenness and Parkash (1971).

Fat content of goat milk of different breeds and regions varied substantially. Chang and Kim (1978) reported that fat content of Sannan goat milk ranged from 2.3 - 4%. Agrawal and Bhattacharya (1978) reported that fat content of Black Bengal (BB), Barbari nannies (BN) and BB x BN were 3.83, 4.66 and 4.92% respectively. Margues, F (1977) observed that the fat content of Murcian Granada goats ranged from 3.6 to 5.9%. Mittal and Pandey (1971) reported that fat content of Barbari and Jamnapari goats were 4.67% and 5.12%.

Skjevdal (1979) reported that goat milk contained relatively high content of saturated fatty acids having chain length of C₄- C₁₂ atoms. The typical flavour of goat milk is due to the presence of free fatty acids (especially C₆ to C₁₀ acids) alongwith KCL content, presence of three different cresols or organic substances in milk.

LACTOSE:

Jenness et al (1964) reported that lactose was a principle dialysable carbohydrate of goat milk as identified by chromatographic method. The lactose content of goat milk is approximately same as that of cow milk. Inositol was the other sugar which were obtained in goat milk. No other carbohydrates were detected in goat milk dialysates.

Nirmalan and Nair (1962) reported the lactose content of goat milk was 5.1% as against 5.52% for cows milk and 5.70% for buffaloes milk (Ghosh and Anantakrishna, 1965). Mittal and Pandey (1971) reported the lactose content of Barbari and Jamnapari goats were 4.12% and 4.15% respectively.

PROTEIN:

Seidler (1951) studied the average variation in the percentage composition of individual goat milk and he found the protein content was 2.29 - 2.77%. Mittal and Panday (1971) observed that the protein content of Barbari and Jamnapari goats were 3.74% and 3.58% respectively. Agrawal and Bhattacharya (1978) reported the protein content of goat milk to be 4.13%, 5.84% and 5.07% for Black Bangal (BB), Barbari (B) and BB x B respectively.

Whitney et al (1976) reported that goat milk contains five principal proteins namely L-lactalbumin,

β -lactalbumin, K-casein, β -casein and LS_2 -casein. They are so named because they appear by composition and properties to be homologous to corresponding proteins of cow milk. Caseinate micelle of goat milk contains more calcium and organic phosphorus. The whey protein content of goats milk is similar to cow milk with the difference that the NPN and proteose-peptone content of goat milk was somewhat less as reported by Parkash and Jenness (1968).

Isolation and characterization of the individual proteins of goats milk have followed much the same pattern as for cows milk (Parkash and Jenness, 1968). Tangle (1908) isolated the whole casein fraction by usual acid precipitation and reported nearly the same elementary composition as for bovine milk. But reports from the work of Holzer (1962) reviewed on the amino acid composition determined by automatic ion exchange method. It was shown to differ in several aspects from that of bovine casein.

Venkatappaiah and Basu (1952) reported that the variation in protein content may be due to inherent differences between the individual animals. Normal goat milk contains 0.5 - 0.6% nitrogen distributed among various components. They showed that goat milk had NPN to be 0.032%. The urea constituted 65%, Amino acid 17%, creatinine 13%, creatine 2.0%, Ammonia 0.8%, uric acid 0.8% and undetermined compounds 13.8% of the total.

Nazareer (1964) worked on the analysis of proteins of goat milk and he reported that on percentage basis the goat milk contained tyrosine 4.49, Tryptophane 1.94, Cystine 0.83, Methionine 2.02, Arginine 5.05, Histidine 2.78 and Lysine 7.72. The values for total and whey protein in goat milk were found to be 3.49 and 9.70 gm/100 ml. Wishahi et al (1965) reported the values of total and whey proteins were 3.49 and 0.59 gm/100 ml. respectively. Ajit Singh (1975) reported that the total protein in goat and cow milks were 3.65 and 3.34% while the casein content was 2.78 and 2.34% respectively.

MINERALS AND SALTS:

Parkash and Jenness (1968) reported that goat milk contains higher amount of Potassium and chloride (both vary considerably) than cow milk.

Trout (1941), Puri and Parkash (1963), Grabenniker et al (1963), Kondo and Mori (1932) reported a higher ash content of goat milk (range 0.70 to 0.85%) than cow and buffalo milks.

Johke and Goto (1962) and Johke (1963) reported the differences in acid soluble nucleotides in cow and goat milks. Goat milk contained considerable amount throughout the lactation but cow milk contained very low concentration except in the earliest stage of lactation. Citrates have seldom been determined in goat milk.

Biando and Chiofalo (1954) reported that goat milk seems to have a tendency of having a higher calcium and low lactose content than cow milk. Basu and Mukharjee (1943) observed that phosphates of goat milk consisted of inorganic ions and complexes. They found an average of 105 mg phosphates/100 ml milk. The acid soluble phosphate consisted of 67.8 mg Inorganic and 13.1 mg of organic phosphate.

2.2. PHYSICO-CHEMICAL CHARACTERISTICS OF GOAT MILK:

2.2.1 VISCOSITY OF GOAT MILK:

Viscosity is the internal friction which tends to resist the sliding of one part of the fluid over another and is the relation between kinetic motion and free surfaces (Arbuckle U.S., 1977). The quantitative measurement of viscosity is expressed in terms of absolute or dynamic viscosity, Kinetic viscosity and relative viscosity. The co-efficient of absolute viscosity ' η ' of a liquid is defined as the force per unit area necessary to maintain a unit velocity gradient between two parallel planes separated by a unit distance. The centimeter-gram-second unit (c.g.s.) of absolute viscosity, the poise, represents a force of 1 dyne per sq. centimeter when the velocity is changing at the rate of 1 cm per sec. per cm. distance across the flow. The ratio of the absolute viscosity to the density is the kinetic viscosity, for which the c.g.s. unit is the Stoke.

The relative viscosity is obtained as the ratio of the absolute viscosity of the liquid to the absolute viscosity of water at the same temperature. An alternative use of the term relative viscosity which, however, has seldom occurred in the literature of dairy science is to denote, for example, the ratio of the viscosity of cream to the viscosity of fat free serum. It is important therefore to know in which sense terms are being used.

METHODS OF MEASUREMENT OF VISCOSITY:

A quantitative measurement of viscosity can be made in three ways:

1. From the time of flow under fixed pressure such as by capillary method (e.g. Ostwald's Viscometer).
2. Measuring the force required to move two layers of liquid past each other such as coaxial cylinder (e.g. McMichael, Conette and Brook field).
3. Measuring the fall of a ball through a column of liquid as is accomplished with falling spheres (e.g. Hoppler's Viscometer).

These three types of viscometers are commonly used in dairy industry to study the viscosities of dairy products.

VALUES OF VISCOSITY FOR GOAT MILK:

Kulkarni and Dole (1956) studied the viscosity of goat milk and recorded the viscosity range of 11.01 - 12.78 in mp at 30°C. Puri et al (1963) reported that the viscosity of goat milk at 27°C ranges from 12.88 to 15.85 mp. Both the groups found that the values for goat milk were somewhat lower than those of cow and buffalo milks. Both concluded that the viscosity is a function of the contents of fat and snf of milk, though not a linear one.

Puri et al (1963) found that the temperature coefficients for buffalo, cow and goat milks were -0.385, -0.332 and -0.456 mp / °C respectively, over the temperature range of 15 - 35°C. Morning and evening milks did not differ in viscosity.

EFFECT OF DIFFERENT HEAT TREATMENTS ON VISCOSITY OF GOAT MILK:

Jannese and Patton (1959) reported that the destabilization of caseinate particles by heat treatment causes them to aggregate to form a three dimensional network entrapping some of the milk serum. The process is first manifested by an increase in viscosity and with the more drastic heat treatment by actual coagulation of the caseinate with a separation of the system.

Considerable work has been reported on the effect of heat treatment on viscosity of cow and buffalo milks

by Puri and Gupta (1955), Samhammer and Weinner (1966) and Mantovani et al (1956). Puri and Gupta reported that heating at 60°C produced little or no change in the viscosity of milk but heating at 80°C resulted a slight increase in viscosity which may be attributed to the changes in colloidal structure of milk proteins and fat globules size.

Puri et al (1963) reported that heating buffalo milk to just boiling for a few minutes increased the viscosity appreciably as compared to pasteurization.

Mantovani et al (1956) studied the effect of pasteurisation and sterilization of milk on its viscosity and reported a progressive increase in viscosity. Prasad et al (1973) reported that the viscosity of raw buffalo milk was 1.8695 which increased by 3.5 and 1.6% respectively due to pasteurization by Holding and H.T.S.T. methods.

Hofi et al (1966) stated that pasteurization of buffalo and cow milks did not show appreciable effect but sterilization caused a significant increase in viscosity of both cow and buffalo milks.

Kulkarni (1968) studied the effect of different heat treatments e.g. pasteurization by Holding method, H.T.S.T. method, boiling, simmering and sterilization on the viscosity of buffalo milk. The author reported that the absolute viscosity of raw buffalo milk was 2.295 to 2.320 sp and pasteurization did not effect the

viscosity. Boiling and Simmering were found to increase the viscosity by 24% whereas sterilization resulted in an increase of viscosity by 30%.

2.2.2 CURD TENSION OF GOAT MILK:

Doan et al (1938) worked on the clotting of milk by rennin and determined the curd strength or curd tension of the clot or gel produced by the action of rennet in a definite time at a definite temperature. The force required to push a knife through the curd was measured. Jenness and Patton (1959) stated that coagulation time of milk was determined merely by adding rennin to milk at a definite temperature and determining the time required for the flocks to form. Practically, renneting was assessed by the clotting time and curd tension. Milk producing a soft flaky curd was considered to be suitable for infant feeding and cheese making.

Frahn (1926) reported that goat milk was apparently somewhat more susceptible to clotting by rennet than cow milk. Although the difference can be said to have been established definitely but the reason could not be established. Gamble et al (1939) and Turner and Garrison (1940) observed that the curd tension of milk from individual goats varies considerably. It declines to a minimum in mid lactation and increases thereafter till the end of the lactation period.

Puri and Parkash (1962) reported that goat milk

clots more rapidly than cow milk under the conditions where the rennet concentration and temperature were lower and thus clotting time were much longer than those reported by Frahm (1926).

Rao et al (1964) found the curd tension of goat milk clotted with rennet to be of the order of 40 gm. which was higher than that of cow milk as examined by them. A higher curd tension for goat milk seems reasonable in view of its shorter clotting time as compared to the cow milk (Jenness and Patton, 1959).

EFFECT OF HEAT TREATMENT ON THE CURD TENSION OF MILK:

Brennemann (1913) reported that favourable results were obtained in terms of curd tension and infant feeding with boiled milk. Several workers like Caulfield and Martin (1934), Doan and Welch (1934) and Berry (1935) reported that the curd tension of milk depends on the time and temperature treatment given to milk. Temperature treatments drastic enough to initiate denaturation in the serum proteins cause a co-lateral reduction in curd tension.

Leighton and Mudge (1932) reported that at higher temperature e.g. autoclaving and sterilization an actual heat coagulation of extreme fineness might be produced which causes the casein more or less immune to enzyme coagulation. Due to obvious complexities, the previous heating of milk and the action of rennin

and pepsin on milk has not been explained satisfactorily. Rogers (1935) observed that the action may be due to the decrease of calcium ion concentration that increases the electric charges carried by the casein micelle, causes some albumin insoluble and the protein itself denatured.

Jenness and Patton (1959) could not establish the fact that the soft curd characteristics of high heat treated milk were due to chemical or purely physical changes. But they stated that the flocculated particles of serum proteins represented points of weakness in the curd.

Sanders and Associates (1936) noticed the softening of milk curd with a slight increase in rennet coagulation time when milk was subjected to pasteurization thereby contradicting the view of Doan and Welch (1934) who stated that there was a negligible effect of pasteurization on the the curd tension of milk. Spur and Wolman (1952) reported that with a progressive increase in time and temperature of heat treatment, the curd formed became softer.

Rao et al (1964) reported that there was only 10% reduction in curd tension of cow and buffalo milks when subjected to pasteurization by Holding or H.T.S.T. methods. Prasad et al (1973) studied the curd tension of buffalo milk after pasteurization by Holding method and heating to high temperature and noted that the curd

tension reduced to 32.5 and 28.1% respectively.

Hill (1931) observed that there was almost no curd tension when milk was evaporated or autoclaved. Chandrasekhara et al (1957) reported a reduction of 76% and 71% in the curd tension of buffalo and cow milks respectively as a result of their boiling. Kulkarni (1968) studied the effect of different heat treatments on the curd tension of buffalo milk. The author reported that pasteurisation reduced the curd tension by 30.5% , boiling and simmering by 89.5% and sterilization by 91.5% as compared to the raw milk.

Hiller et al (1941) studied the effect of pasteurization at 142^o, 145^o and 147^oF for 30 minutes and 160^oF for 15 sec. on some properties of milk. They reported that the whey protein were only slightly denatured by these treatments. The curd tension (Papain-HCL or pepsin-CaCl₂) was greatly reduced (28-56%) by holding treatment but was only slightly affected by H.T.S.T. method.

2.2.3 ACIDITY AND pH OF GOAT MILK:

From time to time several workers like Schultz and Chandler (1921 a), Gemble et al (1939), Trout (1941), Dharmarajan et al (1954), Rao and Dastur (1956), Canuti and Salvadori (1959), Leonhard (1963) and Braunekorff (1965) have recorded the pH and titratable acidity of goat milk. They have reported the pH of goat milk

ranged from 6.3 to 6.7 for sample of individual goats which was somewhat lower than that of cow milk. The titratable acidity in terms of lactic acid has been reported to be ranging from 0.10 to 0.26% but most of the samples ranged from 0.11 to 0.18%. Cheng and Kim (1978) studied an individual breed of goat and reported the titratable acidity of milk to be 0.117 to 0.193% and pH as 6.504 to 7.055 where alcohol test was positive but clot-on-boiling test was negative.

EFFECT OF HEAT TREATMENT ON ACIDITY AND pH OF GOAT MILK:

Duncombe (1924) while studying the effect of heat treatment on milk found that the titratable acidity was increased as a result of heat treatment to milk. The increased acidity was not only proportional to the temperature and duration of heating but also to the increase in pH.

The causes for increase in titratable acidity remained unexplained till the work of Grimbleby (1954). He found that during heating of milk, a part of the lactose was combined with proteins and this protein-lactose combination was responsible for a part of the increased titratable acidity in heated milk. In this reaction the aldehyde group of the lactose was combined with the basic amino group of the proteins releasing the free carbonyl group to exercise their full base binding capacity. It resulted by the fact

that as the titratable acidity was increased in heated milk there was a corresponding decrease in formal titration.

Webb and Johnson (1965) reported that pasteurization produces small shifts in pH and buffering by expulsion of CO_2 and by precipitation of calcium phosphate with release of hydrogen ions. The drastic heat treatments used in sterilization produce acids by degradation of lactose. The rate is slow below 90°C but increases markedly above 100°C .

2.2.4 SPECIFIC GRAVITY OF GOAT MILK:

Sirry and Haasan (1954) reported that the specific gravity for goat milk varied from 1.0262 to 1.0366. Janness and Patton (1959) reported the variation in specific gravity due to difference in the variation in fat content, temperature of milk and difference in the techniques of measurement. Most reports on the specific gravity of goat milk deal with a few individual or herd samples and give little or no information on the method of determination. In some cases, the temperature of measurement is not mentioned. Rangappa (1964) reported that the density of goat milk at 20°C was 1.0278-1.0350.

Parkash and Janness (1968) reviewed the specific gravity of goat milk and observed a wide variation ranging from 1.026 to 1.042 in the specific gravity

of goat milk for individual breeds and different lactation period. For individual Egyptian goat milk, EL-Slany and Mohamed (1978) reported that the specific gravity varied from minimum of 1.021 to a maximum of 1.0278, with an average of 1.0250 at 20°C.

EFFECT OF HEAT TREATMENT ON THE SPECIFIC GRAVITY OF MILK:

Whitaker et al (1927) and Wegener (1953) reported that at temperature above 40°C absolute density of milk decreases but the specific gravity remains virtually constant. But Short (1955) reported that there is a pronounced increase in the specific gravity from 40°C to 90°C. The increase is of the order of 0.00005 per degree centigrade.

Short (1956) studied the effect of pasteurization and sterilization on the density of milk. Pasteurization of milk by both Holder and H.T.S.T. methods, had no effect on the density. On the other hand, due to sterilization there was a decrease in density which was independent of the fat content of the milk. The decrease was approximately 10×10^{-5} gm/ml. or 0.1 lactometer degree. The another suggested that this decrease might be due to the denaturation of the soluble proteins and deposition of calcium salts in sterilized milk.

2.2.5 TOTAL REDUCING CAPACITY OF MILK:

Palmer (1934), McMeekin and Palis (1949)

and Polis et al (1950) reported that β -lactoglobulin was the major reducing fraction of milk proteins.

Jackson (1936), Larson et al (1949) and Larson and Jenness (1950-a) reported that serum proteins mainly albumin fraction and protein fraction associated with the fat globule membrane are the main sources of sulphhydryl groups and volatile sulphides in milk which acts as reducing substances.

Kiermeir and Hamod (1962) observed that milk having more fat and protein on heating liberates more free sulphhydryl groups. The workers reported that this may be due to the presence of certain constituents of fat globule membrane and a rise in the β -lactoglobulin content in heated milk.

Hutton and Patten (1952) and Larson and Jenness (1950) also earlier reported that β -lactoglobulin was the most influential sulphhydryl containing compound of the serum protein.

Manning and Heinselman (1969) reported that β -lactoglobulin contains one sulphhydryl and two disulphide groups per mole (18,300 gm). Makenzie et al (1972) reported that there was only one sulphhydryl group per molecule of β -lactoglobulin. Whitney et al (1976) reported the primary structure of β -lactoglobulin showing 126 aminoacid residues (calculated molecular weight 18,362) out of that five were half cystine.

Janoline and Swaisgood (1975) reported the isolation and characterisation of sulphhydryl oxidase from bovine milk which catalyses the oxidation of -SH group in both small compounds and proteins. The enzyme can involve in the biosynthesis of disulphide bonds in certain proteins.

EFFECT OF HEAT TREATMENT ON THE TOTAL REDUCING CAPACITY OF MILK:

Coulter et al (1948), Hartman et al (1965), Hutton and Patton (1952) and several other workers have studied the effect of heat treatment on sulphhydryl compounds and reported that the heat treatment activates the -SH group associated with origin of cooked flavour, and the antioxygenic properties of heated milk, and aggregation with the caseins. It was observed that there was a linear relationship between the time and temperature of heating and sulphhydryl content of milk and probably high temperature for very short period of heating may give the optimum concentration of the -SH content thus giving a product with increased oxidative stability.

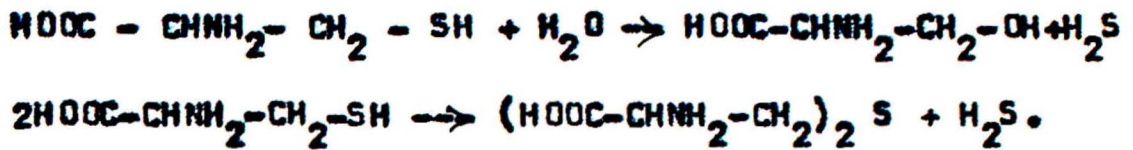
The liberation of sulphides and formation of sulphhydryl groups due to the heating of milk have been well established by the work of Josephson and Doan (1939), Gould and Semmer (1939) and Gould (1940). The authors further observed that the liberation of these sulphur compounds in heated milk has a close

relation to the production of cooked flavour. Gould and Sommer (1939) detected the liberation of sulphides when milk was heated to 76-78°C momentarily, 74-76°C for 3 min., or 70-72°C for 30 minutes. Josephson and Doan (1939) and Gould (1940) obtained positive nitroprusside tests on milk heated to similar temperatures indicating the formation of sulphhydryl groups.

Many investigations have been carried out to determine the sources for the liberation of sulphur compounds in heated milk. Mirsky and Anson (1935) demonstrated that -SH groups appeared on denaturation and coagulation of albumin. Josephson and Doan (1939) concluded that albumin was the principal origin of -SH compounds in heated milk. Tounley and Gould (1943) also observed that albumin was the principal origin of -SH compound in heated milk. Tounley and Gould (1943) also observed that albumin, the major whey protein, was the most likely source for the liberation of sulphur compounds because of the relation between the liberation of sulphur compounds or the denaturation of albumin or also because albumin contained higher sulphur content of which 50-60% was supplied by the heat labile aminoacid cysteine.

The aminoacid cysteine, the principal site of -SH groups in the milk serum proteins, liberated H_2S when it was heated (Jenness and Patton 1959). The chemistry of this decomposition was suggested in

the following two alternative ways :

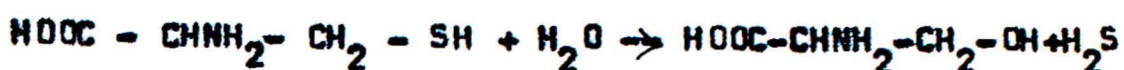


Habeeb (1960), Larson and Jenness (1950), Leslie and Butler (1962) has studied the rate and extent of reaction of SH groups of β -lactoglobulin with various reagents and denaturing conditions and observed that when the proteins are in native state these groups are mostly unreactive but after heat treatment an increased reactivity is markedly noticed after the primary denaturation phase.

Zittle and Co workers (1962) reported the formation of a complex between K-casein and β -lactoglobulin which have been induced by heat treatment. This may involve exposure of the sulphhydryl groups in β -lactoglobulin but there is no evidence for this idea.

Joginder Singh et al (1970) studied the sulphhydryl content of goat milk with acid ferricyanide method and reported that the sulphhydryl content varied from 0.238 to 0.348 mg/ml, with an average of 0.307/mg/ml expressed as cysteine HCl. They also reported that goat milk had about 25% less total reducing capacity than the cow milk and assumed that the products prepared out of goat milk might not have much oxidative stability.

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Mulder and Welstra (1974) reported that a large portion of sulphhydryl compounds in milk is derived from fat globule membranes by heating of milk which causes denaturation of fat globule membrane protein specially glyco-protein.

Davis et al (1978) studied the heat induced changes in the ultra structure of milk using electron-microscopy.

2.2.6 THIOBARBUTARIC ACID (TBA) VALUE:

Oex and Plaisance (1916) indicated that thiobarbutaric acid combines with aldehydes by a simple condensation reaction but the reaction involving oxidised lipids has not been elucidated.

Kohn (1943), and Kohn and Liversedge (1944) studied the reaction of an unknown metabolite with arylamines and thiobarbutaric acid. Barnheim et al (1948) reported that the metabolite was a product of the oxidation of unsaturated fatty acid. These reports alongwith the report of Kusk (1950), and Wilbur et al (1949) indicated the possible applicability of TBA test in the study of oxidised flavour in dairy products.

Dunkley (1951) demonstrated that the TBA test closely correlates with numerical flavour scores of milk samples having oxidised flavour of varied intensity. The test has proved helpful in research work on oxidised flavour and the mechanism of its development.

Bernheim et al (1948) stated that a group containing three carbon atoms was removed from the oxidised fatty acids and combined with the thiobarbituric acid. The compound responsible for the red colour in the reaction of 2-thiobarbituric acid with certain pyrimidines has absorption characteristics similar to those of the compounds formed from oxidised lipids but the nature of the reaction product(s) has not been established.

In fluid milk, the method of detecting browning and milk fat oxidation was given by Dunkley and Jennings (1954). Keeney and Bassette (1959) described a quantitative method for determining 5-hydroxy methyl furfural (HMF) in milk and milk products by spectrophotometric measurement of TBA reaction at 443 m μ .

King (1962) adopted the method of TBA reaction to study oxidised flavour in milk and model system containing fat globule membrane material and ascorbic acid. This method adopted by King is highly satisfactory for detecting and measuring rapid oxidation rates in the model system. The method is very sensitive detector of one of the very early reaction products between reducing sugars and amine compounds.

EFFECT OF HEAT TREATMENT ON TBA VALUES :

Auzand and Woods (1958) studied some factors involving the development of oxidised flavour. In

Other experiment milk was subjected to three treatments namely raw pasteurized (65°C/30 minutes) and heated (76°C/30 minutes). They determined the TBX test periodically and reported that 76°C/30 minutes prevented the development of added flavour whereas 65°C/30 minutes accelerated its development. They observed that the optical densities of raw, pasteurized (65°C/30 minutes) and heated (76°C/30 minutes) milks were (0.027-0.031), (0.027-0.029) and 0.028 respectively.

Belle Poulos *et al* (1963) stated that the determination of the quantity of WRF formed during processing increases the incidence of heat exposures of milk provided the solids content of milk to be analyzed is kept constant which indicates that the total WRF value is a function of the solids content of milk, with high solids yielding more colour.

Conry *et al* (1964) notified the author of Keaney and Bassette's for understanding WRF values are using the method used today (1977) determine WRF values in ultra-heat-treated milk from 90° - 105°C for 3 seconds and observed an increase in the initial WRF values with increase in processing temperature.

Emmanuel and Newman (1971) studied the formation of WRF caused by heat treatment of milk. They reported that the WRF values increased as the temperature at end of the exposure raised with

2-thiobarbituric acid were between 0.07 - 0.09 for UHT treated milk and 0.16 - 0.24 for in-bottle sterilized milk.

CHAPTER III

SCOPE AND PLAN OF WORK

The importance of present investigation and its plan of work is briefly described below.

SCOPE OF WORK:

Due to the nutritional and therapeutic characteristic of goat milk, a considerable interest have developed in U.S. and elsewhere for Research work on goat milk. As goat is considered to be poor man's cow due to its economic maintainance, therefore in India and other tropical countries efforts are being made to popularise the keeping of goats and utilization of its milk for fluid milk consumption and manufacture of various products.

The preceding review of literature reveals that sufficient information is not available on some physico-chemical properties like Viscosity, Curd tension, Acidity and pH, Total reducing capacities, TBA value, Fat and total solids of goat milk as influenced by different heat treatments which are commonly employed in dairy industry in processing of fluid milk and manufacture of products under Indian conditions. It was therefore felt necessary to study these aspects. The present work will help facilitate in the coming days for the industry to handle the available goat milk for the manufacture and marketing of different products in our country in a small scale.

PLAN OF WORK:

Some of the physico-chemical properties of goat milk as affected by various heat treatments will be studied in the present investigation and these are listed below.

1. Viscosity
2. Curd tension
3. Titratable acidity
4. pH.
5. Fat content
6. Specific gravity
7. Total solids
8. Total reducing capacity
9. Thiobarbituric acid value

The different heat treatments which will be given to milk are as follows:

1. Pasteurization by holding method.
(63.0 - 63.5°C for 30 minutes)
2. H.T.S.T. pasteurization.
(71.5 - 72.0°C for 15 seconds)
3. Just boiling.
4. Simmering.
(at 95°C for 3 minutes after first boiling).
5. Sterilization.

Sterilization of milk samples were carried out for 15 minutes in an autoclave, adjusted at 15 psig

steam pressure. The temperature corresponding to this pressure is 121°C which is somewhat higher than the sterilization temperature of 115°C. As it was convenient to adjust the steam pressure at 15 psig therefore it was followed for 15 minutes.

All the experiments will be performed in the existing laboratory conditions. The various tests will be conducted as per ISI standard methods.

* * * *

CHAPTER IV

MATERIAL AND METHODS

COLLECTION OF MILK SAMPLES:

The milk samples used in the present study were obtained from the goats maintained at N.D.R.I., Cattle Yard section. Composite samples of milk were made according to the methods described by the ISI (1968).

HEAT TREATMENT OF MILK:(a) PASTEURIZATION BY HOLDING METHOD:

In a 500 ml. conical flask stoppered with a cotton plug, about 300 ml. of milk was taken and the temperature of milk was raised to 63.0 to 63.5°C by immersing the flask in a water bath (the coming up temperature is usually being 30-35 minutes) and held at that temperature for 30 minutes, and subsequently allowed to cool gradually to room temperature.

(b) H.T.S.T. PASTEURIZATION:

About 300 ml. of milk was taken as above and its temperature was raised to 71.5 - 72.0°C in a water bath and held for 15 seconds and subsequently cooled to room temperature.

(c) JUST BOILING:

In a 500 ml. glass beaker 300 ml. of milk was taken and heated to just boiling on a hot plate and then allowed to cool to room temperature.

(d) BIMMERING:

As above, after first boiling, milk was allowed to simmer at about 95°C for 3 minutes and subsequently cooled to room temperature.

(e) STERILIZATION:

In a 500 ml. conical flask 300 ml. of milk was taken and fitted with a cotton plug and was subjected to sterilization treatment by autoclaving at 15 psig (121°C) for 15 minutes and allowed to cool to room temperature.

4.1 METHODS OF ESTIMATIONS:

All the milk samples were subjected to the following tests:

(a) FAT CONTENT:

It was determined by Gerber method as recommended by the ISI (IS:1958). The test was run in duplicate.

(b) TOTAL SOLIDS:

These were calculated with the help of lactometer reading at 15.5°C and fat percentage, using Richmond's formula:

$$\% \text{age total solids} = \frac{GLR}{4} + 1.2 F + 0.14$$

(c) TITRATABLE ACIDITY:

It was determined by ISI method i.e. titrating known volume of milk against standard sodium hydroxide solution using 1 ml. of 0.5% phenolphthalein as indicator

The results on titratable acidity were expressed in terms of lactic acid. The titratable acidity measured both natural acidity (due to phosphates, citrates, proteins and carbon-di-oxide) as well as developed acidity due to lactic acid.

(d) DETERMINATION OF pH:

All the pH measurements were done electrometrically using a glass electrode and a reference saturated calomel electrode in an Eliso, LI - 10 T model pH meter. The electrode assembly was calibrated using suitable buffer standards of pH 7.0. Necessary temperature was made for each pH determination, and the values were reported at 30°C.

(e) DETERMINATION OF VISCOSITY:

Viscosity was determined by the capillary flow method using Ostwald Viscometer under a fixed pressure, at $30^{\circ} \pm 0.5^{\circ}\text{C}$, and all results were expressed in terms of relative viscosity. Ostwald Viscometer of certified British Standard type was used throughout the determinations.

The viscometer was thoroughly cleaned, successively with dilute alkali solution, tap water, warm chromic acid, tap water and distilled water. It was then washed with acetone to remove water and finally dried by drawing dustfree cold air. Measured quantity of the sample was placed into the viscometer using a pipette. The



OSTWALD VISCOMETER

viscometer filled with the sample was kept in a water bath for 30 minutes, before the time of flow was recorded. The temperature of water bath was maintained at 30°C and was controlled thermostatically with $\pm 0.5^{\circ}\text{C}$. The time of flow of the sample from the upper to the lower mark in the viscometer limb was recorded by a stop-watch calibrated to read to 0.1 seconds. To record the time of flow for each sample, the average for five readings was taken. The relative viscosity of the sample was calculated from the time of flow for the sample and the standard liquid (fresh, all glass, double distilled water) and the relative density of the sample was determined with the help of a specific gravity bottle.

CALCULATIONS FOR DETERMINATION OF RELATIVE VISCOSITY:

All measurements were made at $30^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$.

$$\text{Relative viscosity of the sample} = \frac{t_1}{t_2} \times \frac{(c-a)}{(b-a)}$$

where t_1 = Average time of flow for the sample in seconds.

t_2 = Average time of flow for the water in seconds.

a = Weight of empty specific gravity bottle in gms.

b = Weight of empty specific gravity bottle +
water, in gms.

c = Weight of empty specific gravity bottle +
sample, in gms.

($b-a$) = Mass of distilled water having volume V of
the specific gravity bottle in gms.

($c-a$) = Mass of sample having volume V of the specific
gravity bottle in gms.

(P) DETERMINATION OF CURD TENSION:

The committee of the American Dairy Science Association (1941) suggested a method to determine the curd tension of milk. The method adopted in the present investigation has the same principle as suggested above and the method used by Chandrasekhar et al (1957), Chopra (1963) and Kulkarni (1968). A simple type of curd tension meter devised indigenously was employed. It consists of three steel knives of 1" x 3/4" welded in the form of 'H'. A thin vertical steel rod is attached to the centre of the middle knife. The other end of the rod is bent in the form of a hook which is attached to the thread carrying the pan over a frictionless pulley.

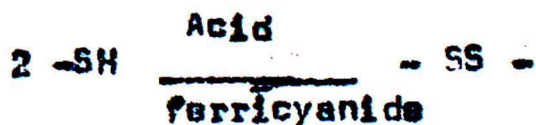
The curd tension of milk was determined as described below.

In a series of uniform beakers of 100 ml. capacity and size 7 cm x 4.5 cm., 50 ml. of milk to be tested was taken and pre-warmed to 37°C. The curd tension knives were placed in the beaker and 2 ml. of 0.2% rennet (Hansen's) solution were added rapidly to all the beakers. The milk in the beakers was stirred immediately using knife and all the beakers were placed in a thermostatically controlled water bath maintained at $37 \pm 1^\circ\text{C}$ for 3 hours. The beakers were then taken out of the water bath and the pan was loaded with lead shots, till the curd tension knife cuts its way through

the curd. The knife and pan were counter-poised and the weight in gms. of the lead shots was taken as a measure of the curd tension. All the measurements were made in duplicate.

(g) TOTAL REDUCING CAPACITY:

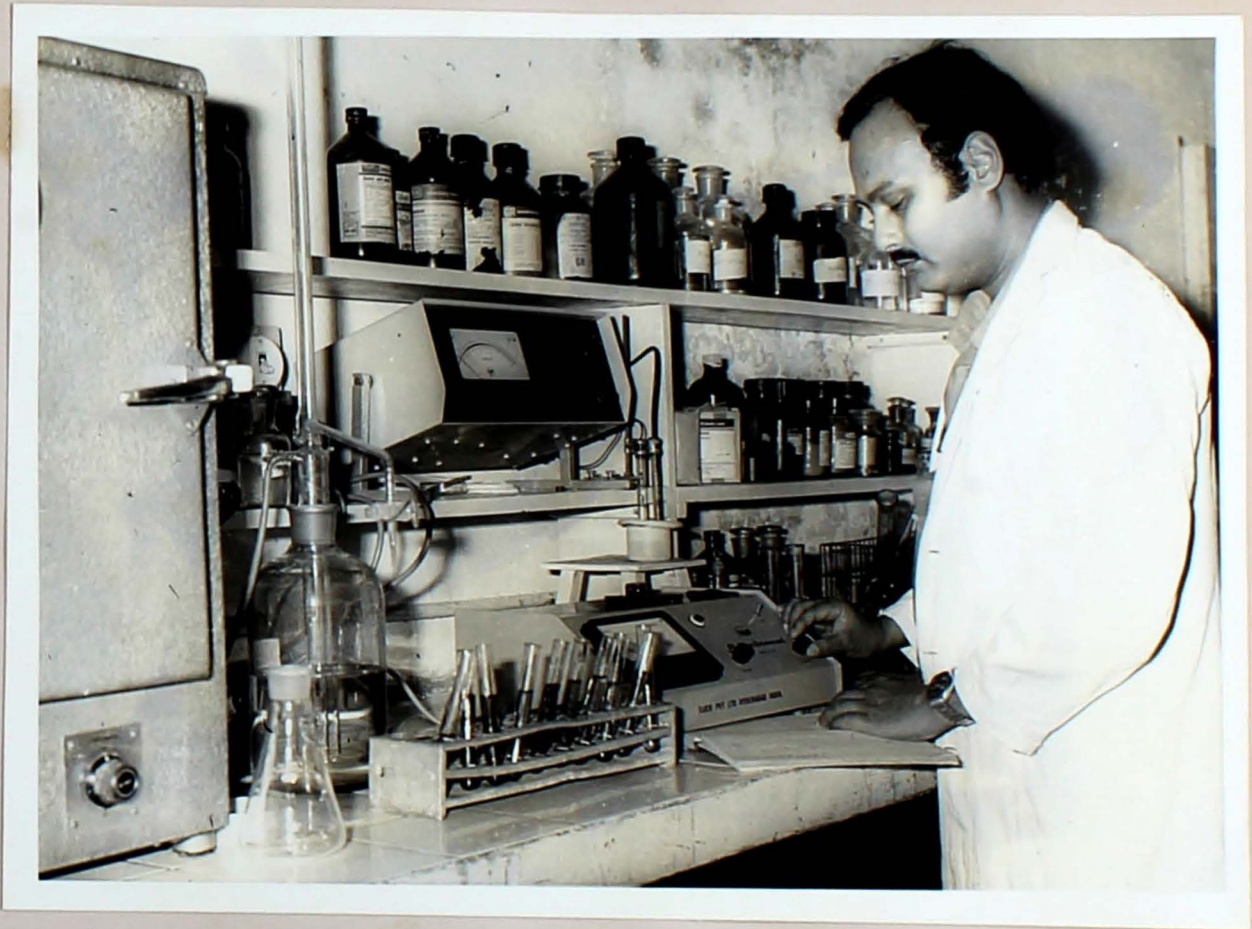
The method of Chapman and Mc-Farlane (1945) and Crowe et al (1948) was adopted for estimating total reducing capacity of milk. The same method was also adopted by Joginder Singh et al (1970) with slight modification. This method involves heating of milk with potassium ferricyanide under specific condition. The sulphhydryl compounds reduce the acid ferricyanide to ferrocyanide and at the same time sulphhydryl compounds are oxidised to disulphide compounds,



Acid ferricyanide reacts with ferric chloride solution to give Prussian blue colour which can be estimated spectrophotometrically at 660 m μ .

The details of method followed in the present investigation are as follows.

To one ml. of milk was added 9 ml. of water and 5 ml. of 0.2 M phosphate buffer of pH 7.4 to get a final pH of 6.5. Five ml. of 1% potassium ferricyanide solution was added. The contents were heated for 20 minutes in a water bath, which was thermostatically



SPECTROCOL
MODEL NO. CL - 23

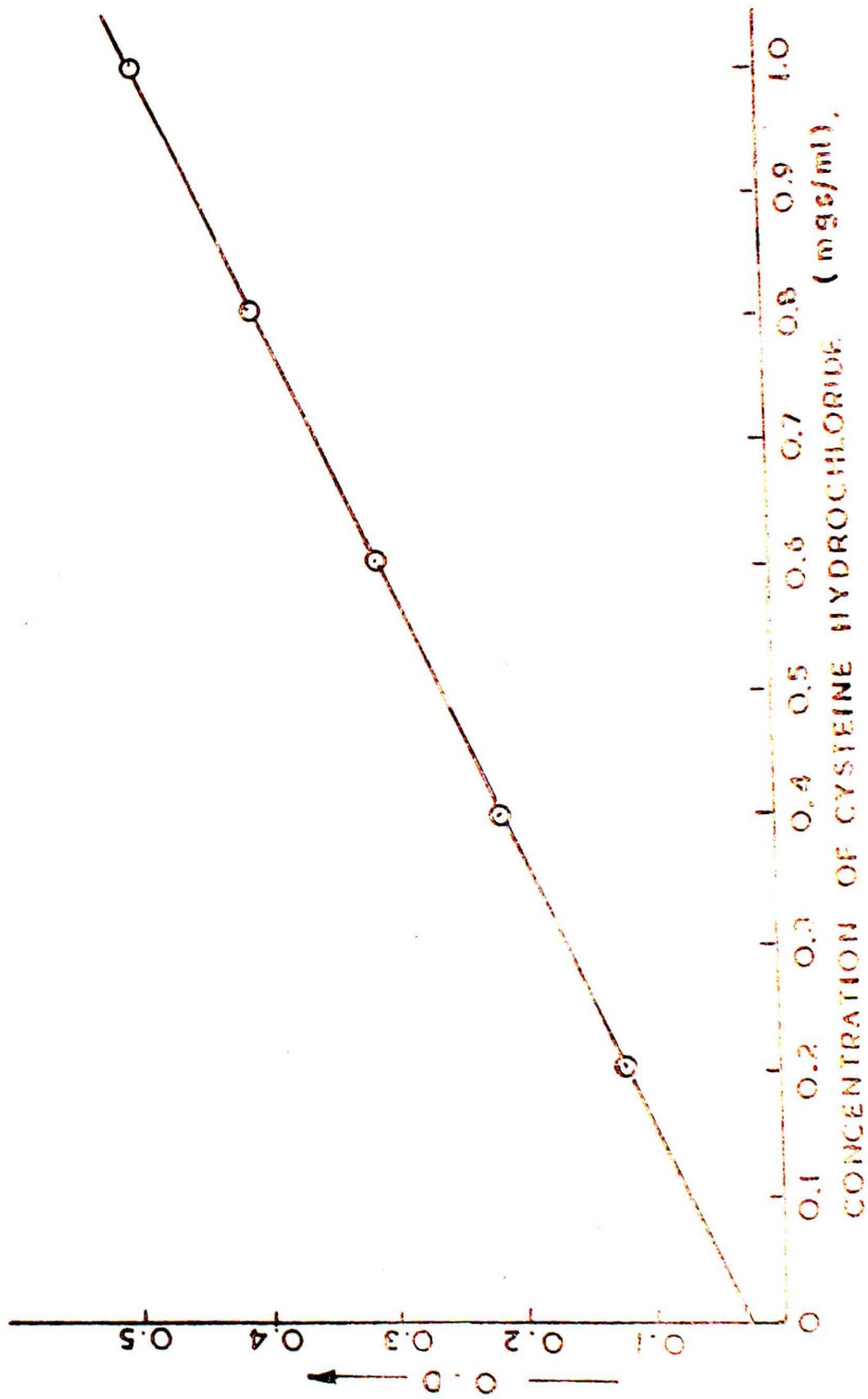
controlled at $70 \pm 1^{\circ}\text{C}$ and were then cooled in ice water bath for 30 minutes. Five ml. of 10% trichloroacetic acid solution was added to each tube, and filtered through Whatman No.40 filter paper. Five ml. of filtrate was mixed with 5 ml. of distilled water and added 1 ml. of 0.1% freshly prepared ferric chloride solution. After 10 minutes the readings were taken in a Spectrocol Model CL-23 against a reagent blank at 660 m μ . Cysteine hydrochloride was used as a reference standard. The values of sulphhydryl were expressed in terms of mg. cysteine HCl per gms. of sample. In the case of sterilized milk the sample was diluted to 2½ times to get the optimum readings.

PREPARATION OF STANDARD CURVE :

Six test tubes (150 x 25 mm size) were taken, washed and thoroughly dried.

1 ml, 0.8 ml, 0.6 ml, 0.4 ml and 0.2 ml of cysteine hydrochloride (50 mg/100 ml.) were taken in five test tubes and then made to 10 ml by adding glass distilled water. Thereafter, 5 ml. of phosphate buffer solution (0.2 M) were added. Five ml. of 1% potassium ferricyanide solution was then added and the tubes were placed at $70 \pm 1^{\circ}\text{C}$ for 20 minutes in a thermostatically controlled water bath and then cooled in ice water immediately. Then added 5 ml of 10% TCA solution to each tube and filtered.

STANDARD CURVE. (OPTICAL DENSITY VS CONCENTRATION).



To 5 ml of filtrate were added 5 ml. of distilled water followed by 1 ml. of 0.1% ferric chloride solution and kept for 10 minutes for colour development and read the colour in a Spectrocol at 660 m μ . A blank was prepared in the same way but adding 10 ml. of distilled water instead of cysteine hydrochloride solution. A curve was plotted taking optical density against concentration of cysteine hydrochloride (mgs./ml).

(h) THIOBARBITARIC ACID METHOD:

Keeney and Bassette (1959) used a method to determine the TBA value spectrophotometrically for milk and milk products. The method for detection of browning was based upon analysis of the HMF by spectrophotometric measurement of the TBA reaction product. This method can detect early symptoms of browning and fat oxidation in milk and milk products. Joginder Singh (1978) used the method to determine TBA value in reconstituted milk. The details of the method are as follows.

Ten ml. of milk sample was pipetted into a 50 ml. test tube and to this was added 10 ml. of 4% trichloroacetic acid (40 gm. TCA diluted in 100 ml water) from a burette and the contents were mixed. The tubes were covered with inverted 20 ml. beakers and placed in a water bath at $70 \pm 1^{\circ}\text{C}$ for 25 minutes. Thereafter, it was removed from the bath and cooled in ice water. Then filtered the contents through Whatman No.42 filter paper. Four ml. of filtrate was pipetted into a test tube.

To this was added 1.0 ml. of 0.05 M TBA (0.72 g. of thioarbituric acid in 100 ml. of water) solution prepared by warming slightly and cooling to 25°C before use. The tubes were then placed in a water bath at 40 ± 1°C for 50 minutes. These were then removed and cooled to room temperature. The absorbance of the solution was measured at 443 mμ against a blank (prepared in the same way as the sample but substituting water for milk) in a Spectrocol, Model CL-23. The results were expressed in terms of optical density as per the method of Della Monica et al (1968).

The TBA values were also expressed as hydroxy methyl furfural in the case of sterilised milk and were calculated according to the formula as below :

$$(\text{Absorbance} - 0.062) \times 76 = \text{micromoles HMF per litre of milk.}$$

* * * * *

CHAPTER V

RESULTS AND DISCUSSION

5.1 VISCOSITY OF GOAT MILK:

The values of viscosity, expressed in centipoise as effected by heat treatment viz. pasteurization by Holding and H.T.S.T. method, Just boiling, Simmering and sterilization are presented in Table - 1 (A). It is evident from the data that the viscosity of goat milk increases as a result of heat treatment given to the raw milk. On an average the value of 1.830 c.p. for original raw milk increased to 2.4861 upon sterilization. Thus the process of sterilization indicates a maximum increase of 35.85% in the viscosity of milk whereas the increase in viscosity was lower in the case of other heat treatments of a lower degree.

The data on viscosity for the individual milk samples has been shown in Appendix table 1. On statistical analysis of the data as given in table 1 (B), it is observed that the increase in viscosity due to all the heat treatments is significant at 1% level when compared with raw milk. Between the methods of Holding to H.T.S.T. pasteurization, Just boiling to simmering the increase in viscosity is not significant.

There is no literature available indicating the effect of heat treatment on the viscosity of goat milk. However, some workers have reported an increase in viscosity of cow and buffalo milks as a result of heat treatment. Kulkarni (1968) reported that the viscosity

TABLE - 1 (A)

VISCOSITY OF GOAT MILK AT DIFFERENT HEAT TREATMENTS

Sl. No.	Nature of Heat Treatment.	No. of milk samples	Viscosity in C.P.			%age increase
			Minimum	Maximum	Average	
1.	Raw milk	15	1.4390	2.0032	1.8300	-
2.	Past. by Holding.	15	1.5040	2.2145	1.9830	8.30
3.	HTST Past.	15	1.5865	2.2654	2.0593	12.53
4.	Just Boiling	15	1.6734	2.3484	2.1541	17.71
5.	Simmering	15	1.7410	2.4102	2.2265	21.66
6.	Sterilization	15	2.3163	2.7354	2.4861	35.85

TABLE - 1 (B)

ANALYSIS OF VARIANCE TABLE

Source of variation	Degren of freedom	Sum of square	Mean sum of square	F. Value
Between blocks.	14	2.46512409	0.176080249	10.199448**
Between treatments.	5	3.79266511	0.758533023	43.9379847**
Error	70	1.20846033	0.0172637190	-
Total	89	7.46625034		

** = Significant in 4% level.

Critical difference = 0.12761

of Buffalo milk increased due to boiling, simmering and sterilization of milk. Jenness and Patton (1959) and Puri and Gupta (1965) also observed an increase in viscosity in the case of cow milk due to heat treatment. They stated that the effect of gentle heating may be due to the changes in the make-up of the caseinate i.e. Colloidal structure of proteins and fat globule size whilst more severe heating might involve gradual denaturation of soluble proteins resulting into heat coagulation.

5.2 CURD TENSION:

Table - 2 A shows the curd tension of goat milk obtained by different heat treatments. The values were compared with the original raw milk. It is observed from the table that a decrease in curd tension occurs due to pasteurization by Holding and H.T.S.T. methods, Just boiling, Simmering and Sterilization. The decrease is more when the heat treatment is increased and it is maximum in the case of sterilization of milk. For example, on just boiling the decrease in curd tension as compared to original raw milk is of the order of 29.89% and the decrease is maximum to the extent of 62.38% upon sterilization because the original average value of 39.847 decreased to 14.989 expressed in terms of gms.

The individual values on the curd tension for the various milk samples subjected to heat treatment are given in Appendix Table - 2. The statistical analysis of the data is presented in Table 2 (B). The increase

in curd tension as a result of heat treatment is significant at 1% level for the different heat treatments when compared with raw milk. The increase is also significant between these methods of pasteurization and just boiling. But between just boiling to simmering the increase is not significant.

Both Chopra (1963) and Rao et al (1964) reported the curd tension of goat milk (raw) clotted with rennet to be of the order of 40 gms. which is very close to our average value of 39.847 for raw milk. Further, Chopra (1963) reported a value of 24.3 - 26.5 gm for the curd tension of cow milk and explained the lower values of curd tension for cow milk in view of its longer clotting time as compared to goat milk.

Our results in the present investigation on the curd tension of raw milk have a wide range between minimum and maximum values i.e. 34.44 and 48.42. The reason being that the different goats were at various stages of lactation. Similar findings were reported by Gamble et al (1939), Turner and Gurrison (1940) that the curd tension of goat milk varied with the lactation period.

Chopra (1963) observed that the lowering in curd tension of heated milk appeared to be due to the reduction of calcium ion concentration and decrease in electrostatic charge carried by caseinate micelles. Possibly, it might also be due to the rendering of some albumin insoluble and the protein itself getting denatured.

TABLE - 2 (A)CURD TENSION OF GOAT MILK AT
DIFFERENT HEAT TREATMENTS

Sl.No.	Nature of Heat treatment.	No. of milk samples	Curd tension in cms.			% age decrease
			Minimum	Maximum	Average	
1.	Raw milk	15	34.44	49.42	39.847	-
2.	Past. by Holding.	15	30.00	48.42	36.992	7.41
3.	HTST Past.	15	29.32	43.22	35.428	16.10
4.	Just Boiling	15	25.50	30.90	27.936	29.89
5.	Simmering	15	19.00	32.93	25.49	36.03
6.	Sterilization	15	13.02	18.40	14.989	62.38

TABLE -2 (B)ANALYSIS OF VARIANCE TABLE

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F. Value
Between blocks	14	352.260026	25.8757161	3.82516023**
Between treatments	5	6087.86510	1217.57302	179.99113**
Error	70	473.522680	6.76460972	
Total	89	6923.64701		

** = Significant at 1% level.
Critical difference = 2.5262.

Thus the change on the casein particles undoubtedly appears to be a factor in curd tension. Higher changes means slow coagulation and soft curd. The lowered curd tension of boiled milk have also be due to the decrease in the hydration of casein or paracasein as the temperature was increased. Our findings in the present investigation, that the curd tension of goat milk after simmering and sterilization becomes still lower are in agreement with the above author.

5.3 TITRATABLE ACIDITY OF GOAT MILK:

The observations on titratable acidity (expressed as percentage lactic acid) of raw goat milk and after its subjecting to different heat treatments is shown in Table 3 (A). The values indicate that there is no change in the titratable acidity when raw milk is pasteurized both by Holding and H.T.S.T. methods. The titratable acidity of original raw milk increased from 0.143 to 0.151, 0.158 and 0.176 on an average as a result of Just Boiling, Simmering and Sterilization respectively. The percentage increase in titratable acidity due to sterilization thus worked out to be 18.5%.

Appendix Table-3 shows the values of titratable acidity for the individual milk samples subjected to different heat treatments viz. pasteurization, just

TABLE - 3 (A)

PERCENT TITRATABLE ACIDITY OF GOAT MILK
AT DIFFERENT TEMPERATURES

Sl. No.	Nature of Heat treatment.	No. of milk samples	% Acidity as Lactic acid			%age increase
			Minimum	Maximum	Average	
1.	Raw milk	15	0.12	0.18	0.148	-
2.	Past. by Holding.	15	0.12	0.18	0.149	-
3.	HTST Past.	15	0.12	0.18	0.148	-
4.	Just Boiling	15	0.12	0.18	0.151	1.9
5.	Simmering	15	0.13	0.19	0.158	6.5
6.	Sterilization	15	0.15	0.21	0.176	18.5

TABLE - 3 (B)

ANALYSIS OF VARIANCE TABLE

Sources of variation	Degree of freedom	Sum of square	Mean sum of square	F. Value
Between blocks	14	0.0272955555	0.00194968253	111.460974**
Between treatments	5	0.00932555555	0.00186511111	106.626129**
Error	70	0.0012244445	0.0000174920642	
Total	89	0.0378455555		

** = Significant in 1% level.

Critical difference = 0.00406.

boiling, simmering and sterilization. The results on statistical analysis (Table 3. B) reveal that the increase in titratable acidity is significant at 1% level when simmering and sterilization of milk is carried out. But when raw milk is pasteurized by Holding and H.T.S.T. methods or boiled then the increase in the titratable acidity is not significant. However, among the treatments the increase in titratable acidity is significant between boiling and simmering and simmering to sterilization.

The values of our titratable acidity (table -3 A) ranged between 0.12 and 0.18 as percent lactic acid. A similar range in the values of titratable acidity of goat milk has been reported by Parkash and Jenness (1968). However, there is no report in literature for the effect of heat treatment on the titratable acidity of goat milk. But Grimbleby (1954) in his studies on cow milk reported that the titratable acidity increased due to heat treatment. The reason for this increase was attributed to a part of the lactose combining with proteins and this protein lactose combination being responsible for a part of the increased titratable acidity in heated milk.

5.4 pH OF GOAT MILK:

The data obtained on the pH values of goat milk as a result of various heat treatments is shown in table 4 (A). It is observed that raw goat milk on an average has got a pH of 6.57. The pH is very slightly decreased due to pasteurization of milk. Boiling and simmering bring about a noticeable decrease in pH, the average values being 6.452 and 6.406. The decrease in pH of milk becomes prominent (5.04%) due to sterilization, the average value decreasing to 6.195 from an original value of 6.57.

The values of pH for individual milk samples are presented in Appendix Table - 4. The results are statistically analysed as given in table 4 (B). The change in the pH of milk on pasteurization is not significant. The decrease in pH is, however, significant at 1% level in the case of just boiling, simmering and sterilization of milk. Between the methods of heating, the decrease in pH is insignificant except between simmering and sterilization.

Various workers like Gamble et al (1939), Trout (1941), Dharmarajan et al (1954), Rao and Dastur (1956) and Parkash and Puri (1960) have examined the pH value for raw goat milks. The ranges of values reported by them are almost similar to our

TABLE - 4 (A)

pH VALUE OF GOAT MILK AT DIFFERENT HEAT TREATMENT

Sl. No.	Nature of Heat treatment.	No. of milk samples	pH Value			% age decrease
			Minimum	Maximum	Average	
1.	Raw milk	15	6.41	6.70	6.570	-
2.	Past. by Holding	15	6.38	6.70	6.502	0.33
3.	HTST Past.	15	6.38	6.69	6.489	0.53
4.	Just boiling	15	6.36	6.59	6.452	1.10
5.	Simmering	15	6.32	6.50	6.406	1.80
6.	Sterilization	15	6.01	6.39	6.195	5.04

TABLE -4 (B)

ANALYSIS OF VARIANCE TABLE

Sources of variation	Degree of Freedom	Sum of square	Mean sum of square	V. Value
Between blocks	14	0.40868217	0.0291915835	11.0767273**
Between treatments	5	1.09608888	0.219217776	83.1820422**
Error	70	0.18447785	0.00263539785	
Total	89	1.6892489		

** = Significant with 1% level.

Critical difference = 0.049862

findings in the present investigation. No worker has reported the effect of heat treatments on the pH values of goat milk. However Subhash Chandra (1974) observed a slight decrease in the pH values of cow and buffalo milk due to heating. Our results, though on goat milk, also show a similar trend.

5.5 FAT, SPECIFIC GRAVITY AND TOTAL SOLIDS CONTENT OF GOAT MILK:

Though no change is expected in fat and total solids as a result of heat treatment of milk, but the study was conducted to have an idea about the quality of milk (with respect to its solids content) being studied for its physico-chemical characteristics as affected by heat treatment.

The observations recorded on fat, specific gravity and total solids of goat milk are shown in Tables - 5, 6 and 7 respectively. The individual values for various milk samples have been presented in Appendix Tables - 5, 6 and 7. It is evident from the results that there is no change in fat, specific gravity and total solids of milk as a result of pasteurization, boiling, simmering and sterilization. A very slight increase has, however, been noted in specific gravity and total solids of milk in the case of simmering



TABLE - 5

FAT CONTENT OF GOAT MILK AT DIFFERENT
HEAT TREATMENT

Sl. No.	Nature of Heat treatment	No. of milk samples	Fat percent			% age difference
			Minimum	Maximum	Average	
1.	Raw milk	15	3.0	4.5	4.00	-
2.	Past. by Holding	15	3.0	4.5	3.99	0.25
3.	H.T.S.T. Past.	15	3.0	4.5	3.99	0.25
4.	Just boiling	15	3.0	4.5	3.98	0.50
5.	Simmering	15	2.9	4.5	3.98	0.50
6.	Sterilization	15	3.0	4.5	4.00	-

TABLE - 6

SPECIFIC GRAVITY OF GOAT MILK AT
DIFFERENT HEAT TREATMENT

Sl. No.	Nature of Heat treatment.	No. of milk samples	SPECIFIC GRAVITY			% age increase
			Minimum	Maximum	Average	
1.	Raw milk	15	1.0300	1.0332	1.0317	-
2.	Past. by Holding	15	1.0300	1.0333	1.0318	0.3
3.	H.T.S.T. Paste	15	1.0300	1.0333	1.0318	0.3
4.	Just boiling	15	1.0300	1.0333	1.0319	0.6
5.	Simmering	15	1.0300	1.0336	1.0320	0.9
6.	Sterilization	15	1.0300	1.0336	1.0320	0.9

TABLE - 7

TOTAL SOLID CONTENT OF GOAT MILK AT
DIFFERENT HEAT TREATMENT

Sl. No.	Nature of Heat treatment.	No. of Milk samples	Total Solid percent			% age increase
			Minimum	Maximum	Average	
1.	Raw milk	15	11.240	13.790	12.878	-
2.	Paste by Holding	15	11.240	13.790	12.880	0.015
3.	H.T.S.T. Paste	15	11.240	13.790	12.878	-
4.	Just boiling	15	11.315	13.780	12.887	0.069
5.	Simmering	15	11.220	13.840	12.895	0.132
6.	Sterilization	15	11.290	13.840	12.940	0.481

and sterilization, obviously because a little evaporation of water takes place during these processes.

Our data in table 5 shows a minimum fat percentage of 3.0% and a maximum of 4.5%, with an average fat content of 4.0% in goat milk. A few workers have reported the fat content of goat milk including Indian breeds of goats. Mittal and Pandey (1971) observed the fat content of Barbari and Jamnapuri goats to be 4.67 and 5.12 respectively. Chang and Kim (1978) reported a range of 2.3 - 4.7% of fat in Saanen goat milk. Agrawal and Bhattacharya (1978) reported a fat content, of 3.83, 4.66 and 4.92% for Black Bengal., Barbari nannies, and Black Bengal x Barbari nannies breeds respectively. Our findings on fat content resemble with the above workers taking into account that fat content varies due to different breeds and regions.

The average value of specific gravity for goat milk (table - 6) in the present investigation was found to be 1.0332. Sirry and Hassan (1954) reported specific gravity of 1.0262 to 1.0366 for goat milk. Jenness and Patton (1959) stated that specific gravity of goat milk varies due to variation in fat content, temperature of milk and the method of measurement. Parkash and Jenness (1968) reported a wide variation

ranging from 1.026 to 1.042 in the specific gravity of goat milk for individual breeds and different lactation period. Our results are in close agreement with these workers considering the factors (like fat content, breed and lactation period etc.), responsible for the variation in specific gravity of goat milk.

Whitaker et al (1927) and Wegener (1953) observed virtually no change in the specific gravity of cow milk on heating above 40°C. But Short (1955) reported a pronounced increase in the specific gravity of cow milk on heating from 40-90°C. In the present work a slight increase of 0.3% in specific gravity was observed due to pasteurization of goat milk. Boiling increased the value by 0.6% whereas both simmering and sterilization resulted in an increase of 0.9% which by all means is almost insignificant.

Table - 7 reveals an average value of 12.878% of total solids in goat milk. The increase in total solids due to even a severe heat treatment like simmering and sterilization is very small and insignificant as stated earlier as well.

5.6 TOTAL REDUCING CAPACITY (TRC) OF GOAT MILK:

Table - 8 (A) indicates the values of total reducing capacity (expressed as mg. cysteine HCl/mf. of milk) of goat milk and its changes due to different

TABLE -B (A)

TOTAL REDUCING CAPACITY (TRC) OF GOAT MILK
AT DIFFERENT HEAT TREATMENT

Sl. No.	Nature of heat treatment.	No. of milk samples	TRC in mgs. of cysteine Hcl/ml.			% age increase
			Minimum	Maximum	Average	
1.	Raw milk	15	0.225	0.445	0.310	-
2.	Past. by Holding	15	0.225	0.465	0.318	2.58
3.	H.T.S.T. Past.	15	0.250	0.475	0.327	5.48
4.	Just boiling	15	0.260	0.485	0.342	10.32
5.	Simmering	15	0.260	0.557	0.364	17.41
6.	Sterilization	15	0.625	1.250	0.804	191.61

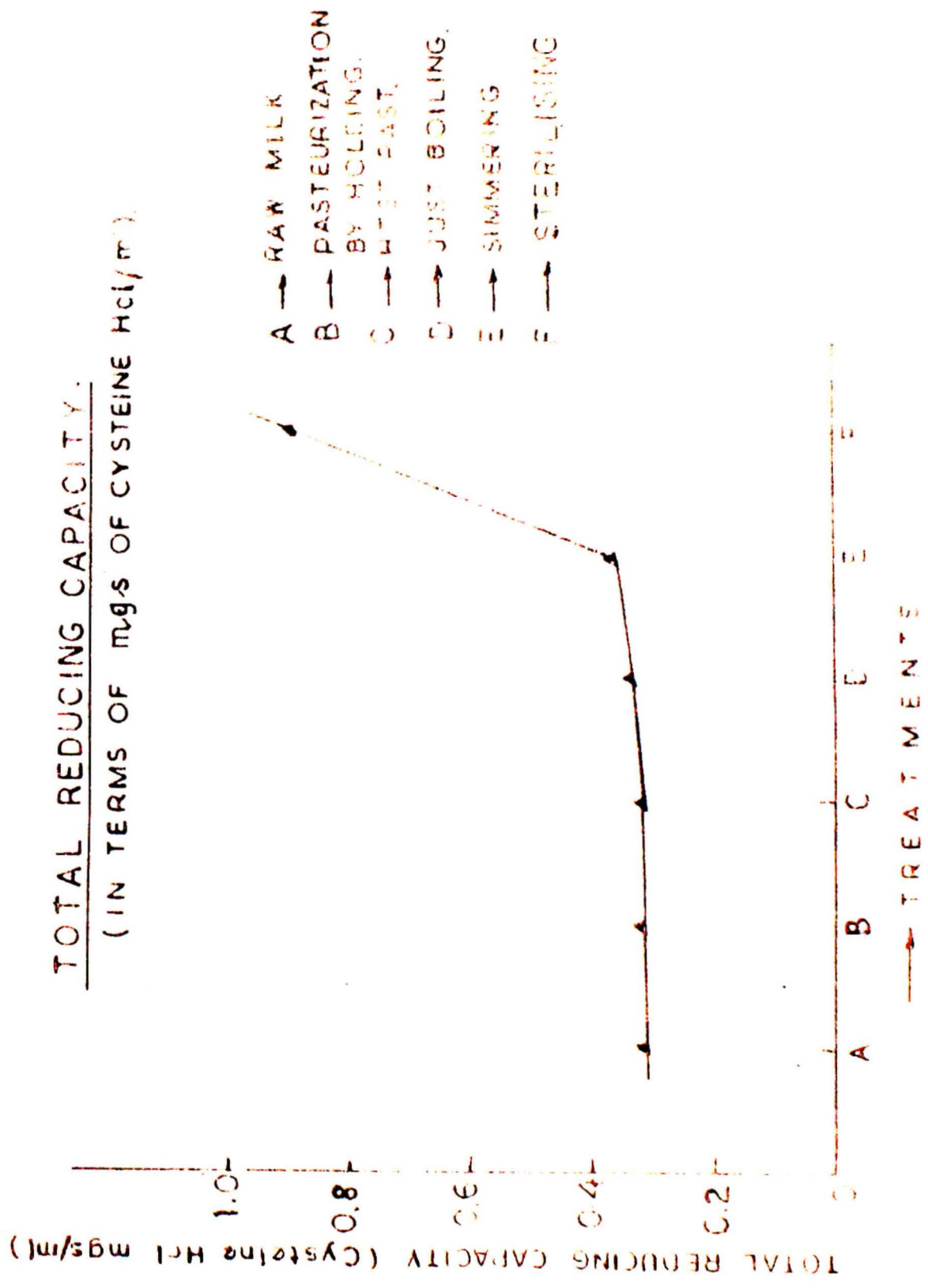
TABLE -B (B)

ANALYSIS OF VARIANCE TABLE

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F. Value
Between blocks	14	0.933628482	0.0666877487	8.60316734**
Between treatments	5	4.11152112	0.822304224	106.082766**
Error	70	0.542607417	0.00775153453	
Total	89	5.58775702		

** = Significant in 1% level.
Critical difference = 0.08551

TOTAL REDUCING CAPACITY.
 (IN TERMS OF μ GS OF CYSTEINE HCl/m³).



heat treatments. The average value of 0.310 increased to 0.327 and 0.342 due to H.T.S.T. pasteurization and just boiling of milk. The increase was slightly more upon simmering (value, 0.364) whereas due to sterilization the increase was about three fold. The trend of increase in the TRC values due to various heat treatments has also been exhibited in the figure attached.

The individual values on TRC for the different samples have been given in Appendix Table - 8. On statistical analysis (Table 8-8), it is observed that the increase in TRC due to heating is not significant in all other processes except sterilization wherein the increase is significant at 1% level. Among the heat treatments, the increase in TRC is significant only between simmering and sterilization of milk.

No work is traceable in literature on the effect of heat treatment of goat milk on its total reducing capacity.

However, several workers as already stated under the chapter 2.0 have observed an increase in the TRC of cow and buffalo milks when these are subjected to various heat treatments. In the present

investigation on goat milk we have observed a similar increase in TRC of goat milk as a result of heat treatment.

Joginder Singh et al (1970) examined the TRC of raw goat milk and reported an average value of 0.307 expressed as mg cysteine HCl/ml. of milk. Their value is slightly lower than our findings in the present investigation. This difference is obviously due to the variation in the breed of the animals and may also be due to other factors like lactation period and ^{feed etc} which affect the composition of milk.

5.7 THIOBARBITARIC (TBA) ACID OF GOAT MILK:

The results on TBA values of goat milk have been presented in table 9 (A). The data reveals that there is only a slight increase in the TBA values expressed as absorbance at 443 m μ when milk is pasteurized. The increase is more than one and a half times due to boiling and simmering of milk. The sterilization of milk has shown about four times increase in the absorbance values, as the original value of raw milk increased from 0.037 to 0.144 upon sterilization. The findings have also been presented graphically in the attached figure and steep rise in the values is evident from the graph when milk is sterilized.

TABLE - 9 (A)

THIOBARBUTARIC ACID (TBA) VALUE IN ABSORBANCE OF
GOAT MILK AT DIFFERENT HEAT TREATMENT

Sl. No.	Nature of Heat treatment.	No. of milk samples	TBA value			% age increase
			Minimum	Maximum	Average	
1.	Raw milk	15	0.030	0.050	0.037	-
2.	Past. by Holding	15	0.030	0.050	0.040	8.108
3.	H.T.S.T. Past.	15	0.035	0.054	0.043	16.216
4.	Just boiling	15	0.040	0.075	0.052	40.54
5.	Simmering	15	0.045	0.090	0.061	64.864
6.	Sterilization	15	0.120	0.170	0.144	289.189

TABLE - 9 (B)

ANALYSIS OF VARIANCE TABLE

Sources of variation	Degree of freedom	Sum of square	Mean sum of square	F. Value
Between blocks	14	0.00566522221	0.000404659729	6.65897740 ^{**}
Between treatments	5	0.124403555	0.0248807111	410.046510 ^{**}
Error	70	0.00424744445	0.000606777778	
Total	89	0.134316222		

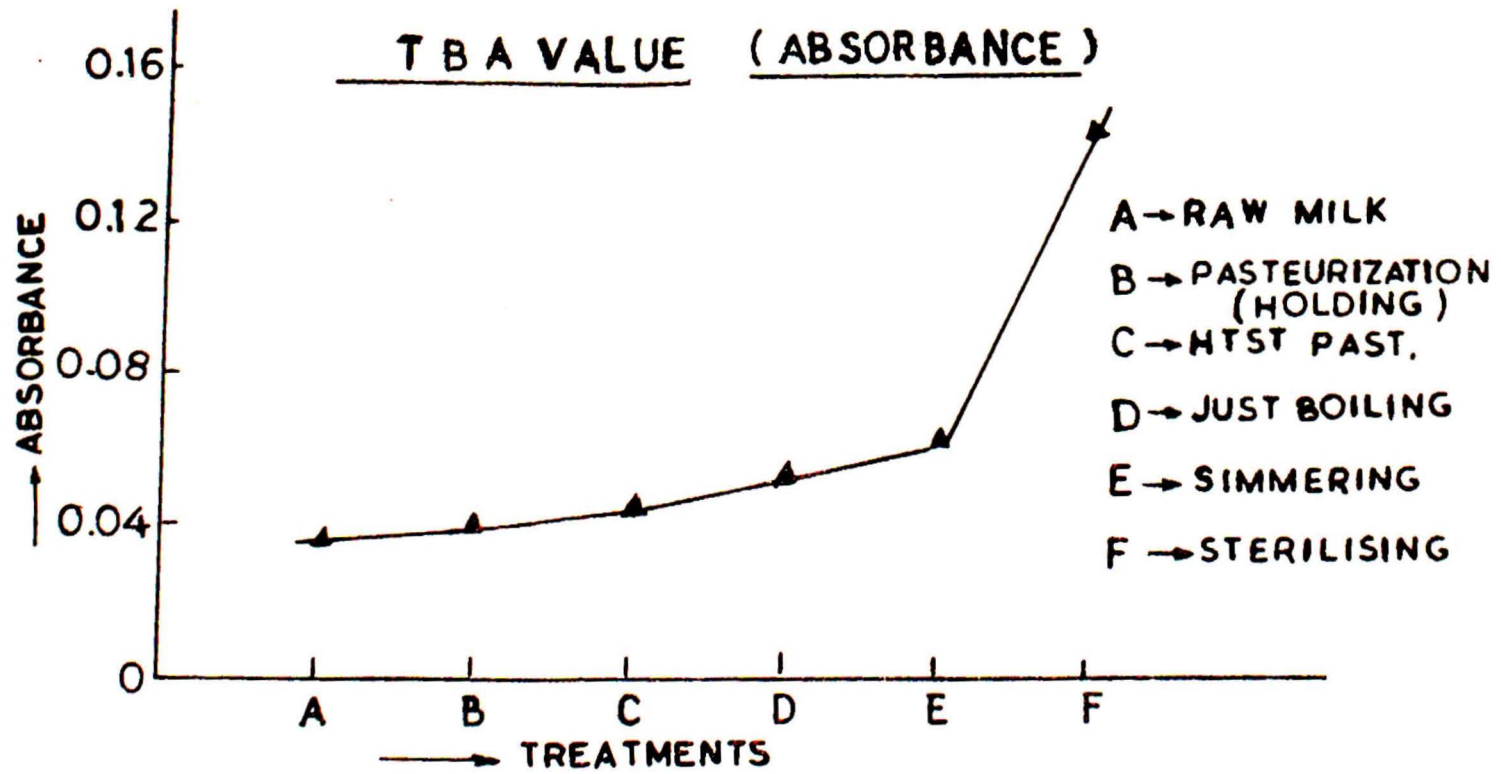
** = Significance in 1% level.

Critical difference = 0.007506

Appendix Table - 9 shows the TBA values of the individual goat milk samples. The data was analysed statistically as shown in Table - 9 (B). The increase in TBA values due to pasteurization of milk is not significant. But the increase become significant at 1% level in the subsequent operations of just boiling, simmering and sterilization. Among the treatments, the increase is not significant between the methods of pasteurization but it is significant between all other heat treatments.

Since sterilization of milk involves a severe heat treatment, a slight brownish colour also appears in the product alongwith a cooked flavour development. As 5-hydroxy methyl furfural formed is an index of colour and flavour, the values for sterilized milk were also expressed as micromole HMF/lit. of milk. The individual values have been given in the Appendix Table - 10. The HMF values for sterilization milk were found to vary from 4.408 to 8.208 with an average of 6.2826.

Della Monica et al (1968) reported that the HMF formed during processing measures the incidence of heat exposure of milk provided the solid contents of milk to be analysed is kept constant. They observed that the total HMF colour is a function of the solids



content of milk, with high solids yielding more colour. Samuelson and Nielsen (1970) reported that HMF values expressed as absorbance at 443 m μ for UHT treated cow milk were between 0.07 - 0.09 and for in bottle sterilized milk between 0.16 - 0.24. The results in our present investigation for sterilized milk vary between 0.120 - 0.170 with an average of 0.144. expressed as absorbance. Our slightly lower values than the above authors can be attributed to the compositional differences between the cow and goat milks or a lesser heat treatment given in our experiment.

* * * *

CHAPTER VI

SUMMARY

6.1 The importance of the present investigation has been high-lighted in the chapters on Introduction (1.0) and Scope of work (3.0). The various aspects of work done earlier by different authors has been reviewed in the chapter (2.0) on the physico-chemical characteristics of goat milk as affected by heat treatments viz. pasteurization by Holding and H.T.S.T. methods, Just Boiling, Simmering and Sterilization.

6.2 Samples of goat milk were obtained from the goat herd (Saanen, Beetal, Alpine, Saanen x Beetal x Alpine, Saanen x Beetal, Beetal x Alpine cross bred goats) maintained at the Institute Farm. The various heat treatments to goat milk were subjected in the Dairy Technology Division.

6.3 Pasteurization by Holding method was carried out at $63 - 63.5^{\circ}\text{C}$ for 30 minutes and for H.T.S.T. method at $71.5 - 72.0^{\circ}\text{C}$ for 15 seconds. For just boiling, milk was brought to boil momentarily without any holding. In the case of simmering, milk was first brought to boil and then simmered at 95°C for 3 minutes. For sterilization, a steam pressure of 15 psig (121°C) was employed for 15 minutes. All these heat treated milk samples were allowed to cool

and examined in duplicate for their physico-chemical properties, viz. Viscosity, Curd tension, Acidity and pH, Fat content, Specific gravity, Total solids content, Total reducing capacity and Thiobarbuteric acid.

6.4 Viscosity of goat milk was measured by Ostwald's viscometer; Curd tension by Tencimetric method after coagulation with rennet; Acidity, pH, Fat, Specific gravity and total solids by ISI methods; Total reducing capacity by Acid ferricyanide method and TBA values by Kennay and Bassette method.

6.5 Viscosity of goat milk was observed to increase when raw milk was subjected to heat treatment, the increase being more with a higher heat treatment. The increase in viscosity was found to be the maximum when heat treatment was severe as in the case of sterilization.

6.6 Curd tension of goat milk was found to decrease with the increase in heat treatment to milk. The decrease in curd tension was maximum in the case of sterilized milk.

6.7 Acidity of goat milk was not affected when raw milk was pasteurized by Holding and H.T.S.T.

methods. There was no significant increase in acidity when milk was just boiled, but the increase became progressively significant on simmering and sterilization of milk.

6.8 pH of goat milk was observed to decrease slowly as raw milk was heated to pasteurization, boiling and simmering. The decrease in pH was comparatively more in the case of sterilization.

6.9 Specific gravity, fat and total solids of goat milk were not affected due to heat treatment as expected. However, total solids were increased slightly on simmering and sterilization of milk because of some water evaporation.

6.10 Total reducing capacity of goat milk was observed to increase as a result of heat treatment. The increase was very little on pasteurization, followed by boiling and simmering of milk. The total reducing capacity of milk was found to increase by about three fold on sterilization.

6.11 TBA values of milk were found to increase slightly as a result of boiling and simmering. However, in the case of sterilization the increase in TBA values - of milk became significant.

BIBLIOGRAPHY

B I B L I O G R A P H Y

- Apple, H.J. 1935 J. of Am. Vet. Med. Assoc. 40, 33.
- Aurand, L.W., Woods, A.E. and Roberts, W.M. 1958 J. of Dairy Sci. 42, 961-968.
- Arbuckle, W.S. 1977 Book on Ice Cream AVI/pub.
- Agrawal, K.P. and Bhattacharya, N.K. 1978 Ind. J. of Ani. Sci., 48 (12), 882-886.
- Brennemann, J. 1913 J. Am. Med. Assoc. 60, 575.
- Basu, K.P. and Mukharjee, K.P. 1943 Ind. J. of Vet. Sci., 13, 231.
- Bernheim, F. Bernheim, L.C. and Wilber, K.M. 1948 J. Biol-chem. 174, 257-264.
- Burton, H., Blondo, G. and Chiofalo, L. 1954 J. Dairy Res. 21, 194.
- Caulfield, W.J. and Martin, W.H. 1934 23, 12, 24-29.
- Chapman, R.A. and McFarlane, W.D. 1945 Can. J. Res., 23B, 91.
- Crowe, L.K., Jenness. S., Robert and Coulter, S.T. 1948 J. Dairy Sci. 31, 595.
- Coulter, S.T., Jenness, R. and Crowel, K. 1948 J. Dairy Sci. 31, 986.
- Chandrasekhara, M.R., Suaminathan, M., Bhatia, D.S. and Subramanyam, V. 1957 Food Sci. 6, 10, 226.
- Canuti, A. and Salvadori, F. 1959 Dairy Sci. Abs. 22, 808.

- Craig, J.C., Jr.
Aceto, N.C. and
Della Monica, E.S. 1961 J. Dairy Sci., 44, 1827.
- Chopra, V.C. 1963 M.Sc. Thesis, N.D.R.I.,
Karnal.
- Chandra, S. 1974 M.Sc. Dissertation,
N.D.R.I., Karnal.
- Cheng, J.I. and
Kim, Y.K. 1978 Dairy Sci. Abs. 42, 2.
- Dox, A.U. and
Plaisance, C.P. 1916 J. Am. Chem. Soc. 38,
2164-2166.
- Duncombe, F. 1924 J. Dairy Sci., 7, 245.
- Doan, F.J. 1927 J. Dairy Sci. 10, 501-12.
- Doan, F.J. and
Welch, R.C. 1934 Pa. Agr. Expor. Sta.
Bull. 312.
- Doan, F.J. 1938 J. Dairy Sci. 21, 739.
- Doan, F.J., Babcock,
C.J., Chambers, L.A.,
Flora, C.C., Hull,
R.E., Mueker, U.S.,
Sawyer, H.H. and
Storrs, A.B. 1938 M. Dairy Sci. 24, 826.
- Doan, F.J. 1941 J. Dairy Sci. 24, 825-27.
- Dunkley, W.L. 1951 Food Technol., 5, 342-346.
- Dunkley, W.L. and
Jennings, U.C. 1951 J. Dairy Sci. 34, 1064.
- Dharmarajan, C.S., Rao,
R.V. and Desai, K.M. 1954 Ind. J. Vet. Sci. 24, 51.
- Della Monica, E.S.,
Craig, J.C. and
Calhoun, R.J. 1968 J. Dairy Sci. 51, 352.

- Davies, F.L., Shankar,
P.A., Brooker, B.E.
and Hobbs, D.G. 1978 J. Dairy Sci. 45, 53.
- El-Slany and Mahmood 1978 Egy. J. Dairy Sci. 6(2)
239-245.
- Frahm, J. 1926 Cited from Dairy Sci.
Abs. 30 (2) 67-68 (1968).
- FAO production Year
book. 1977 Food Agri. Organ. U.N.,
Rome.
- Food and Agri. Org. 1979 Monthly Bulletin, 2(11)
44-56.
- Could, I.A. and Sommer,
H.H. 1939 Tech. Bull. 164, Michigan
State College Agri. Exptl.
Station, East Lansing, U.S.A.
- Could, I.A. 1940 Milk Dealer. pp. 553.
- Gamble, J.A., Ellis,
N.R. and Beeby, A.K. 1939 Tech. Bull. U.S. Dep.
Agric. 671.
- Grimbleby F.H. 1954 J. Dairy Sci. 21, 207.
- Grabennikov, E.P.,
Soroka, V.R. and
Sabadash, E.V. 1963 Dairy Sci. Abs. 25, 1502.
- Ghosh, S.N. and
Anantakrishnan, C.P. 1965 Ind. J. Dairy Sci. 22, 49.
- Hill, R.L. 1931 Utah Agr. Exptl. Sta. Bul.
287.
- Miller, N.S., Babcock,
C.J. and Ellis, N.R. 1961 Cited from Dairy Sci. Abs.
22 (2) 67-67 (1968).
- Mutton, J.H. and
Petton, S. 1952 J. Dairy Sci. 25, 699.

- Habeeb, A.F.S.A. 1960 *Can. J. Biochem. Physiol.* 38, 269 (1960).
- Holler, H. 1962 *Milchwissenschaften* 17, 485.
- Holtman, G.H. Swanson, A.M. and Stahmann, M.A. 1965 *J. Dairy Sci.* 48, 780.
- Hofi, A.A., Rifaat, I.D. and Khorshid, M.A. 1966 *Ind. J. Dairy Sci.* 12, 122-25.
- I.S. 1183, Specification of density hydrometers for the use in milk. 1957 *Ind. Std. Inst. 9-Mathura Rd. New Delhi-1.*
- I.S. 1224, Determination of fat in whole milk, etc. by garbar method. 1958 *Ind. Std. Inst. Manik Bhawan, New Delhi-1.*
- Jackson, C.J. 1936 *J. Dairy Sci.* 7, 29.
- Josephson, D.V. and Doan, F.J. 1939 *Milk Dealer*, 22, 35-54.
- Jenness, R. and Patton, S. 1959 *Pub. by John Wiley and Sons, Inc. New York.*
- Jenness, R. and Prakash, S. 1971 *J. Dairy Sci.* 54, 123.
- Jenness, R., Rogehr, E.A. and Solan, R.E. 1964 *Comp. Biochem. Physiol.* 37, 139.
- Jinks, T and Coto, T. 1962 *J. Dairy Sci.* 45, 735.
- Jinks, T. 1963 *J. Biochem., Tokyo.* 54, 388.
- Jandlins, V.C. and Suisagood, M.E. 1975 *J. Biol. Chem.*, 250, 2332.
- Jaindhari, V.K. 1978 *M.Sc. Dissertation, U.P. Univ., Kural.*

Kondo, K. and Mori, S.	1932	J. Chem. Soc. Japan, B1, 1163.
Kohn, H.I.	1943	Federation Proc. 2, 25-27.
Kohn, H.I. and Liversedge	1944	J. Pharma Biol. Exptl. Therap. 12, 292-311.
Kuck, S.K.D.	1950	Arch. Biochem. 26, 651-64.
Kulkarni, P.S. and Dale, K.K.	1956	Ind. J. Physiol. 8, 44.
Kulkarni, B.R.	1960	Proc. Ind. Acad. Sci.
Keeney, R. and Bassette.	1959	J. Physiol. 131, 240.
King, R.L.	1962	J. Physiol. 116, 114.
Kierweir, F. and Hamel, R.J.E.	1962	J. Physiol. 116, 419 (1964).
Laighton, A. and Payne, C.S.	1962	J. Physiol. 116, 114.
Larson, R.J., Jerness, R. and Zedler, R.F.	1963	J. Physiol. 116, 114.
Larson, R.J. and Jerness, R.	1963	J. Physiol. 116, 114.
Leslie, J., Butler, L.H.	1963	J. Physiol. 116, 114.
Leitch, I.	1963	J. Physiol. 116, 114.
Leitch, I. and Jerness, R.	1963	J. Physiol. 116, 114.
Leitch, I. and Jerness, R.	1963	J. Physiol. 116, 114.

- Mantovani, G., Maduri, A. and Valenti, G. 1956 D.S.A. 19, (8) 6736.
- Manning, P.B., Heinselman, A.L., Jenness, R. and Coulter, S.T. 1969 J. Dairy Sci. 52, 886.
- Mittal, J.P. and Pandey, M.D. 1971 Agra Univ. J. of Res. Sci. 20 (3) 7-12.
- MacKenzie, G.H., Norton, R.S. and Sawyer, W.H. 1972 J. Dairy Res. 38, 343.
- Mulder, H. and Walstra, P. 1974 Centre for Agri. Pub. and Documentation, Wageningen, the Netherland, 1974.
- Marques, F. 1977 Dairy Sci. Abs. 42 (1) 54 (1980).
- Nollbohm, F.E. and Phillipi, K. 1933 Cited from Dairy Sci. Abs. 30 (?) (1960).
- Nirmalan, G. and Nair, M.K. 1962 Kerala Vet. 1, 49.
- Nazarov, Z. 1964 Dairy Sci. Abs. 22, 3038.
- Oppenheimer, K. 1901 Med. Wehnschr. 7, 105.
- Palmer, A.H. 1934 J. Biol. Chem. 104, 359.
- Powell, M.E. & Palmer, A.H. 1936 J. Dairy Sci. 18, 1401.
- Puri, B.R., Lakshmpol, M.L. and Gupta, S.C. 1952 Ind. J. Dairy Sci. 5, 189.
- Puri, B.R. and Gupta, H.L. 1955 Ind. J. Dairy Sci. 8 (2) 78-82.
- Puri, B.R. and Parkash, S. 1961 Ind. J. Dairy Sci. 14, 73.

- Puri, B.R. and Parkash, S. 1962 Ind. J. Dairy Sci. 15, 28.
- Puri, B.R. and Parkash, S. 1963 Ind. J. Dairy Sci. 18, 17.
- Parkash, S. and Jenness, R. 1968 Dairy Sci. Abs. 30 (2) 67-87.
- Prasad, C., Kulkarni, S.M., Ladkani, B.G. and Mulay, C.A. 1973 J. Dairy Food Sci. and Technol 11, 1.
- Prasad, C., Kulkarni, S.M., Ladkani, B.G. and Mulay, C.A. 1974 J. Food Sci. and Technol. 11 (3), 135-37.
- Rogers, L.A. 1935 Fundamentals of Dairy Sci. 2nd , 214.
- Rao, M.B. and Dastur, N.N. 1956 Indian, J. Dairy Sci. 9, 114.
- Rao, R.V., Chopra, V.C., Stephen, J. and Bhalarao, V.R. 1964 J. Fd. Sci. Technol, Mysore 1, 19.
- Rangappa, K.S. 1964 Indian J. of Dairy Sci. 17, 137.
- Schultz, E.W. and Chandler, L.R. 1921 J. Biol. Chem. 46, 129.
- Sanders, G.P., Matheson, K.J. and Burkey, L.A. 1936 J. Dairy Sci. 19, 395.
- Seidler, L. 1951 Milchwissenschaft 6, 58.
- Spur, R. and Wolman, I.J. 1952 Dairy Sci. Abs. 15 (2) 152 a.
- Sirry, I. and Hassan, H.A. 1954 Indian J. Dairy Sci. 7, 183.

- Short, A.L. 1955 J. Dairy Res. 22, 69.
- Short, A.L. 1956 J. Dairy Tech. 2, 81.
- Samhammer, E. and Ueirner, K. 1966 XVII Int. Dairy Congr. Vol. B 387-92.
- Singh, K.B., Ogra, J.L. and Rao, Y.S. 1968 J. Agri. Sci. 7, 59.
- Singh, J., Balerao, V.R., Norang, A.S. and Rao, V.R. 1970 J. Food Sci. Tech. 1, 139.
- Singh, Ajit. 1975 Ph.D. Thesis.
- Singh, Joginder 1978 Ph.D. Thesis, N.D.R.I., Karnal.
- Samuelson, E.G. and Nicheen, P. 1970 Milchwissenschaften, 25, 541.
- Skjevdal, T. 1979 Dairy Sci. Abs. 42 (2) (1980).
- Tangl, F. 1908 Cited from Dairy Sci. Abs. 30, (2), 67-87 (1968).
- Turner, C.W. and Garrison, E.R. 1940 Dairy Sci. Abs. 2 (2), 164.
- Trout, G.M. 1941 Bull. Milch. St. Univ. Agric. Exp. Stn. 23, 254.
- Townley, R.C. and Gould, I.A. 1943 J. Dairy Sci., 26, 689.
- Venkatappaiah, D. and Basu, K.P. 1952 Indian J. Dairy Sci. 5, 95.
- Whitaker, R., Sharmen, J.M. and Sharp, P.L. 1927 J. Dairy Sci. 10, 361.
- Wilbur 1949 Arch. Biochem., 26, 351-54.
- Wegener, H. 1953 Milchwissenschaften 8, 433.

- Webb, B.H. and Johnson, A.A. 1965 Fundamentals of Dairy Chem. West Port, Con. Avi. Pub. Co.
- Wishahi, A.E., Mohammed, A.Z. and Auny, A.Y. 1965 Dairy Sci. Abs. 22, 2837.
- Whitney, R.M., Brunner, J.R., Ebner, K.E., Farrell, H.M., Josephson, R.V., Morr, C.V. and Swaisgood, H.E. 1976 J. Dairy Sci. 59, 795.
- Zittle, G.A., Thompson, M.P., Custer, J.H. and Carbullis, J. 1962 J. Dairy Sci. 45, 807.
- Zedow, J.G. 1970 Aust. J. Dairy Tech., 25, 123.

APPENDIX

APPENDIX TABLE NO - 1

EFFECT OF DIFFERENT HEAT TREATMENTS ON THE VISCOSITY
IN CENTIPOISE OF GOAT MILK

Sample No.	Raw Milk	Pasteurised Milk		Just Boiling	Simmering (95°C/3 mts)	Sterilization (121°C/15 mts.)
		Holding method	H.T.S.T. method			
1.	2.0394	2.1567	2.2145	2.2763	2.4102	2.5544
2.	2.0713	2.1203	2.1926	2.2579	2.3894	2.4745
3.	1.7939	2.1095	2.1120	2.2599	2.3059	2.3394
4.	1.9390	2.1301	2.1309	2.2631	2.3022	2.3163
5.	2.09914	2.2145	2.2351	2.3484	2.4102	2.6883
6.	1.7402	1.8025	2.0110	2.3031	2.3634	2.3936
7.	1.8210	2.1035	2.2654	2.2901	2.3100	2.3765
8.	1.9345	2.2100	2.2314	2.2651	2.2994	2.3835
9.	1.8645	1.9932	2.0934	2.2321	2.3012	2.3346
10.	2.0032	2.1625	2.2236	2.3067	2.3770	2.5341
11.	1.8146	2.1273	2.2205	2.2830	2.3036	2.4104
12.	1.4523	1.5759	1.6583	1.6789	1.7410	2.5750
13.	1.6342	1.6845	1.7904	1.9036	1.9974	2.6320
14.	1.4390	1.5040	1.5865	1.6734	1.8567	2.5445
15.	1.8041	1.8634	1.9239	1.9706	2.0313	2.7354
Average	1.8300	1.9830	2.0593	2.1541	2.2265	2.4861

APPENDIX TABLE NO-2.

EFFECT OF DIFFERENT HEAT TREATMENTS ON THE CURD
TENSION (GM.) OF GOAT MILK

Sample No.	Raw Milk	Pasteurized Milk		Just Boiling	Simmering (95°C/3 mts.)	Sterilization (121°C/15 mts.)
		Holding method	H.T.S.T. method			
1.	38.40	36.84	32.00	30.04	27.50	15.00
2.	34.84	30.00	30.00	27.24	25.30	17.50
3.	36.60	37.00	30.20	30.14	27.34	18.40
4.	34.44	30.00	29.32	27.00	26.84	14.20
5.	38.24	36.00	30.40	28.40	25.12	13.50
6.	39.40	35.48	32.50	25.50	22.65	15.48
7.	41.40	36.28	33.16	30.00	27.24	14.44
8.	48.42	48.42	43.22	27.62	26.58	15.14
9.	37.00	34.30	30.60	25.33	24.43	13.02
10.	43.00	39.00	36.50	27.65	24.50	16.00
11.	41.50	38.00	36.70	30.90	24.00	14.80
12.	40.00	36.00	34.00	26.29	19.00	15.10
13.	41.20	37.44	30.80	26.60	23.42	13.06
14.	42.60	40.20	37.42	29.04	25.50	15.20
15.	40.55	38.42	34.60	27.30	32.93	14.00
Average	39.85	36.89	33.43	27.94	25.49	14.99

APPENDIX TABLE NO - 3

EFFECT OF DIFFERENT HEAT TREATMENTS ON THE TITRATABLE
ACIDITY (EXPRESSED AS LACTIC ACID)
OF GOAT MILK

Sample No.	Raw Milk	Pasteurised Milk		Just Boiling	Simmering (95°C/3 mts.)	Sterilization (121°C/15 mts.)
		Holding method	H.T.S.T. method			
1.	0.14	0.14	0.14	0.15	0.15	0.17
2.	0.12	0.12	0.12	0.12	0.13	0.15
3.	0.14	0.14	0.14	0.14	0.14	0.16
4.	0.15	0.15	0.15	0.15	0.16	0.19
5.	0.13	0.14	0.13	0.14	0.15	0.17
6.	0.14	0.14	0.14	0.15	0.16	0.18
7.	0.17	0.17	0.17	0.17	0.17	0.19
8.	0.15	0.15	0.15	0.15	0.16	0.17
9.	0.13	0.13	0.13	0.13	0.13	0.16
10.	0.16	0.16	0.16	0.16	0.17	0.19
11.	0.17	0.17	0.17	0.18	0.18	0.20
12.	0.17	0.17	0.17	0.17	0.19	0.20
13.	0.18	0.18	0.18	0.18	0.19	0.21
14.	0.14	0.15	0.14	0.15	0.15	0.16
15.	0.13	0.13	0.13	0.13	0.14	0.15
Average	0.148	0.149	0.148	0.151	0.158	0.176

APPENDIX TABLE NO - 4

EFFECT OF DIFFERENT HEAT TREATMENTS ON THE pH VALUE OF GOAT MILK.

Sample No.	Raw Milk	Pasteurised Milk		Just Boiling	Simmering (95°C/3 mts.)	Sterilization (121°C/15 mts.)
		Holding method	H.T.S.T. method			
1.	6.44	6.42	6.42	6.40	6.40	6.27
2.	6.45	6.44	6.42	6.38	6.32	6.15
3.	6.51	6.50	6.48	6.46	6.39	6.12
4.	6.52	6.49	6.49	6.46	6.30	6.01
5.	6.70	6.70	6.69	6.59	6.44	6.20
6.	6.55	6.59	6.56	6.48	6.33	6.07
7.	6.60	6.58	6.56	6.50	6.50	6.39
8.	6.41	6.38	6.38	6.36	6.34	6.16
9.	6.48	6.46	6.46	6.42	6.42	6.29
10.	6.50	6.48	6.46	6.41	6.40	6.18
11.	6.60	6.58	6.54	6.50	6.50	6.39
12.	6.41	6.38	6.38	6.36	6.34	6.06
13.	6.48	6.45	6.44	6.42	6.42	6.09
14.	6.54	6.52	6.50	6.50	6.50	6.20
15.	6.57	6.56	6.56	6.54	6.50	6.26
Average	6.57	6.50	6.49	6.45	6.41	6.20

APPENDIX TABLE NO - 5

EFFECT OF DIFFERENT HEAT TREATMENTS ON THE FAT CONTENT OF
GOAT MILK

Sample No.	Raw Milk	Pasteurised Milk		Just Boiling	Simmering (95°C/3 mts.)	Sterilization (121°C/15 mts.)
		Holding method	H.T.S.T. method			
1.	3.00	3.00	3.00	3.00	2.90	3.00
2.	3.10	3.10	3.10	3.10	3.10	3.10
3.	4.50	4.40	4.40	4.40	4.50	4.50
4.	4.00	4.00	4.00	3.95	4.00	4.00
5.	4.10	4.00	4.00	4.10	4.10	4.10
6.	4.00	4.00	4.00	4.00	3.90	4.00
7.	3.70	3.70	3.70	3.70	3.70	3.70
8.	4.00	4.00	4.00	3.95	3.90	4.00
9.	3.90	3.90	3.90	3.85	3.90	3.80
10.	4.30	4.30	4.30	4.30	4.20	4.30
11.	4.20	4.20	4.20	4.15	4.20	4.20
12.	4.00	4.00	4.00	4.00	4.00	4.00
13.	4.50	4.50	4.50	4.45	4.50	4.50
14.	4.50	4.50	4.45	4.50	4.45	4.50
15.	4.30	4.30	4.30	4.30	4.30	4.30
Average	4.00	3.99	3.99	3.98	3.98	4.00

APPENDIX TABLE NO - 6.

EFFECT OF DIFFERENT HEAT TREATMENTS ON THE SPECIFIC GRAVITY OF GOAT MILK

Sample No.	Raw Milk	Pasteurised Milk		Just Boiling	Simmering (95°C/3 mts.)	Sterilization (121°C/15 mts.)
		Holding method	H.T.S.T. method			
1.	1.0300	1.0300	1.0300	1.0303	1.0304	1.0302
2.	1.0320	1.0320	1.0320	1.0320	1.0321	1.0322
3.	1.0315	1.0319	1.0319	1.0319	1.0320	1.0320
4.	1.0310	1.0310	1.0310	1.0311	1.0310	1.0310
5.	1.0320	1.0325	1.0325	1.0325	1.0325	1.0322
6.	1.0320	1.0322	1.0322	1.0324	1.0325	1.0325
7.	1.0320	1.0320	1.0320	1.0322	1.0322	1.0320
8.	1.0318	1.0318	1.0318	1.0319	1.0320	1.0320
9.	1.0317	1.0317	1.0318	1.0320	1.0321	1.0324
10.	1.0332	1.0333	1.0333	1.0333	1.0336	1.0336
11.	1.0331	1.0331	1.0331	1.0332	1.0332	1.0332
12.	1.0331	1.0331	1.0331	1.0331	1.0331	1.0332
13.	1.0330	1.0330	1.0330	1.0332	1.0332	1.0332
14.	1.0300	1.0300	1.0300	1.0300	1.0300	1.0300
15.	1.0305	1.0306	1.0306	1.0304	1.0302	1.0303
Average	1.0317	1.0318	1.0318	1.0319	1.0320	1.0320

APPENDIX TABLE NO - 7.

EFFECT OF DIFFERENT HEAT TREATMENTS ON THE TOTAL
SOLIDS CONTENT OF GOAT MILK

Sample No.	Raw Milk	<u>Pasteurised Milk</u>		Just Boiling	Simmering (95°C/3 mts.)	Sterilization (121°C/15 mts.)
		Holding method	H.T.S.T. method			
1.	11.240	11.240	11.240	11.315	11.220	11.290
2.	11.860	11.860	11.860	11.860	11.880	11.910
3.	13.415	13.395	13.395	13.395	13.540	13.540
4.	12.690	12.690	12.680	12.590	12.690	12.690
5.	13.060	13.060	13.065	13.185	13.185	13.110
6.	12.940	12.965	12.965	13.040	12.945	13.065
7.	12.580	12.580	12.580	12.630	12.630	12.580
8.	12.890	12.890	12.890	12.855	12.820	12.940
9.	12.745	12.745	12.770	12.760	12.845	12.800
10.	13.600	13.600	13.600	13.600	13.580	13.700
11.	13.455	13.455	13.455	13.420	13.480	13.480
12.	12.940	12.940	12.940	12.940	12.940	13.240
13.	13.790	13.790	13.790	13.780	13.840	13.840
14.	13.040	13.040	12.990	13.040	12.980	13.040
15.	12.925	12.950	12.950	12.900	12.850	12.875
Average	12.878	12.880	12.878	12.887	12.895	12.940

APPENDIX TABLE NO - B

EFFECT OF DIFFERENT HEAT TREATMENTS ON THE TOTAL REDUCING
CAPACITY (EXPRESSED AS mg. CYSTINE HCl/g. MILK)
OF GOAT MILK

Sample No.	Raw Milk	Pasteurised Milk		Just Boiling	Simmering (95°C/3 mts.)	Sterilization (121°C/15 mts.)
		Holding method	H.T.S.T. method			
1.	0.390	0.400	0.425	0.445	0.465	1.250
2.	0.360	0.375	0.385	0.410	0.450	1.187
3.	0.445	0.465	0.475	0.485	0.557	1.650
4.	0.280	0.290	0.320	0.340	0.360	0.900
5.	0.305	0.390	0.405	0.425	0.445	0.950
6.	0.260	0.260	0.270	0.300	0.330	0.900
7.	0.200	0.290	0.300	0.310	0.330	0.825
8.	0.300	0.315	0.315	0.320	0.340	0.800
9.	0.270	0.270	0.280	0.300	0.310	0.700
10.	0.235	0.250	0.250	0.270	0.280	0.650
11.	0.225	0.225	0.250	0.260	0.260	0.650
12.	0.250	0.250	0.250	0.260	0.280	0.625
13.	0.325	0.330	0.330	0.345	0.350	0.775
14.	0.260	0.260	0.260	0.270	0.300	0.700
15.	0.385	0.400	0.400	0.400	0.415	1.000
Average	0.310	0.318	0.327	0.342	0.364	0.904

APPENDIX TABLE NO. - 9

EFFECT OF DIFFERENT HEAT TREATMENTS ON THE TBA VALUES

(EXPRESSED AS OPTICAL DENSITY) OF GOAT MILK.

Sample No.	Raw Milk	Pasteurised Milk		Just Boiling	Simmering (95°C/3 mts.)	Sterilization (121°C/15 mts.)
		Holding method	H.T.S.T. method			
1.	0.050	0.052	0.054	0.059	0.070	0.14
2.	0.045	0.050	0.052	0.070	0.075	0.14
3.	0.035	0.035	0.035	0.045	0.048	0.17
4.	0.040	0.050	0.050	0.060	0.065	0.16
5.	0.035	0.035	0.035	0.045	0.065	0.13
6.	0.045	0.050	0.070	0.075	0.090	0.14
7.	0.030	0.035	0.035	0.045	0.050	0.15
8.	0.030	0.035	0.035	0.040	0.045	0.12
9.	0.040	0.040	0.045	0.055	0.065	0.17
10.	0.030	0.035	0.040	0.050	0.050	0.13
11.	0.050	0.050	0.050	0.055	0.055	0.16
12.	0.030	0.030	0.035	0.040	0.045	0.14
13.	0.035	0.035	0.040	0.045	0.060	0.13
14.	0.030	0.035	0.035	0.050	0.065	0.14
15.	0.040	0.040	0.045	0.060	0.070	0.15
Average	0.037	0.040	0.043	0.052	0.061	0.14

APPENDIX TABLE - 10

EFFECT OF STERILIZATION ON TBA VALUE IN MICROMOLE
HMF PER LIT. OF GOAT MILK

No. of milk samples.	Sterilization (at 15 psig/15 minutes)
1	5.928
2.	5.928
3.	8.208
4.	7.448
5.	5.168
6.	5.928
7.	6.688
8.	4.408
9.	8.208
10	5.168
11.	7.448
12.	5.928
13.	5.168
14.	5.928
15.	6.688
Average	6.2826.

VERIFIED
Manjeet Singh
Signature

