STUDIES ON PREPARATION OF CHHANA FROM TREATED BUFFALO MILK AND ITS SUITABILITY FOR RASAGOLLA

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CERTIFICATE

Sri M. Suguna Rao, has satisfactorily prosecuted the course of research and that the thesis entitled "Studies on preparation of chhana from treated buffalo milk and its suitability for Rasagolla" submitted, is result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any University.

(M. RAMA RAO)
Major Advisor.

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CERTIFICATE

This is to certify that the thesis entitled "Studies on preparation of chhana from treated buffalo milk and its suitability for Rasgolla" submitted in partial fulfilment of the requirements for the degree of Master of Veterinary Science (Dairy Technology) of the Andhra Pradesh Agricultural University Hyderabad, is a record of the bonafide research work carried out by Sri M. Suguna Rao under my guidance and supervision. The subject of the thesis has been approved by the student's advisory committee.

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of investigation have been duly acknowledged by him.

(M. RAMA RAO)
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ABSTRACT

An investigation was carried out inorder to evolve a suitable combination of buffalo milk with different treatments and coagulants for production of chhana suitable for acceptable quality of rasagolla. The product obtained by using variable combinations of buffalo milk such as buffalo milk alone, buffalo milk with 0.3 per cent sodium citrate, buffalo milk with 20 per cent dilution by water, buffalo milk with 20 per cent dilution by water with 0.3 per cent sodium citrate and by using coagulants such as citric acid, lactic acid, calcium lactate was compared with cow milk chhana obtained by same coagulants.

The quality of chhana as well as rasagolla obtained during the course of investigation was evaluated in respect of moisture content, protein, pH, acidity, springiness, penetrometer reading. The recovery of total solids by these combinations was also recorded.

Basing upon the information generated from this investigation it is recommanded that;

i. For higher total solids recovery buffalo milk 20 per cent dilution by water with 0.3 per cent sodium citrate coagulated with calcium lactate is preferable,

ii. Among coagulants calcium lactate results in highest total solids recovery irrespective of raw material used,

iii. High moisture in chhana is obtained from buffalo milk with 30 per cent dilution by water with lactic acid as coagulan

iv. Cow milk coagulated with calcium lactate results in high protein content in chhana,

v. Sodium citrate treatment results in high moisture, low protein, high Ph and low acidity in chhana irrespective of raw materials; and

vi. Citric acid when used as coagulant results in low acidity in chhana irrespective of raw materials.

For best quality rasagolla buffalo milk with 20 per cent dilution by water with 0.3 per cent sodium citrate with citric acid as a coagulant is recommended which is almost similar to that of rasagolla from cow milk chhana.

INTRODUCTION

CHAPTER I

INTRODUCTION

Among the Indian milk products chhana is an important organic acid coagulated whole milk product. It is used primarily as a base and filler for variety of Indian sweets such as Rasagolla, sandesh etc. Rasagolla commands an important place among Indian sweets due to its popularity and its export potential for which chhana is used as a base.

About four per cent of total milk produced in India is converted into this product (Aneja *et al*., 1982) and its production is concentrated mostly in North-Eastern parts of India. Although PFA regulations permit the use of buffalo milk as a base material for chhana, cow milk is largely used for chhana meant for Rasagolla making, because it yields superior and acceptable quality.

Although some information is available on utilisation of buffalo milk for chhana making, there is need for further investigation in order to simplify the technique of chhana preparation using buffalo milk in place of cow milk without quality problems.

Keeping in view this aspect an investigation has been planned to modify buffalo milk by dilution with water and/or with permitted additive such as sodium citrate as raw material and coagulating with three different coagulants such as citric acid, lactic acid and calcium lactate to evolve a suitable combination for chhana production with the following objectives:

1. To study the effect of coagulants, dilution and/or addition of sodium citrate on the solids recovery and quality of chhana from buffalo milk.

2. To compare the physico-chemical characteristics of chhana prepared from the treated buffalo milk with that of cow milk.

3. To study the suitability of chhana prepared from treated buffalo milk for Rasagolla making.

In order to determine the suitability of chhana obtained from variable combinations for an acceptable quality of Rasagolla the quality of chhana has to be evaluated in respect of moisture content, pH, acidity, springiness and penetrometer reading.

The present investigation is therefore expected to help in evolving simple technology for conversion of buffalo milk into a good quality Rasagolla, a delicious Indian sweet meat.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Chhana is an organic acid coagulated Indian milk product which enjoys great popularity in eastern parts of India. This product is becoming increasingly popular in other parts of India in recent times because it is used as a base and filler for a delicious Indian sweet meat "Rasagolla". The quality of rasagolla mostly depends upon the quality of chhana which inturn is influenced by type and composition of milk; temperature of heat treatment and coagulation; type and amount of coagulant used, pH of coagulation, type and amount of additives such as emulsifiers and stabilizers etc. The review hereunder covers published information on the aspects which have direct and/or indirect influence on quality of chhana and rasagolla including recent developments in chhana making technology.

2.1 COMPOSITIONAL DIFFERENCES BETWEEN COW AND BUFFALO MILK

Utilisation of buffalo milk for preparation of chhana has received ever increasing interest in recent years because of its abundant availability although cow milk yields better chhana. The compositional differences in cow and buffalo milk which influence chhana quality are reviewed hereunder.

According to Davies (1939) buffalo milk has 84.2 per cent water, 6.6 per cent fat, 3.9 per cent protein, 5.2 per cent lactose, 0.8 per cent ash and cow milk contain 86.6 per cent water, 4.6 per cent fat, 3.4 per cent protein, 4.9 per cent lactose and 0.7 per cent ash.

IDRI Annual Report (1968) stated that Murrah buffalo milk contain 83.63 per cent water, 6.56 per cent fat, 3.88 per cent protein, 5.23 per cent lactose and 0.70 per cent ash and Sindhi cow contain 86.07 per cent water, 4.90 per cent fat, 3.42 per cent protein, 4.91 per cent lactose and 0.70 per cent ash.

According to Henderson (1971) Jersey cow contain 86.09 per cent water, 5.37 per cent fat, 3.92 per cent protein, 4.93 per cent lactose and 0.71 per cent ash.

Akhundov *et al.* (1983) studied the composition and properties of milk of buffaloes and observed 8.75 per cent milk fat, 4.37 per cent protein, 4.85 per cent lactose and 0.79 per cent minerals. The calcium and phosphorus contents were observed to be 0.168 and 0.134 per cent respectively.

El-Derbary *et al.* (1983) studied milk composition of 30 Kenadi cows and found the average values for milk fat, SNF, TS and Sp gr. over the first 32 weeks of lactation as 4.75 per cent, 8.96 per cent , 13.68 per cent and 1.031 respectively.

2.1.1 Proteins

Proteins exists in milk in the form of a complex particles or micelle with considerable quantities of calcium and phosphate and a little of magnesium and citrate. The proteins remaining in solution after removal of the casein are called whey proteins.

Ghosh and Anantakrishnan (1964) observed that the per cent caseins ranged from 2.32 to 3.14 and 2.72 to 3.60 in cow and buffalo milks respectively.

Singhal and Ganguli (1965) studied the electrophoretic pattern and N-terminal amino acids of caseins from cow and buffalo milks after trypsin action and stated that the mobilities of α , β and γ casein components vary for cow and buffalo milks.

Dilanyan *et al.* (1966) has showed that buffalo milk contains more α -casein and less γ -casein than the cow milk.

Ganguli (1969) extensively studied the differences between the cow and buffalo milk protein and found that except globulin all the fractions are in higher concentrations in buffalo milk. Buffalo milk casein was found to have less associated charge than cow milk casein. The milk of cow was observed to contain both K-casein A and K-casein B either singly or as blend (A/B), whereas buffalo milk samples exhibited the presence of K-casein A B together. The sialic acid content of buffalo milk casein was estimated to be almost half of cow milk casein. The casein particles were observed to differ in size being larger in buffalo milk than in cow milk, consequently the former settled at a lower centrifugal force.

Majumdar and Ganguli (1970) in their electrophoretic studies found that the major difference in the composition of casein from cow and buffalo milk was in the κ-casein fraction. In cow the relative concentration of κ-casein-A was remarkably higher than κ-casein-B, where a reverse was the case with buffalo milk .

Pershotam Kumar *et al.* (1971) observed the differences in the micellar and soluble caseins in buffalo and cow milk and reported the values as 78.02, 0.80 & 70.63 and 3.32 per cent respectively.

Ramachandran *et al.* (1973) studied the electrophoretic pattern of cow and buffalo milk proteins and observed that at pH 8.6 (Veronal) the α- and β -casein of cow milk migrate faster than the corresponding fractions of buffalo milk and at pH 6.5 the α - and β -caseins of buffalo milk have higher mobility than corresponding fractions of cow milk by paper electrophoresis. Further starch gel electrophoresis of cow and buffalo casein using cacodylate buffer was found to resolve cow milk casein into 7 components and buffalo milk casein into 9 components. By polyacrylamide gel electrophoresis the author found that cow skim milk gives 8 components and that of buffalo skim milk 9 components.

Sood *et al.* (1976) reported that in both cow and buffalo milks smaller micelles contained less calcium and phosphate and more κ-casein than the larger micelle.

Jayaram and Nair (1979) observed the electrophoretic behaviour of buffalo milk casein and concluded after comparativ study that either α s_1 casein might be absent in the buffalo mi[lk] caseins or if present it might be in negligible quantities.

Clark *et al.* (1983) studied the buffering capacity of bovine milk proteins and stated that bovine α-lactalbumin and β-lactoglobulin - A and B were able to buffer half as much 0.1 M Hcl as could casein. The major buffering capacity of the whey proteins was in the pH range 4.0 - 4.5 and that of casein was at pH 5.0 - 6.3. It is concluded that casein would provide more buffering capacity than the whey protein in the new born.

Jurea *et al.* (1983) studied the amino acid contents of milk of Slovakian pied cows and observed the mean values of 16 amino acids as lysine 0.236, histidine 0.096, arginine 0.113, asparatic acid 0.252, threonine 0.154, serine 0.172, glutamic acid 0.704, proline 0.302, glycine 0.068, alanine 0.108, valine 0.171, methionine 0.042, isoleucine 0.146, leucine 0.296, tyrosine 0.154, phenylalanine 0.154 traces amounts of cystine.

Al-Abdm *et al.* (1984) reported that both cow and buffalo paracasein complex had higher moisture contents than the corresponding caseins. Fat, calcium and inorganic 'P' were higher in casein and para casein complex of buffaloes than of cow's milk and para casein from both buffaloes and cow's milk contained more calcium and inorganic phosphate than the corresponding casein.

Mehanna *et al.* (1984) reported that buffaloes K-casein contained less sialic acid and hexose than cow K-casein, whereas their phosphate contents were only slightly different. The amino acid composition of buffaloes K-casein, and its fractions were found to be similar but not identical.

2.1.2 Milk Fat

Fat enriches flavour and contribute to body and texture of chhana. The compositional differences of fat of cow and buffalo milk are reviewed hereunder.

Ahmed and Rifat (1969) stated that the buffalo milk fat contained higher amounts of similar nature of carbonyls than cow milk fat.

According to Albanico *et al.* (1969) the poly unsaturated fatty acids, tetra and pentaenoic were significantly in higher amounts in buffalo than in cow milk fat.

Ramamurthy and Narayanan (1971) reported that the fatty acids 4:0, 16:0 and 18:0 were distinctly higher and the fatty acids 6:0, 8:0, 10:0, 12:0 and 14:0 were significantly lower in buffalo than in cow milk fat.

Pruthi *et al.* (1972) found that the phospholipids in buffalo milk contained fatty acids from C_{12} to C_{26} and that their characteristic feature was the presence of C_{22}, C_{23} and C_{24} saturated fatty acids and C_{25} and C_{26} unsaturated fatty acids.

Ramamurthy (1972) reported that the intramolecular distribution of fatty acids between 1, 3 - and 2 - positions of triglycerides were non-random and similar in cow and buffalo milk fat.

Ramamurthy and Narayanan (1976) stated that the trisaturate glyceride contents were similar in cow and buffalo milk fats however the high melting triglyceride contents of buffalo milk fats (average 8.7%) were higher than that of cow milk fat.

According to Ramamurthy (1976) buffalo milk fat is richer than cow milk in butyric acid, the long chain fatty acids (Palmitic and stearic acids) and some polyunsaturated acids such as tetraenoic and pentaenoic acids. Decenoic acids is however found in traces in buffalo milk fat.

Hofi et al. (1977) found that buffalo milk contained less fat globular membrane material than cow milk fat.

Gone et al. (1980) stated that buffalo milk fat was characterised by higher levels of branched chain fatty acids (2.7%); lower levels of linolic acid (0.5%) than in cow milk fat (1.8% and 0.9%).

Sankhla et al. (1981) studied the physico-chemical constan of milk fat from various species and reported that Reichert - Meissel number was high in buffalo milk than in sheep, cow and goat. They further stated that goat milk was highest cholestrol followed by cow, buffalo and sheep.

Armughan et al. (1982) studied the triacylglycerol composition of buffalo milk fat and stated that $C_{18:1}$ fatty acids were concentrated in high melting triglycerides; $C_{6:0}$, $C_{8:0}$ and $C_{10:0}$ tend to be located in medium melting triglycerides and low melting triglycerides were unique in containing all of the $C_{4:0}$.

Kuldip et al. (1982) reported that the buffalo milk fat globular membrane contains approximately 60 per cent protein, and 40 per cent lipid, neutral lipids comprised about 73 per cent of the total lipids. The rest being phospholipids. Triglycerides formed the major neutral lipid component whereas phosphotidyl choline and sphingomyeline were found to be the major phospholipid component.

2.1.3 Minerals

Ismail et al. (1971 i) studied about the minerals, calcium and magnesium in cow and buffalo milks related to their stabili on heating and they stated that - the concentration of total, soluble and ionic calcium and magnesium are higher in buffalo milk, than in cow milk. Precipitation and deionisation of calcium and magnesium occurred and increased on heating in buffalo than in cow milk. The concentration of soluble and ionic calcium or magnesium in all heated milks were found to be always higher in buffalo than in cow milk.

Ismail et al. (1971 ii) reported that the sum of soluble phosphorus and soluble citrate in cow milk was nearly double than that of in buffalo milk and the inorganic phosphorus is higher in buffalo than in cow milk.

Ismail *et al.* (1971 iii) studied about the relationship of calcium and magnesium to phosphate and citrate in cow and buffalo milks related to their stability on heating and stated that the ratios of the sum of total calcium + magnesium to the sum of total phosphate + citrate and the sum of ionic calcium + magnesium to the sum of soluble phosphate + citrate were 0.66, 0.70 and 0.31 for buffalo milk and 0.47, 0.33 and 0.13 for cow respectively. The two later ratios were found to be decreased with increasing of the severity of heating the milk. The decrease was higher in buffalo than cow milk, and was more affected by forewarming.

Ismail *et al.* (1971 iv) studied comparatively the minerals in cow and buffalo milks to their stability on heating and concluded that the change in milk stability on heating at different temperatures is greater in buffalo milk, due to the greater change in the salt system of the former milk than that of the latter.

Pinto *et al.* (1978) estimated mineral contents in fresh milk samples and reported mean value in g/l were Na = 0.35, K = 1.97, Ca = 1.28, P = 0.82 and Ca/P = 1.58. Further a significant correlations between Na and K contents were also reported.

Ganguli (1979) studied about the minerals in milk and stated that among minerals in cow or buffalo milk calcium, phosphorus and chlorides are relatively more prominent and next comes sodium and potassium. Buffalo milk is even more rich in calcium and phosphorus.

De (1980) reported the mineral salt differences in cow and buffalo milks and stated that buffalo milk contain more calcium and phosphorus (0.22% and 0.13%) than cow milk (0.12% and 0.09%). The calcium/phosphorus ratio is higher in buffalo milk (2.26) than cow milk (1.96). There are more cations (Ca and Mg) in buffalo milk but fewer anions (phosphate and citrate) lastly the soluble forms of calcium, magnesium and citrate are lower in buffalo milk than cow milk.

2.2 EFFECT OF HEAT ON MILK AND ITS CONSTITUENTS

Processing of milk invariably involves heat treatments. Heat induced changes are reviewed hereunder:

2.2.1 Effect of Heat on Casein

On paper electrophoresis of raw milks from various species Dostioco and Uberatalle (1964) observed three fractions. On heat treatment the authors reported an increase in the third peak at the cost of first two peaks.

Pallansch *et al.* (1966) observed electrophoretically a new unique compound of high molecular weight having mobility between α S and β -caseins obtained from milk heated to 115°C for different periods. The authors further observed that the compound increased with increasing heat treatments.

Fitzpatric and Sullivan (1967) could demonstrate interaction between α and β -caseins along with complex formation with β lactoglobulin when milk was subjected to different processings. Complex formation was observed to be dependent upon the type of treatment given to milk.

Murthy *et al.* (1958) reported that high temperature short time sterilization of milk did not hydrolyse protein (casein) but it denatured some serum proteins.

Brown (1963) reported that mobility of casein increased with increasing heat treatments (180° to 300°F) of milk indicating the break down of micellar casein into smaller aggregates

Kenkare and Hansen (1967) demonstrated a reversible heat induced dissociation of α S-casein complex into α S-casein and K - casein which occurred between 45°-54°C as revealed by sephadex gel filtration and ultra centrifugation.

Tessier *et al.* (1969) observed complex formation of β -lactoglobulin and K - casein when a mixture of these proteins was heated at 80°C. Further extensive degradation of K - casein was observed when it was heated to 140°C.

Demios et al. (1973) concluded that on pasteurisation of milk at various temperatures α s and β -caseins were not affected whereas K - casein was destructed with increase in pasteurization temperatures.

Deissmann (1977) heated cow milk from 65° to 120°C for a period ranging from 30 seconds to 30 minutes and observed that the electrophoretic mobility of casein fractions changes even below 100°C. It was further observed that immunoglobulins were most affected and α -lactalbumin was least affected and proteose peptone fractions were not significantly denatured below 110°C.

Aggregation of buffalo acid casein on heating to 90°C was more when compared with cow acid casein as observed by Stephen and Ganguli (1977).

Hexoses and in hexosamines in casein samples were observed to increase whereas sialic acid decreased when milk was treated at various temperatures upto sterilization as reported by Arnughan et al. (1979).

Ganguli (1979) reported that cow K - casein stabilises α s -casein against precipitation by calcium better than buffalo K - casein.

Haggag et al. (1982) studied the heat induced changes in buffalo casein micelles and observed that casein micelles and β -lactoglobulin obtained from buffaloes milk were redispersed in fresh and preboiled filtered ultrafiltrate from the same milk.

2.2.2 Effect of Heat on Whey Proteins

Ramsdell and Whittar (1953) concluded that the albumin and globulin of milk may be denatured by heating the milk and thus rendered coagulable by acid, salts or rennet.

Larson and Rolleri (1955) concluded that out of all serum proteins, lactalbumin was the most resistant for denaturation.

Koyama and Suzuki (1964) observed heat coagulation of lactalbumin between pH 4.27 and 5.80 and the temperature of coagulation from 68.5° to 88.0°C.

Melachouris and Tucky (1966) reported that denaturation of whey proteins markedly increased as the heat treatment increased and total albumin showed a low degree of denaturation at the lower temperature of heating but, at the higher temperature the denaturation was similar to that of the whey protein fraction.

Sullivan (1971) observed whey proteins of milk as highly heat labile than casein and undergo conventional heat induced denaturation.

Sabarwal and Ganguli (1972) reported that buffalo milk whey proteins were more susceptible to heat denaturation than those of cow milk, with or without micellar casein. Cow micellar casein stabilized whey proteins against heat denaturation more than buffalo micellar casein in their respective milks.

2.2.3 Effect of Heat on Fats

Bandyopadhyay and Ganguli (1976) studied about the status of fat globule membrane proteins in sterilised milk and they proposed that high treatment of milk like sterilization, brings about structural changes in the milk fat globular membrane.

Ramamurthy (1976) stated that the amount of high melting triglycerides in buffalo and cow milk fats depending upon the season of year ranging from 8.9 to 12.3 and 3.0 to 6.6 per cent respectively. Due to this difference the triglycerides crystallise much earlier in buffalo than cow milk fat and at a given temperature, the amount of crystallised fat or solid fat is much higher in the case of buffalo than cow.

Singh et al. (1976) reported that fat globule membranes from cows milk were fractionated and isolated as three distinct fractions, outer layer, inner layer and interfacial fluff. Chemical analysis of these fractions revealed the following composition (expressed as a per cent of total solids) - protein outer layer 27.40, inner layer 19.61, interfacial fluff 26.61; Lipids - outer layer 63.44, inner layer 41.02 and interfacial fluff 54.02 per cent respectively. According to them phospholipids appeared to constitute about 17, 27 and 23 per cent of the total lipids in the outer, inner and interfacial layers respectively. Neutral lipids contents were found to be similar (about 60% of total lipids) in all three fractions.

Sreethashyam *et al.* (1981) studied buffalo and cow milk fat fractions by crystallization of four fractions of each type of fat at three different temperatures viz., 30°C (fraction IV solid), 25°C (fraction III solid) and 18°C (fraction II and I solid and liquid respectively). The yield of the respective fraction was 42.9, 40.4, 11.4 and 6.2 per cent for buffalo butter fat and 25.8, 34.9 and 10.7 per cent for cow butter fat.

2.2.4 Heat Induced Changes in Minerals

Gehrke *et al.* (1963) studied the ionic equilibria in raw and heat treated skim milks and reported that 96 - 98 per cent of calcium and magnesium in raw skim milk were available in free form, whereas the calcium availability was progressively decreased by heat treatment at increasing temperatures and reached 8 per cent of total after 15 minutes at 120°C. However the authors reported that the total cationic and anionic activity was not altered. Similar observation was also made by Baker *et al.* (1964).

Christianson *et al.* (1964) determined the ionised calcium and magnesium in milk and reported that only small proportions of calcium and magnesium were in ionic state and the rest formed complexes with other constituents. The authors also observed that the ionic calcium decreased with increase in pH, addition of citrate or with heat treatment.

Jennes and Coulter (1954) observed that reduction in calcium ion concentration was helpful in stabilizing milk during further stages of drying, when solids were high and particularly casein being susceptible to destabilization.

According to Evenhuis (1967) calcium and phosphate ratio in milk serum at a particular heating temperature was of great importance for the heat stability of milk, whereas phosphate activity largely depends on the pH and on the total phosphate of the milk serum. The authors also showed that on heating milk, the Ca^{++} ion activity increased by dissociation of the calcium citrate complex proportionately to heating temperature.

Pyne (1969) studied the calcium concentration in relation to the heat coagulation of milk. It was observed by the author that the 'effective' calcium ion concentration correlates some what better with the coagulation time of heated milk than the actual calcium ion concentration in milk. However, he reported that even with both these estimations the coagulation promoting properties of milk serum at higher temperature cannot be measured satisfactorily.

Rose and Tessier (1969) demonstrated the differences in the mineral compositions of ultra filtrates obtained from the heat treated and cold milks. According to these authors calcium and phosphate passing in ultrafiltrate at 200°F (93.3°C) was nearly 5.0 per cent and 82.0 per cent respectively of that found when the milk was cooled to 80°F (26.7°C) on the other hand, the hydrogen ion concentration of ultrafiltrate collected at 200°F (93.3°C) was merely double that of ultrafiltrate obtained at 80°F (26.7°C)

Pyne (1962) showed that the influence exerted by milk salts on the phenomenon of heat coagulation was complicated by various side effects of heating milk which include denaturation of serum-proteins, disintegration of casein, production of acid from displacement of phosphate equilibrium and decomposition of lactose and casein, formation of protein complexes and protein lactose combinations.

Jennes and Patton (1959) stated that as per the Sommer and Hart theory the optimum stability of milk depend on a certain ratio of calcium and magnesium ions to those of phosphates and citrates. This concept was useful in developing practical procedures for controlling stability of milk during boiling and sterilization.

Fox and Hoynes (1975) while studying the influence of colloidal calcium phosphate and β -Lactoglobulin on the heat stability of milk observed that reduction in the level of colloidal calcium phosphate (CCP) progressively increased the heat stability of milk at pH values $\angle$ 7.0. The authors suggested that the true effect of β-lactoglobulin was to shift the heat stability pH curve to more acid pH value and to sensitise the caseinate system to heat induced calcium phosphate precipitation at pH values $>$ 7.0.

Balwant Rai Puri et al. (1977) stated that exchange of calcium by sodium in the caseinate complex enhances heat stability of milk. This effect increases with increase in the extent of the exchange but as sodium to calcium ratio in the complex exceeds 1:2, there is marked destabilization of the milk.

Okonogi et al. (1979) studied the effect of inorganic and organic salts upon heat stability of skim milks subjected to demineralisation. The authors observed that due to change in salt equilibrium the extensive heat stability changed to limited heat stability at low pH in demineralized skim milk samples on heating at 130°C.

Sindhu and Roy (1982) reported that heat treatments of buffalo milk caused significant lowering in the concentrations of soluble Mg only and not in other mineral constituents. Concentrations of Ca, K, Na and Cl in the soluble phase decreased slightly that of citrate marginally increased and 'P' content was un altered after the milk was heated.

2.3 ROLE OF STABILISERS AND THEIR ADDITIVES IN CHANGE OF MILK CHARACTER

Templeton *et al.* (1929) reported that addition of either citric acid or an equal amount of sodium citrate to milk increased the volatile acidity by approximately 80 per cent and did not increase the total acidity more than 10 per cent.

Gould and Frantz (1945) reported that sodium citrate added as a stabiliser caused rearrangement of salts resulting in a change of buffer capacity which might have decreased the titrable acidity.

Potts and Loskema (1960) considered salt balancing stabiliser in yoghurt as an important factor for preventing whey separation.

Chandrasekhara *et al.* (1967) have suggested that treatment of buffalo milk with either a mixture of sodium diphosphate and sodium phosphate or with 0.1 to 0.2 per cent sodium citrate prior to coagulation to obtain soft chhana.

Kadan and Rulgers (1968) noticed that addition of citrates and polyphosphates increased soluble calcium and magnesium and the effect appeared to be more pronounced with increasing in chain length of polyphosphates.

Olson (1966) reported that sodium citrate added at one per cent level of lactic cultures showed preservation effect due to its buffering action.

El-Sokkary and Al-Sadek (1969) stated that the addition of phosphates or citrate (0.8 to 1.0 gm/100 g milk) to whole milk increased heat stability.

Vaisya and Bose (1973) observed that sodium citrate had reducing effect on curd tension, but volatile acidity increased sharply giving curd of improved flavour.

Kurner (1976) observed that citrates and phosphates prevent fat separation and avoid free fat release during manufacture of processed cheese.

Kruk (1979) who stated that stabilisers added at 0.01 to 0.04 per cent increased casein hydration by 6 - 12 per cent thereby increased the moisture contents in final product.

2.4 DEVELOPMENTS IN CHHANA MAKING TECHNOLOGY

2.4.1 Preparation of Chhana

De and Ray (1954) were the first to make a systematic study on chhana making and prescribed standardised method of its preparation. As per their findings in order to obtain a desirable body and texture in chhana the strength of the coagulant should be 1 to 2 per cent and the pH of the coagulation should be 5.4. Further the coagulation should be carried out at 80°C to 85°C and completed within 30 seconds. Fresh cow milk containing around 4 per cent fat and free from colostrum was recommended for good quality chhana.

El-Sokkary and El-Sadek (1969) stated that the addition of phosphates or citrate (0.5 to 1.0 gm/100 gm milk) to whole milk increased heat stability.

Baisya and Bose (1973) observed that sodium citrate had reducing effect on curd tension, but volatile acidity increased sharply giving curd of improved flavour.

Warner (1976) observed that citrates and phosphates prevent fat separation and avoid free fat release during manufacture of processed cheese.

Kruk (1979) who stated that stabilisers added at 0.01 to 0.04 per cent increased casein hydration by 6 - 12 per cent thereby increased the moisture contents in final product.

2.4 DEVELOPMENTS IN CHHANA MAKING TECHNOLOGY

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Date *et al.* (1968) recommended cow milk for chhana making. They have prescribed a method of boiling the milk for around 5 minutes and allowing to cool by 10° to $15^{\circ}F$, where after a 0.60 to 0.75 per cent lactic acid solution could be added to small lots of milk and immediately poured for draining. Then chhana should be cooled by washing with cold tap water.

Jagtiani *et al.* (1960) demonstrated that more the amount of calcium added to cow milk the harder was the chhana. They have also tried ion exchange resins to reduce calcium content of milk but chhana obtained from such treated milk did not come out satisfactorily for Rasagolla making. According to them addition of 0.2 to 0.3 per cent citrate in buffalo milk as softening agent and storing the hot milk for some time before precipitation helps in producing a very soft chhana which can be used very satisfactorily for Rasagolla making.

Rao (1971) studied the quality of chhana from crossbred cow's milk and recommended that use of 4 per cent fat milk and 0.35 per cent citric acid coagulant by weight of milk would be an ideal combination for chhana suitable for Rasagolla making.

Kanda and De (1972) studied the chhana production from buffalo milk and reported that freshly produced buffalo milk preferably standardized to 4.0 per cent fat and homogenised at 176 kg cm^2 (after pre heating to $60^{\circ}C$) should be brought to boil and promptly cooled to $70^{\circ}C$. Coagulation should then be rapidly effected preferably by addition of 1 per cent citric acid solution to a pH of 5.7 and chhana separated from whey by delayed straining technique with a muslin cloth.

Jagtap and Shukla (1973) working with Kankrej cow's milk and stated that the boiling of homogenised milk with 4.9 per cent fat provided highest yield and percentage recovery of total solids without affecting the quality of chhana.

Jailkhani (1978) studied the utilisation of goat milk for khoa and chhana making and reported that for chhana making the most suitable combinations are 6 per cent fat in milk, 5.5 pH of coagulation and 80°C temperature of coagulation.

Srivastava and Singh (1978) investigated on utilisation of substandard milk for chhana and sweet making and concluded that milk mixed with 75 per cent of fresh milk (pH 6.25) gave acceptable products. The yield of chhana was 14.05 per cent Vs. 14.70 per cent when fresh milk was used.

Shashikawal (1979) studied on utilisation of concentrated and dried milk for chhana making and reported that with higher total solids content in the concentrated milk the coagulation was not complete and loss of milk solids in whey was very high.

Kanwal Soni et al. (1980) reported that buffalo milk, boiled and subsequently coagulated at 70°C with lactic acid at pH 5.7 employed delayed straining after standing at room temperature for 30 minutes yielded chhana having a soft and smooth body suitable for the manufacture of Rasagolla.

Moorthy and Rao (1982) studied production and quality of chhana from goat milk and reported that goat milk with 5 per cent fat and with citric acid as coagulant resulted in higher yields but milk with 3 per cent fat gave chhana with high moisture content. Fat losses in whey were observed to be minimum when lactic acid was used as coagulant and when milk fat was 3 per cent and better quality rasagolla was obtained from chhana made from 4 per cent fat using lactic acid as coagulant.

Sen and De (1984) studied on the use of calcium lactate as a coagulant for chhana and indicated that the yield was higher (23.6 and 24.8%) when compared to citric acid (16.8% and 18.0%) at coagulation temperatures of 86°C and 80°C respectively.

Vaghela *et al.* (1984) reported that super heated condensed milk and addition of glycerolmonostearate and sodium alginate each at 0.15 per cent level gave the best quality chhana from buffalo milk, for rasagolla making which was comparable to cow milk chhana organoleptically.

2.4.2 Recovery and Composition of Chhana

Srinivasan and Anantakrishnan (1964) have reported that the average composition of chhana from cow and buffalo milk prepared under standard conditions using sour chhana whey as coagulant. The respective values for moistures was 53.4 and

51.6 per cent, fat 24.7 and 29.7 per cent, protein 17.6 and 14.5 per cent, lactose 2.2 and 2.4 per cent and ash 2.1 and 1.9 per cent.

Rao (1971) reported that the crossbred cow milk of 4 per cent fat with 0.25 per cent citric acid coagulant gave highest average yield of 17.39 per cent.

Singh and Ray (1977) obtained 20 per cent recovery of chhana when sour whey was used as coagulant while with citric acid and lactic acid the yield was 19 per cent.

Jailkhani (1978) reported that the average chemical composition of standardized chhana as 55.37 per cent moisture, 23.52 per cent fat, 17.26 per cent protein, 2.21 per cent lactose (by difference) and 1.63 per cent ash.

2.4.3 Factors Affecting Physical Quality of Chhana

The body and texture of chhana are influenced by compositional factors like type of milk, calcium content of milk, fat level of milk, presence of colostrum and adulterants. The processing factors like temperature of coagulation, type of coagulant, strength of coagulant, pH of coagulation and straining methods also affect the body and texture.

2.4.3.1 Type of milk: Jagtiani et al. (1980) found that the buffalo milk contains more calcium and yields harder chhana which would be unsuitable for rasagolla making.

Abraham and Rao (1977) used sour milk for chhana making. According to them sour milk ranging from 0.25 to 0.28 per cent acidity could be utilised for the preparation of good quality chhana by adding sodium citrate at the rate of 0.8 per cent and washing the chhana with water. Such chhana yielded rasagolla which was similar to those prepared from fresh milk.

Iyer (1978) reported that in general buffalo milk chhana was harder than its counterpart from cows and mixed milks. The product from buffalo milk was cohesive and losses of milk solids in whey were higher.

Jailkhani and De (1978) reported that chhana from goat milk was similar to that of cow milk, except that it was whitish in colour, it has soft body and smooth texture with a mild acid flavour.

2.4.3.2 Calcium content of milk Jagtiani et al. (1980) demonstrated that the more amount of calcium added to cow milk, the harder was the body of chhana. They have also tried the ion exchange resins to reduce the calcium load of buffalo milk, but the chhana obtained was not satisfactory for rasagolla making.

Daigya and Bose (1974) studied the effect of chemical additives and different salts on the quality of chhana. They observed that the addition of calcium and magnesium chloride to milk produced chhana with soft body, whereas sodium chloride, sodium acetate and sodium citrate did not affect the chhana body significantly.

2.4.3.3 Fat level of milk Ray and De (1953) reported that a minimum fat level of 4 per cent cow milk is essential for production of suitable body and texture in chhana. A fat level lower than this resulted in a hard and rubber body and a coarse texture. They also suggested that the milk with higher fat percentages such as 5 per cent and above are also not desirable.

Date et al. (1968) reported that the buffalo milk adjusted to 4.5 per cent fat and treated with sodium citrate or phosphate mixture may also be used for rasogolla making.

Jailkhani (1978) recommended goat milk with 4 per cent fat level for chhana for quality sandesh.

Moorthy and Rao (1982) suggested 4 per cent fat in goat milk for chhana for quality rasogolla.

2.4.3.4 Presence of colostrum Ray and De (1953) reported that the presence of colostrum in milk affects the texture of chhana and becomes too pasty. Colostrum in cow milk also changes the normal light yellow colour of chhana to a deeper yellow.

2.4.3.5 Adulterants Ray and De (1953) reported that the adulteration of milk with only water reduced the yield of chhana but its texture and flavour remain unaffected. They also report that adulteration of milk with starch resulted in a gelatenous mass on coagulation.

Iyer (1978) concluded that adulteration of milk with 25 per cent water was quite effective as far as soft body of the product from buffalo milk was concerned.

2.4.4 Processing Factors

2.4.4.1 Type of coagulants De and Ray (1954) reported that the two types of coagulants namely citric acid and lactic acid have their characteristic effect on the physical quality of the product. They have also reported that chhana made from citric acid coagulant was good for making sandesh. Whereas chhana made from lactic acid was good for making softer rasogolla.

Srinivasan and Anantakrishnan (1964) have reported that milk coagulated by lactic acid or sour whey produced hard chhana with granular body and texture while coagulated with citric acid or lime juice resulted in a product with soft body and texture.

Ahuja et al. (1977) concluded that citric acid solution always resulted in harder body and texture while lactic acid and sour whey did not show any influence on the quality of final product.

Singh and Ray (1977) studied the effect of milk coagulants on the quality of chhana and chhana whey and reported citric acid did not impart any flavour to chhana whereas lactic acid and sour chhana whey resulted in slightly sour taste and acidic flavour.

Sen *et al.* (1984) reported that the per cent recovery of milk solids in calcium lactate chhana is more than citric acid chhana.

2.4.4.2 Effect of coagulant strength De and Ray (1954) reported an acid strength of coagulant solution ranging from 1 to 2 per cent for citric acid result in soft and smooth chhana.

Date *et al.* (1958) found good result with 0.5 to 0.75 per cent lactic acid for chhana making.

Srinivasan and Anantakrishnan (1964) stated that too dilute acid solutions did not affect the composition of chhana, but that of sour chhana whey did influence the final quality of chhana.

Aneja *et al.* (1977) successfully employed that the sour chhana whey with a developed acidity of about 0.6 per cent lactic acid which was attained in 3 days at 37°C for chhana making.

Sen (1985) reported that a 6 per cent solution of calcium lactate gave the most acceptable quality of chhana.

2.4.4.3 pH of coagulation De and Ray (1954) have reported that the pH of coagulation between 5.4 and 5.5 produced soft and smooth chhana while lower pH resulted in chhana with hard texture.

Srinivasan and Anantakrishnan (1964) observed that coagulation of milk at pH 5.3 produced smooth and soft chhana.

Kundu and De (1972) reported 5.7 as the optimum pH of coagulation for buffalo milk to achieve a suitable product for rasagolla making.

Jailkhani (1978) recommended 5.5 as the optimum pH for achieving a product from goat milk suitable for peda and sandesh making.

Bhattacharya *et al.* (1980) stated that good quality chhana obtained at pH 5.4.

2.4.4.4 Effect of temperature of coagulation: De and Ray (1954) reported that rapid incorporation of coagulant (15 to 45 seconds prevented the temperature to fall below 82°C contrary to which the product become very soft and smooth.

Kundu and De (1972) considered a coagulation temperature of 70°C to be the best for quality chhana.

Aneja *et al.* (1977) and Bhattacharya *et al.* (1980) proposed the coagulation temperature at 80°C.

2.4.4.5 Effect of homogenisation: Kundu and De (1972) observed that homogenised milk produces soft and smooth chhana. The percentage of moisture, yield and milk solids recovery in chhana increased and hardness value decreased on homogenisation of milk (60°C) at 176 kg/cm^2 pressure.

Jagtap and Shukla (1973) reported that the boiled milk homogenized at 100 kg/cm^2 pressure with 4.9 per cent fat provides highest yield and percentage recovery of total solids, fat, protein without affecting the quality of chhana.

Gajendran and Rao (1976) obtained buffalo milk chhana of suitable quality for rasagolla by homogenising 5 per cent fat milk at 140 kg/cm^2 coagulating with 0.5 per cent citric acid at 70°C.

Jailkhani (1978) concluded that homogenisation of goat milk at 2800 PSI resulted in chhana with lesser score for body and texture and also for acceptability than unhomogenised milk.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methodologies employed during present investigation for the technological analytical and statistical aspects.

3.1 LOCATION

The experiment was conducted at the Milk Processing Plant and Laboratories of Dairy Science Department, College of Veterinary Science, Rajendranagar, Hyderabad.

3.2 RAW MATERIALS

3.2.1 Milk

Cow and buffalo milk obtained in sterilised aluminium cans from healthy animals of Dairy Experimental Station, Andhra Pradesh Agricultural University, Hyderabad was used in this experiment.

3.2.2 Citric acid

Obtained from Sarabhai M Chemicals, Baroda was used.

3.2.3 Lactic acid

Ninety per cent extrapure obtained from E. Merck, Bombay was used.

3.2.4 Calcium lactate

Obtained from E.Merck, Bombay was used.

3.2.5 Sodium citrate

According to PFA (1956) sodium citrate can be used both as stabiliser and salt. Obtained from Sarabhai M. Chemicals, 3.2.6 Sugar

Commercial grade of sugar conforming to ISI specifications was used.

3.2.7 Maida

Quality maida obtained from local market was used.

3.2.8 Cardamom

Best quality obtained from local market was used.

3.2.9 Vanila flavour

Vanila flavouring essence conformed to PFA rules manufactur by Jayanthi Industries, Madras was used.

3.3 PROCESSING TECHNIQUES

3.3.1 Separation of Milk

Separation of milk was done under sanitary conditions with a hand operated vulcan level cream separator.

3.3.2 Standardisation of Milk

Standardisation of cow milk to 4.5 per cent fat and buffalo milk for 6 per cent fat was done by using required amounts of cream/skim milk from respective sources.

3.3.3 Method of Preparation of Chhana

The method recommended by Kundu and De (1972) was used with the following modifcations for preparation of chhana.

One kg milk was heated in a heavy base alluminium coagulation vessel to a temperature of 82.5 ± 0.5°C, while stirring continuously to avoid burning and prevent skin formation. The milk was cooled to the required temperature of 72°C for addition of coagulant. The time taken for heating was 7 to 10 minutes and for cooling was 2 - 5 minutes. The coagulation was effected within a minute. The speed of stirring of milk during heating and addition of coagulant was 80 - 100 revolutions per minute.

The delayed method of straining was adopted in this study. The mixture of chhana solids and whey was transferred over a piece of cloth (of suitable size) spread over a clean vessel. The four corners of the cloth were tied together without any pressure and then held over the whey container. Straining of whey being facilitated by gentle turning of the chhana in the cloth a couple of times. After about 1 minute of draining as above the whole mass was immersed in enough tap water and kept in that condition till it cooled down. Chhana was then hung till all droppings stopped. The total time taken for straining was between 30-60 minutes.

3.3.4 Preparation of Rasagolla

The technique followed for the preparation of rasagolla and the quantities of different ingredients was taken as per the procedure mentioned in the outlines of Dairy Technology by De (1980).

3.3.5 Packing and Storage of Rasagolla

Rasagolla with 40 per cent sugar syrup was aseptically packed in pre-sterilized tins and kept in dry cool temperature.

3.4 ANALYTICAL METHODS

3.4.1 Milk

3.4.1.1 Sampling of milk: Sampling of milk was done as per the procedure laid down in IS: 1479 (Part II) - 1961.

3.4.1.2 Fat and SNF estimation: The milk was tested for fat and SNF, as per the procedure described in IS: 1224 (Part I) 1977 and IS: 3188 - 1966 and found to be 4.5 per cent fat for cow milk, 6 per cent for buffalo milk and SNF found to be ranged from 8.3 to 8.6 for standardised cow milk and from 8.8 to 9.0 in standardised buffalo milk.

3.4.1.3 Skim milk: The sampling and testing of skim milk was done as per the procedure laid down in IS: 1479 (Part-II) 1961 and in IS : 1224, 1977 respectively.

3.4.2 Cream

The sampling and testing of cream was done as per the procedure laid down in IS: 1224, 1977.

3.4.3 Preparation of Chhana

Cow milk standardised to 4.5 per cent fat and 8.5 per cent SNF was used to make control chhana by using all the 3 types of coagulants viz., citric acid, lactic acid and calcium lactate in this experiment. Buffalo milk standardised to 6 per cent fat and 9 per cent SNF, treated by addition of stabilisers and water was used in this studies for preparation of chhana was prepared and designated coagulants.

A total of 15 batches chhana was prepared and designated as T_1 to T_{15}. Control chhana made from cow milk with all the three coagulants was designated as T_1, T_2 and T_3. Buffalo milk without any addition was coagulated simultaneously by all the three coagulants and chhana prepared was designated as T_4, T_5 and T_6. Buffalo milk treated with sodium citrate at 0.3 per cent was also converted to chhana by using all the three coagulants was named as T_7, T_8, T_9 and the chhana made with 20 per cent dilution of milk with water was designated as T_{10}, T_{11} and T_{12} and milk with 20 per cent dilution with water and addition of 0.3 per cent sodium citrate was designated as T_{13}, T_{14} and T_{15}.

The details of variable combinations used in this experiment during chhana making were as follows. These combinations were selected after extensive preliminary trails.

T_1 Cow milk with citric acid as a coagulant

T_2 Cow milk with lactic acid as a coagulant

T_3 Cow milk with calcium lactate as a coagulant

T_4 Buffalo milk with citric acid as a coagulant

T_5 Buffalo milk with lactic acid as a coagulant

T_6 Buffalo milk with calcium lactate as a coagulant

T_7 Buffalo milk with addition of 0.3 per cent sodium citrate with citric acid as a coagulant

T_8 Buffalo milk with addition of 0.3 per cent sodium citrate with lactic acid as a coagulant.

T_9 Buffalo milk with addition of 0.3 per cent sodium citrate with calcium lactate as a coagulant.

T_{10} Buffalo milk with 30 per cent dilution by water and citric acid as a coagulant.

T_{11} Buffalo milk with 30 per cent dilution by water and lactic acid as a coagulant.

T_{12} Buffalo milk with 30 per cent dilution by water and calcium lactate as a coagulant.

T_{13} Buffalo milk with 20 per cent dilution by water and 0.3 per cent sodium citrate coagulated with citric acid.

T_{14} Buffalo milk with 20 per cent dilution by water and 0.3 per cent sodium citrate coagulated with lactic acid.

T_{15} Buffalo milk with 20 per cent dilution by water and 0.3 per cent sodium citrate coagulated with calcium lactate.

3.4.4 Chhana

The chhana obtained in the above manner was analysed for the following:

3.4.4.1 <u>Moisture</u>: The moisture content in chhana obtained from different treatments was determined by modified gravimetric method as per the procedure described by AOAC (1980) as follows:

Three grams of chhana sample was taken into a clean, dry aluminium dish and spread the sample over the bottom of the dish with the help of a glass rod. The dish with sample was then hea on boiling water bath for 30 minutes with occasional stirring of the contents. The dish was then transferred to an oven and kept at 100°C ± 1°C for 4 hours. The dish was then cooled in a dessicator and weighed accurately. The procedure of heating in the oven (for 30 minutes). Cooling and weighing was repeated until a constant weight was obtained.

3.4.4.2 <u>Per cent recovery of total solids</u>: The chhana obtained in each combination weighed and per cent recovery of total solids was calculated after estimation of moisture.

3.4.4.3 <u>Protein</u>: Protein was estimated by using micro Kjeldahl method prescribed by AOAC (1960).

3.4.4.4 <u>pH</u> : A digital pH meter (Elico model - (1 - 20)) was used as per the instructions to measure the pH of chhana.

3.4.4.5 <u>Estimation of titratable acidity</u>: The titratable acidity of each sample of chhana was determined as per the procedure of AOAC (1960) given for cheese.

3.4.4.6 <u>Consistency of chhana</u>: Consistency of chhana was studied by

- Penetrometer reading
- Springiness.

<u>Penetrometer reading</u>:

Hardness of sample was measured by using penetrometer manufactured by M/s. United Scientific Company, Madras having confirming to the specifications of American Oil Chemists Society - Tentative method, Cs 16-160 (1964). Each penetrometer reading was taken in m.m. in the time limit of 30 seconds at 30°C ± 2°C temperature.

Springiness:

Springiness of chhana was estimated by using apparatus developed by Gera (1978) as follows:

A smooth ball was formed from 15 g of sample. This was placed over a round watch glass and kept under the bob. The main rod was unclamped and lowered so that the bottom of the bob just touch the top of product ball. The ball was pressed by lowering the bob under a weight of 110 g for 10 seconds. This reading was noted on the scale and then weight removed. After allowing the product ball to regain its shape for 2 minutes another reading was taken by allowing the bob just to touch the top surface of product ball.

The recovery of original height of ball was expressed as per cent springiness.

$$\text{Per cent springiness} = \frac{H_R - H_D}{H_D - H_o} \times 100.$$

H_o = Original height of the ball.

H_D = Height after depression under weight.

H_R = Height upon recovery after removal of weight.

3.4.5 Rasagolla

Rasagolla was prepared from 15 types of chhana and was judged by panel of 6 judges trained as per the procedures given in IS : 6273 (Part I) - 1971 and IS : 8140 - 1976 and also by using score card given in page 42 designed for this purpose.

3.4.6 Statistical analysis

The data obtained during the experiment was analysed as per the methods given by Snedecor and Cochran (1968).

SCORE CARD FOR RASAGOLLA

(Hedonic rating)

Panel member: Date :

Name: Time :

Dairy products:

Instructions: Sweet prepared with chhana made from cow, buffalo milk and treated buffalo milk with different coagulants. You are requested to assess overall acceptability of the sweet. Write scores opposite to characteristics and under samples.

Liked extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

Characteristics	Samples														
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}
Flavour															
Body and texture															
Colour															
Overall acceptability															

Remarks:

SIGNATURE

RESULTS

CHAPTER IV

RESULTS

This chapter deals with results obtained during the course of investigation. Aspects related to moisture content, per cent recovery of total solids, protein content, pH, acidity, penetrometer reading of chhana, springiness per cent of chhana and organoleptic evaluation of Rasagolla have been presented.

4.1 MOISTURE CONTENT OF CHHANA

The moisture per cent in chhana obtained from different variable combinations is presented in Table 1 and figs. 1 and 2.

The average per cent moisture in chhana from cow milk was found to be 59.8 per cent when citric acid was used as a coagulant, 60.07 per cent when lactic acid was used and 58.7 per cent with calcium lactate whereas in chhana from buffalo milk, the moisture contents were 57.11, 57.75 and 56.60 per cent respectively.

The buffalo milk which was treated with 0.3 per cent sodium citrate resulted in chhana with an average moisture content of 57.85, 58.11 and 56.73 with citric acid, lactic acid and calcium lactate respectively.

The buffalo milk with 30 per cent dilution alone and 30 per cent dilution with 0.3 per cent sodium citrate treatment gave an average moisture contents of 59.93, 57.79 and 60.61, 58.63 and 57.07, 56.97 per cent for citric acid, lactic acid and calcium lactate respectively.

Table 1. Effect of different types of coagulants and raw materials on moisture content of [illegible]

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	Average
T_1	59.80	60.10	59.50	59.70	59.90	60.15	59.45	59.60	60.00	59.80	59.80
T_2	60.10	60.12	59.90	60.25	60.10	59.88	60.20	60.15	59.90	60.10	60.07
T_3	58.75	58.65	59.00	58.40	58.70	59.10	58.30	58.78	58.62	58.70	58.70
T_4	57.18	57.15	56.94	57.30	57.10	56.88	57.40	57.15	56.96	57.10	57.11
T_5	57.65	57.75	58.00	57.60	58.10	57.55	57.70	57.80	57.66	57.76	57.76
T_6	56.45	56.55	57.00	56.58	56.48	56.42	57.10	56.45	56.50	56.40	56.60
T_7	57.40	57.50	58.00	57.48	57.45	57.38	58.10	57.41	57.38	57.46	57.56
T_8	58.15	58.10	57.98	58.18	57.88	58.25	58.20	57.96	58.16	58.22	58.11
T_9	56.70	56.85	56.80	56.65	57.00	56.68	56.72	56.60	56.56	57.10	56.76
T_{10}	59.85	59.95	60.10	59.90	60.20	59.80	60.15	59.88	59.76	59.78	59.93
T_{11}	60.55	60.65	60.60	61.00	60.30	60.48	60.25	61.10	60.72	60.68	60.61
T_{12}	57.15	56.96	57.10	56.96	56.85	57.25	56.85	57.25	57.15	57.20	57.07
T_{13}	57.86	57.70	58.10	57.65	58.08	57.46	57.80	57.90	57.66	57.80	57.79
T_{14}	58.53	58.60	58.65	59.00	58.25	58.47	58.36	59.10	58.70	58.66	58.63
T_{15}	56.85	56.96	57.10	56.76	57.20	57.36	56.80	57.00	56.90	56.78	56.97

T_1 to T_{15} = Treatments

R_1 to R_{10} = Replications.

Table 2. Analysis of variance for testing the effect of different variable combination on moisture per cent of chhana

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F. Value
Raw materials	4	136.00	34.00	191.72836**
Coagulants	2	85.68	42.84	241.57699**
Interaction	8	28.21	3.5126	17.77021**
Error	135	23.94	0.1773333	
Total	149	270.83		

** Significant at 1% level of probability

<u>Critical difference</u>

For raw materials = 0.0851291
For coagulants = 0.067408
For interaction = 0.149183.

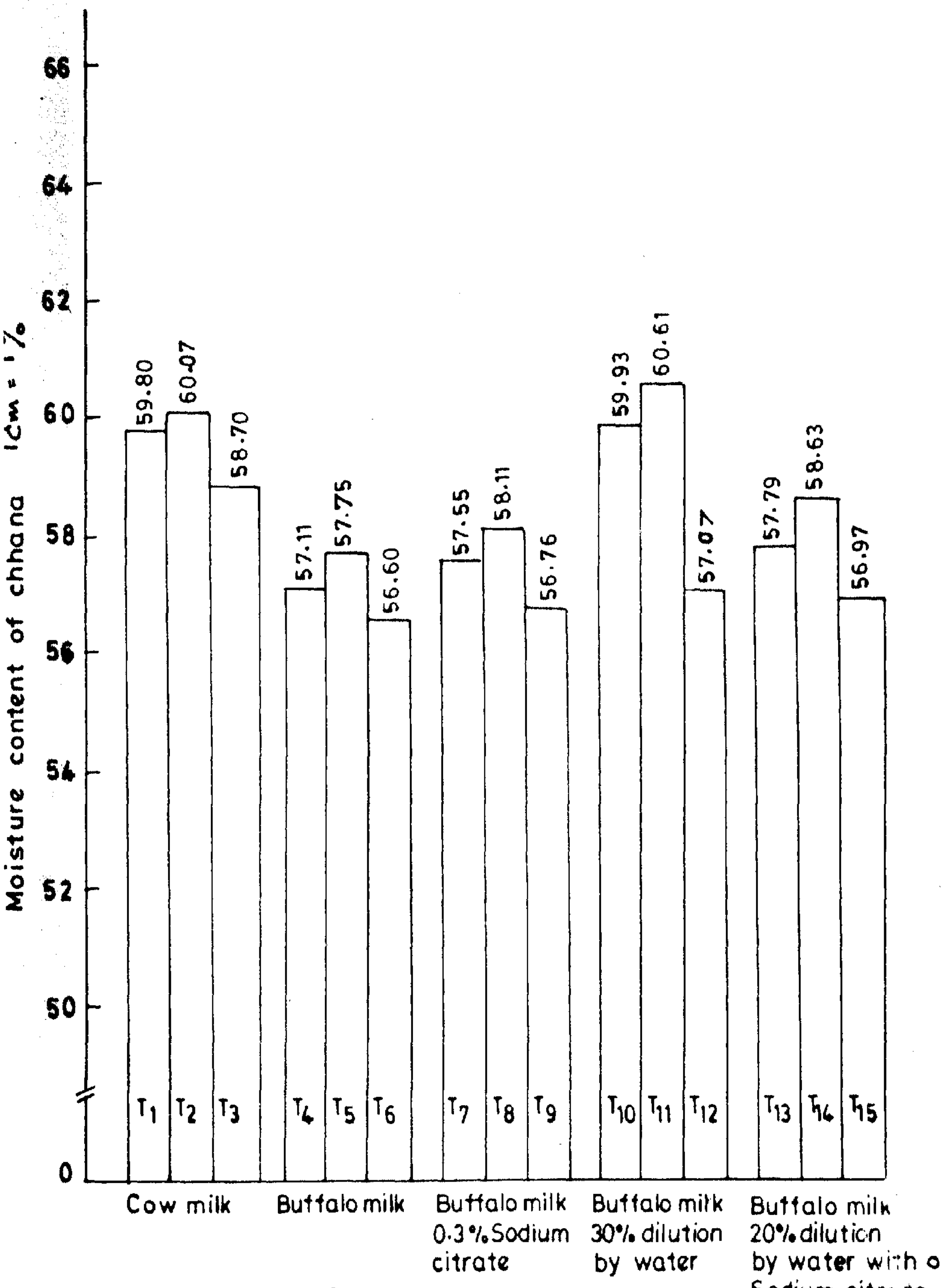


Fig.1 Effect of different treatments on moisture content of chhana

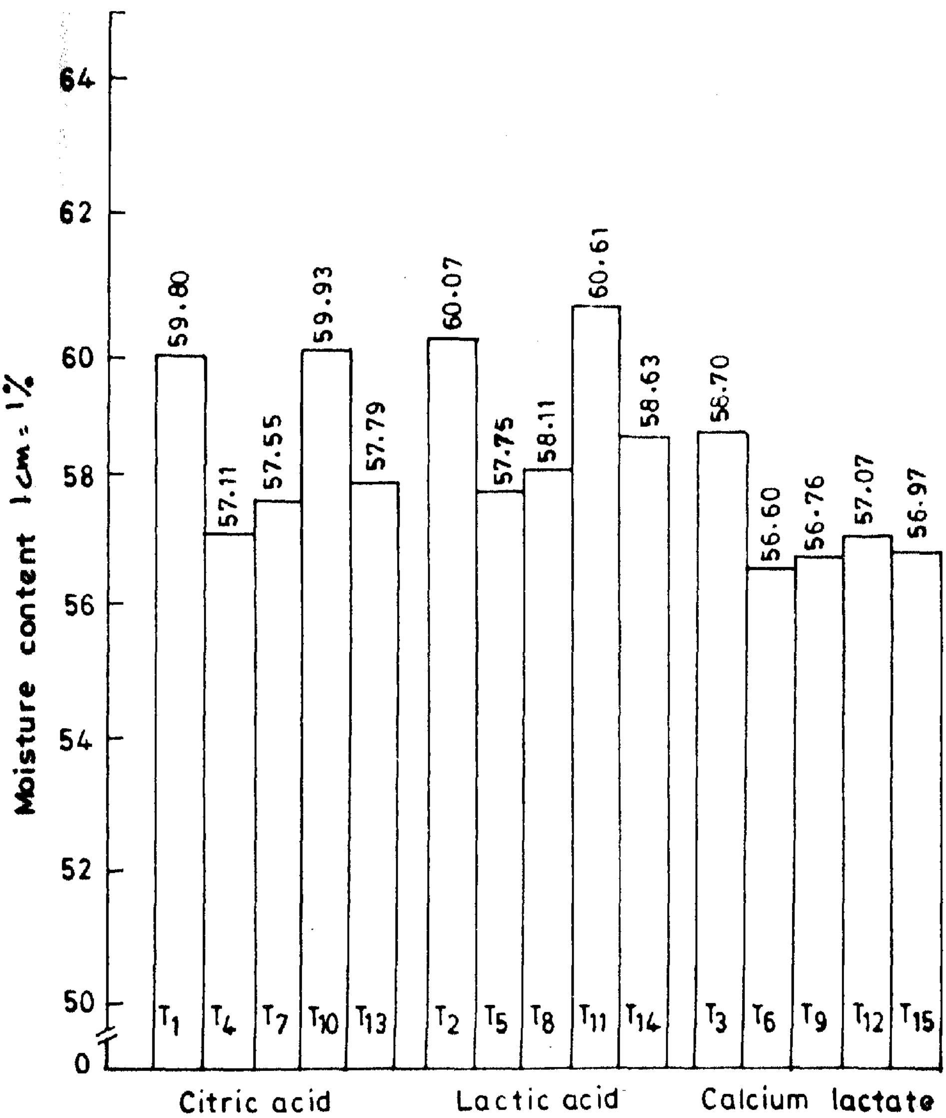


Fig.2 Effect of different coagulants on moisture content of chhana

Analysis of variance for testing the effect of variable combinations i.e., raw materials, coagulants and their interactions presented in Table 2 shows the F values as 191.72936, 281.57899 and 17.77021 respectively.

The critical differences calculated are found to be 0.6961291 0.397408 and 0.48153 for raw materials, coagulants and interaction between these two respectively.

4.2 PER CENT RECOVERY OF TOTAL SOLIDS

The average per cent recovery of total solids from different variable combinations is presented in Table 3 and Figs. 3 and 4.

The average per cent recovery of total solids in chhana from cow milk was found to be 61.56 per cent when citric acid was used as a coagulant 60.96 per cent when lactic acid was used and 66.74 per cent with calcium lactate, whereas in chhana from buffalo milk the per cent recovery of total solids was 69.00, 68.84 and 73.51 per cent respectively.

The buffalo milk which was treated with 0.3 per cent sodium citrate resulted in chhana with average per cent recovery of total solids of 70.46, 69.28 and 74.66 per cent with citric acid, lactic acid and calcium lactate respectively.

The buffalo milk with 20 per cent dilution alone and 20 per cent dilution with sodium citrate treatment gave an average per cent total solids recovery of 67.07, 70.61 and 66.82, 69.00 and 73.83, 74.92 per cent for citric acid, lactic acid and calcium lactate respectively.

[illegible]

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	Average
T_1	61.30	61.38	61.84	61.22	62.15	61.15	61.76	61.22	61.86	61.54	61.56
T_2	61.07	60.43	61.60	60.69	60.46	61.41	61.54	60.54	60.98	60.77	60.96
T_3	66.47	67.89	66.55	66.88	67.35	65.56	67.84	65.96	66.84	66.33	66.74
T_4	70.08	69.84	68.75	71.16	69.64	68.70	69.86	69.70	71.46	70.07	69.93
T_5	68.89	68.86	68.74	69.54	69.83	68.63	67.26	68.92	68.74	69.00	68.84
T_6	74.47	74.00	72.96	72.22	74.86	74.23	72.79	72.42	73.51	73.97	73.61
T_7	70.67	70.56	69.86	70.87	70.36	71.32	68.99	70.70	70.60	70.75	70.46
T_8	69.19	69.13	70.61	68.86	70.51	69.26	68.69	69.33	68.64	68.66	69.28
T_9	74.76	74.94	74.45	75.14	73.82	74.94	75.01	74.79	74.96	73.79	74.66
T_{10}	67.30	66.94	68.40	66.64	66.14	67.57	66.60	66.48	67.08	67.60	67.07
T_{11}	65.50	65.58	66.23	65.18	66.71	66.61	66.25	65.20	65.39	65.63	65.82
T_{12}	73.35	74.41	73.34	73.30	74.86	74.10	73.97	73.69	73.26	73.20	73.83
T_{13}	70.60	70.38	70.53	71.11	70.37	71.80	70.16	70.52	70.50	70.16	70.61
T_{14}	69.12	68.48	69.43	68.67	69.9369	69.73	69.24	67.65	69.18	68.87	69.00
T_{15}	75.30	76.16	74.72	75.15	76.36	73.75	75.24	74.71	74.71	75.20	74.92

T_1 to T_{15} - Treatments

R_1 to R_{10} - Replications.

Table 4. Analysis of variance for testing the effect of different variable combinations on percentage recovery of total solids during chhena making

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F. Value
Raw materials	4	1513.17	378.2925	822.90606**
Coagulants	2	998.05	499.025	1085.5361**
Interaction	8	42.93	5.36625	11.67329**
Error	135	62.06	0.4597037	
Total	149	2616.21		

** Significant at 1% level of probability

Critical difference

For raw materials = 1.119204
For coagulants = 1.444387
For interactions = 0.7913971

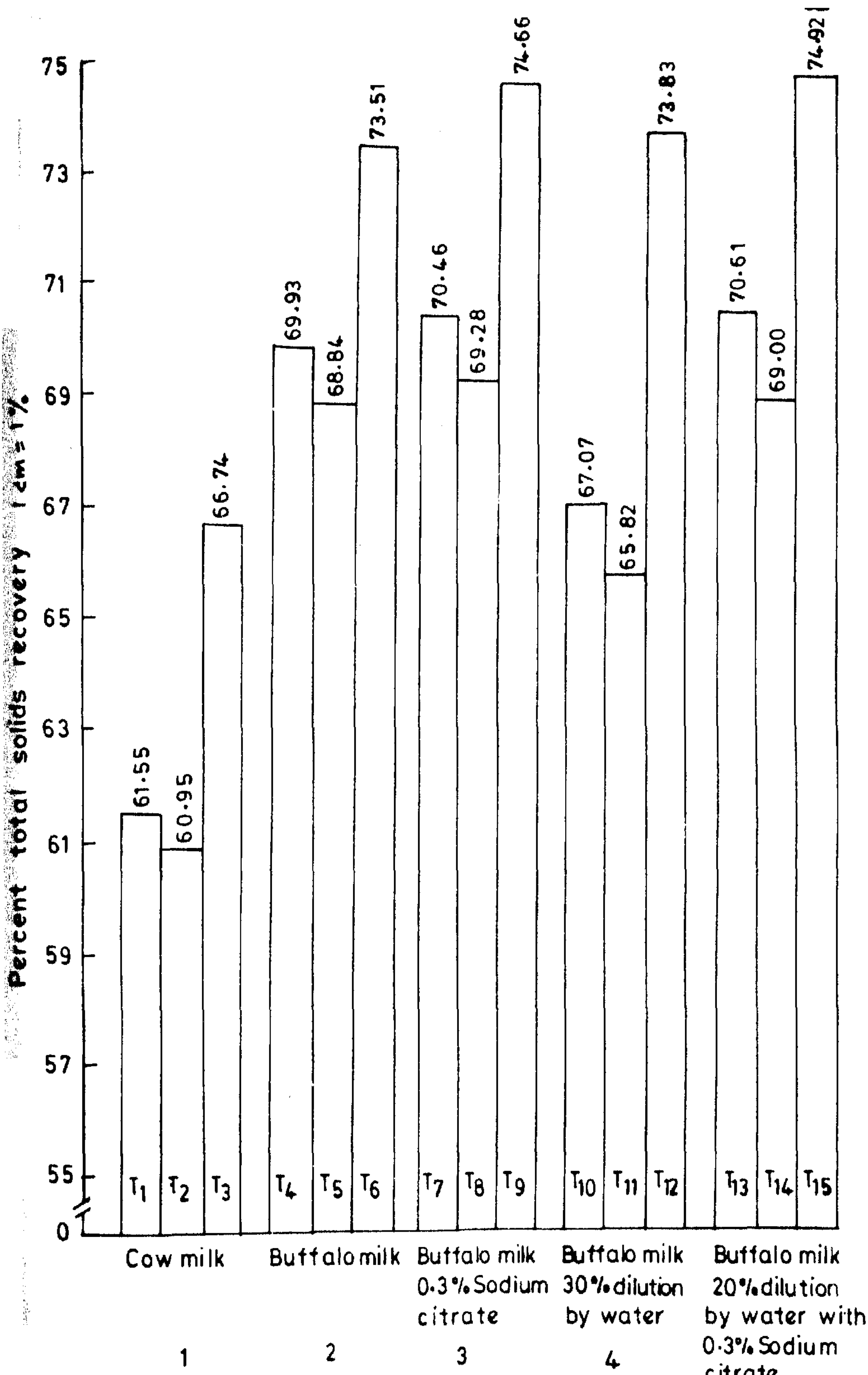


Fig.3 Effect of different treatments on percent total solid recovery of chhana

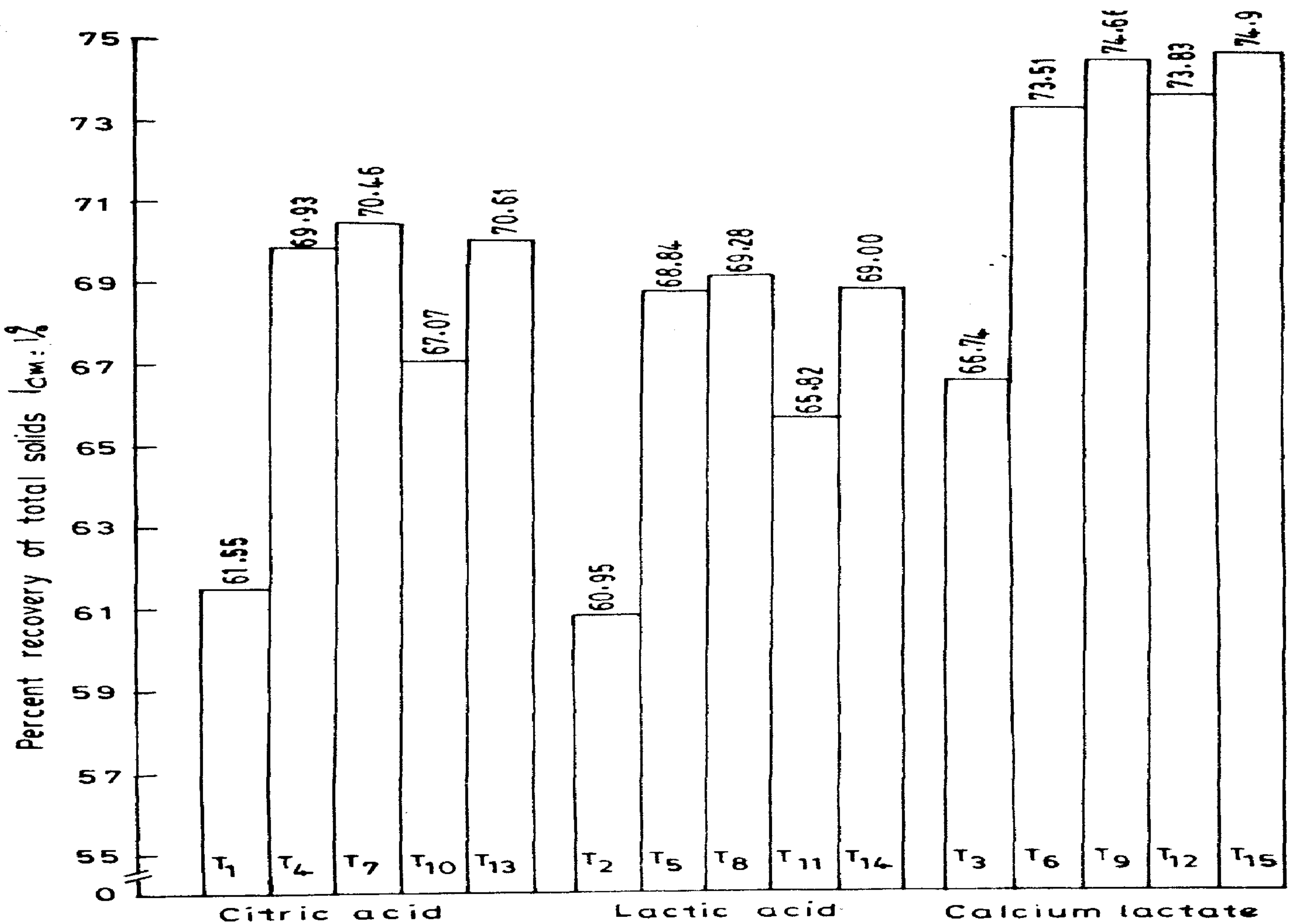


Fig. 4 Effect of different coagulants on percent recovery of total solids

Analysis of variance for testing the effect of variable combinations i.e., raw materials coagulants and their interactions presented in Table 4, shows the F values as 822.90516, 1085.8361 and 11.67328 respectively. The critical difference for the same is 1.119204, 1.444867 and 0.7013071.

4.3 PROTEIN

The average protein contents in chhana obtained from variable combinations presented in Table 5 and Fig. 5 shows that the average protein content in chhana from cow milk as 16.9 per cent when citric acid was used as a coagulant, 16.72 per cent for lactic acid and 17.08 per cent for calcium lactate whereas for buffalo milk chhana the protein contents are 16.11, 14.97 and 15.36 respectively.

The buffalo milk which was treated with 0.3 per cent sodium citrate gave an average protein contents of 14.64, 14.86 and 14.92 per cent respectively and the buffalo milk with 30 per cent water dilution and 20 per cent water dilution plus 0.3 per cent sodium citrate gave an average protein contents of 14.21, 14.80 and 14.13 14.23 and 14.51, 14.38 for the same 3 types of coagulants.

Analysis of variance for testing effect of raw materials, coagulants and interaction between these two presented in Table 6 shows F values for these as 736.344, 35.977826 and 0.5036415 respectively. The critical differences calculated are found to be 0.3827545, and 0.4354[illegible] for raw materials and coagulants respectively.

Table 5. Effect of different types of coagulants and raw materials on protein content of channa

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	Average
T_1	16.86	16.96	17.00	16.80	17.10	16.70	16.90	17.11	16.76	16.88	16.90
T_2	16.78	16.62	17.05	16.50	16.65	17.00	16.70	16.56	16.60	16.76	16.72
T_3	17.10	16.98	17.15	16.90	17.20	17.26	17.16	17.14	16.80	17.12	17.08
T_4	15.10	14.96	15.00	15.14	15.30	14.90	15.15	15.30	15.11	14.98	15.11
T_5	14.90	15.10	14.86	15.06	14.70	14.88	15.15	14.96	15.22	14.86	14.97
T_6	15.33	15.22	15.16	15.30	15.30	15.35	15.40	16.00	15.18	15.32	15.36
T_7	14.60	15.06	14.20	14.56	14.05	15.10	14.28	14.58	14.76	14.60	14.64
T_8	14.43	15.00	14.76	14.50	14.68	15.08	14.30	14.48	14.62	14.38	14.66
T_9	14.86	15.02	14.80	15.00	14.05	14.85	15.10	14.90	15.20	14.76	14.92
T_{10}	14.20	13.96	14.45	14.36	14.30	14.20	14.18	13.98	14.28	14.25	14.21
T_{11}	14.20	13.90	14.25	14.16	14.30	13.96	14.16	14.20	14.10	14.18	14.13
T_{12}	14.45	15.00	14.90	14.48	14.80	15.05	14.25	14.45	14.80	14.25	14.61
T_{13}	14.40	15.05	[illegible]	14.45	14.48	15.00	14.20	14.40	14.48	14.36	14.50
T_{14}	14.30	13.98	14.40	14.35	14.50	15.00	14.38	14.45	14.38	14.26	14.38
T_{15}	14.45	15.10	14.32	14.50	15.11	14.52	14.38	14.48	14.40	14.52	14.53

T_1 to T_{15} - Treatments

R_1 to R_{10} - Replications.

Table 6. Analysis of variance for testing the effect of different variable combinations on protein content of chhana

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F. Value
Raw materials	4	134.599	33.64975	736.844**
Coagulants	2	3.286	1.643	35.977528**
Interaction	8	0.184	0.023	0.5036415^{NS}
Error	135	6.1651	0.0456674	
Total	149	144.2341		

** Significant at 1% level of probability

NS - Non significant

Critical difference

For raw materials = 0.3527546
For coagulants = 0.4554048

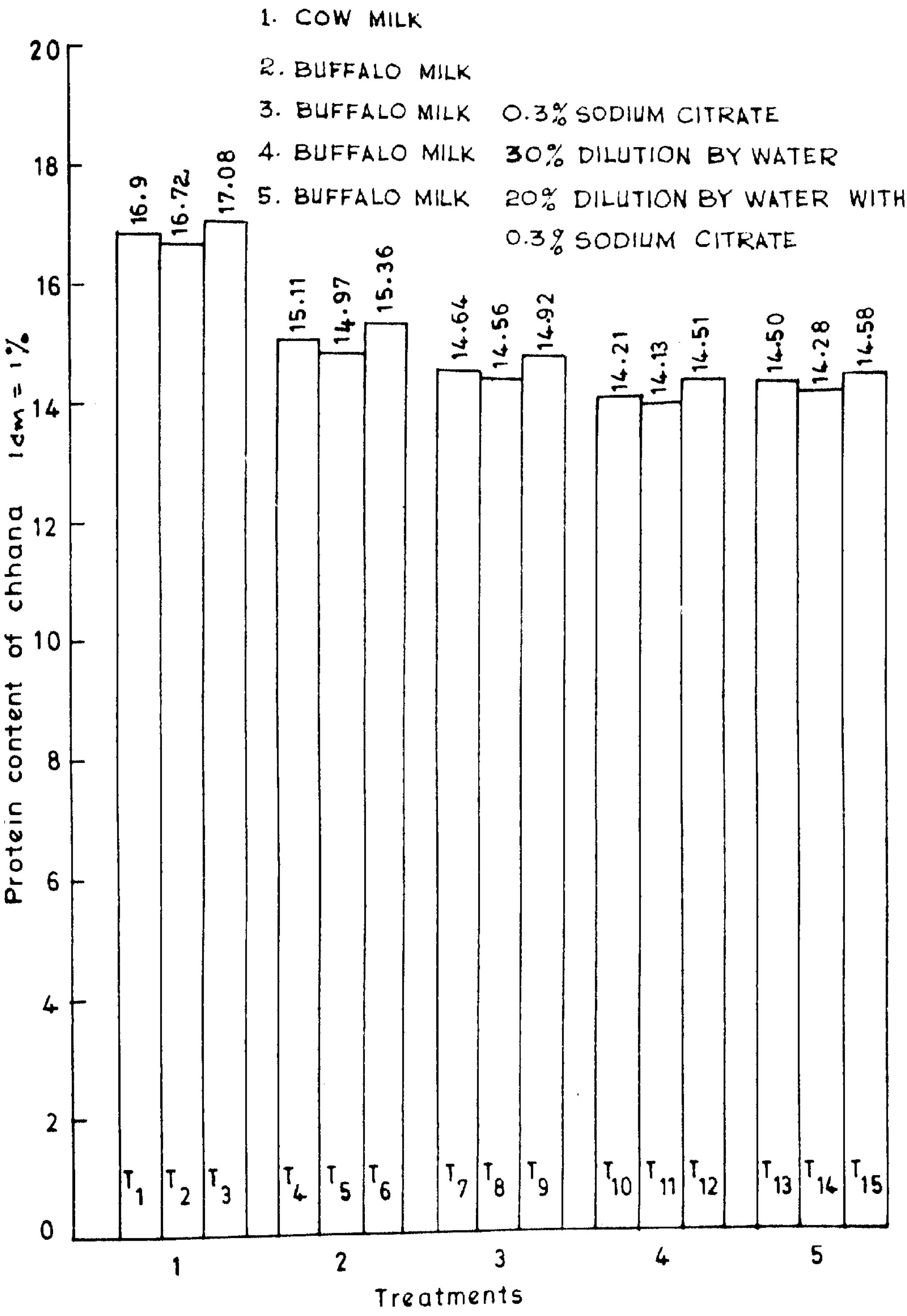


Fig. 5 Effect of different treatments on protein content of chhana

4.4 pH OF CHHANA

pH of chhana taken from different variable combinations is presented in the Table 7 and Fig. No.6 reveals that the average pH value for chhana from cow milk as 5.63 when citric acid was used as a coagulant, 5.66 when lactic acid was used as a coagulant and 5.64 for calcium lactate, whereas for pH value for buffalo milk chhana was 5.62, 5.67 and 5.66 respectively.

Buffalo milk which was treated with 0.3 per cent sodium citrate gave an average pH values of 5.73, 5.74 and 5.74 for citric acid, lactic acid and calcium lactate respectively. Buffalo milk with 30 per cent dilution and 30 per cent dilution with 0.3 per cent sodium citrate resulted in chhana with 5.64, 5.71 and 5.66, 5.71 and 5.65, 5.71 respectively for the above 3 coagulants respectively.

Analysis of variance for testing the effect of variable combinations i.e., raw materials, coagulants and interaction between these two is presented in the Table 8. The F values for these combinations found to be 56.035890, 2.6620423 and 0.4220487 respectively.

The critical difference calculated is found to be 0.001867 for raw materials.

Table [illegible]. Effect of different types of coagulants and raw materials on pH of channa

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	Average
T_1	5.52	5.53	5.48	5.54	5.60	5.60	5.65	5.60	5.49	5.65	5.63
T_2	5.50	5.55	5.60	5.49	5.65	5.63	5.66	5.59	5.62	5.68	5.66
T_3	5.50	5.53	5.45	5.60	5.65	5.63	5.62	5.60	5.63	5.55	5.64
T_4	5.65	5.73	5.57	5.60	5.60	5.65	5.55	5.63	5.70	[illegible]	5.62
T_5	5.68	5.70	5.60	5.75	5.63	5.70	5.60	5.65	5.63	5.65	5.67
T_6	5.68	5.70	[illegible]	5.75	5.65	5.66	5.67	5.63	5.65	5.60	5.66
T_7	5.75	5.60	[illegible]	5.65	[illegible]	5.77	5.74	5.70	5.76	5.60	5.73
T_8	5.72	5.70	5.70	5.70	5.77	5.77	5.75	5.74	5.76	5.72	5.74
T_9	5.73	5.72	5.60	5.76	5.78	5.74	5.60	5.70	5.77	[illegible]	5.74
T_{10}	[illegible]	[illegible]	[illegible]	[illegible]	5.73	5.60	[illegible]	[illegible]	5.65	5.70	5.64
T_{11}	5.76	[illegible]	5.60	5.70	5.62	5.70	5.72	5.70	5.63	5.65	5.66
T_{12}	5.80	5.58	5.65	5.64	[illegible]	5.70	5.60	5.64	5.68	5.65	5.65
T_{13}	5.73	5.70	5.71	5.69	5.70	5.77	5.60	5.68	5.70	5.71	5.71
T_{14}	5.72	5.70	5.77	5.75	5.72	5.72	5.64	5.68	5.68	5.70	5.71
T_{15}	5.76	5.67	5.74	5.67	5.74	[illegible]	[illegible]	5.74	5.72	5.69	5.71

T_1 to T_{15} - Treatments

R_1 to R_{10} - Replications.

Table 8. Analysis of variance for testing the effect of different variable combinations on pH of chhana

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F. Value
Raw materials	4	0.669006	0.1672515	56.026899**
Coagulants	2	0.0153	0.00765	2.5626423^{NS}
Interactions	8	0.0100794	0.0012599	0.4220487^{NS}
Error	135	0.4030146	0.0029852	
Total	149	1.0974		

** Significant at 1% level of probability

NS = Non significant

Critical difference

For raw materials = 0.0901867

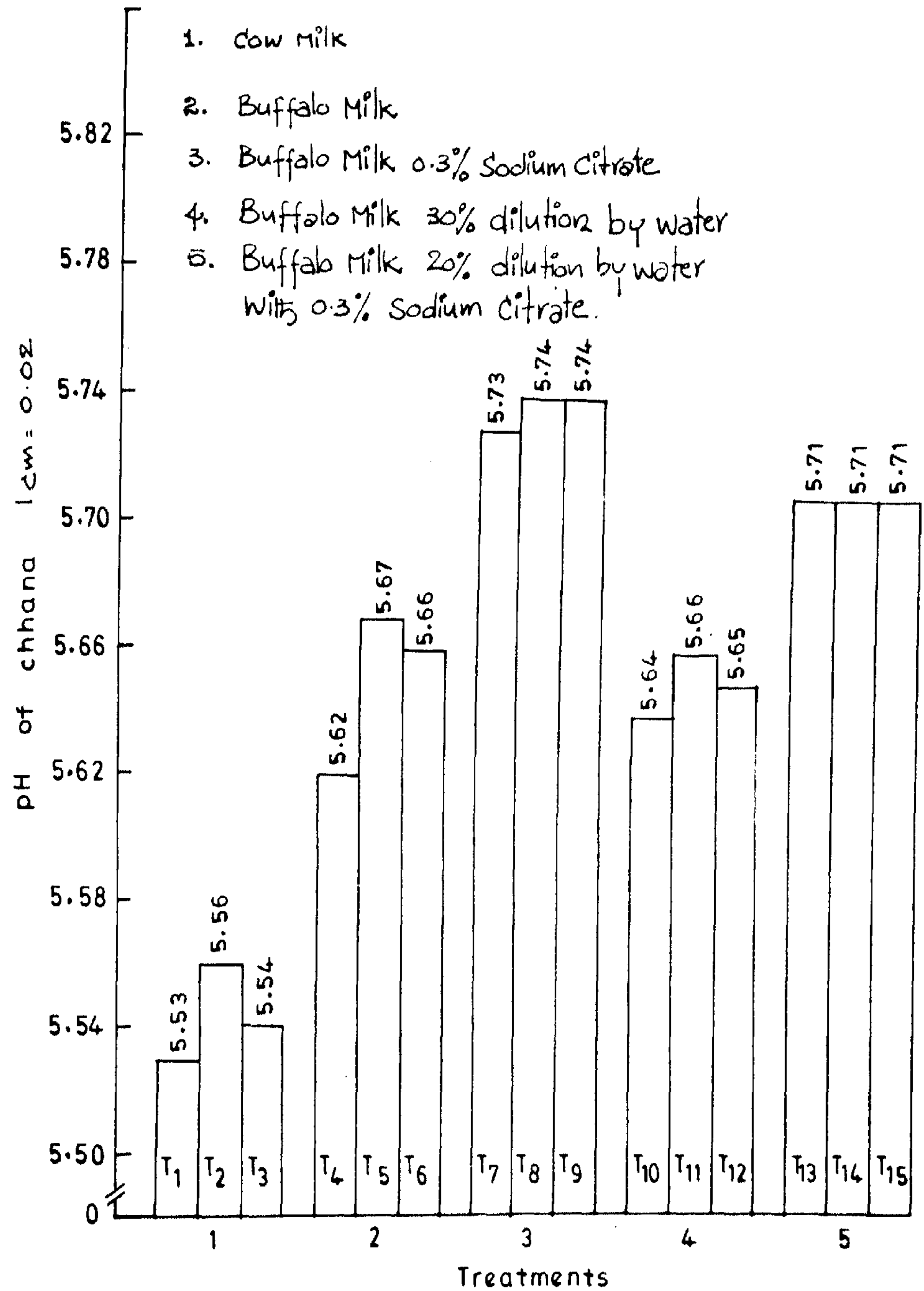


Fig.6 Effect of different treatments on pH of chhana

4.8 TITRATABLE ACIDITY OF CHHANA

Acidity of chhana obtained from different variable combinations is presented in the Table 9 and Fig. No.7.

The average acidity of chhana from cow milk was found to be 0.236 when citric acid was used as a coagulant and 0.252 for lactic acid and 0.240 for calcium lactate and for buffalo milk chhana 0.230, 0.236 and 0.227 respectively.

Buffalo milk which was treated with 0.3 per cent sodium citrate gave an average acidity of 0.215, 0.217 and 0.217 per cent with citric acid, lactic acid and calcium lactate respectively Buffalo milk with 30 per cent dilution and 30 per cent dilution with 0.3 per cent sodium citrate resulted in chhana with 0.214, 0.213 and 0.216, 0.216 and0217, 0.217 for the above 3 coagulants respectively.

Analysis of variance for the effect of variable combinations on the acidity of chhana is presented in the Table 10 reveals F values as 205.28736 for raw materials, 27.413793 for coagulants and 7.2701149 for interaction respectively. The critical differences calculated are found to be 0.0063586, 0.0088991 and 0.0043125 for raw materials, coagulants and interactions between them respectively.

Table 9. Effect of different types of coagulants and raw materials on per cent acidity of chhana

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	Average
T_1	0.240	0.228	0.235	[illegible]	[illegible]	0.225	0.245	[illegible]	[illegible]	0.230	0.235
T_2	0.250	[illegible]	[illegible]	[illegible]	[illegible]	0.255	0.246	0.255	0.254	0.251	0.253
T_3	0.241	0.237	[illegible]	[illegible]	[illegible]	0.242	0.236	0.243	0.248	0.238	0.240
T_4	0.220	0.218	[illegible]	[illegible]	[illegible]	0.222	[illegible]	0.217	0.220	0.218	0.220
T_5	0.230	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.218	[illegible]	0.236	0.236	0.236
T_6	0.230	[illegible]	[illegible]	[illegible]	[illegible]	0.225	0.221	0.226	0.227	0.226	0.227
T_7	0.213	0.214	[illegible]	[illegible]	[illegible]	0.213	[illegible]	0.217	0.211	0.214	0.215
T_8	0.215	0.215	[illegible]	[illegible]	[illegible]	[illegible]	0.210	0.215	0.210	0.217	0.217
T_9	0.221	0.218	[illegible]	[illegible]	[illegible]	[illegible]	0.213	0.213	0.210	0.216	0.217
T_{10}	0.212	0.215	[illegible]	[illegible]	[illegible]	0.216	[illegible]	[illegible]	0.218	0.213	0.214
T_{11}	0.213	0.216	[illegible]	[illegible]	[illegible]	0.218	0.221	0.220	0.216	0.218	0.216
T_{12}	0.215	0.217	[illegible]	[illegible]	[illegible]	[illegible]	0.222	0.222	0.218	0.220	0.217
T_{13}	0.215	0.213	[illegible]	[illegible]	[illegible]	0.213	0.218	0.215	0.210	0.213	0.213
T_{14}	[illegible]	0.216	[illegible]	[illegible]	[illegible]	[illegible]	0.218	0.216	0.210	0.215	0.216
T_{15}	0.217	0.216	[illegible]	[illegible]	[illegible]	0.218	0.214	0.216	0.215	0.217	0.217

T_1 to T_{15} - Treatments

R_1 to R_{10} - Replications.

Table[10] . Analysis of variance for testing the effect of different variable combinations on acidity per cent of chhana

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F.Value
Raw materials	4	0.0156739	0.00392	225.28736**
Coagulants	2	0.0009533	0.0004807	27.413793**
Interactions	8	0.0010122	0.0001265	7.2701149**
Error	135	0.0023537	0.0000174	
Total	149	0.0199931		

** Significant at 1% level of probability

Critical difference

For Raw materials = 0.0068566
For coagulants = 0.0053801
For Interactions = 0.0048125

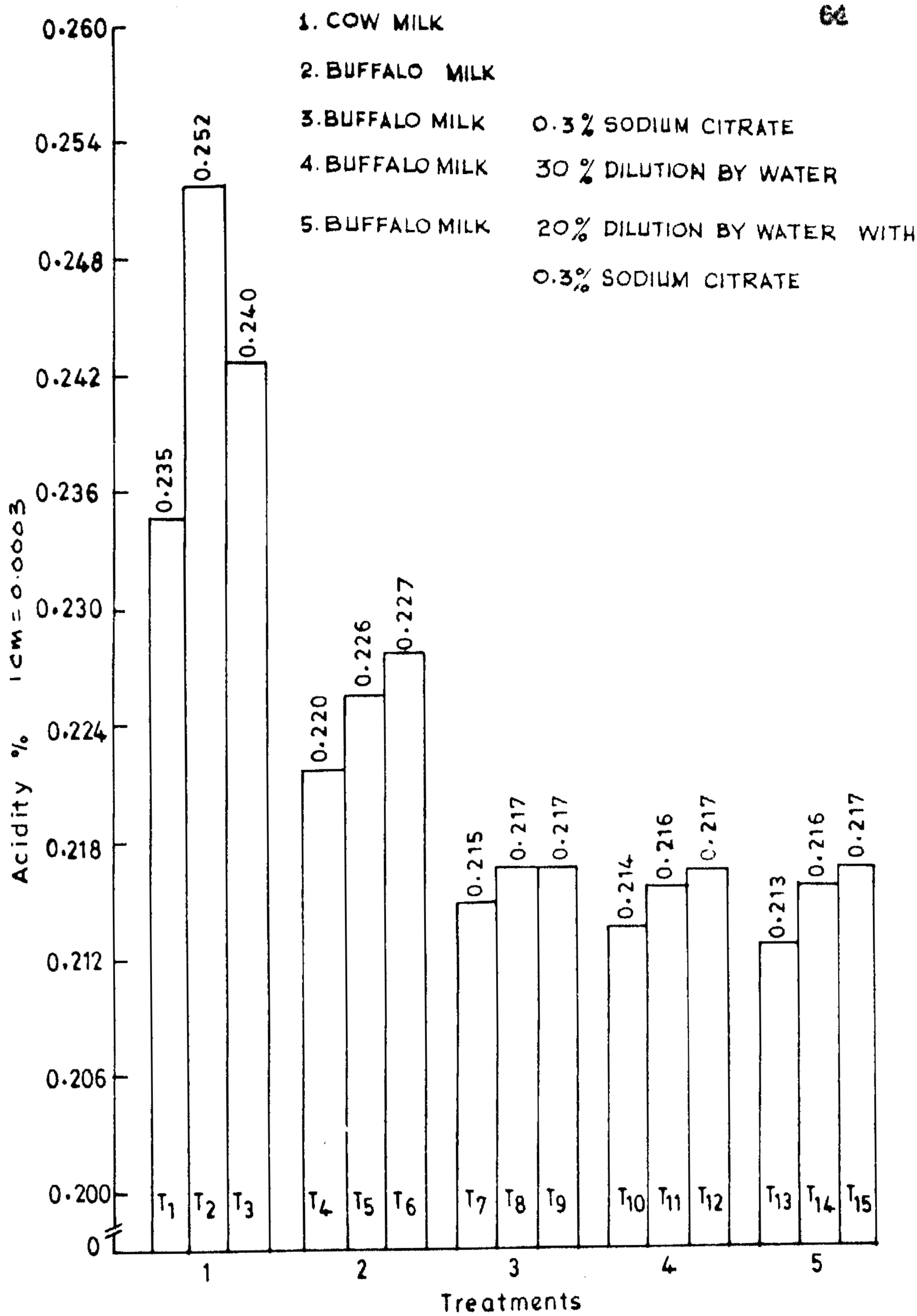


Fig. 7 Effect of different treatments on acidity of chhana

4.6 PENETROMETER READING

The average penetrometer readings of chhana obtained from variable combinations is presented in Table 11 and Figs. 8 and 9. The average penetrometer reading for chhana from cow milk was found to be 40 for citric acid, 36 for lactic acid and 38 for calcium lactate and for buffalo milk 29, 26 and 28 respectively.

The buffalo milk which was treated with 0.3 per cent sodium citrate gave an average penetrometer readings of 34, 31 and 33 for citric acid, lactic acid and calcium lactate respectively. The buffalo milk of 30 per cent dilution and 20 per cent dilution plus 0.3 per cent sodium citrate gave an average penetrometer readings of 36 and 39, 33 and 36 and 34 and 37 respectively for both the two treated milks with the same 3 types of coagulants.

Analysis of variance presented in Table 12 was calculated to test the effect of variable combinations i.e., raw materials, coagulants and interaction between these two and F values found to be 219.17793, 63.916084 and 2.0456612 respectively. The critical differences are found to be 2.403, 3.102 and 1.230 for raw materials, coagulants and interactions of them respectively.

Table 11 Effect of different types of coagulants and raw materials on pentrometer reading of chhan

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	Average
T_1	40	39	41	38	42	40	38	42	42	38	40.0
T_2	35	36	36	34	37	33	35	37	33	35	36.0
T_3	35	37	36	36	38	34	37	36	36	36	36.0
T_4	29	30	28	28	30	27	31	28	30	29	29.0
T_5	26	25	27	24	28	25	27	26	25	27	26.0
T_6	29	27	28	27	29	28	26	30	27	29	28.0
T_7	33	35	34	34	35	33	36	32	33	35	34.0
T_8	30	32	33	29	31	31	30	32	30	32	31.0
T_9	34	32	33	30	35	30	34	31	35	33	33.00
T_{10}	37	35	36	36	36	37	38	34	36	37	36.0
T_{11}	33	36	31	34	32	32	34	35	33	31	33.0
T_{12}	35	35	31	34	32	34	35	32	33	31	34.0
T_{13}	38	40	37	41	30	39	38	40	37	41	39.0
T_{14}	35	37.	38	34	36	36	35	37	38	34	36.0
T_{15}	39	37	38	36	39	36	38	38	39	33	37.0

T_1 to T_{15} - Treatments

R_1 to R_{10} - Replications.

Table 19. Analysis of variance for testing the effect of different variable combinations on consistency of chhana by penetrometer readings

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F. Value
Raw materials	4	1857.33	464.3325	219.17793**
Coagulants	2	292.00	146.00	68.916084**
Interaction	8	34.67	4.33375	2.0456612*
Error	136	286.00	2.1185185	
Total	149	2470.00		

* Significant at 5% level of probability
** Significant at 1% level of probability

Critical difference

For raw materials = 2.403
For coagulants = 3.102
For interactions = 1.39

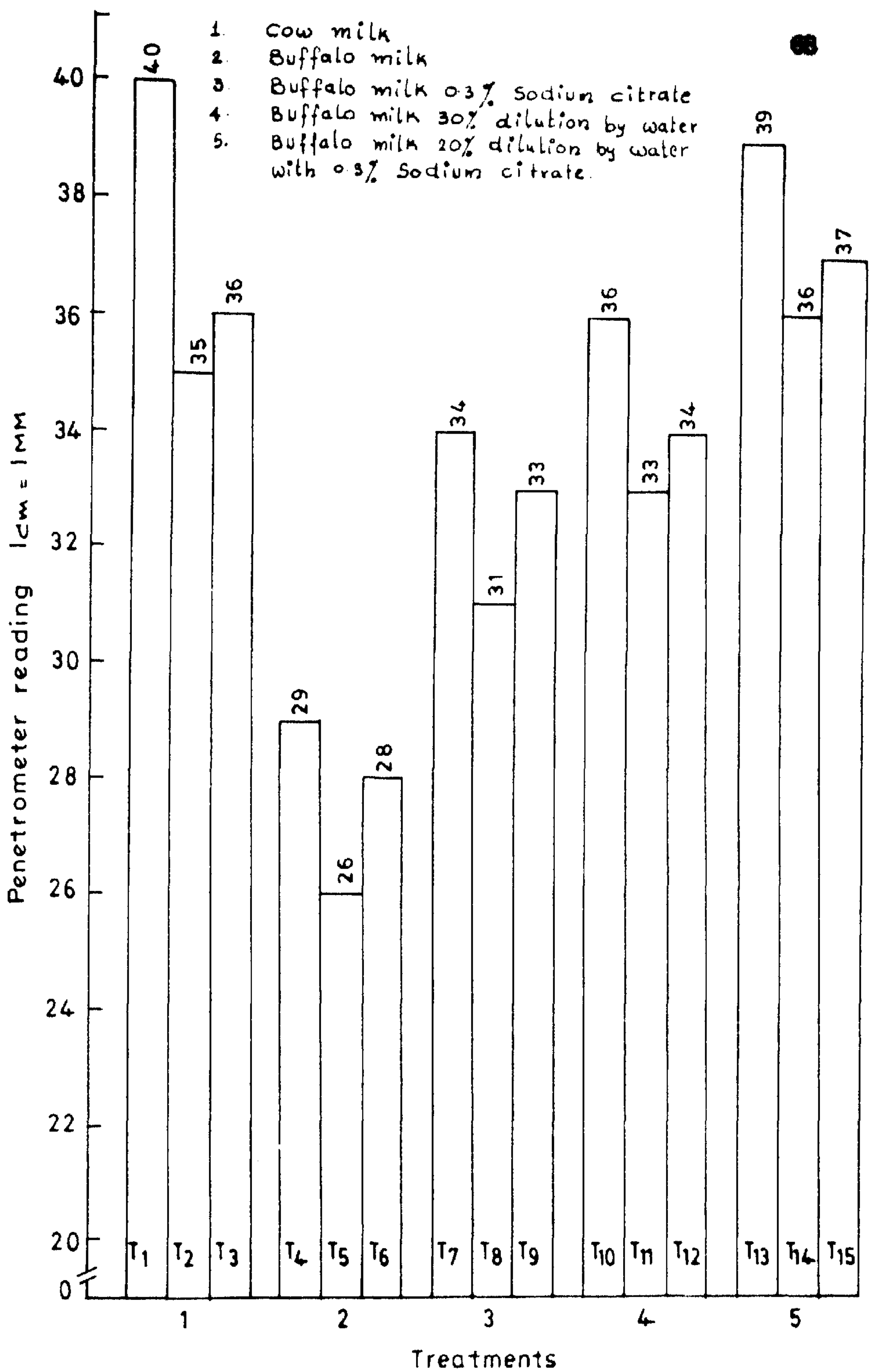


Fig.8 Effect of different treatments on penetrometer reading of chhana

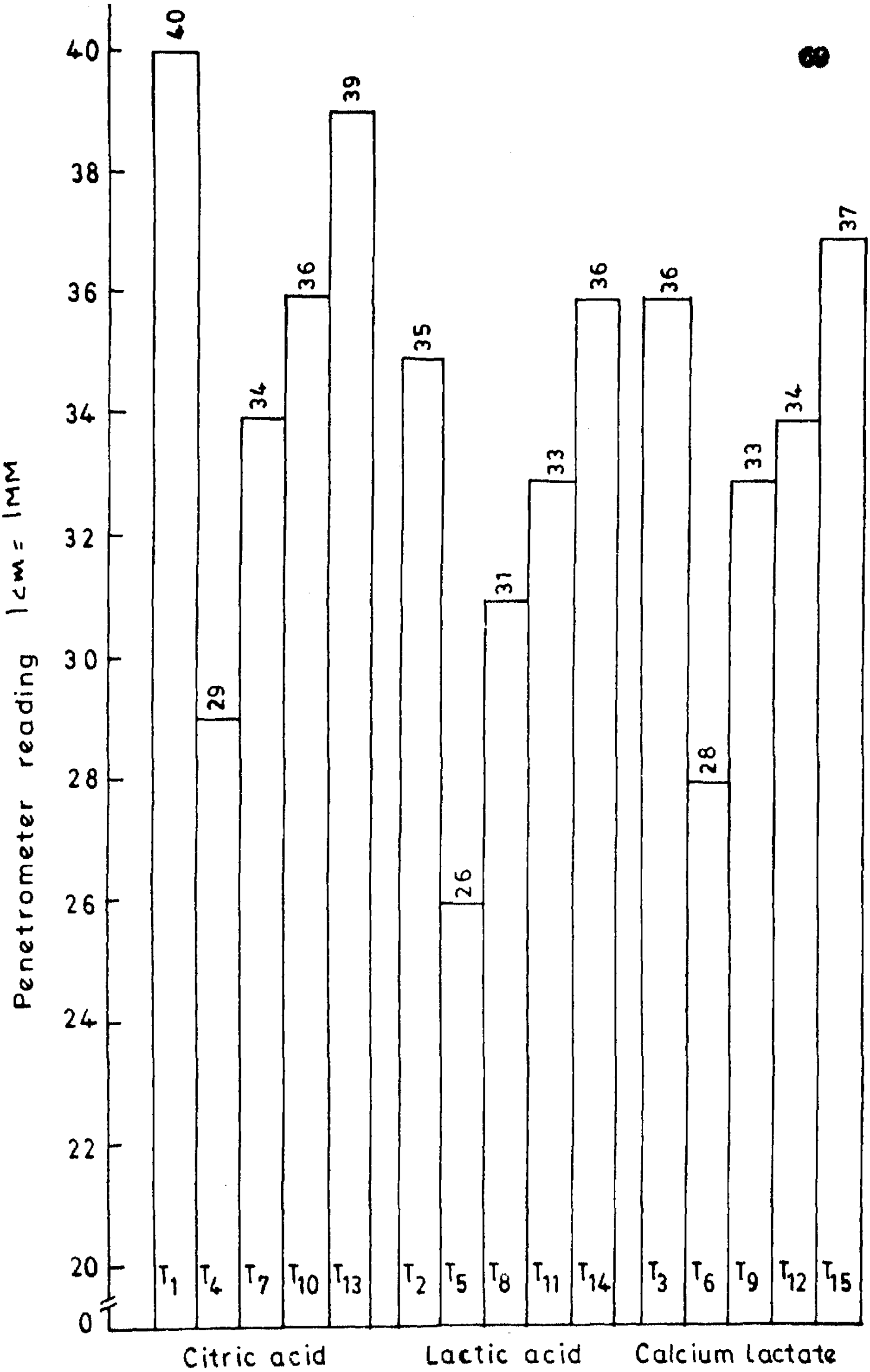


Fig.9 Effect of different coagulants on penetrometer reading of chhana

4.7 SPRINGINESS

Springiness of chhana obtained from different variable combinations is presented in the Table 13 and Fig. No.10.

The average springiness in chhana from cow milk was found to be 43.55 per cent when citric acid was used as a coagulant, 45.63 per cent when lactic acid was used and 44.54 per cent with calcium lactate whereas in chhana from buffalo milk the springiness per cents were 66.17, 67.04 and 66.86 respectively.

The buffalo milk which was treated with 0.3 per cent sodium citrate resulted in chhana with average per cent springiness of 63.56, 64.47 and 63.97 with citric acid, lactic acid and calcium lactate respectively.

The buffalo milk with 30 per cent dilution and 20 per cent dilution with sodium citrate treatment gave an average per cent springiness of 53.93, 49.25 and 56.16, 52.10 and 54.02, 52.05 for citric acid, lactic acid and calcium lactate respectively.

Analysis of variance for testing the effect of variable combinations i.e., raw materials, coagulants and their interactions presented in Table 14 shows the F values as 35332.537, 437.3719 and 49.435836 respectively. The critical differences calculated are found to be 0.4380403, 0.566799 and 0.3104482 for raw materials, coagulants and interactions between them respectively.

Table13. Effect of different types of coagulants and raw materials on springiness of chhana

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	Average
T_1	43.60	43.45	43.55	44.00	43.40	43.30	43.20	43.00	43.45	44.10	43.65
T_2	45.55	45.65	45.00	44.95	45.50	45.55	44.90	45.10	45.60	45.60	45.63
T_3	44.50	44.65	45.10	44.95	44.50	44.55	43.95	45.00	44.55	44.65	44.64
T_4	66.30	65.95	66.40	66.00	66.28	65.98	66.50	66.25	65.90	66.30	66.17
T_5	66.95	67.10	66.65	66.90	67.30	67.15	67.00	66.75	67.25	67.29	67.04
T_6	66.48	66.50	66.45	67.10	66.65	66.53	66.40	67.00	66.35	66.30	66.55
T_7	63.50	64.00	62.95	63.55	63.50	64.10	62.90	63.60	64.10	63.45	63.56
T_8	64.45	64.50	65.10	64.00	64.15	64.95	64.40	64.35	64.40	64.48	64.47
T_9	64.00	63.95	63.90	63.90	63.85	64.10	63.85	64.30	63.30	64.15	63.97
T_{10}	54.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	54.15	53.70	54.30	53.93
T_{11}	55.10	56.18	54.50	[illegible]	55.30	54.56	55.30	54.35	55.40	55.36	55.16
T_{12}	54.15	54.10	[illegible]	[illegible]	54.11	53.85	54.10	53.80	54.00	53.96	54.02
T_{13}	49.30	49.75	49.55	49.45	48.90	49.35	[illegible]	49.40	48.96	49.25	49.25
T_{14}	52.10	51.05	51.15	51.00	52.25	51.18	52.13	51.85	52.35	52.10	52.10
T_{15}	52.00	51.90	52.10	51.85	[illegible]	52.15	51.18	51.00	52.30	52.00	52.05

T_1 to T_{15} - Treatments

R_1 to R_{10} - Replications.

Table 14 Analysis of variance for testing the effect of different variable combinations on springiness per cent of chhana

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F. Value
Raw materials	4	1001[illegible].027	2503.0067	35382.837**
Coagulants	2	61.88	30.94	437.3719**
Interactions	8	27.077	3.407135	49.435836
Error	136	9.66	0.0707607	
Total	149	10111.434		

** Significant at 1% level of probability

<u>Critical difference</u>

For raw materials = 0.4380403
For coagulants = 0.663780
For interactions = 0.3104488

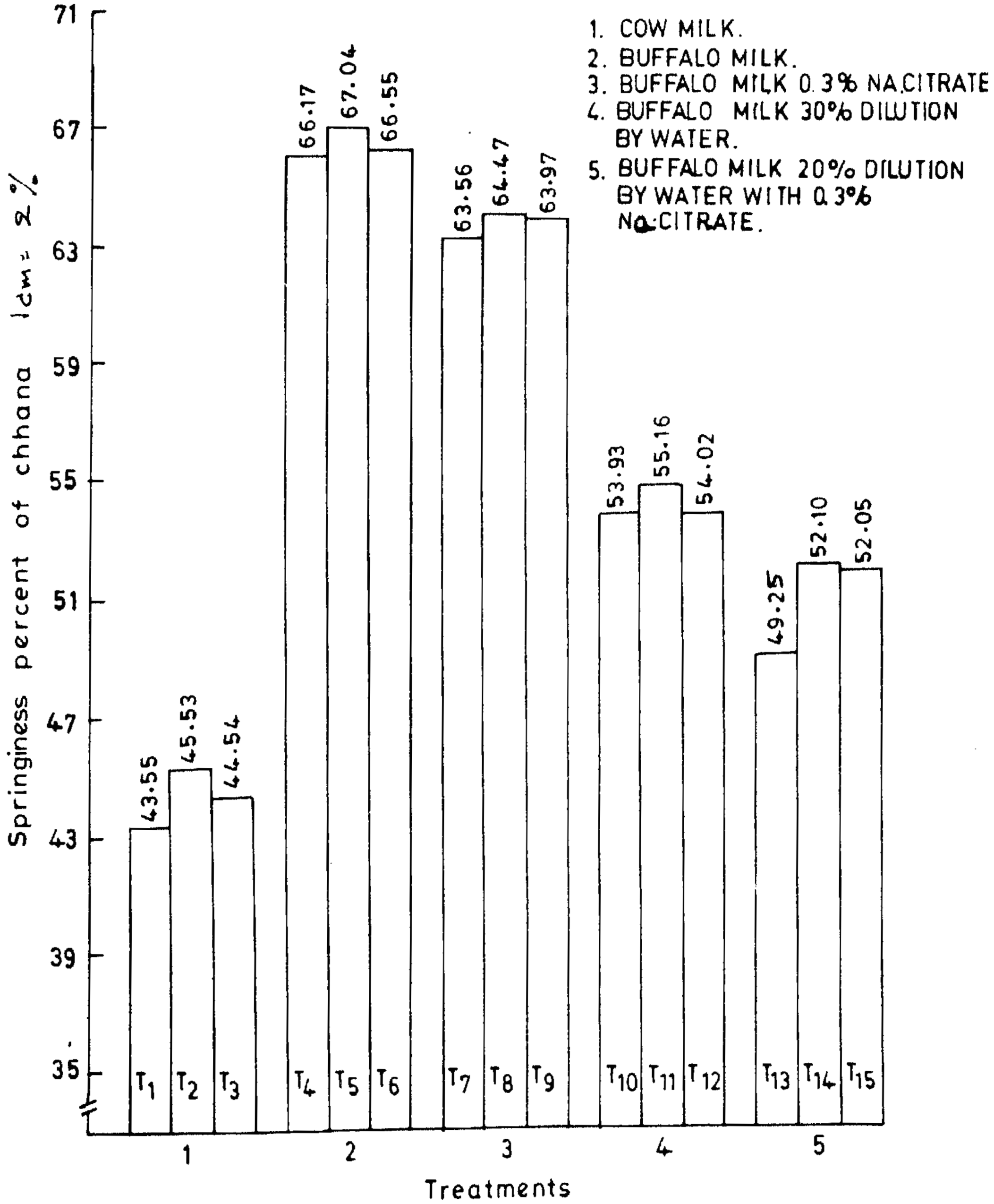


Fig.10 Effect of different treatments on springiness of chhana

4.8 ORGANOLEPTIC EVALUATION OF RASAGOLLA

The organoleptic evaluation of rasagolla obtained from different variable combinations given as a score out of 9 for overall acceptability of rasagolla is presented in the Table 15 and Fig. No. 11.

The average score of rasagolla from cow milk chhana was found to be 8.88 when citric acid was used as a coagulant, 8.86 when lactic acid was used and 8.90 for calcium lactate. Whereas rasagolla from buffalo milk chhana scored 6.33, 6.20 and 6.36 respectively.

The buffalo milk which was treated with 0.3 per cent sodium citrate resulted in rasagolla of average score of 8.64, 8.46 and 8.60 with citric acid, lactic acid and calcium lactate respectively.

The buffalo milk with 30 per cent dilution alone and 30 per cent dilution with 0.3 per cent sodium citrate resulted in rasagolla with an average score of 8.00, 8.96 and 7.86, 8.83 and 7.93, 8.38 for citric acid, lactic acid and calcium lactate respectively.

Analysis of variance for testing the effect of variable combinations i.e., raw materials, coagulants and and interactions between these presented in Table 16 shows the F values as 1818.2821, 3.6607366 and 0.2112842 respectively. The critical differences calculated are found to be 0.2217377 and 0.2360034 for raw materials and coagulants respectively.

Table 15. Effect of different types of coagulants and raw materials on overall acceptability score given by 6 judges

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	Average
T_1	9.00	8.88	8.95	8.95	8.92	8.95	9.00	9.00	8.80	8.93	8.93
T_2	8.95	8.85	8.75	[illegible]	8.78	8.85	8.92	8.95	8.85	8.80	8.85
T_3	8.95	8.95	8.85	8.90	8.80	8.80	8.95	9.00	8.85	8.80	8.90
T_4	6.18	6.35	6.50	6.35	6.15	6.50	6.45	6.40	6.60	6.25	6.38
T_5	6.32	6.95	6.25	6.35	6.20	6.30	5.90	6.25	6.40	6.35	6.29
T_6	6.25	6.30	6.50	6.35	6.10	6.50	6.40	6.35	6.50	6.20	6.25
T_7	8.55	8.50	8.70	8.50	8.45	8.50	8.40	8.55	8.75	8.55	8.54
T_8	8.35	8.45	8.60	8.35	8.35	8.40	8.45	8.65	8.50	8.50	8.46
T_9	8.45	8.35	8.65	8.40	8.30	8.45	8.45	8.75	8.55	8.50	8.49
T_{10}	7.95	7.90	8.15	8.00	7.85	7.95	8.20	8.00	7.90	8.10	8.00
T_{11}	7.90	7.95	7.80	7.95	7.90	7.75	7.80	7.80	7.85	8.00	7.95
T_{12}	7.95	7.90	7.80	8.00	7.85	7.85	7.85	8.00	7.95	8.10	7.93
T_{13}	8.95	8.90	8.95	9.00	8.85	8.90	9.00	8.95	9.00	8.95	8.95
T_{14}	8.90	8.85	8.70	8.85	8.75	8.80	8.95	8.90	8.80	8.85	8.82
T_{15}	8.85	8.90	8.00	8.90	8.80	8.80	8.85	8.75	8.95	8.92	8.85

T_1 to T_{15} = Treatments

R_1 to R_{10} = Replications.

Table 16. Analysis of variance for testing the effect of different variable combinations on organoleptic quality of rasagolla

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F. Value
Raw materials	4	138.457	34.61425	1918.2821**
Coagulants	2	0.3485	0.17425	9.6567356**
Interactions	8	0.0305	0.0038125	0.2112843NS
Error	135	2.436	0.018044	
Total	149	141.272		

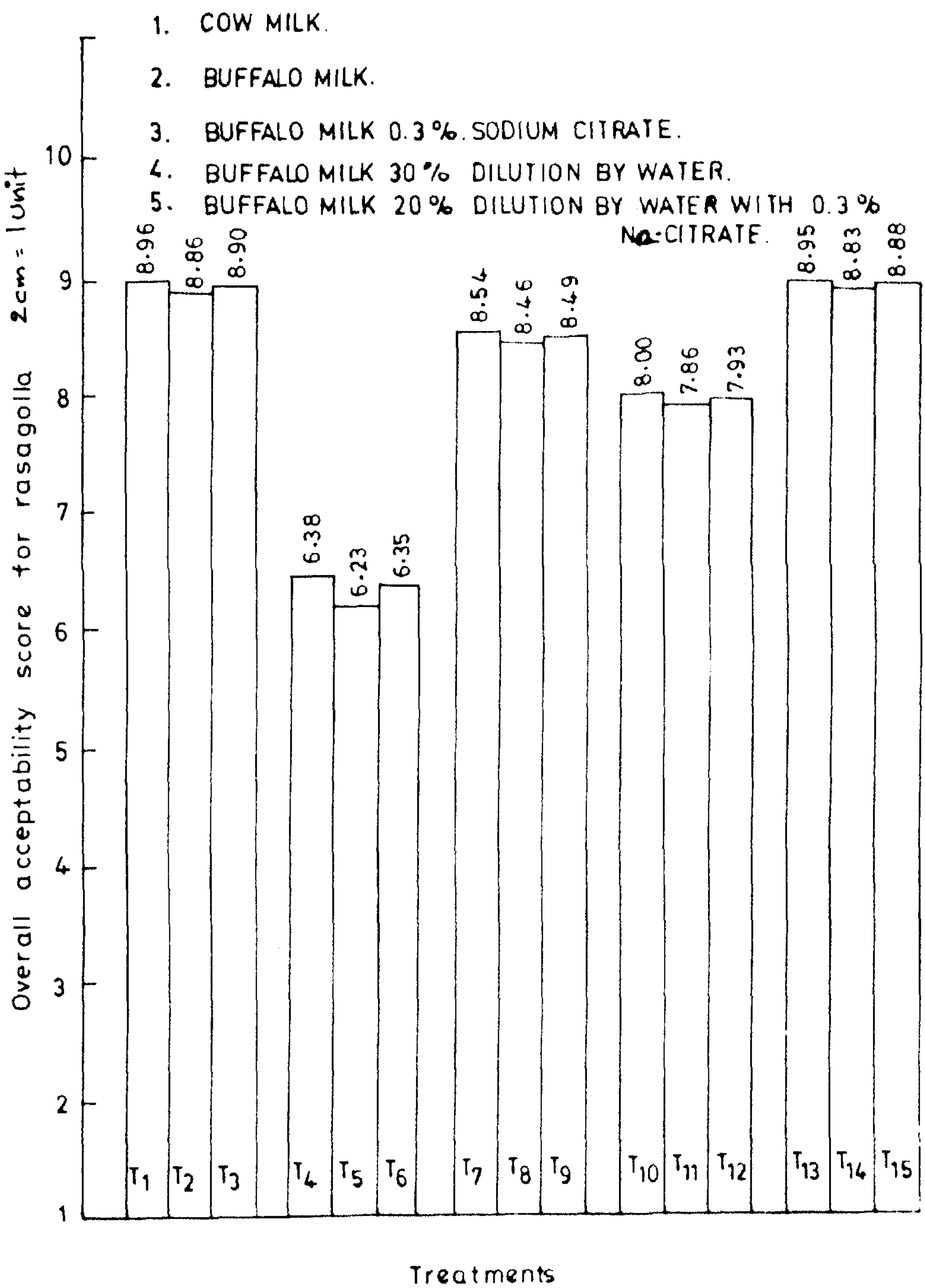
** Significant at 1% level of probability

NS - Non significant

Critical difference

For raw materials = 0.0217377
For coagulants = 0.[illegible]

Fig 11. Effect of different treatments on organoleptic quality of rasagolla



The results observed by analysis of chhana obtained from variable combinations have been presented and projected in figures.

DISCUSSION

CHAPTER V

DISCUSSION

5.1 MOISTURE CONTENT OF CHHANA

The F values obtained by analysis of variance shown in Table indicates that at 1 per cent level of probability the raw materials coagulants and their interaction had significant effect on moisture content of chhana.

The comparison of average moisture content of chhana made from different variable combinations as shown in Table 1 indicate that the buffalo milk with 30 per cent dilution by water coagulated with lactic acid resulted in highest moisture content of 60.61 per cent whereas buffalo milk alone with calcium lactate coagulation resulted in lowest moisture content of 66.00 per cent.

Average moisture contents of buffalo milk chhana when compared with the chhana obtained from buffalo milk treated with 0.3 per cent sodium citrate gave slightly higher moisture contents, however the mean values of moisture contents of chhana from different variable combinations when compared with critical difference of raw materials (0.6031791) no significant difference between buffalo milk alone and buffalo milk with 0.3 per cent sodium citrate was observed. Further, no significant difference was observed between buffalo milk with 0.3 per cent sodium citrate and buffalo milk with 30 per cent dilution with 0.3 per cent sodium citrate and between buffalo milk with 30 per cent dilution and cow milk.

The critical difference also indicates that moisture conten in chhana from cow milk differs significantly from that of buffa milk alone, buffalo milk 30 per cent dilution with water and buf milk 30 per cent dilution by water and with 0.3 per cent sodium citrate.

The moisture content in chhana resulted from different variable combinations when compared with critical difference of coagulants (0.307428) no significant difference observed between citric and lactic acids whereas calcium lactate significantly differed with citric and lactic acids.

The interactions of coagulants and raw materials when compared with critical difference (0.460.50) the following observations were made.

Buffalo milk with 0.3 per cent sodium citrate coagulated with calcium lactate was not significantly different with buffalo milk alone coagulated with calcium lactate and buffalo milk with 30 per cent dilution by water and treated with 0.3%sodium citrate coagulated with calcium lactate. Further buffalo milk with 30 per cent dilution by water coagulated with calcium lactate did not differ significantly with buffalo milk alone coagulated with citric acid and buffalo milk with 30 per cent dilution by water with addition of 0.3 per cent sodium citrate coagulated with calcium lactate. There was no significant difference between buffalo milk with addition of 0.3 per cent sodium citrate with citric acid and buffalo milk alone with lactic and citric acid

Buffalo milk with 30 per cent dilution by water treated with 0.3 per cent sodium citrate with citric acid was statistically similar to that of buffalo milk alone coagulated with lactic acid and buffalo milk with addition of 0.3 per cent sodium citrate coagulated with lactic acid.

Cow milk coagulated with lactic acid, buffalo milk 30 per cent dilution by water coagulated with lactic acid, and buffalo milk 30 per cent dilution by water with addition of 0.3 per cent sodium citrate coagulated with lactic acid did not differ significantly with cow milk coagulated with calcium lactate. Further, cow milk coagulated with citric acid did not differ significantly with buffalo milk 30 per cent dilution by water coagulated with calcium lactate, but buffalo milk 30 per cent dilution by water coagulated by citric acid was significantly differed with that of cow milk coagulated with lactic acid.

The critical difference further indicates that the buffalo milk channa prepared by the addition of 0.3 per cent sodium citrate coagulated with lactic acid differed significantly with buffalo milk diluted by 30 per cent water with addition of 0.3 per cent sodium citrate coagulated with lactic acid. Further, cow milk coagulated with calcium lactate differ with cow milk channa prepared by using citric acid, and cow milk channa with lactic acid coagulant differed with buffalo milk diluted by 30 per cent water coagulated with lactic acid.

In general it was observed that buffalo milk coagulated with all the three coagulants resulted in low moisture channa compared to that of cow milk chhana. Calcium lactate was observed to result in low moisture chhana compared to other 2 coagulants irrespective of raw material differences.

5.2 PER CENT RECOVERY OF TOTAL SOLIDS

The F values obtained by analysis of variance shown in Table 4, indicates that at 1 per cent level of probability the raw materials, coagulants and their interactions had significant effect on per cent recovery of total solids during chhana making.

The comparison of average per cent recovery of chhana made from different variable combinations as shown in Table 3 indicates that the percent recovery of milk solids from buffalo milk with 20 per cent dilution with water and 0.3 per cent sodium citrate treatment with calcium lactate as coagulant gave an highest average per cent recovery of 74.92, whereas the cow milk with lactic acid gave an average lowest per cent of total solids recovery being 60.86 per cent.

The mean values of per cent recovery of total solids of chhana from different variable combinations when compared with critical difference of raw materials (1.110004) significant difference between cow milk and buffalo milk with 20 per cent dilution, and buffalo milk with 20 per cent dilution and buffalo milk alone was observed.

No significant difference between buffalo milk alone and buffalo milk with addition of 0.3 per cent sodium citrate, and buffalo milk 0.3 per cent sodium citrate and buffalo milk 30 per cent dilution by water with 0.3 per cent sodium citrate was observed.

The per cent recovery of total solids by using different coagulants when compared with critical difference, (1.444837) no significant difference was observed between citric and lactic acids whereas calcium lactate significantly differed with citric and lactic acids.

The interaction of coagulants and raw materials when compared with critical difference (0.7012071) the following observations were made.

Cow milk with citric acid differ from cow milk with lactic acid and buffalo milk 30 per cent dilution with lactic acid and buffalo milk 30 per cent dilution with lactic acid differed with cow milk calcium lactate. Buffalo milk 30 per cent dilution by water with 0.3 per cent sodium citrate with citric acid differ with buffalo milk alone with calcium lactate and buffalo milk 30 per cent dilution by water with citric acid differed with buffalo milk with lactic acid. Buffalo milk with 0.3 per cent sodium citrate with lactic acid differed with buffalo milk with citric acid and buffalo milk 30 per cent dilution by water with calcium lactate differ with buffalo milk 0.3 per cent sodium citrate with calcium lactate.

Cow milk coagulated with calcium lactate did not differ with buffalo milk 30 per cent dilution by water with citric acid. Buffalo milk coagulated with lactic acid did not differ with buffalo milk 20 per cent dilution by water and 0.3 per cent sodium citrate with lactic acid and also not differed with buffalo milk 0.3 per cent sodium citrate with lactic acid. Buffalo milk alone with calcium lactate did not differ with buffalo milk 30 per cent dilution by water with calcium lactate. Buffalo milk 0.3 per cent sodium citrate with citric acid not differed with buffalo milk 20 per cent dilution by water with 0.3 per cent sodium citrate with citric acid.

Buffalo milk with 0.3 per cent sodium citrate coagulated with calcium lactate did not differ significantly with buffalo milk 20 per cent dilution and 0.3 per cent sodium citrate with calcium lactate.

In general it was observed that the average per cent recovery of total solids was significantly differed among coagulants, raw materials and their interactions.

The highest average per cent recovery of total solids with calcium lactate among coagulants in this study was comparable to results obtained by Sen and De (1984).

5.3 PROTEIN CONTENT

The F values obtained by analysis of variance shown in Table 6 indicates that at 1 per cent level of probability the raw materials, coagulants had significant effect on protein content of chhana but interaction of coagulants and raw materials had no significant effect.

The comparison of average protein content of chhana made from different variable combinations as shown in Table 6 indicates that chhana obtained from cow milk with calcium lactate resulted in highest protein content (17.08) whereas the buffalo milk 30 per cent dilution by water with lactic acid gave an average lowest protein content (14.13). It was also observed that protein content in chhana from buffalo milk treated with sodium citrate had low values compared to buffalo milk alone.

The mean values of protein content of chhana from different variable combinations when compared with critical difference of raw materials (0.3627548) significant difference was observed between buffalo milk alone with buffalo milk treated with 0.3 per cent sodium citrate and cow milk.

The protein content obtained by using different coagulants when compared with critical difference (0.4504048), no significant difference was observed between citric acid, lactic acid and calcium lactate.

In general it was observed that protein content of the chhana from buffalo milk had the lowest value than the chhana obtained from cow milk. This result was comparable to the results obtained by Gyanendra Kumar and Srinivasan (1982). From the Table it was also observed that stabilizers had shown effect on protein per cent of chhana as buffalo milk treated with 0.3 per cent sodium citrate had lowest protein content compared to chhana obtained from buffalo milk alone.

5.4 pH OF CHHANA

The F values obtained by analysis of variance is shown in Table 6 indicates that at 1 per cent level of probability the raw materials had significant effect on pH of chhana. However the coagulants and interaction of coagulants and raw materials had no significant effect on pH of chhana.

The comparison of average pH values of chhana made from different variable combinations as shown in Table 7 indicated that pH of chhana made from buffalo milk treated with 0.3 per cent sodium citrate had higher pH values compared to other combinations. Chhana obtained from cow milk had low pH (5.53) with citric acid as a coagulant, whereas chhana obtained from buffalo milk treated with 0.3 per cent sodium citrate coagulated with lactic acid and calcium lactate had slightly high pH (5.74).

The mean values of pH of chhana obtained from different variable combinations when compared with critical difference of raw materials (0.0001007), cow milk pH differed significantly with buffalo milk pH, and also differed with buffalo milk treated with 0.3 per cent sodium citrate, however the other combinations did not differ statistically.

Chhana prepared with and without sodium citrate treatment to buffalo milk when compared, the pH values were higher in chhana of sodium citrate treatment and this may be due to sodium salts used as a stabiliser which tends to raise pH as reported by Jenness and Patton (1969).

4.5 TITRATABLE ACIDITY OF CHHANA

The F values obtained by analysis of variance shown in Table 10 indicates that at 1 per cent level of probability the raw materials, coagulants and their interactions had significant effect on acidity of chhana obtained from different variable combinations.

The comparison of average acidity of chhana obtained from different variable combinations as shown in Table 9 indicates that chhana obtained from cow milk had higher acidity compared to other combinations. Chhana obtained from cow milk with lactic acid had high acidity (0.252) whereas chhana obtained from buffalo milk with 20 per cent dilution by water with sodium citrate, coagulated with citric acid had low acidity (0.213).

The mean values of acidity of chhana obtained from different variable combinations when compared with critical difference of raw materials (0.0068656) acidity of cow milk chhana significantly differed to that of buffalo milk chhana, and also buffalo milk alone differed with that of chhana prepared from buffalo milk treated by 0.3 per cent sodium citrate.

Acidity of chhana obtained from buffalo milk by 30 per cent dilution with water did not significantly differ with buffalo milk treated with 0.3 per cent sodium citrate. Further, buffalo milk with 30 per cent dilution with water also did not significantly differ to that of buffalo milk with 20 per cent dilution and with 0.3 per cent sodium citrate addition.

The mean values of acidity of chhana obtained from different coagulants when compared with critical difference (0.0082891) no significant difference was observed between coagulants. The interactions of coagulants and raw materials when compared with critical difference (0.0048126) acidity of buffalo milk chhana from citric acid differed with buffalo milk chhana coagulated with lactic acid and chhana from cow milk coagulated with citric acid differed significantly to that of chhana obtained from calcium lactate coagulation of both cow and buffalo milks. However the other combinations did not differ significantly with each other.

In general it was observed that chhana from cow milk had higher acidity values compared to other combinations and it was also observed that stabilizer i.e., sodium citrate shown the effect by lowering the acidity slightly in treated samples. This was in agreement with the observations of Gould and Frantz (1946) who reported that sodium citrate added as a stabilizer caused rearrangement of salts resulting in a change of buffer capacity which might have decreased titratable acidity.

5.6 PENETROMETER READING

The F values obtained by analysis of variance shown in Table 12 indicates that at 1 per cent level of probability the raw materials, coagulants had significant effect on penetrometer reading of chhana. Whereas at 5 per cent level of probability the interaction of coagulants and raw materials had significant effect on them.

The comparison of average penetrometer readings of chhana made from different variable combinations as shown in Table 11, indicates that cow milk coagulated with citric acid gave an highest penetrometer reading of 40, whereas buffalo milk with 30 per cent dilution by water and treated with 0.3 per cent sodium citrate with citric acid coagulant gave next highest penetrometer reading. The least penetrometer reading of 28 was observed for chhana from buffalo milk alone with lactic acid.

The mean values of penetrometer readings of chhana from different variable combinations when compared with critical difference of raw materials (2.403), cow milk differed significantly with buffalo milk alone and with buffalo milk with 30 per cent dilution by water, and buffalo milk treated with 0.3 per cent sodium citrate. Further, buffalo milk alone was found to differ significantly with that of buffalo milk treated with 0.3 per cent sodium citrate.

Buffalo milk with 20 per cent water and with addition of 0.3 per cent sodium citrate did not differ significantly with cow milk.

The penetrometer readings obtained from chhana prepared by using different coagulants when compared with critical difference (3.102) no significant difference between citric acid and calcium lactate, lactic acid and calcium lactate was observed. But significant difference was observed between citric acid and lactic acid.

The interaction of coagulants and raw materials when compared with critical difference (1.29) the following observations were made.

Buffalo milk with lactic acid significantly differed with buffalo milk coagulated with citric acid and calcium lactate. Buffalo milk with citric acid differed significantly with buffalo milk treated with 0.3 per cent sodium citrate coagulated with lactic acid. The latter differed significantly with buffalo milk treated with 0.3 per cent sodium citrate coagulated with calcium lactate, and buffalo milk 20 per cent dilution by water with addition of 0.3 per cent sodium citrate coagulated with citric acid.

Chhana obtained from buffalo milk with 20 per cent dilution by water and 0.3 per cent sodium citrate resulted in significantly different chhana with calcium lactate and citric acid as far as penetrometer reading was concerned. However buffalo milk with 0.3 per cent sodium citrate coagulated with calcium lactate did not differ significantly with buffalo milk diluted with 30 per cent water coagulated with lactic acid and calcium lactate.

Cow milk coagulated with lactic acid did not differ with buffalo milk with 0.3 per cent sodium citrate coagulated with citric acid and buffalo milk 30 per cent dilution by water coagulated with calcium lactate. Further cow milk with lactic acid was not significantly differed with cow milk coagulated with calcium lactate, buffalo milk 30 per cent dilution by water with citric acid and buffalo milk 20 per cent dilution by water with 0.3 per cent sodium citrate with lactic acid and calcium lactate. No significant difference between cow milk coagulated with citric acid and buffalo milk 20%dilution by water with 0.3% sodium citrate coagulated with citric acid was also observed.

In general it was observed that raw materials, coagulants and their interaction directly influenced the penetrometer readings of chhana which indicates that the consistency of chhana was influenced by variable combinations. Chhana prepared by treated buffalo milk with 20 per cent dilution by water and 0.3 per cent sodium citrate addition coagulated with citric acid was found to have same consistency to that of chhana from cow milk coagulated with citric acid.

5.7 SPRINGINESS

The F values obtained by analysis of variance is shown in Table 14, indicates that at 1 per cent level of probability the raw materials, coagulants and their interaction had significant effect on per cent springiness of chhana.

The comparison of average per cent springiness of chhana made from different variable combinations as shown in Table 13 indicates that the per cent springiness for buffalo milk chhana coagulated by lactic acid was found to be (67.04) highest among all different variable combinations, whereas the cow milk chhana with citric acid had lowest per cent springiness (43.66).

The mean values of per cent springiness of chhana from different variable combinations when compared with critical difference of raw materials (0.4390403), all the different variable combinations are significantly differ with each other.

The per cent springiness of chhana obtained by using different coagulants when compared with critical difference (0.860799) all the three coagulants are significantly differed with each other.

The interaction of coagulants and raw materials when compared with critical difference (0.3104402) all combinations are significantly differed with each other except that buffalo milk diluted with 30 per cent water coagulated with citric acid and with calcium lactate.

In general it was observed that consistency of the chhana indicated by springiness per cent. Chhana from cow milk which was used as control had low values and comparable with buffalo milk with 30 per cent dilution by water and with 0.3 per cent sodium citrate addition.

It was also observed with springiness per cent values that buffalo milk diluted with 20 per cent water and treated with 0.3 per cent sodium citrate coagulated with citric acid had almost similar consistency to that of cow milk chhana coagulated with citric acid which indicates the dilution of buffalo milk with 20 per cent water and treatment with 0.3 per cent sodium citrate result in good quality chhana.

5.8 ORGANOLEPTIC EVALUATION OF RASAGOLLA

The F values obtained by analysis of variance is shown in Table 16 indicates that at 1 per cent level of probability the raw material and coagulants had significant effect on organoleptic quality of rasagolla, but interaction of raw materials and coagulants had no significant effect on organoleptic quality of rasagolla.

The comparison of average score values for rasagolla obtained from different variable combinations as shown in Table 16, indicates that rasagolla obtained from cow milk chhana with citric acid coagulant had highest score (8.96) whereas buffalo milk alone with lactic acid had lowest score (6.83). The table further indicates that rasagolla obtained from buffalo milk with 20 per cent dilution by water with 0.3 per cent sodium citrate and coagulated with citric acid had scored next highest score compare to cow milk chhana with citric acid being 8.96.

The mean values of organoleptic evaluation score values of rasagolla obtained from different variable combinations when compared with critical difference of raw materials (0.2217377) the following observations were made.

Rasagolla from cow milk chhana differed significantly with all 3 combinations, but it was not significantly differed with rasagolla obtained from buffalo milk diluted with 20 per cent water and treated with 0.3 per cent sodium citrate.

Rasogolla from buffalo milk alone, and buffalo milk with 0.3 per cent sodium citrate, and buffalo milk with 30 per cent dilutin by water significantly differed from rasagolla obtained from buffalo milk 20 per cent dilution by water with 0.3 per cent sodium citrate addition.

The average score values of rasagolla obtained from different coagulants when compared with critical difference (0.2863834), rasagolla from citric acid significantly differed to that of lactic acid and calcium lactate.

In general it was observed that rasagolla obtained from buffalo milk with 20 per cent water dilution and with 0.3 per cent sodium citrate resulted in almost same quality rasagolla to that of cow milk rasagolla which was used as a control. It was also observed that raw materials significantly affected the quality of rasagolla. Further with dilution of milk and with sodium citrate treatment significant effect was observed in the quality of rasagolla. These observations were in consistent with the observations of Ray and De (1953), Jagtiani et al. (1960) and Iyer (1978).

It was also observed that citric acid coagulant had given good quality rasagolla followed by calcium lactate and lactic acid coagulants.

Finally it was observed from this analysis that buffalo milk with addition of 20 per cent water treated with 0.3 per cent sodium citrate coagulated with citric acid resulted in acceptable quality of rasagolla which was almost similar to that of rasagolla obtained from cow milk by using citric acid as coagulant.

The results presented in preceding chapter have been discussed in this chapter.

SUMMARY AND CONCLUSION

CHAPTER VI

SUMMARY AND CONCLUSIONS

There are so many factors which influence the quality of chhana and subsequently the acceptability of rasogolla. In the present investigation various factors and their variable combinations responsible to influence quality of chhana have been taken into consideration. Main emphasis was to find the suitability of buffalo milk with different treatments for chhana making and to investigate its comparability with chhana from cow milk which is normally recommended and preferred for this product. Accordingly buffalo milk alone, buffalo milk diluted with water and diluted buffalo milk with an additive such as sodium citrate have been used as raw material for the preparation of chhana using 3 different coagulants such as citric acid, lactic acid and calcium lactate. The results obtained have been tabulated, analysed and summarised as follows:

1. Highest average per cent recovery of total solids with calcium lactate among coagulants was observed.

2. Calcium lactate coagulant was observed to result in low moisture content in chhana.

3. Buffalo milk treated with 0.3 per cent sodium citrate gave slightly high moisture content than others which were not treated with sodium citrate.

4. Chhana obtained from cow milk had higher protein content compared to buffalo milk chhana.

5. Sodium citrate resulted in low protein content in chhana from diluted buffalo milk when compared to chhana obtained from buffalo milk alone.

6. pH of chhana made from buffalo milk treated with 0.3 per cent sodium citrate had higher values compared to buffalo milk alone.

7. Chhana from cow milk had resulted in higher acidity per cent compared to other combinations.

8. Buffalo milk treated with sodium citrate had resulted in low acidity compared to buffalo milk alone.

9. Buffalo milk 20 per cent dilution by water with 0.3 per cent sodium citrate addition coagulated with citric acid was found to have high penetrometer readings indicates similar consistency of chhana from cow milk.

10. Springiness per cent also revealed that buffalo milk 20 per cent dilution by water with 0.3 per cent sodium citrate had similar consistency to that of cow milk chhana.

11. Organoleptic evaluation was also revealed that buffalo milk with 20 per cent dilution by water, with 0.3 per cent sodium citrate with citric acid resulted in good quality rasagolla and comparable to cow milk rasagolla.

Taking into consideration the above results of investigation buffalo milk with 20 per cent dilution by water with 0.3 per cent sodium citrate coagulated with citric acid is recommended for smooth chhana and also acceptable quality of rasogolla.

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