5. DISCUSSION

5.1. Survey on tradition of dudh churpi

The organized milk sectors and private vendors of Bhutan, Sikkim and Darjeeling procure milk from different villages of these areas where motorable road facility exists. But, thousands of milk producers of remote villages still can not sale their surplus milk to these agencies due to topographical constraints. Unprocessed milk, where clean milk production is not practiced, develops acidity within 4-5 h. Hence to preserve milk solids, the milk producers of those places convert their surplus milk into butter, churpi and dudh churpi. Churpi and dudh churpi are believed to be highly nutritious, energy giving and a shelf stable product (SSP). They can be shelved upto one year and, therefore, provide a vehicle for preserving the valuable nutrients in milk and making those nutrients available throughout the year. During mastication, they help in greater amylase secretion which, in turn, provides higher activation energy duriong uphill trekking.

5.2. Analyses of market samples of dudh churpi

5.2.1. Chemical, sensory and instrumental analyses

Wide variation in the contents of moisture, fat and protein in the market samples of dudh churpi from different sources was likely due to the difference in type of milk, method of separation, heat treatment of the curd and treatment with concentrated sugar solution of milk. Lactose and glucose-galactose content of the samples of Bhutan and Sikkim indicated little or no evidence of lactose hydrolysis. Considerable hydrolysis of milk sugar in the samples of Darjeeling might apparently be due to the lack of heat treatment of milk and/or green curd and higher moisture content at the onset of drying An appreciable amount of lactose was found in the market samples of chhana (Nasir *et al.* 1987). Free fat content ranged between 23 and 25% of total fat. High free fat content in the samples of dudh churpi may be explained as the combined action of scraping and agitation during cooking of green curd and treatment of partially dried product (prechurpi) with concentrated sugar solution. This causes rupture of fat globule membrane resulting in the release of higher amount of free fat. Coagulation of protein in the fat globule membrane also contributes to freeing of fat (Ranganadhan and Rajorhia 1989).

Water-dispersible protein (WDP) of market samples of dudh churpi varied from 6.5 to 13.5% of the total protein content. The higher WDP in the samples of Darjeeling indicated that a smaller portion of the total protein was transferred to the solid network, and that resulted in lower cohesive force and cosequently less hard dudh churpi. In the market samples of churpi, the WDP content was reported to be 5.7-12.3% of total protein (Pal 1994).

High titratable acidity and low pH in the samples of Darjeeling could be associated with high moisture content at the onset of drying of the product which might have initiated greater microbial metabolism.

Among the milk and milk products, cheddar cheese and churpi which give 1.7 and 1.5 MJ/100 g energy respectively (De 1980; Pal 1994) are comparable to the energy value of dudh churpi (1.6 MJ/100 g).

Compared to other chhana-based milk products (Sen and Rajorhia 1989), the free fatty acid (FFA) of dudh churpi was fairly high. The reason for higher release of FFA could be due to the hydrolysis of fat by exocellular lipases of pseudomonads which are not inactivated even after ultra-high temperature (UHT) processing (Renner 1979).

Prolonged drying at elevated temperature (>30°C) and in open air could be responsible for higher 2-thiobarbituric acid (TBA) value of market dudh churpi (Wadsworth and Bassette 1985). Moreover, milk contains many minor polyunsaturated fatty acids, and the autooxidation of dairy products can lead to a multitude of saturated and unsaturated aldehydes resulting in higher TBA values (Kurtz 1974).

Tyrosine value in the samples of Bhutan and Sikkim was much less than that of fermented dairy products (Vema and Anand 1987), which indicated little or no evidence of proteolysis in dudh churpi. Severe heat treatment during preparation of dudh churpi in Sikkim and Bhutan might cause the destruction of milk proteases resulting in a lower tyrosine value. Probably due to lack of heat treatment of milk/green curd the tyrosine value in the samples of Darjeeling was fairly high.

Heat processing of milk and other food products leads to complex changes and interactions among the constituents. During a study of effect of heat on milk at elevated temperature, the observation was made that the product, after heat sterilization, developed a capacity for reacting with p-dimethylaminobenzaldehyde (p-DMAB). By measuring the p-DMAB reactivity, the extent of heat treatment to milk and milk products could be found out (Hansen 1967). It was evident that the samples of dudh churpi of Darjeeling had less p-DMAB reactivity and were much less heat treated than the samples of two other sources.

5-Hydroxymethylfurfural (HMF) is one of the intermediate products of Maillard reaction and its formation depends primarily on heating temperatures, moisture content and also storage conditions. Both free and total HMF content in the samples of three different areas were exceptionally high than any other dairy products (Caric *et al.* 1984). The samples of Sikkim with maximum HMF content resulted in minimum reflectance, and those of Darjeeling with least HMF content showed maximum reflectance. Higher reflectance could be explained by the formation of melanoidin. During Maillard reaction HMF or furfural is produced under acidic conditions, and reductones and dehydroreductones are produced under mild acidic to basic conditions. These can undergo Strecker degradation, and at high temperatures fragmentation products from the Amadori product are produced. Polymerization of the products from the second phase yields brown melanoidin pigments in the third and final phase of the Maillard reaction (Labuza and Saltmarch 1981). These brown pigments interferes the passage of light through the samples. Higher HMF value could be attributed due to higher heat treatment such as open pan heating with constant stirring which together reduced the inhibitory effect of free sulphydryls on browning, as incorporation of oxygen during stirring oxidizes free sulphydryls (Nagendra *et al.* 1991). This can be further attributed to higher heat treatment in pan because the heat source is limited to bottom of the pan and provides greater activation energy for HMF accumulation (Golubonic *et al.* 1983). Moreover, direct contact of super-saturated solution of lactose with hot surface of pan could enhance lactose caramelization resulting in the formation of HMF (De 1980).

5.2.2. Relationship between sensory attributes and intrinsic parameters

A high negative correlation ($P<0.001$) of flavour with lactic acid is presumably associated with the growth of microorganisms by utilizing lactose (Mandokhot and Garg 1985). Lactose degradation is further evident from high titratable acidity/low pH values of the samples of Darjeeling. A high level of lactic acid gives rise to sour smell and taste which are not desired in dudh churpi. Significantly adverse effect of FFA and TBA on the flavour of dudh churpi could be associated with lipolysis and with the autooxidative products of unsaturated fatty acids, mainly oleic, linoleic and linolenic together with phospholipids (Kinsella *et al.* 1967). Browning is not usually desirable in food products because of the production of reducing substances, fluorescent substances and disagreeable flavour materials during Maillard reaction (Nickerson 1974). But these substances seem to influence the characteristic flavour profile of dudh churpi, and consequent to this postulation a high positive correlation (P<0.001) of free and total HMF with flavour was observed.

A higher heat treatment provides greater activation energy to form higher amount of free and potential HMF (Berk 1976) and increases the protein-protein interactions (Saio *et al.* 1968; Catsimpoolas *et al.* 1969,1970) leading to higher compactness. This justifies the positive correlation (P<0.001) of p-DMAB reactivity and free and total HMF values with body and texture scores of dudh churpi. A high tyrosine content indicates extensive protein hydrolysis which is detrimental to the characteristic body and texture profile of dudh churpi. Extensive protein hydrolysis in the samples of churpi of Darjeeling resulted in brittle and crumbly body (Pal 1994). Thus, a high negative correlation (P<0.001) was observed with body and texture scores and tyrosine content of dudh churpi.

5.2.3. Relationship between chemical composition and Instron parameters

A high positive correlation (P<0.01) of Instron hardness with total solids of dudh churpi and a negative correlation (P<0.01) with WDP may be explained in the light of moisture and protein contents of the product. Increase in total solids content decreases free moisture and increases the protein proportion of the product (Patel *et al.* 1993) resulting in greater hardness. Higher WDP means that only a smaller portion of the total protein was tranferred to the solid network resulting in lower hardness. Inelastic stretching of the protein molecules caused by the combined effect of coulombic repulsion and thermal vibration increases the entropy of a system (Jolly 1965). The possibility of such an effect cannot be ignored in dudh churpi, since it undergoes severe heat treatment in the three different stages. A similar observation was made in churpi (Pal 1994).

Contrary to hardness, cohesiveness in khoa decreased substantially with the increase in its total solids content. This might be due to the decreased free moisture content in the product. The increase in total solids was accompanied by a decrease in cohesiveness of khoa (Rajorhia *et al.* 1991; Patel*et al* 1993). Total fat, free fat, WDP and total sugar presumably have a declining effect in the interparticle binding causing a less cohesive dudh churpi.

Since gumminess is a product of hardness and cohesiveness, it showed a positive correlation with total solids and a negative correlation with WDP content.

The significant impact of compositional variables on Instron texture parameters provides ample information in determining textural chracteristics of the product. No literature is available on such inter-relationships of dudh churpi. However, the impact of compositional variables on Instron textural parameters is found in chhana (Desai 1988), Khoa (Gupta *et al.* 1990) and churpi (Pal 1994).

5.2.4. Relationship between sensory textural descriptors and Instron texture profile parameters

A high positive correlation (P<0.01) was found between Instron hardness and sensory firmness of dudh churpi. Similar correlations were observed in cottage cheese, chhana, paneer, khoa and churpi (Parry and Carroad 1980; Desai 1988; Patil *et al.* 1990; Pal 1994).

Lack of appreciable correlation between Instron cohesiveness and sensory crumbliness indicates that organoleptically perceived crumbliness of dudh churpi may not necessarily be reflected in instrumental cohesiveness as was found in khoa (Patil *et al.* 1990).

Springiness of dudh churpi in combination with hardness predicted better firmness ($P<0.001$) than what it could predict alone. A similar observation was made in khoa and churpi (Patil *et al.* 1990; Pal 1994). Thus, dudh churpi with greater hardness tended to be more springy.

Instron chewiness was significantly correlated ($P<0.001$) with sensory chewiness of dudh chrupi. The corresponding regression equation exhibited only 25% variation in sensory chewiness as explained by Instron chewiness. The poor influence of instrumental chewiness on sensory chewiness may be explained in the light of the followiing phenomenon. Chewiness measured by Instron is taken to represent the sensory chewiness at the bulk level, i.e. considering the whole mass or piece of the product taken for a bite, as in the case of pop corn, unlike in khoa, chhana and paneer, which essentially being granular in nature, exibit chewiness more at the particle level than at the bulk level, i.e. when jaws crushing the piece or bulk come close to each other so that individual grains are crushed. Although the chewiness of individual granules may centribute some of the chewiness of the bulk, it is mainly the hardness, cohesiveness and springiness of these granules that should determine sensorily perceived chewiness (Patil *et al.* 1990). Hence, the Instron chewiness need not necessarily reflect the sensory chewiness of structurally particulate products such as dudh churpi.

As observed in the present study, it is relatively easy to find definite relationship between instrumental and sensory data on certain individual attributes of food texture rather than having a decisive picture of a product texture from its instrumental profile.

5.3. Optimization of process parameters in the manufacturing dudh churpi

5.3.1. Milk used in cooking prechurpi

5.3.1.1. Fat level

During the process of cooking prechurpi, milk flows to prechurpi through a semi-hard coating on its surface. Since it is difficult to obtain a perfect semi-permeable membrane in food systems, there is always some solid diffusion into the food (Rahman 1992). Accordingly the percent total fat, free fat, FFA and TBA values of dudh churpi increased with the increase in fat level in milk used for cooking. Rancid flavour in dudh churpi cooked in milk of 2.0 and 3.0% fat could presumably be due to the higher amount of carbonyls (Day *et al.* 1963). A higher TBA value further justifies this statement (Sidewell *et al.* 1955). Flat flavour in dudh churpi when cooked in skim milk (0.1%) fat is probably due to less amount of fat in the product, since the agreeable flavour of rich milk and of other dairy products is largely due to milk fat (Eckles *et al.* 1973).

Samples of dudh churpi cooked in skim milk exhibited greater Instron values compared to the samples cooked in milk of other fat levels. Lower fat and higher protein content in the samples of dudh churpi when cooked in skim milk exhibited greater aggregation of protein molecules which gave rise to higher instrumental values.

Flavour attribute of dudh churpi, cooked in skim milk, scored less due to less amount of fat present in dudh churpi. Dudh churpi cooked in milk of 2.0 and 3.0% fat also had a lower flavour score due to the association of higher FFA and TBA values. Samples of dudh churpi, cooked in milk of 1.0% fat showed greater potentiality with respect to all the sensory attributes and chemical data. Sensory, chemical and instrumental data of the samples of dudh churpi, cooked in milk of 1.0% fat, closely resembled the data of the best available market churpi of Bhutan. Hence, 1.0% fat was condidered the optimum fat level in milk for cooking prechurpi.

5.3.1.2. Sugar concentration

Higher sensory scores and instrumental values in the samples of dudh churpi, cooked in milk of 1.0% fat and 2.0% sugar, could be explained by maximum solid diffusion during cooking of prechurpi. Lower ($P<0.05$) sensory scores and the instrumental values except cohesiveness, springiness and gumminess in the samples of dudh churpi, cooked in milk of 1.0% fat and 1.0% sugar compared to the samples cooked in milk of 1.0% fat and 2.0% sugar, could be explained by the quicker approach towards concentration equilibrium because of higher concentration of sugar in milk and less water activity gradient thereof (Chaudhari *et al.* 1993). However further increase of sugar concentration in cooking medium (i.e. 3% sugar) lead to deposition of solids on prechurpi surface leading to lower rates of diffusion and deterioration of the quality.

Crystallization of sugar on the surface of the product increases with the increase in sugar level in milk. Direct contact of super-saturated solution with hot surface of pan could enhance lactose caramelization resulting in the formation of higher HMF (De 1980). Higher HMF values in the samples of dudh churpi, cooked in milk of 3.0% sugar, resulted in less ($P<0.05$) colour and appearance score compared to the samples, cooked in milk of less sugar content.

Thus, cow milk of 1.0% fat and 2.0% sugar was found optimum for cooking prechurpi.

5.3.1.3. Total solids content

Increase in sensory scores with the increase in total solids content in milk, used for cooking prechurpi, could be associated with increased concentration gradient. This can further be clarified that osmotic pressure of a solution is directly proportional to its concentration at constant temperature (Palit 1962).

There was no difference ($P<0.05$) in body and texture scores of the samples of dudh churpi, cooked in milk of 23.40 and 29.25% total solids content. Since the instrumental parameters are solely related with the rheology of a product, there was no difference ($P<0.05$) in instrumental values of the samples of dudh churpi, cooked in the milk of 23.40 and 29.25% total solids content.

Hence, cow milk of 1.0% fat, 2.0% sugar and 29.25% total solids content was found optimum for cooking prechurpi.

5.3.2. Time of cooking prechurpi

In general, the amount of diffused solids from milk increases with the increase in cooking time of prechurpi, but the rate of diffusion gradually decreases (Chaudhari *et al.* 1993). Indifference ($P<0.05$) in flavour and body and texture scores in the samples of dudh churpi cooked in milk for 15 and 20 min justifies this statement. Colour and appearance score in the samples of dudh churpi, cooked in milk for 15, min was significantly ($P<0.05$) higher than the samples cooked in milk for 20 min. This could be attributed by enhanced Maillard reaction and formation of larger amount of melanoidin.

Lower (P<0.05) cohesiveness, gumminess and chewiness in the samples of dudh churpi cooked in milk for 20 min than the samples cooked in milk for 15 min could be attributed due to more concentration of sugar in the samples and correspondingly less percent protein.

Hence, milk of 1.0% fat, 2.0% sugar and 29.25% total solids and 15 min cooking time were found optimum for cooking prechurpi.

5.3.3. Moisture level

Prechurpi of 40 and 35% moisture levels, cooked in milk of 1.0% fat, 2.0% sugar and 29.25% total solids for 15 min and dried at four different temperature conditions had significantly (P<0.05) lower scores with respect to all the sansory attributes compared to the prechurpi of 30 and 25% moisture levels but cooked and dried under identical conditions. This could be attributed to low concentration of osmotic solution of the samples, since both equilibrium and adsorption rate increase with the increase in osmotic syrup concentration (Rahman 1992). Poor sensory scores (P<0.05) in the samples of dudh churpi, cooked at 25% moisture level than the samples, cooked at 30% moisture level could be explained by the loss of membrane integrity or change in the pore size due to prolonged heating (Rahman 1992).

Thus, 30% moisture level in prechurpi was found optimum for cooking in milk of 1.0% fat, 2,0% sugar and 29.25% total solids content.

5.3.4. Drying behaviour of cooked prechurpi

Higher rate of drying at the onset of the drying process under all temperature conditions can be attributed to the higher moisture potential available for removal. The rate of drying decreased as the replenishment of water from interior to the surface of prechurpi could not cope up with the fast removal of moisture from the surface. An increase in drying temperature reduced the drying time because it increased the rate of drying.

Since there was no significant ($P<0.01$) difference in Instron parameters of the samples of dudh churpi under each individual temperature conditions, the size of dudh churpi had no effect on its body and textural characteristics.

The samples of dudh churpi exhibited no significant ($P<0.01$) differnce with respect to all the Instron parameters when dried traditionally and in a drying chamber at 35°C . The data on Instron parameters also resemble closely with the best available market samples of Bhutan.

Hence drying of dudh churpi in a drying chamber at 35°C was found optimum and economical, since it saves 50% production time compared to traditional drying process.

No literature is available on drying characteristics of dudh churpi. Pal (1994) presented drying data by Page's model and reported that the size of churpi had no effect on its body and textural characteristics. Ajibola *et al.* (1988) adequately expressed drying data by Page's model and reported that increase in blanching time reduced the drying time of pregelled yam pieces. Muthu and Chattopadhyay (1982) suitably presented thin layer drying characteristics of parboiled rice by Page's model.

5.4. Packaging and storage of dudh churpi

Increase in titratable acidity might be the cause of microbial action by the aerobic spore counts or could be attributed to certain chemical reactions taking place during storage leading to the production of organic acids (Parry 1974).

The production of FFA was minimum when 0.1% potassium sorbate was incorporated into milk at the time of cooking and the samples were packed in a glass container. In khoa, peroxide value and FFA content increased consistently with storage period irrespective of the type of pouches used for packaging (Sharma *et al.* 1978). Similar observations were made in khoa (Narang 1969; Rudreshappa amd De 1971; Rao *et al.* 1977).

The change in tyrosine value which is an indication of proteolysis during storage of the samples is believed to be due to the survival of native as well as bacterial proteases which are not destroyed even by UHT processing (Lindquist 1970).

Browning increased steadily with storage time in control (unpacked) samples. But, in the samples packed in low density polyethylene (LDPE), high density polyethylene (HDPE) and glass containers there was a significant increase of browning only towards the later part of the storage. This could only be explained as a result of progression of the the Maillard browning reaction.

Decrease in sensory scores with the increase in storage period could be explained as a result of interactions of all the physico-chemical parameters discussed above.

The physico-chemical parameters and sensory attributes under all conditions decreased significantly ($P<0.001$) with the incorporation of sorbate in the samples. Potassium sorbate was the only chemical that was found to exert maximum inhibitory effect on microbial growth and maximum accelerating effect on keeping quality (Jha *et al.* 1977). Samples of dudh churpi with 0.1% sorbate packed in glass containers exhibited least change with respect to all the physico-chemical parameters and sensory attributes.

The quadratic regression model with correlation coefficient of more than 0.94 for moisture, free HMF, total HMF and reflectance with storage period holds good to explain the changes. These relationships are applicable upto the point of interest or upto the shelf-life of the product as the polynomial relationships can not be extended very much beyond the last data point.

Analysis of variance of mean overall acceptability scores of the product samples indicated that there was a significant ($P<0.001$) difference due to the use of packaged material and preservative. The shelf-life of the samples without sorbate and stored in glass container increased more than 4-fold over that of the control samples. The shelf-life of the samples enhanced almoct 8-fold when sorbate was incorporated in the samples stored in glass container over the samples without sorbate and stored traditionally. Shelf-life of khoa could be increased upto 10-11 days at 30°C by the incorporation of sorbate (Jha *et al.* 1977). The inhibitory effect of sorbate on microbial activity by inhibiting various enzymes, specifically those in citric acid cycle was reported by Lueck (1980).

The present study has shown that in order to get good quality dudh churpi from cow milk, it is necessary to cook prechurpi of 30% moisture level in milk of 1.0% fat, 8.7% SNF, 2.0% sugar and 29.25% total solids content for 15 min at 60°C. The cooked samples are to be dried in a drying chamber maintained at 35°C till a moisture level approximately of 15.00% is reached.

5.5. Water sorption characteristics of dudh churpi

5.5.1. Sorption isotherms of dudh churpi

The sorption process is of prime importance since many physical properties of macromolecular materials are greatly modified by the prescence of sorbed moisture. Dudh churpi is a porous and proteinaceous dairy product. Desorption and/or adsorption processes may alter its water sorption characteristics which control the texture profile of the product. Sorption isotherms are the graphical plots representing the relationship between equilibrium moisture content and water activity of a product. The isotherm drawn by joining the experimental data points showed the typical type II sigmoid shape common to most food product (Sawhney *et al.* 1991b). The typical sigmoidal shape of the isotherm of dudh churpi resembled the shapes of the isotherms of other dairy products, like caesin (Bandyopadhyay *et al.*1987), khoa (Sawhney *et al.* 1989) and paneer based convenience food (Rao 1993). Dudh churpi adsorption isotherm showed three regions of a typical isotherm as was reported in milk protien by Kinsella and Fox (1987). Water uptake is rapid in region I, slows down in region II and is accelerated in region III. Region I is represented by monolayer water which is strongly bound to proteins. Region II includes multilayer water which is under transition to natural properties of free water. Some of this water is available for chemical reactions. The water in region III is in free state, held in voids, crevices and capillaries (Kinsella and Fox 1987).

5.5.2. Equations describing isotherms of dudh churpi

Equations for fitting water sorption isotherms in foods are of special interest in many aspects of food preservation where dehydration is involved. Among them, are prediction of drying times, prediction of shelf-life of a dried product in a packaging material and also evaluation of the thermodynamic functions of the water sorbed in foods (Chirife and Iglesias 1978). Labuza (1968) discussed the selection and usefulness of isotherm equations.

Two major selection criteria for engineering calculations are accuracy and simplicity. For the prediction of drying times, or the shelf-life of packaged foods, the user is interested in an equation that fits closely to the experimental results rather than the correctness of the theory on which the equation is based. With these criteria in mind, nine equations were used in fitting the isotherm of dudh churpi and the goodness of fit was evaluated for each equation in terms of root mean square (RMS) value. It has been found that Caurie's equation was the best to characterize sorption behaviour of dudh churpi in full range of a_w. This equation is valid from zero a_w 0-0.85 for most foods (Caurie 1970).

5.5.3. Effect of temperature on isotherms of dudh churpi

Temperature of adsorption or desorption is known to affect the sorption characteristics of foods (Berlin *et al.* 1973). Temperature had considerable influence on sorption isotherm of dudh churpi. The effect of temperature on GAB isotherm parameters has been reported in soy protein, whey protein and sodium caesinate (Weisser 1985) and khoa (Sawhney *et al.* 1991b). In these products, Caurie's constants M_m and C decreased with increasing temperature.

Water sorprtion generally decreases with increasing temperature. When the temperature was increased from 24°C to 35°C, there was a decrease in water sorption in casein (Gal *et al.* 1962) and whey protein concentrates (Berlin *et al.* 1973). Noguchi (1981) stated that hydrophobic hydration of biopolymers melts off rapidly with rising temperature (20°-40°C). Similarly, hydration around the polar groups decreases by 50% during such a temperature rise, whereas electrostricted hydration around charged groups is less sensitive in this temperature range.

5.5.4. Properties of bound water and surface area of the adsorbent

The physical state of water in foods is most relevant to the product development since it influences the rate of physical, chemical, enzymatic and microbial changes that could occur in many foods. The bound water is of utmost importance because this water is reported to be unavailable either for microbial growth or for chemical reactions in foods (Caurie 1981). Some of the aspects of bound water in dudh churpi such as its density, its relation to surface area of adsorbent, number of adsorbed layers etc. have been studied in order to assess changes in the sorbed water caused by cooking and drying process of dudh churpi and temperature change. At lower a_w (0-0.3), moisture is strongly bound to hydrophilic, charged and polar groups of proteins. The water also gets hydrogen bonded to specific groups and plays an integral role in stabilization of protein molecules, and this water may also include that of hydrophobic hydration (Kinsella and Fox 1987).

It is interesting to note that the density of bound water decreases with the decrease in amount of bound water and surface area. This shows that the decrease in bound water content is not in proportion to the decrease in surface area. The density of normal free water is determined by distances between water molecules which are determined by the forces acting between the molecules. The closer the intermolecular distances, the greater are the forces acting between the molecules and, therefore, higher the density of water. When a monolayer of moisture is adsorbed on the surface of adsorbent, the intermolecular distances between water molecules are reduced and at the same time they are affected by surface forces of high magnitude which together alter the density of adsorbed moisture (Caurie 1981). In dudh churpi, the increase in sorption temperature resulted in considerable decrease in bound water, but did not cause proportional decrease in surface area.

This resulted in loose packing of water molecules causing corresponding decrease in density of sorbed water.

5.6. Consumer response to laboratory-made dudh churpi

Consumer response studies play a key role in developing a new or traditional food product. These are used as a tool to assess the performance of a food product, if introduced in consumer market. However, caution is advocated for depending solely on these studies because actual consumer response varies from region to region owing to several factors, like religious restrictions, familiar practices, experience and social and economic considerations. In fact, the reaction of respective consumer has to be gathered in the area in which the product is intended to be marketed.

The laboratory-made dudh churpi was highly acceptable by the chemical and sensory tests. But the consumers' opinion is vital in determining the actual acceptability of a product. The significance of reliable consumer opinion in product development can not be over-emphasized (Schaefer 1981). In the present investigation, the laboratory-made and the best quality market samples of dudh churpi were equally acceptable, indicating the potentialities of the innovations made in the present study in large scale production of dudh churpi.

5.7. Cost of production of dudh churpi

The cost analysis is always dependent on a number of variable factors and existing process facilities. An existing product plant can accommodate the production of dudh churpi for effective and economic utilization of the plant variables. This costing is also expected to generate interest among the existing dairy units to plan product diversification. It should encourage many unemployed and entrepreneurs in establishing small scale dudh churpi production centres.

It is revealed from the present investigation that dudh churpi is a protein-rich, highly nutritious and shelf-stable milk product. Dudh churpi prepared under optimized process conditions and suitably packed may be a highly profitable venture for small entrepreneurs.

Observed interrelationship between chemical and Instron texture profile parameters indicates the possibility of using a single parameter to know the product's texture which, in turn, will facilitate the quality control programme. This also leads to the possibility of dudh churpi as a nutritious substitute of chewing gum by minor alterations of the chemical parameters.