REVIEW OF LITERATURE
CHAPTER - II

REVIEW OF LITERATURE

Paneer is one of the most important indigenous dairy product. Paneer and channa prepared in the same way, but in case of paneer, after coagulation sufficient weight applied to drain the whey, while in case of chhana, No pressure is applied for draining the whey. Therefore the product review would cover not only the work directly related to paneer but also cover the relevant work done on chhana. Important references associated to the present study have also been quoted under the following suitable heads:

2.1. Method of paneer making

2.2. Factor's affecting the quality of paneer.

2.3. Yield and Recovery of Total solids and fat in paneer.

2.4. Quality of Paneer

   (i) Sensory quality of paneer.

   (ii) Chemical quality of paneer.

   (iii) Physico-chemical changes during paneer manufacture.

   (iv) Microbiological quality.

2.5. - Shelf life of paneer.

2.6. - Rheology of paneer

2.7. - Cost of production.
2.1. METHODS OF PANEER MAKING

2.1.1. Traditional Method:

Manufacture of paneer from boiled milk using sour whey as coagulating agent was described by Srinivasan and Anantakrishnan (1964). Sour whey was added to hot milk with through mixing the contents. The coagulated mass was emptied over a piece of coarse muslin cloth held over another vessel. The curd was collected by draining of the whey and later by pressing the paneer and finally it was washed with cold water and packed.

2.1.2. Improved/Scientific Method:

A procedure for the manufacture of Paneer at pilot plant level was standardized by Bhattacharya et al. (1971). Buffalo milk having 6 per cent fat was heated to 82°C in cheese vat for 5 minutes and cooled to 70°C. Coagulation was brought about by the addition of 1 per cent solution of citric acid to milk slowly with constant stirring till clear whey separated out. After complete coagulation the stirring was stopped and the curd allowed to settle down for 5 minutes. During this period, the temperature of the whey was not allowed to drop below 63°C. The curd was filled in hoop lined with strong and clean muslin cloth. The hoop was a rectangular frame (35x28x10 cm). The frame was rested on a wooden plank and filled with the curd before covering with another plank, on the top. The pressure was applied on the top of the hoop by placing a weight of 45 kg for about 15-20 min. The pressed block of the curd was removed from the hoop, cut into 6-8 pieces and dipped in chilled water (Temp. 4°-6°C) for 2-3 hours. The chilled pieces of paneer were then removed from water and placed on wooden planks for 10-15 minutes for
water draining. Subsequently they were wiped, wrapped in parchment paper and stored in cold room (at 10°C) before being sold.

Rationalization of processing parameters in the manufacture of paneer were attempted by Sachdeva and Singh (1988a). They showed that for attaining the prescribed legal compositional standards, a minimum of 5.8 per cent fat is required in buffalo milk having 9.5 per cent S.N.F. They recommended standardization of milk to a fat : S.N.F. ratio of 1:1.65, heating to 90°C without any holding, coagulation at 70°C at a pH between 5.30-5.35 with 1% citric acid solution to obtain good quality paneer.

An industrial level, manufacture of paneer has been developed by the National Dairy Development Board (N.D.D.B.) and is used in the organised sector (Aneja 1997). In this process milk heated to 85°C to obtained a co-precipitate through a plate heat exchange and pumped to a cheese vat and cooled to 75°C. Hot milk is coagulated by adding citric acid solution with proper mixing. The curd is left to settle for 10-15 minutes without agitation. The whey is then drained and the curd heaps are filled in cheese hoops with a muslin cloth and pressed for 10-15 minutes at a pressure of 3 kg per sq. cm to remove the whey and the final blocks are dipped in cold water at 4°C for three hours for cooling and firming the paneer.

2.1.3. Upgrading of Existing Technology:

Pal and Garg (1989) studied the utilization of sour buttermilk in the manufacture of paneer. They standardized buffalo milk to a fat : S.N.F. ratio of 1:1.64 (average fat 5.8%) by adding sour buttermilk and paneer prepared therefrom, referred to as buttermilk extended paneer (BEP), compared with control paneer (CP). Initially
certain problems such as self coagulation of milk during heating and development of acidic smell, sour taste and grainy texture in BEP were faced. These problems were solved by adopting two additional manufacturing steps, i.e. Neutralization of sour buttermilk to about 0.15% acidity before use and washing of curd with hot water (72°C) before pressing. The BEP so prepared, was as much as acceptable as CP. The moisture content and yield of BEP were higher than CP, the recovery of solids in BEP and its rheological properties were not at large variance from that of C.P. Addition of sour buttermilk at higher temperature (80°C), had no detrimental effect on the sensory quality and yield of B.E.P.

Singh and Kanawjia (1989) prepared recombined milk by blending buffalo skim milk powder, butter oil and water. The author's reported that quite acceptable quality paneer could be manufactured using upto 18 per cent total solids in milk, 2000 psi homogenization pressure, 90°C coagulation temperature and one per cent citric acid solution as coagulant.

Gupta et al. (1995) described manufacture of paneer from concentrated buffalo milk using reverse osmosis (RO) to about 1.5 and 2.0 fold (25 and 33% T.S. respectively). RO concentrates as such and after dilution to the composition of normal buffalo milk (6.0 fat and 9.5% T.S.) were used for the manufacture of paneer. RO Paneer had higher moisture contents than control paneer and hence, yields were about 2 to 3 per cent higher. The recovery of T.S. in RO paneer was always 76.8% whereas, in control paneer, it was 67% despite distinct variations in texture profile of RO and control paneer, the sensory score of the 2 products were similar.
2.1.4. Process Mechanization:

The underlying principle involved in one of the suggested approaches is "in-package" thermal processing directed at (a) heat/acid coagulation of concentrated milk with minimum whey separation followed by textuarization, (b) Inactivation of microorganisms to obtain long shelf-life under ambient condition. The suggested approach would permit real mechanization of manufacturing processes and enhance shelf-life employing largely indigenously available equipment (Rao, 1991).

2.2. FACTORS AFFECTING THE QUALITY OF PANEER:

The quality of paneer varies from quality of milk, type of milk, heat treatment, type of coagulant, strength of coagulant, amount of coagulant required, coagulation temperature and pH of coagulation (Rao et al. 1992).

2.2.1. Type of Milk:

Shukla et al. (1984) prepared paneer from cow and buffalo mixed milk (50:50) having a fat content of 5%, and found quality was superior product than cow milk alone, but yet, certain investigation have shown that acceptable quality of paneer can be obtained from milk containing as low as 3.5% fat (Anon 1984).

Sachdeva et al. (1985) reported a good quality paneer having desirable frying properties from buffalo milk is deliberated more suitable compared to cow milk.

Sachdeva et al. (1985) showed that about one third of buffalo milk can be replaced with cow milk without any adverse effect on flavour and body and texture of paneer.
Milk with lower fat per cent (3.5%) even yet not adopting to the legal standards, results in a product with a comparatively better sensory attributes (Vishweshwaraiah and Anantakrishanan 1985 : Chawla et al. 1987).

Shukla (1988) reported that paneer made from goat milk was not acceptable as it did not form a compact mass.

Purthi and Koul (1989) studied on crossbred(H.F.x Sahiwal) cows milk having 3.7% fat or more, yields a satisfactory product and meet the legal standards also.

Sachdeva (1991) reported that cow milk paneer is less flavoured, soft, Guambly and fragile than buffalo milk paneer.

Sachdeva and Prokepek (1992) was produced paneer from cow milk and founded acceptable sensory properties.

Pal and Yadav (1992) concluded that milk fat and fat in D.M. level of 3.5 and 40.42 per cent, respectively adequate for producing good quality paneer.

Acharya and Gupta (1992) observed that buffalo milk is better than cow milk for production of yoghurt, khoa and paneer. But it is less suitable for production of chhana and cheddar cheese.

2.2.2. Quality of Milk :

De et al. (1971) and De (1980) prepared paneer from acidic milk having a titratable acidity (T.A.) of 0.20 to 0.23 per cent. They observed that product was of a poorer quality. Moreover, by using milk of more than 0.28 per cent, the flavour of paneer becomes unacceptable and can not be masked even by incorporating added flavour.
Chawla et al. (1985) also prepared that homogenization of buffalo milk, homogenization of buffalo skim milk and then mixing with unhomogenized cream did not result in any improvement in the flavour quality of low fat paneer.

Vishweshwaraiah and Anantakrishnan (1985) observed that homogenization of cow milk is recommended to bring about improvement in the yield and to improve the organoleptic score of paneer.

2.2.3. Heat Treatment of Milk:

Bhattacharya et al. (1971) recommended heating to 82°C for 5 minutes and cooling to 70°C before coagulation whereas Rao et al. (1984) suggested a temperature of 85°C. In order to maximise total solids recovery, it is desirable to heat the buffalo milk to 90°C without holding (Sachdeva and Singh, 1988a).

Menu Gupta (1985) claimed extension to shelf-life when milk maintained at 80°C for 10 minutes was coagulated at 70°C.

Ghodekar (1989) reported that, Heat treatment of milk is an important technological requirement of the process, which affects the sensory and microbiological quality of paneer.

2.2.4. Type of Coagulant:

Several worker's have used different coagulant such as citric acid solution (Bhattacharya et al. 1971 : Rao et al. 1984 and Katiyar, 1993), one day old whey (Singh et al., 1984), sour whey of 48 hours old (Sachdeva et al., 1985 : Vishweshwaraiah and Anantakrishnan, 1985) and whey cultured with L. acidophilus (Menu Gupta, 1985 : Sachdeva et al., 1985). However, the basis of recommendations by P.F.A. (1983) in
selecting sour milk as one of the coagulants is not known and was strongly criticised. No mention has been made about its acidity content, as low acidity milk is said to be a very inefficient coagulant while that with high acidity is a curd itself (Singh et al. 1984).

Utilization of non conventional and low cost coagulants such as hydrochloric acid (Shukla et al., 1984 : Sachdeva and Singh, 1987), phosphoric acid (Sachdeva and Singh, 1987), tartaric acid (Shukla et al., 1984) and acetic acid (Vishweshwaraiah and Anantakrishnan, 1985) have been effectively used in the manufacture of paneer.

2.2.5. Strength of Coagulant :

Bhattacharya et al. (1971) reported that, the optimum strength of coagulant required for the production of good quality paneer is 1 per cent citric acid solution.

Vishweshwaraiah and Anantakrishnan (1985) reported 2 per cent citric acid solution also yielded a good quality paneer when prepared from cow milk.

Sachdeva and Singh (1987) observed that when non-conventional coagulants are used in paneer manufacture, the strength of hydrochloric acid, phosphoric acid and acidophilus whey should be 0.6 per cent in order to get a satisfactory quality product.

2.2.6. Amount of Coagulant :

Usually, 2.0 gms to 3.0 gms of citric acid or lactic acid per kg of fresh milk is needed for the preparation of paneer. Rao et al. (1984) reported that 3 gms of citric acid per kg of buffalo milk is required for producing the best quality of paneer. This was contradicted by Sachdeva and Singh (1988a) who found that 2.1 gms of citric acid or lactic acid per...
kg of milk yields the best quality of paneer from buffalo milk. For making good quality of paneer from cow milk, 2.34 gms of citric acid or lactic acid is required for 1 kg of milk. (Vishweshwaraiah and Anantakrishnan, 1985), while Chawla et al. (1987) reported that 1.95 gms citric acid is sufficient for making paneer from 1 kg of cow milk regardless of its fat level. When HCl (0.60%) is to be used as coagulant, 1.5 gms is necessary to get complete coagulation (Sachdeva and Singh, 1987). The quality of coagulant required was slightly more in case of homogenized milk as the yield gets increased after homogenization in case of cow milk (Vishweshwaraiah and Anantakrishnan, 1985).

The corresponding values are 2.04 gms and 1.90 gms for one kg of homogenized and unhomogenized milk, respectively. If sour whey and acidophilus whey are to be used as coagulants, the quantities required for complete coagulation are 295 ml and 225 ml in case of sour whey (Vishweshwaraiah and Anantakrishnan, 1985) and acidophilus whey (Sachdeva and Singh, 1987), respectively, per litre of milk. It seems logical to attribute these variations is reported values of requirement of acid in the differences in buffering capacity of milk (mainly protein and colloidal salt) and pH/temperature requirements to achieve coagulation.

2.2.7. Temperature of Coagulation:

Several workers' have suggested 70°C coagulation temperature. (Bhattacharya et al. 1971; Rao et al., 1984; Sachdeva and Singh, 1988a; Pal et al., 1991; and Arora et al., 1996). However, it is possible to prepare paneer of good quality at a coagulation temperature of 80°C from both buffalo (Shukla et al., 1984) and cow milk (Vishweshwaraiah and Anantakrishnan, 1985).
Sachdeva and Singh (1988a) studied the effect of coagulation temperature on total solids recovery and moisture absorption and reported that coagulation temperatures higher than 70°C results in hard and dry paneer and at lower temperature, free moisture on the surface.

2.2.8. pH of Coagulation:

De (1980) reported that moisture retention in paneer decrease with the fall of pH and consequently, the yield also decreases.

Vishweshwaraiah and Anantakrishnan (1985) observed that paneer made from cow milk at coagulation pH of 5.0, the second maximum as compared to 5.5 pH. However at this pH of coagulation moisture, yield and solids recovery were showed to be less.

Sachdeva and Singh (1988a) reported that optimum pH of coagulation should be 5.35 from product quality and recovery of total solids point of view when the paneer is made from buffalo milk.

Sachdeva et al. (1991) obtained optimum pH of coagulant ranging from 5.20 to 5.25 for making of good quality paneer made from cow milk.

2.2.9. Combined Effect Between Coagulant and Temperature on Paneer Making:

Vishweshwaraiah (1979) prepared paneer by coagulating the milk at 80°C was found to be best, as against other ranges of temperature (70°C, 85°C and 95°C). It was also found that acid strength of 2 per cent gave best results against 1.5, 3.0 and 5.0 per cent fat.

Rao et al. (1984) were prepared paneer using three different heat treatments (80, 85, and 90°C) prior to coagulation at 70°C with three
levels of citric acid (0.3, 0.4 and 0.5 per cent). They were reported that heat treatment at 85°C in combination with 0.3 per cent citric acid gave the highest yield of paneer with lowest fat losses in whey and low acidity, highest moisture per cent and organoleptic score.

**Singh and Kanawjia (1991)** used four different heat treatments (80, 85, 90 and 95°C and four different levels of calcium chloride (0.00, 0.10, 0.15 and 0.20 per cent) for manufacture of paneer. They were found that 90°C temperature with 0.15 per cent calcium chloride gave optimum result.

**Arya and Bhaik (1992)** reported that good quality of paneer can be made from cross bred cow's (4.5 and 5.2% fat) by coagulating at 85°C against 80°C and 90°C temperature and adding 0.10 per cent calcium chloride against 0.05 and 0.15 per cent.

**Katiyar (1993)** concluded that 90°C temperature of final heating of milk and 0.25 per cent citric acid was produced paneer of excellent quality conforming legal standard with lowest cost of production from Bhadawari buffalo milk.

### 2.3. Yield and Recovery of Total Solids and Fat In Paneer:

**Bhattacharya et al. (1971)** recorded yield 11.86, 16.83, 19.83 and 20.90 per cent, recovery of total solids 47.08, 57.20, 59.08 and 60.81 per cent, and fat retention 55.00, 91.80, 88.35 and 90.29 per cent in paneer obtained from skimmed milk and standardized buffalo milk with 3.5, 5.0 and 6.0 per cent fat, respectively.
De, (1980) recorded average recovery of the milk constituents in chhana, prepared under the standard technique from whole cow and buffalo milk are as fat 90 and 85 per cent, protein 89 and 91 per cent; lactose 7 and 12 per cent, mineral salts 48 and 60 per cent respectively.

Sachdeva (1983) obtained heat treatment of milk up to 90°C not only increased the recovery of total solids but also increased the yield of paneer.

Rao et al. (1984) reported that the highest yield (20.35%) and total solids with the lowest fat loss in whey (0.49%) was in case of paneer made from milk heated to 85°C followed by coagulation with 0.3 per cent citric acid. These parameters were adversely affected with the increase in amount of citric acid irrespective of temperatures of heat treatment.

Vishweshwaraiah and Anantakrishnan (1986) prepared paneer from cow milk standardized to 3.0, 3.5, 4.0 and 4.5 per cent fat, by coagulating at 80°C, using 2 per cent citric acid solution as coagulant. They recorded yield 15.62, 16.62, 16.86 and 18.12 per cent in paneer and fat loss in whey was 0.12, 0.20, 0.25 and 0.30 per cent respectively.

Chawla et al. (1987) found yield 20.60, 21.16, 22.00 and 22.00 per cent total solids retention 63.14, 62.91, 64.43, and 65.22 per cent and recovery of fat 95.54, 95.55, 95.20 and 92.98 per cent in paneer made from Buffalo milk standardized 4.5, 5.0, 5.5 and 6.0 per cent fat, respectively.
Verma (1987) prepared paneer from Bhadawari buffalo milk and obtained recovery of paneer 18.79, 19.81, 20.69 and 22.13 per cent at 4.5, 5.0, 5.5 and 6.0 per cent fat level, respectively.

Sachdeva and Singh (1988b) recorded yield 23.2 per cent and recovery of total solids 63 per cent in paneer made at 70°C coagulation temperature. The total solids recovery can be increased to 67.8 per cent with the increase in coagulation temperature up to 90°C while yield was decreased to 21.3 per cent.

Singh and Kanawjia (1988) reported yield 17.4 per cent and total solids recovery 59.8 per cent at a coagulation temperature of 85°C which can be increased to 18.10 and 61.80 per cent, respectively, with the incorporation of 0.10 per cent calcium chloride in milk.

Pal and Garg (1989) recorded yield 20.53 per cent, recovery of total solids 65.54 per cent and recovery of fat 95.79 per cent in paneer obtained from buffalo milk standardized to an average fat and SNF ratio of 1:1.64 (average fat 5.8%).

Roy (1990) found yield 17.75, 20.00 and 21.49 per cent: total solids retention 59.37, 62.61 and 64.11 per cent and fat recovery 91.28, 89.77 and 88.80 per cent in paneer made from filled milk having 3.5, 4.5 and 5.5% fat, respectively. The yield and recovery of total solids in paneer were increased with the increase in temperature of final heating of milk from 85 to 90°C, the respective values being 21.14, 21.60 and 62.15 and 64.10 per cent, respectively.

Pal et al. (1991) prepared paneer from mixed milk were heated at 90°C and 118°C separately, before coagulation. The respective values for yield, total solids retention and fat recovery in paneer at these
temperature were: 17.17 and 19.75 per cent, 56.15 and 59.22 per cent and 90.26 and 93.84 per cent, respectively.

Singh and Kanawjia (1991) found yield 22.00 per cent and total solids recovery 64.13 per cent in buffalo milk paneer made by using 70°C as coagulation temperature.

Pal and Yadav (1992) prepared paneer from various blends of buffalo and cow milk. Each blend was standardized to three different fat levels viz. 6.0, 3.5 and 1.5 per cent. They recorded the yields 22.75, 19.92 and 16.42 per cent, recovery of total solids 67.88, 64.92 and 57.95 per cent and fat recovery 88.61, 88.73 and 90.75 per cent, respectively.

Katiyar (1993) was using three different heat treatment (80°C, 90°C and 100.17°C) and three levels of citric acid (0.25, 0.35 and 0.45 per cent) for making of paneer from Bhadawari buffalo milk. He reported that heat treatment at 90°C in combination with 0.25 per cent citric acid gave the highest yield (20.95%) of paneer.

Roy and Singh (1994) prepared filled paneer (Dalda brand vanaspati and Ginni brand, Groundnut oil) which was heated to 90°C without any holding followed by coagulation at 90°C, 80°C and 70°C by 4 per cent citric acid solution. Coagulation of milk at 70°C resulted in higher yield than that obtained at 80°C and 90°C.

Arora et al. (1996) reported that the addition of calcium chloride increased the yield and total solids of paneer made from buffalo milk.

Agnihotri and Pal (1996) prepared paneer from Barbari Goat milk (4.86% fat and 8.96% S.N.F.) at 87-88°C heat treatment with 0.15
per cent citric acid. The yield of the product ranged from 13.3 to 19.3 per cent (Mean 16.4 per cent).

2.4. QUALITY OF PANEER:

2.4.1. Sensory Quality of Paneer:

Bhattacharya et al. (1971) noticed that flavour of raw paneer made from 6.0 and 5.0 per cent fat milk was very good, where as, paneer made from 3.5 per cent fat milk and from skimmed milk was good and fair, respectively. The paneer samples at 3.5 and 5.0 levels of fat showed fair and very good body and texture, respectively. The skimmed milk produced paneer of hard body and texture.

Rao et al. (1984) reported that paneer samples obtained with heat treatment of 85°C and 0.3 per cent citric acid scored highest due to the superior flavour, body and texture and colour and appearance. Sensory score decreased with increase in amount of citric acid for any selected heat treatment, which may be due to relatively low moisture content and acid content in the product which affected flavour body and texture of the product.

Chawla et al. (1985) prepared paneer from standardized buffalo milk containing 6.0 to 0.05 per cent fat and evaluated organoleptically using 9 point hedonic scale. There was a direct relationship between fat content and scores of flavour, body and texture. The corresponding scores of these attributes at 6.0 and 4.5 per cent fat level were 7.8, 7.6 and 7.6, 7.0, respectively. The respective scores for colour and appearance remained 7.5 and 7.6 at the same levels of fat.

Roy (1990) showed a positive association between fat content and the acceptability of paneer. The lowest score (6.0) was for 3.5
per cent milk paneer, whereas, the corresponding values for 4.5 and 5.5 per cent milk paneer were 6.5 and 7.0, respectively. The maximum score for body and texture of paneer (7.75) was in case of the product made from 5.5 per cent milk followed by 7.0 and 6.0 for 4.5 per cent and 3.5 per cent fat milk, respectively. The average score for colour and appearance was almost same (8.0) at all the fat levels. They further reported that as the temperature of final heating of milk was increased from 85°C to 90°C, the flavour and body and texture scores also increased accordingly. The score were 6.5 and 7.0 for flavour and 7.0 and 7.75 for body and texture, respectively. The colour and appearance score were similar (8.0) at both the temperature.

Pal et al. (1991) observed that the sensory qualities of low fat paneer obtained after heating the milk at 118°C improved considerably as compared to a heat treatment of 90°C. Excepting appearance score for body and texture, odour, taste and overall acceptability were higher in former than latter. All the sensory attributes in (i) scored more than 4.0 and 5.0 point hedonic scale. Where in (ii) the score for different attributes were more than 3 but less than 4, except for physical appearance.

Sachdeva et al. (1991) observed that addition of 0.08 per cent calcium chlorides into cow milk, encourage the development of paneer with compact, sliceable firm, cohesive body and a closely knite texture.

Pal and Yadav (1992) studied the effect of different fat levels viz. 6.0, 3.5 and 1.5 per cent in milk on the sensory characteristics of paneer. They observed that the appearance was not affected to a remarkable extent, however, the paneer with 1.5 per cent fat level scored
some what lower than other two samples. The score for body and texture, odour and taste were consistently decreased with the decreased in fat levels.

Arya and Bhaik (1992) studied the suitability of cross-bred cow's milk for the manufacture of good quality of paneer. The standardized milk (2.2, 4.5 and 5.2 per cent fat) and various coagulation temperature at 80°C, 85°C and 90°C was used for paneer making. They found that to improve physico-chemical and organo-leptic quality of paneer of different fat levels of calcium chlorides (0.00, 0.05, 0.10 and 0.15 per cent) were added to milk prior to coagulation. They observed that good quality paneer can be made from Cross-bred cow milk (4.5 and 5.2 per cent fat) by coagulating it at 85°C and adding 0.10 per cent calcium chloride. They further observed that milk with 2.2 per cent fat also produced fairly acceptable quality paneer although it was softer and did not conform to P.F.A. specification.

Roy and Singh (1994) studied the effect of coagulation temperature and the effect of certain additives (pregelatinized potato starch and sodium alginate) on production and quality of filled paneer. They found hard and dry paneer at 90°C of coagulation temperature. Whereas, coagulation temperature at 70°C having the best body and textural characteristics. The addition of sodium alginate did not improve the quality of the filled paneer.

Arora et al. (1996) prepared paneer from standardized buffalo milk (control) and from buffalo milk diluted with water to 4.6 per cent fat and 8.0 per cent S.N.F.; 0.00, 0.025, 0.05 and 0.075 per cent calcium chloride was added the diluted the milk. They found that without added calcium chloride to made diluted milk had a weak, soft body and
moist surface and received flavour, body and texture and appearance scores respectively (on 9 point scale) of 7.1, 6.1 and 9.3 compared with 8.6, 8.5 and 8.7 for control paneer, when 0.05 per cent calcium chloride was added to diluted milk, the score were correspondingly 8.50, 8.35 and 8.55 and the paneer was described as normal. Addition of 0.075 per cent calcium chloride, resulted in paneer that was chalky, hard and had a dry surface.

Pant et al. (1996) recorded that soya paneer instead of milk paneer affected the flavour of bread rolls sandwiches and taste in cutlets. Other sensory attributes were not affected.

Dwivedi et al. (1998) reported that cow milk chhana and rasogolla was light yellow, where as that from goat milk was white in colour. The flavour of chhana of goat milk was found pleasant and slightly acidic than cow milk chhana. There was virtually no differences in rasogolla obtained from cow and goat milk chhana. Moisture content of chhana was slightly higher (P < 0.05) in goat than cow milk.

2.4.2. Chemical Quality of Paneer:

Several workers observed that paneer having wide variations in their chemical composition. Which may be attributed to the differences in the initial composition of milk, method of manufacture and losses of milk solids in whey.

Bhattacharya et al. (1971) reported moisture 63.10, 56.25, 56.77 and 54.76 per cent; fat 20.49 19.12, 22.30 and 25.98 per cent and total nitrogen 4.45, 3.14, 2.91 and 2.80 per cent in paneer made from; buffalo skim milk (0.01% fat) and milk with 3.5, 5.0 and 6.0 per cent fat, respectively. They concluded that there must be atleast 5.0 per cent fat in
buffalo milk to get 50 per cent fat on dry matter basis in paneer, as specified in food laws.

Arora (1972) noticed that the average composition of paneer prepared from milk with 6.0 per cent fat was moisture 54.7 per cent, total solids 45.3 per cent, fat 26.0 per cent and pH 6.0.

Vishweshwaraiah (1979) found moisture 54.4 per cent, total solids 45.6 fat 22.8 per cent in paneer prepared from milk testing 4.5 per cent fat.

Rajorhia et al. (1984) compared the samples of paneer collected from local markets of karnal and Delhi with one manufactured from buffalo milk testing 5.8 per cent fat, under controlled conditions at N.D.R.I. karnal. They found the average composition of market and control samples as moisture 51.38 and 50.72 per cent, fat 26.91 and 27.13 per cent, protein 17.63 and 17.99 per cent, lactose 2.04 and 2.29 per cent, ash 1.89 and 1.87 per cent and titratable acidity 0.77 and 0.78 per cent, respectively.

Rao et al. (1984) found that the average moisture and titratable acidity of paneer samples with 85°C and 0.3 per cent citric acid resulted in the highest and the lowest with 51.05 and 0.47 per cent on the day of preparation, respectively. When the paneer samples of this treatment were packed in polythene sachets, the average moisture decreased to 50.97 and 50.75 per cent by 3rd and 6th day of storage at refrigeration temperature, while the average acidity of these samples increased to 0.48 and 0.49 per cent after the same periods of interval. with increase in heat treatment of milk from 80 to 90°C, an increase in the moisture and acidity was observed with the different levels of citric acid. It was further observed for a given temperature, as the quantity of citric
acid increased, the average titratable acidity and fat content in paneer also increased.

Vishweshwaraiah and Anantakrishnan (1986) prepared paneer from cow milk standardized to 3.0, 3.5, 4.0 and 4.5 per cent fat, by coagulating at 80°C using 2 per cent citric acid solution as coagulant. They analysed the paneer for its moisture and fat and reported that paneer made from milk with 4.5 per cent fat confirmed the legal standards, had the moisture 54.85 per cent and fat 23.45 per cent.

Bandyopadhyay (1987) reported approximate paneer composition as moisture 52 - 58, fat 23-27, protein 22 - 26, lactose 2.1- 2.3 and ash 2.0 - 2.2 per cent.

Chawla et al. (1987) showed the effect of different fat levels in milk on the composition and quality of paneer. They prepared the paneer from standardized buffalo milk containing fat from 0.05 to 6.0 per cent. Paneer samples had moisture 56.78, 56.71, 55.19 and 53.10 per cent, fat, 20.87, 22.58, 23.80 and 25.36 per cent, protein 18.25, 17.23, 17.99 and 17.48 per cent and titratable acidity 0.225, 0.220, 0.220 and 0.220 per cent at 4.5, 5.0, 5.5 and 6.0 per cent fat levels, respectively. He further reported that a minimum level of 5.0 per cent fat is required in milk to meet the minimum level of 50 per cent FDM as per PFA rules.

Sachdeva and Singh (1987) recorded moisture 54.10 per cent, fat 23.50 per cent, protein, 18.20 per cent, lactose 2.40 per cent and ash 1.80 per cent fat in paneer made from buffalo milk testing 5.8 per cent fat.

Verma (1987) reported moisture 49.05, 49.17, 50.31 and 52.38 per cent, fat 27.50, 25.76, 25.00 and 22.00 per cent and protein
17.89, 18.72, 19.38 and 19.44 per cent in paneer prepared from Bhadawari buffalo milk having 6.0, 5.5, 5.0 and 4.5 per cent fat, respectively.

Desai (1988) showed moisture 48.30, 52.40 and 49.00 per cent, fat 29.20, 23.40 and 26.10 per cent and protein 18.50, 20.30 and 20.80 per cent in paneer obtained from standardized buffalo milk 6.0% at, cow milk 4.0% fat and mixed milk 5.0% fat, respectively.

The coagulation temperature of 85°C was found the best against 75°C, 80°C and 90°C in paneer manufacturing from cow milk and the moisture, fat and protein contents of paneer were 53.90, 24.80 and 17.60 per cent, respectively, at the recommended temperature (Singh and Kanawjia, 1988).

Pal and Garg (1989) prepared paneer from buffalo milk standardized to an average fat and SNF ratio of 1:1.64 (fat 5.8% average) and reported moisture 51.26 per cent, fat 27.00 per cent, protein 17.28 per cent, ash 2.00 per cent and titratable acidity 0.195 per cent in the product. The present acidity was increased from initial value 0.195 to 0.310 per cent on 10th day of storage at 7± 1°C.

Purthi and Koul (1989) made paneer from cross bred cow's milk with 3.5, 3.7, 4.0, 4.2 and 4.5 per cent fat and recorded moisture 54.6, 51.1, 51.3, 51.1 and 49.7 per cent, fat on dry matter basis 48.3, 51.7, 53.9, 54.0 and 57.4 per cent respectively. Paneer samples obtained from milk testing 3.7 per cent fat or more were found to be meeting the PFA standards.

Roy (1990) recorded moisture 55.85, 54.40 and 53.70 per cent, fat 18.00, 20.20 and 22.75 per cent and protein 20.00, 19.65 and
18.75 in paneer prepared from filled milk containing 3.5, 4.5 and 5.5 per cent fat, respectively. The titratable acidity of fresh filled paneer was 0.216 per cent. The acidity had a tendency to increase during storage at 6-8°C temperature. The final value was 0.388 per cent at the time of spoilage.

**Pal et al. (1991)** reported the chemical composition of low fat paneer made from a mixture of cow and buffalo milk (3.5% fat) heated separately at 90° and 118°C without holding. The various constituents in paneer at these temperatures were: Moisture 55.06 and 58.81 per cent, fat 18.40 and 16.63 per cent, lactose 2.43 and 2.60 per cent, ash 1.9 and 1.87 per cent and titratable acidity 0.15 and 0.15 per cent, respectively.

**Singh and Kanawjia (1991)** prepared paneer and found moisture 55.19 per cent; fat 23.8 per cent and protein 17.99 per cent in buffalo milk paneer. The corresponding values of moisture, fat and protein were 58.10, 23.31 and 16.14 per cent in case of recombined milk paneer, respectively.

**Pal and Yadav (1992)** reported moisture 54.33, 58.01 and 60.54 per cent, fat 23.37, 15.59 and 18.29 per cent, protein 16.53, 19.91 and 23.60 per cent, lactose 2.26, 2.24 and 2.22 per cent and ash 1.75, 2.02 and 2.40 per cent in paneer obtained from various blends of cow and buffalo milk standardized with 6.0, 3.5 and 1.5 per cent fat, respectively.

**Sayed et al. (1992)** prepared paneer from standardized cow milk (4.5% fat and 8.5% S.N.F.), standardized buffalo milk (6.0 per cent, fat 9.5 per S.N.F.) and cow skim milk (0.1% fat). They reported paneer composition as protein 18.43, 16.42 and 27.78 per cent, fat 24.12, 28.22 and 4.0 per cent, moisture 55.26, 53.00 and 62.14 per cent and total solids recovery 46.77, 53.16 and 42.17 per cent, respectively.
Roy and Singh (1994) prepared paneer from filled milk which was subjected to heat treatment of 90°C without any holding followed by coagulation at 90°C, 80°C and 70°C, separately. They observed paneer compositions at these temperature were moisture 54.55, 53.40 and 51.20 per cent, Total solid recovery 65.33, 65.91 and 66.65 per cent, respectively.

Boghra and Mathur (1995) reported that buffalo milk paneer had a higher fat (26.5 vs 23.0 per cent), protein (18.6 vs 17.9 per cent) ash content (1.98 vs 1.46 per cent) lower moisture (50.9 vs 54.7 per cent) and lactose content (2.0 vs 2.94 per cent) than paneer made from cow milk.

Agnihotri and Pal (1996) made paneer from Barbari goat milk (4.86% fat and 8.96 per cent, S.N.F.) at 87-88°C heat treatment with 0.15 per cent, citric acid, paneer contained 46.9 per cent, moisture, 20.0 per cent protein, 27.0 per cent fat and 1.93 per cent ash, respectively.

Arora et al. (1996) reported that the addition of calcium chloride increased the fat, protein, fat in DM, pH and T.S. recovery of paneer made from diluted milk (4.6% fat and 8.0% S.N.F.).

Dwivedi et al. (1998) observed that the chemical composition of chhana and rasogolla obtained from the cow and goat milk may be regarded to be suitable for making rasogolla's as that of cow milk.

2.4.3. Physico-chemical Changes During Paneer Manufacture:

The coagulation process in paneer manufacture is regarded as consequence of the chemical and physical changes in casein brought about by the combined influence of heat and acid treatment. This phenomenon involves the formation of large structural aggregates of casein from the normal colloidal dispersion of discrete casein micelles, in
which milk fat and coagulated serum proteins are entrapped together with whey. During the formation of coagulated serum proteins are entrapped together with whey. During the formation coagulum, the major changes that take place include (i) the progressive removal of tricalcium phosphate from the surface of casein and its conversion into monocalcium phosphate and soluble calcium salt and (ii) progressive removal of calcium from calcium hydrogen caseinate to form soluble calcium salt and free casein. When the pH of milk system drops, the colloidal particles become isoelectric, i.e. the net electric charge become zero with the formation of "Zwitter-ion". Under such circumstances the dispersion is no longer stable, the casein gets precipitated and forms a coagulum (Ling, 1956). Isoelectric precipitation may be induced by the addition of calcium as it has a key role in the formation of coagulum. It increases the curd tension by providing closer and more abundant linkage between casein micellers. Probably this might be one of the several reasons for the good quality paneer obtained from buffalo milk.

The development of typical rheological characteristics of paneer could be due to preponderant and intensive heat induced protein-protein interactions (Richert, 1975).

The β-lactoglobulin and K-casein interact by sulphydryl disulphide interchange when heated together (Sawyer, 1969). Interaction between heated K-casein and B-lactoglobulin as evidenced by electrophoretic changes is initiated at approximately 65°C, at 99°C (Long et al., 1963). However, there are reports that lactalbumin and B-lactoglobulin also do interact (Hunziker and Tarassuk, 1965) and the complex so formed appears to be able to interact with K-casein (Baer et al., 1976; Elfagm and Wheelock, 1977).
2.4.4. Microbiological Quality:

The microbiological quality of paneer depend upon the condition of post-manufacture, handling packaging and storage of the product.

Sachdeva (1983) observed the microbiological load in paneer at different storage intervals at refrigeration temperature. Total plate count of fresh paneer was on the order of $69 \times 10^3 /g$ which was increased consistently during storage reaching final value on the order of $67 \times 10^5$ after 12 days. The yeast and mould count of fresh paneer was $35 \times 10^1 /g$ which increased to $142 \times 10^1 /g$ after 12 days. The paneer was almost free from coliform.

Rajorbia et al. (1984) reported that higher microbial load in market paneer as compared to laboratory paneer. The market and laboratory paneer had following mean microbial contents. Total plate count $2021 \times 10^5$ and $34 \times 10^5$, coliform count $250 \times 10^5$ and $20 \times 10^2$ and yeast and mould count $30 \times 10^3$ and $13 \times 10^1$, respectively.

Vishweshwaraiah and Anantakrishnan (1985) observed the 54 market samples. They found 49 samples having a count less than $5 \times 10^3$ were judged after analysing, to be good quality and 5 samples showed counts more than $5 \times 10^3 /g$.

Paarashar (1987) also showed higher plate count in market paneer ($1 \times 10^3 /g$) than dairy paneer ($8 \times 10^4 /g$).

Verma (1987) found that different fat levels in milk had no effect on the yeast and mould count of paneer which ranged from 251 to 331/g in fresh paneer.
Kumar (1988) reported that microbial quality of market and laboratory paneer is differ from each other. The standard plate count of market samples ranged from $1910 \times 10^4$ while in laboratory samples it ranged from $106 \times 10^3$ to $456 \times 10^3$ with an average value of $203 \times 10^3$. The coliform count of market and laboratory samples ranged from $8 \times 10^3$ to $350 \times 10^3$ and $0$ to $75$ with overall mean value of $66 \times 10^3$ and $12$, respectively. The respective values for yeast and mould count of market and laboratory sample ranged from $14 \times 10^2$ to $16 \times 10^3$ and $120$ to $290$ with overall mean values of $49 \times 10^2$ and $203$.

Sachdeva and Singh (1990) observed the microbiological characteristics of paneer stored at $8-10^\circ$C and reported that total plate count related well with its spoilage. The fresh paneer samples showed that the initial count ranged from $23 \times 10^3$ to $90 \times 10^3$. The total plate count of the spoiled samples ranged from $158 \times 10^4$ to $45 \times 10^6$. The initial yeast and mould count of fresh samples varied over a narrow range of $35 \times 10^1$ to $52 \times 10^1$ while at the time of spoilage it ranged from $53 \times 10^2$ to $63 \times 10^3$. The coliform were negligible. Its initial count was not more than $3$ to $4$ in first dilution of all paneer samples and this increased to a maximum of $30-50$ over the storage periods.

Roy (1990) studied on the paneer and reported total plate count of fresh paneer samples ranged from $31 \times 10^2$ to $48 \times 10^2$, while in spoiled samples stored at $8 - 10^\circ$C, it ranged from $12 \times 10^4$ to $40 \times 10^4$. The increase in number of microorganisms influenced the flavour score of paneer samples to a great extent. The initial yeast and mould count of filled paneer was $3 \times 10^1$. During storage there was a gradual increase in yeast and mould count. The yeast and mould count at the time of spoilage ranged from $80 \times 10^1$ to $23 \times 10^2$. The initial coliform count was zero to $2$
in the first dilution, this increased to a maximum of 40 to 60 over the storage periods.

**Kumar and Sector (1991)** reported that there was a consistent increase in microbial counts of control paneer samples during storage at 15°C. The initial total plate count, 3.0 x 10³ increased to 2.8 x 10⁵ on fourth day and 9.0 x 10⁶ on seventh day during storage. The initial level of coliform count increased from 90 to 3.5 x 10⁵ and 8.0 x 10⁶ after fourth day and seventh day during storage, respectively. The yeast and mould count increased from initially 10 to 50 and 250 after same periods of storage.

**Rao et al. (1992)** reviewed that the fresh paneer prepared under strict conditions does not contain organisms capable of producing diseases in human beings (Menu Gupta, 1985). Similarly, Thakral (1986) indicated that coliforms, yeast and moulds are completely destroyed during heating of milk at 82°C for 5 minutes but these contaminants reappear in the paneer through different sources if strict sanitary conditions are not followed.

### 2.5. SHELF LIFE OF PANEER:

**Bhattacharya et al. (1971)** observed that the keeping quality of paneer stored at 10°C showed that flavour and body and texture were the attributes most susceptible to storage deterioration, while the quality continued to be good and fair after three and six days of storage, respectively.

Similarly, **Arora and Gupta (1980)**, **Chawla (1981)** and **Rao et al. (1984)** indicated that paneer could be kept good for six days at
6-8°C temperature of storage although it starts loosing its freshness on the 3rd day.

Sachdeva (1983) observed a shelf-life of 18 days under refrigeration when paneer samples were packed in parchment paper and for 16 days in tightly wrapped heat shrunk film (cryvac). Paneer prepared from mixed cow and buffalo milk of 5 per cent fat could retain its original characteristics only upto 3 days when stored at 15°C and 8 days at 5°C without developing any fungus growth or foul smell (Shukla et al., 1984).

Pal and Garg (1989) studied the keeping quality of paneer stored at 7±1°C. In fresh paneer the scores for flavour, body and texture and colour and appearance were 7.73, 7.76 and 8.00 on 9.0 point hedonic scale, respectively. These scores were decreased gradually upto 6 days of storage. But an abrupt fall in the scores of flavour and appearance was noticed after 8 days of storage but thereafter none of the paneer samples was acceptable. The scores for flavour, body and texture and colour and appearance were 6.38, 6.82 and 6.39 on 8th day, respectively.

Roy (1990) worked on the shelf-life of paneer packed in polythene and stored at refrigeration temperature (6-8°C) an observed that in fresh paneer the scores for flavour, body and texture and colour and appearance were 7.0, 7.0 and 8.0 (on 9.0 point heconic scale), respectively. There was almost no deterioration upto 4th day. On 8th day, flavour, body and texture and colour and appearance scores decreased to 6.0, 6.5 and 6.5, respectively. The filled paneer samples became unacceptable on 10th days due to development of objectionable odour and slime on the surface of paneer.

Sachdeva and Singh (1990) reported that paneer blocks dipped in plain water for two hours and then packed in polythene
pouches, kept well for a period of about 10 days. A gradual deterioration was observed in flavour score during storage and samples became unacceptable after 10 days, because of development of a putrid odour and an acidic and bitter taste. A gradual but very slight decrease in the body and texture was also noticed during storage, which occurred due to the loss of moisture. The growth of a non-uniform greenish-yellow slime was responsible for the lower score for appearance in case of spoiled samples.

2.6. RHEOLOGY OF PANEER:

The knowledge of rheological properties is important for an objective assessment of body and texture of the product. The desired textural properties such as firmness, cohesiveness and chewiness depend upon the various processing parameters tried for the manufacture of paneer.

Shukla et al. (1984) studied that paneer manufactured using citric acid had maximum hardness, but lower values for gumminess and chewiness. However, the paneer prepared using citric acid, tartaric acid as coagulant showed maximum gumminess and chewiness.

Desai (1988) studied rheological properties of paneer in detail and reported higher values of firmness in buffalo milk paneer followed by cow milk paneer. However, after frying, the firmness of cow milk paneer was drastically increased to three times as compared to twice in buffalo milk paneer. After cooking the firmness is drastically reduced in all the paneer samples.

Dharmpal and Garg (1989) found that the rheological properties such as cohesiveness, springiness and chewiness of conventional buttermilk extended and butter milk extended low fat paneer
were almost similar. However, the hardness of controlled paneer was higher. They further reported that lowering of coagulation temperature from 80° to 70°C decreased the hardness, gumminess and chewiness in all the paneer samples.

2.7. COST OF PRODUCTION:

Cost of production of paneer made from milk of 4.5 per cent fat was Rs. 14.48 per kg (Vishweshwaraiah, 1979).

Katiyar (1993) recommended lowest cost of production of paneer from Bhadawari buffalo milk was Rs. 35.89 /kg with paneer sample prepared at 90°C with 0.25 per cent citric acid irrespective of fat level in milk.