2. REVIEW OF LITERATURE

Paneer is popular traditional heat and acid coagulated dairy product. It is mainly used as a base material for the preparation of large number of culinary dishes in almost all parts of the country. About 45-50 per cent of total milk produced is converted into variety of traditional milk products by heat and acid coagulation, heat desiccation and fermentation. Indian traditional products market is estimated to be more than Rs. 6,500 crores (Patil, 2004)

As the traditional dairy product preparation is labour intensive and the quality of finished products are highly variable in terms of physical, chemical, microbiological and sensoric properties, there is an urgent need to produce uniform and high quality products through modernization (Patil, 2002)

Paneer is highly nutritious and whole some food as it contains milk fat, protein, minerals, vitamins and other minor nutrients of milk. In recent years, there has been growing interest in the newly developed product as per the consumer’s requirements. The butter and cheese spreads are not popular in India due to high cost, higher fat per cent and poor spreadability. Therefore, newly developed product paneer spread has bright prospects in the Indian diet.
2.1 Paneer

According to PFA (1983), paneer is been defined as a product obtained from cow or buffalo milk or combinations thereof by precipitation with sour milk, lactic acid or citric acid. It shall not contain more than 70 per cent moisture and milk fat content shall not be less than 50 per cent of the dry matter. The milk fat content of skim milk paneer shall not exceed 13 per cent of dry matter.

Typically paneer is a marble to light creamy white in appearance. It must have firm and cohesive body with slight sponginess. The texture should be more compact (close knit), smooth and velvety. The flavour should be pleasingly mild acidic, slightly sweet and nutty (Dharmpal and Gupta, 1985; Patil and Gupta, 1986).

As per the Bureau of Indian standards (IS:1983), the total plate count should not exceed $5 \times 10^5$, coliform count not more than 90 and yeast and mould count not more than 250 cfu/g in paneer.

2.1 Effect of various processing parameters on the quality of paneer.

Processing of milk and milk products plays vital role in the manufacture of dairy products, hence standard processing parameters have to be followed to meet the desired quality of the product. Rao et al., (1992) reviewed the status of existing technology and new approaches for the manufacture of paneer. Wide variations with respect to chemical, microbiological and rheological properties of paneer, factors affecting the quality of paneer, changes during manufacture and effect of preservatives and packaging materials on the shelf life have been discussed.
2.1.1 Effect of heat treatment of milk

Heat treatment is one of the technological requirements of the process, which affects the sensory and microbiological quality of paneer (Ghodekar, 1989). Bhattacharya et al., (1971) recommended heating of milk to 82°C for 5 min and cooling to 70°C before coagulation, whereas, Rao et al., (1984) suggested a temperature of 85°C. In order to maximize the 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 of shelf-life of paneer when milk was heated to 80°C and held for 10 min followed by coagulation at 70°C. Lo and Bastian (1998) reported that more whey proteins (denatured) were recovered in cheese manufactured from milk heated to 85°C than in cheeses manufactured from milk heated to 72°C. They found that maximum denaturation and hydration of whey proteins occurred in milk heated above 80°C.

2.1.2 Effect of coagulation temperature on the quality of paneer

Coagulation temperature of 70°C has been suggested as optimum, at higher and lower temperature of coagulation paneer yields hard and soft body respectively (Bhattacharya et al., 1971: Singh and Kanawjia 1988).

2.1.3 Effect of various coagulants on the quality of paneer.

Citric acid is Generally Regarded As Safe (GRAS) additive that does not impart any flavour to food to which it is added (Kabara, 1981). According to PFA(1983) citric
acid, lactic acid and sour milk are permitted for use as coagulants for the manufacture of paneer.

Many scientists used citric acid solution as a coagulant in the manufacture of paneer and related products as it yields good body and texture to the acid coagulated product (Bhattacharya et al., 1971; Rao et al., 1984; Vishweshwaraih and Ananthakrishnan 1985; Sachdeva et al., 1985; Purnachandrarao 1991; Salini, 2001; Usha 2004)

Citric acid is a well-recognized food additive and brings rapid coagulation of milk. Vishweshwaraiah (1979) used citric acid, lactic acid and sour whey as coagulants for the preparation of paneer and reported that citric acid yielded desirable body and texture, appearance and taste.

2.1.4 Effect of concentration of coagulant on the quality of paneer

The optimum strength of coagulant required for the production of best quality of paneer is 1% citric acid solution (Bhattacharya et al., 1971; Singh and Kanawjia, 1988). Two per cent citric acid solution also yielded a product of good quality when prepared from cow milk (Vishweshwaraiah and Ananthakrishnan, 1985). Shelke et al., (2002) used citric acid solution of 1.5% during the production of chhana for rasogolla preparation.

2.1.5 Effect of homogenization of milk on the quality dairy products

Homogenization of cow milk is recommended to bring about improvement in the yield and to improve the sensory score of paneer (Vishweshwaraiah and Ananthakrishnan, 1985). Homogenization of buffalo milk did not result in any improvement in the flavour quality of low fat paneer (Chawla et al., 1985)
Michael et al., (1998) reported that homogenized milk resulted in curd shattering during manufacture of mozzarella cheese. But unhomogenized milk (control) did not cause similar shattering of curd in cheese preparation. The chemical composition of all the cheeses was similar, although the moisture contents of the cheese made from homogenized products tended to be higher. Cheeses made from homogenized milk or creams were significantly more whitish than the control.

2.1.6 Preparation of low fat butter spread

Reddy et al., (2000) standardized the process for the manufacture of protein enriched low fat butter spread containing chhana. The standardized method consisted of kneading of chhana to a fine paste followed by addition of butter and incorporation of 2 per cent salt, blending for 30 min. Chhana was added at 30, 40 or 50 per cent levels to butter in the preparation of spreads. Incorporation of chhana in butter had increased the moisture, protein and improved the spreadability, whereas, the fat content, hardness and flavour scores decreased. Based on the various physico-chemical and sensory attributes, use of 40 per cent chhana was found to be best suited for the preparation of butter spread.

2.1.7 Preparation of spread like products

Tamime (1978) developed a process for making ‘Labneh’ from stirred yoghurt that involved separation of some whey from curd in a separator and packaging the product before cooling. ‘Labneh’ contained 23.7 per cent total solids, 10.26 per cent fat, 9.0 per cent protein and 3.77 per cent carbohydrate. It is considered that the product has a
potential as a new dairy spread in Europe and North America, and that it could be used in salad dishes, or as a dip or for the production of cheese-cake like product.

2.1.8 Effect of processing variables on the quality of processed cheese spread

Natural cheese and other dairy ingredients have been successfully used to produce various types of spreads.

The quality of processed cheese products is controlled by various factors, viz, the age and type of cheese, processing conditions, moisture content in the end product, amount and type of emulsifying salts used and finally the added flavouring ingredients (Meyer, 1973 and Kosikowski, 1982). The technical data available on processed cheese products are limited since most of these products are manufactured by industrial organizations (Tamine and Younis, 1991)

2.1.9 Role of tri sodium citrate

Trisodium citrate is a unique buffering salt used in beverages, confectionaries and numerous foods products. Together with citric acid it ensures precise pH adjustment over a wide range. As a sequestering agent, it forms complexes with cations like Ca\(^+\), Mg\(^+\) and heavy metals, thus supporting the efficacy of antioxidants (www.vlelark.com/food additives, 2005).

2.2 Effect of incorporation of whey protein concentrate (WPC) and sodium caseinate on the quality of dairy products

2.2.1 WPC
2.2.1.1 Significance of whey/whey proteins

Whey is one of the major dairy byproducts of dairy industry. It contains nearly about 50 per cent of total solids present in milk. As per FAO (2004), world dried whey production is about 2.038 million tones. In India the whey production is estimated to about 4.8 million tons (Aneja, et al., 2002)

Whey nutrients represent a huge quantity of nutritionally rich food. In spite of its high nutritional quality, whey is still being largely wasted and not used for human consumption (Alum, 1980). One hundred kilogram’s of whey protein contain about 2.5 g of cystine and 2.8 g of cystein. Whey protein contains all the essential amino acids including isoleucine, lysine, threonine, and tryptophan (Irvine et al., 1984). The protein efficiency ratio of whey protein is 3.6 against 3.8 of whole egg and 2.9 of casein. Net Protein Utilization is 76 for whey protein, against 94 for whole egg (Renner, 1983; Renner and Abd-El-Salam, 1991).

Whey protein possess good functional properties such as foaming, emulsifying, gelling and water binding (Mathews, 1984; Molder and Jones, 1987; Patel and Kilara, 1990a; Nakai and Lichan, 1985). Since whey protein possess excellent nutritional and functional properties they are used in various foods like soups, sauces, toppings and dressings, ready to eat snacks foods, confections and beverages (Kennedy, 1985; Sienkiewicz and Riedel, 1990; Gupta and Thapa, 1991 and Aalbersberg, 1991). Whey protein concentrate has higher emulsification capacity than skim milk powder (Melachouris, 1984 and Mulvihill, 1991).
Glass and Hedrick (1997) analysed the commercially produced cheddar cheese whey powder and reported values of moisture, lactose, total protein, NPN, total ash and fat were 3.7 per cent, 69.4 per cent, 13.0 per cent, 0.50 per cent, 8.30 per cent and 1.03 per cent respectively. Spray dried whey powder could be utilized for beverages, soups, sauses, gravies, frozen desserts, youghurt, cheese spreads and infant formula because of its excellent functional and nutritional properties

2.2.1.2 Utilization of whey protein/WPC in spread like products.

The process for the manufacture of a water-in-oil emulsion in dairy spread comprises preparing a fat phase and an aqueous phase, and emulsifying the two phases together. The fat phase comprises 50 Kg butter, 18 Kg butter-oil, 1 Kg emulsifier and 0.01 Kg colouring. The aqueous phase comprises 38.75 kg ultrafilterd cheese base, 45.7 kg cultured buttermilk, 8.0 kg water, 1.5 kg salt and 0.4 kg emulsifying salt. The two phases are vigorously agitated at 40°C to form the water in oil emulsion. The spread is high in protein, low in fat and have good keeping quality (Whelton and Gallagher, 1988). Milk proteins are often added to dairy spreads for their organoleptic, functional and nutritional properties (Chateris, 1995).

Heimlich et al., (1994) prepared dulche-de-leche (a sweet dairy spread) with the admixture of ultrafiltered whey protein concentrate and compared it with the traditional product. Replacement of milk at 50% level was chosen, as preliminary trial showed that it was possible to obtain a product of smooth texture and glossy appearance at this substitution level. They concluded that the replacement of milk with whey protein concentrate at a 50% level did not significantly change the flow behavior of the spread.
2.2.1.3 Utilization of whey protein/WPC in dairy products.

The dairy industry has potential in the utilization of WPC in development of various dairy products. WPC has been successfully used in dairy spreads. An acceptable quality of processed cheese food was prepared by replacing 20 per cent of cheese solids with WPC (Thapa and Gupta, 1992; Irvine et al, 1984). Improvement in the sensory score has been observed for cheese added with WPC at the rate of 10g/l to milk (Santoro, 1994).

Yoghurt has been prepared by replacing 50 per cent of skim milk solids with WPC (35 per cent protein) and the resultant product had better flavour, body and texture with minimum whey separation compared to control (Jayaprakasha, 2000). Kulfi prepared by replacing skim milk solids to an extent of 80% with WPC resulted in the product with higher overrun, better mouth feel and improved acceptability than control kulfi (Jayaprakasha and Brueckner, 1999).

2.2.1.4 Composition of whey proteins

<table>
<thead>
<tr>
<th>Whey protein</th>
<th>Per cent</th>
<th>Molecular weight (da)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ß-lactoglobulin</td>
<td>45-57</td>
<td>18,400</td>
</tr>
<tr>
<td>α-Lactalbumin</td>
<td>15-25</td>
<td>14,200</td>
</tr>
<tr>
<td>Bovine serum albumin</td>
<td>3.5-10</td>
<td>69,000</td>
</tr>
<tr>
<td>Immunoglobulins</td>
<td>4-10</td>
<td>1,50,000-9,00,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>------</td>
<td>---</td>
</tr>
<tr>
<td>Glycomacropeptide</td>
<td>15-20</td>
<td>700</td>
</tr>
<tr>
<td>Lactoferrin</td>
<td>3</td>
<td>77,000</td>
</tr>
<tr>
<td>Lactoperoxidase</td>
<td>0.4</td>
<td>78,000</td>
</tr>
<tr>
<td>Lysozyme</td>
<td>Traces</td>
<td>14,000</td>
</tr>
<tr>
<td>Growth factor</td>
<td>Traces</td>
<td>7000-8000</td>
</tr>
</tbody>
</table>

Source: Rajesh and Sangwan (2002)

2.2.2 Sodium caseinate

2.2.2.1 Effect of incorporation of sodium caseinate on the quality of products

The bovine sodium caseinate, a well characterized protein and product containing casein are widely used in the food industry because of their contribution to desirable flavour, emulsifying, whipping, hydrating properties, viscosity characteristics (Kinsella, 1984 and Fares et al., 1998). In low fat dairy desserts, sodium caseinate can serve as a fat replacer (Barr, 1990).

2.3 Effect of replacement of milk fat with vegetable oils on the quality of food products.

2.3.1 Filled paneer

Chawla (1981) reported that the blends of skim milk and vegetable oils were homogenized during the production of filled paneer. The resultant product was hard and
brittle compared to paneer prepared from unhomogenised blends. Hence, they concluded that homogenization of filled milk for paneer preparation was not suitable.

Roy and Singh, (1999) observed beany flavour in paneer made from filled milk using soy oil even after frying and cooking, hence the product was unacceptable. They reported that this might be attributed to the flavour reversion phenomenon of soy oil. It has a strong tendency to revert when exposed to air or high temperature. Soy oil develops objectionable flavour through oxidation. Mild flavour reversion produces a slight beany flavour, which in more advanced stage, may become ‘painty’ or ‘fishy’.

The use of buffalo milk with high fat levels obviously escalates the price of paneer. Several attempts have been made to minimize the cost of production of paneer such as reduction in fat content of milk, use of milk by-products and inexpensive vegetable solids (Chawala et al., 1987; Dharam pal and Garg, 1989 and Kanawajia et al., 1995)

2.3.2 Dairy spread

Hehir and Feagan (1977) made a dairy spread having butter like taste by adding a mixture of sunflower oil and soy oil in the range 15-25 per cent by weight of the total fat to cream.

2.3.3 Butter like dairy spread
Johnson et al., (1998) described a process for the manufacture of butter like dairy spread that contained vegetable fat greater than 30 per cent in terms of total fat content and was spreadable at refrigeration temperature.

2.4 Effect of incorporation of soy solids on the quality of products.

Soybean, a leguminous crop rich in protein, ranks first in the nutritive value among all the legumes. It is not only rich in essential amino acids but also contains B-complex vitamins, Vitamine E and Vitamine K, as well as minerals such as iron, calcium, phosphorous and magnesium.

Composition of soybean

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>6.53</td>
</tr>
<tr>
<td>Protein</td>
<td>42.61</td>
</tr>
<tr>
<td>Fat</td>
<td>20.23</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>25.22</td>
</tr>
<tr>
<td>Ash</td>
<td>5.41</td>
</tr>
</tbody>
</table>

(Shurpalekar et al., 1961)

The International Committee on Nutrition has recommended 60g of protein/day/person with net protein utilization (NPU) of 65. It is well known fact that it would not be possible to achieve this NPU in our diets without the use of vegetable proteins (at the rate of 30g/day) such as soy protein. (Rajendran et al., 2004).
2.4.1 Soy solids

Soy proteins are available as three main forms of products namely soy flour, soy protein concentrates and soy protein isolates. Major proteins present in soybean are albumin, globulin and glutamines (Betsiashvite et al., 2002).

2.4.1.1 Soy solids in dairy product

Vaidehi and Shivaleela (1989) reported that addition of soy flour up to 15 per cent level in gulabjamun mix did not had any negative effect on the its sensory characteristics. Further, soyflour incorporation resulted in increase in the volume of the product and yield. Deka and Rajor (1988) developed acceptable dahi like product using soy and buttermilk solids in the ratio of 1:1.5

Babje et al., (1992) examined the possibility of blending soymilk with buffalo milk and reported that incorporation of soymilk at 20 per cent level in buffalo milk had no adverse effect on the taste, colour and springiness of paneer.

2.4.1.2 Soy proteins (soy flour) in meat and bakery products

The present day’s extensive use of soy proteins in meat products is attributed to their functional properties. They are used in sausages, gravyes, soups etc. Various functional properties of soy proteins are water binding, viscosity, gelatin, cohesion, adhesion, elasticity, emulsification, fat absorption etc (Anderson, 2000).

Roasted or un-roasted soy flour can be used at 8 per cent level in the preparation of buffalo meat burger with acceptable sensory quality (Mori et al., 2004).
Pratima and Yadav (2004) developed biscuits using soy flour, whey and skim milk at 15, 75 and 50 per cent levels, which was acceptable to consumers.

2.5 Effect of incorporation of flavour enhancers on the acceptability of product.

2.5.1 Significance of Spices

The spices are used in comparatively small quantities in the food products. These are quite important ingredients, even indispensable, as their presence, even in small quantities does improve the eating qualities of the products, as well as the physical characteristics.

The presence of antimicrobial property of Black pepper is well reported by (Al-Jalay et al, 1987). Clove buds contain 15 to 20 per cent oil, which contain 82 per cent eugenol, 7 per cent caryophylene, 1 per cent alpha humulene, 7 per cent eugenylacetate. Among these components, eugenol is the major active principal compound, which possess antimicrobial activity. This is also considered under GRAS ingredients. The medicinal (anti-microbial) properties are well recognized. (Deans and Ritchie, 1987; and Elgayar et al, 2001). Cinnamon contains 0.5 to 2 per cent essential oils of which 76 per cent cinnamicdehyde, 5 per cent cinnamylacetate, 4 per cent eugenol and 2 per cent linalool. Among these components cinnamicdehyde and eugenol are the major active principal compounds which possess antimicrobial activity (Al-khayat et al., 1985). There is no legal constraint on use of cinnamon oil, as they are GRAS (Generally Regarded as Safe) ingredients. The medicinal properties (antimicrobial) of cinnamon are confirmed by Dean and Ritchie, 1987; Mau et al., 2001
2.5.2 Essential oils and their composition.

The essential oils are defined as a group of odorous principles, which are isolated from various plant components such as leaves, fruits, bark, roots, wood, berries, seeds, flowers, twigs, buds etc. Essential oils are extracted by three basic methods such as steam distillation, selective solvent extraction and mechanical expression. They consist of a mixture of alcohols, aldehydes, esters, ethers, ketones, phenols, terpenes etc. and these oils when added to foods have a preserving effect due to their inhibitory effect on the growth of the microorganisms (Marino et al., 1999). The Food and Drug Administration (USA) considers most of the essential oils as GRAS.

The exploration of naturally occurring antimicrobials for food preservation received increasing attention due to raising consumer awareness of “natural” food production and a growing concern of microbial resistance towards conventional preservatives. In food preservation a variety of herbs and spices have traditionally been used to extend shelf life. Essential oils and their components are becoming popular as naturally occurring antimicrobial agents (Walker, 1994).

2.5.3 Spices in dairy products and other

Wendroff and Wee (1999) reported that coating of cheese with 20 mg of mixed spice oil containing olive and black pepper showed mold inhibition and with improved organoleptic quality than un-coated cheese.

Nair et al., (1996) studied bacteriostatic and bactericidal properties of black pepper and cumin against *E.coli*, *Salmonella virchow* and *S. aureus*. They found
that black pepper showed bacteriostatic effect, which could be used in meat preparation but not cumin.

Farag et al., (1989b) tested the inhibitory effect of some Egyptian essential oils: frosage leaves, rosemary leaves, clove flower and fruits of caraway and cumin. Clove flower bud and thyme leaves and their basic constituents against gram positive and negative bacteria at very low concentration to prevent the microbial growth. They observed that gram positive bacteria were more sensitive than gram negative bacteria.

George and Pandalai (1988) studied the antimicrobial activity of essential oils of cinnamon and clove against *S. aureus*, *E.coli*, *Salmonella typhosa* and *Bacillus dysenteries*. They recorded the therapeutically usefulness of essential oils in the treatment of the infection of digestive track in the form of stable and non irritant emulsion.

Cinnamicaldehyde is the major antimicrobial compound in cinnamon, a widely used spice in Indian food cuisines. It exhibits antimicrobial activity and inhibits mold growth and mycotoxin production (Deans and Ritchie, 1987).

Essential oil of cinnamon bark showed potent antibacterial activity against most organisms tested at 1:64 dilutions. (Bullerman et al., 1997 and Narayan et al., 1978).

Essential oils of cinnamon and clove are known to possess antimicrobial activity. Essential oils and their constituents have been used extensively as flavour ingredients in a wide variety of beverage and confectionary products and in various applications including toothpaste, cosmetics, skin ointments, disinfectant and shampoo (Deans and Ritchie, 1987).

2.5.4 Effect of heat treatment on antibacterial activity of essential oil.
Hsic (2000) found that cinnamon extract was stable after heat treatment up to 100°C for 20 minutes and its antimicrobial activity was not significantly affected by autoclaving. Thermal stability of cinnamon will allow the cinnamon extracts to be potential food addition for use in food processing when heat treatment is used.

Mau et al., (2001) studied thermal stability of mixed extracts of Chinese chive, cinnamon and cornifructus at 120°C for 15 minutes and examined for anti-microbial activity. They found that after heating, the antimicrobial activity of mixed extracts remained stable or even slightly enhanced due to slight concentration.

2.6 Shelf life

2.6.1 Shelf life of paneer and like products.

2.6.1.1 Paneer

Paneer, like other indigenous products, is a highly perishable product and suffers from limited shelf life, largely because of its high moisture content (Arora and Gupta 1980). Its shelf life is reported to be only six days under refrigeration, though its freshness is lost within three days (Bhattacharya et al., 1971). The spoilage in paneer occurs mainly due to the growth of microorganisms, which bring about various physico-chemical changes leading to the development of off-flavour in the product (Thakral et al., 1990).

Food additives such as sorbic acid (Ranawat et al., 1983), potassium sorbate, solutions of H₂O₂ and brine and delvocid (Sachdeva, 1983) have been tried successfully
to increase the shelf life of paneer, though they are not permitted in paneer under PFA, 1955 (Pawankumar., and Bector, 1991).

2.6.1.2 Chhana butter spread

Reddy et al., (1999) studied the shelf life of chhana butter spread with or without addition of 0.1 per cent sodium benzoate and 0.1 per cent potassium sorbate stored at $4^\circ$C and $10^\circ$C. Chhana butter spread, without added preservative had a shelf life of 15 days at both $4^\circ$C and $10^\circ$C. They further noted that addition of potassium sorbate increased the shelf life of the spread up to 45 days at $10^\circ$C and 60 days at $4^\circ$C and the use of sodium benzoate up to 60 days at $10^\circ$C and 75 days at $4^\circ$C storage temperatures.

2.6.1.3 Effect of thermization on the microbial quality of cheese

Hirvi and Griffiths (1998) stated that catalase activity was present in cheese made from raw milk but was only present at low concentrations in cheese manufactured from thermized milk. However, high catalase activity was observed in commercial samples of sharp and extra sharp cheddar cheese that was apparently due to the growth of catalase producing yeasts in cheese during maturation. Treatments at temperatures from 60° to 63°C gave at least a 4-log reduction of Salmonella sp. and a 2-log reduction of L. monocytogenes in milk (D’Aoust, 1989 and Farber et al., 1988). In addition, pathogens such as Salmonella spp and L.monocytogenes did not grow in hard cheeses (Johnson et al., 1990).

2.6.2 Effect of microwave and vacuum packaging on the shelf life of food products
Microwaves used in food industry for heating are the Industrial, Scientific and Medical (ISM) frequencies 2,450 MHz or 915 MHz, corresponding to 12 cm or 25 cm in wavelength. Microwaves are generated by magnetron that converts electrical energy (60 HZ) into an electromagnetic field with centers of positive and negative charges. Majority of foods contain a substantial proportion of water. The molecule structure of water consists of a negatively charged oxygen atom and positively charged hydrogen atoms and it forms an electrical dipole. When microwave is applied to a food, dipoles in the water attempt to orient themselves to the field. Since the rapidity oscillating electric field changes from positive to negative and back again several million times per second, the dipole attempt to follow and these rapid reversals create frictional heat. The increase in temperature of water molecule heats surrounding components (Ohlsson and Bengtsson, 2002).

2.6.2.1 Microwave heating

Microwave has been successfully applied in the food and dairy industries in processing of fruits and vegetables, cereals, meats, butter, yoghurt and ice cream mixes to inactivate number of microbes, enzymes and bacteriophages. (Sukhbir et al., 1999; Young and Jolly, 1990 and Schiffman, 1992).

Microwave heating is preferred over the conventional heating of product because it is rapid and less deteriorative to the product quality if properly controlled. Microwave heating systems can be turned on or off instantly, the product can be treated after being packaged. Microwaves are reflected by metals, transmitted by electrically neutral
materials such as glass, most plastics, ceramics and paper, and absorbed by electrically charged materials (Mullin, 1995)

Microwave heating technique was introduced during the sixties. At the beginning of 1980s, the possibility of applying microwave energy was widely recognized. There are advantages evident, such as faster operation, energy saving, higher product quality (retention of nutritional and sensory properties) as in application like enzyme inactivation, sterilization, tempering and drying of food products. The quality of microwave-pasteurized milk would be higher than that of conventionally pasteurized milk due to rapid, uniform heating and because of the lack of hot contact surfaces (Fito et al., 2005).

Many studies have been undertaken to increase the shelf life of milk (Kathleon et al, 1988). Villamiel et al., (1996) showed that microwave pasteurization of milk for 2.5 min resulted in 97.7 per cent reduction of bacteria. Microwave heat treatment of milk for 3, 8 and 10 min completely inactivated C. jejuni, Y. enterocolitica and L. monocytogenes, respectively (Sieber, 1996). Thompson and Thompson (1990) demonstrated that a domestic microwave oven could be used effectively to reduce aerobic plate counts in raw goats milk by up to 6 log cycles without impairing the organoleptic quality.

Assinder (1971) reported that microwave could be used for sterilization of milk. He demonstrated that a jet of milk could be heated to 200°C in 40 milliseconds, before being cooled by turbulent mixing with jets of cold sterile milk. The sterile product was reported to be virtually distinguishable from the starting material and the shelf life of the treated milk increased substantially.
Burfoot et al., (1988) examined the microwave pasteurization of prepared meals using a continuous tunnel device. The product was heated to 80-85° C for few minutes, sufficiently to inactivate vegetative pathogenic bacteria.

Karthikeyan (2005) subjected paneer to continuous microwave (2450 MHz) for a period of 40 sec at 1 kWh in PET laminated packaging material and recorded the storage stability at 30±1° C and 7±1° C. He reported that the shelf-life of microwave treated paneer increased to 2 and 21 days at 30±1°C and 7±1°C respectively, as against untreated (not exposed to microwave) paneer that had 1 day and 7 days when stored at 30±1°C and 7±1°C respectively.

2.6.2.1.1 Thawing/ tempering

Tempering of butter, frozen foods have been the most successful application of microwave in the dairy industry (George, 1997). Thawing of frozen products has limited applicability in the dairy industry. However, melting of various products like fats from bulk containers, offers advantages of more efficient transport (Young and Jolly, 1990).

2.6.2.1.2 Cheese

Hussain et al., (1980) used microwaves for cooking Hallum cheese before and after pressing and compared with the conventional process in which the pressed curd is cooked in the whey. Properties of the microwave-cooked cheese were similar to that of the conventionally cooked cheese. Tochman et al., (1985) used microwave for in pack
thermal treatment of cottage cheese and reported that the microbial count reduced immediately after microwave treatment.

2.6.2.2 Vacuum packaging

Sachdeva et al., (1991) reported that shelf life of paneer at 6±1°C was 8 days, which could be extended to 38 days with vacuum packaging. Kanawajia et al., (1990) observed the efficiency of vacuum packaging in increasing the shelf life of control samples and the samples dipped for 2 h in solutions containing Hydrogen peroxidase and Delvocid

3. MATERIAL AND METHODS

The standard materials and desired methodology employed during the development of milk based and filled paneer spread are described in this chapter. The methods for chemical, microbiological, rheological and sensory evaluation of paneer spread is presented.

3.1 MATERIALS

3.1.1 Milk