CHAPTER II

REVIEW

OF

LITERATURE
2. REVIEW OF LITERATURE

Fermented foods are of great significance because they provide and preserve vast quantities of nutritious foods in a wide diversity of flavors, aromas and textures, which enrich the human diet. Over 3500 traditional, fermented foods exist worldwide (Anon, 2003). Although the evolution of the fermentation process was strictly intuitive, the production of sour milk soon became the established pattern of preservation, and since early 1900s, defined micro-organisms have been used to prepare these products. The exact origin(s) of the making of fermented milks is difficult (Gupta, 2000) to establish, but it could date from some 10-15000 years ago as the way of life of human beings changed from food gatherer to food producer (Tamime and Robinson, 1999). As early as 18th Century Metchnikoff suggested the use of fermented dairy products in human diet to cure various disorders related to the gastrointestinal problems (Mahadevan, 1991). The worldwide market for these products continues to increase in response to the demands of an increasingly health-conscious public.

Dietetic fermented dairy drink is a traditional mesophilic fermented milk beverage of India. It is essentially prepared by blending dahi with salt, spices and certain cereals. This chapter encompasses the review pertaining to the composition, physico-chemical, sensory properties and effect of processing parameters on quality of dahi and dietetic fermented dairy drink. Since, there is scarcity of literature on fermented dairy drink, thus relevant research efforts in comparable western products like yoghurts, stirred yoghurts, yoghurt beverages, yoghurt drinks and fermented milks in general, have also been reviewed keeping in mind the above-mentioned areas.

2.1 FERMENTED MILKS - DEFINITION
The International Dairy Federation (IDF 1992a, IDF 1992b) published general standards of identity for fermented milks that could be briefly defined as follows: ‘Fermented milks are prepared from milk and/or milk products (e.g. any one or combinations of whole, partially or fully skimmed, concentrated or powdered milk, buttermilk powder, concentrated or powdered whey, milk protein (such as whey proteins, whey protein concentrates, soluble milk proteins, edible casein and caseinates), cream, butter or milk fat—all of which have been manufactured from raw materials that have been at least pasteurized) by the action of specific microorganisms, which results in a reduction of the pH and coagulation.

Mercosul (1998) defined fermented milk as "products to which other food substances may be added or not, obtained by pH decrease in milk or reconstituted milk, to which other lactic products may be added or not by lactic fermentation, through the action of specific microorganisms".

2.2 CLASSIFICATION OF FERMENTED MILKS

Khurana and Kanawji (2007) described Fermented milks are manufactured throughout the world and approximately 400 generic names are applied to traditional and industrialized products (Kurmann et al., 1992), but in actual essence the list may only include a few varieties. In the 1980s, Kurmann (1984) classified fermented milks into a ‘family tree’ (see Figure 2.1; Bylund, 1995), which was based primarily on the optimum growth requirements of the starter cultures (i.e. mesophilic and thermophilic microflora). Taking into account the microorganisms that dominate the product, including their principle metabolites, Robinson and Tamime (1995) proposed a scheme for the classification of fermented milks into:

- Lactic fermentations that include (a) mesophilic type, e.g. cultured buttermilk, *filmjolk, tatmjolk* and *langofil*; (b) thermophilic type, e.g. yoghurt, Bulgarian butter-milk, zabadi, *dahi, lassi* and (c) therapeutic or probiotic type, e.g. acidophilus milk, *Yakult, ABT, onka, vifit*; products within this group
constitute by far the largest number known worldwide;

- Yeast – lactic fermentations (*kefir*, *koumiss*, *acidophilus* yeast milk); and
- Mold – lactic fermentations (Villi).

Certain, closely related products are manufactured from fermented milks by de-wheying, examples include *labneh*, *skyr*, *ymer* and *shrikhand*. Tamime and Marshall (1997) have detailed the manufacturing stages of these types of fermentations. The different methods available to manufacture concentrated fermented milks are as follows: (a) cloth bag or Berge system; (b) mechanical or nozzle separators; (c) ultrafiltration (UF); and (d) product formulation (Tamime and Robinson, 1999). Another broad classification of fermented milks given by Batish *et al.* (2001) is depicted in Table 2.1.

**TREES OF FERMENTED MILKS**

Fig. 2.1 The Family Tree of Fermented Milk Types. Adapted from Kurmann (1984)

### 2.3 FERMENTATION PROCESS

#### 2.3.1 Mechanism of Gel Formation

Amice-Quemener *et al.* (1995) studied during fermented milk manufacture; a
gradual conversion of lactose into lactic acid by suitable microorganisms causes the pH to decrease.

Singh et al., (1997) studied that acidification impacts many properties of casein, which influences their gelation properties during the formation of cultured products. Acid production by LAB results in increasing buffering in the vicinity of pH 5 due to buffering by lactic acid itself (pKa 3.95).

Table 2.1 Broad classification of fermented milks. Adapted from Batish et al. (2001)

<table>
<thead>
<tr>
<th>Name</th>
<th>Country of Origin</th>
<th>Microflora</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dahi</strong> (dadhi)</td>
<td>India, Persia</td>
<td><em>L. lactis</em> ssp. lactis, <em>S. salivarius</em> ssp. thermophilus, <em>L. delbreukii</em> ssp bulgaricus, <em>plantarum</em>, lactose fermenting yeasts, mixed culture (not defined)</td>
</tr>
<tr>
<td>Shrikhand (chakka)</td>
<td>India</td>
<td><em>S. salivarius</em> ssp. <em>thermophilus</em>, <em>L. delbreukii</em> ssp. <em>Bulgariicus</em></td>
</tr>
<tr>
<td><strong>Lassi</strong></td>
<td>India</td>
<td><em>L. lactis</em> ssp. lactis, <em>S. salivarius</em> ssp. thermophilus, <em>L. delbreukii</em> ssp. <em>Bulgariicus</em></td>
</tr>
<tr>
<td>Acidophilus Milk</td>
<td>Australia</td>
<td><em>L. acidophilus</em></td>
</tr>
<tr>
<td>Yoghurt (Bio-ghurt)</td>
<td>Middle Asia, Balkans</td>
<td><em>S. salivarius</em> ssp. thermophilus, <em>L. delbreukii</em> ssp. <em>bulgaricus</em>, <em>Micrococcus</em> and other lactic acid, cocci, yeasts, molds</td>
</tr>
<tr>
<td>Kumiss</td>
<td>Asiatic steppes</td>
<td><em>L. delbreukii</em> ssp. <em>bulgaricus</em>, <em>L. acidophilus</em>, <em>Torula kumiss</em>, <em>Saccharomyces lactis</em>, micrococi, spore forming bacilli</td>
</tr>
</tbody>
</table>
Tamine and Robinson (1999) observed that casein micelles are composed of different protein fractions that are associated with one another via Ca-phosphate bridges. The $\alpha$-La/$\beta$-Lg interactions with $\kappa$-casein (linked by $\text{--SH}$ and $\text{--SS}$ bridges) partially protect the micelles.

Lucey and Singh, (2003) observed that acid production by LAB results in several changes in the physicochemical properties of casein micelles. There is a reduction in the surface charge (zeta potential) from the originally high net negative charge in milk to close to no net charge with the approach of iso electric point of casein (pH 4.6). This allows the approach and aggregation of casein molecules through hydrophobic and electrostatic (+, - charges) interactions. Steric repulsions remain from macro peptide hairs (although these may curl up as pH drops) and aggregation of casein particles occurs as the pH approaches the iso electric point.

Lucey (2004) revealed that the high buffering helps to slow down the pH decline somewhat but as the bacteria are now mostly in their growth phase the pH continues to decrease until most starter cultures start to become inhibited by the low pH (below pH of about 4.8, however it depends on the type/strain of bacteria).

Lucey, (2004) observed that in fermented milk gels, made from heated milk, the high gelation pH (e.g. 5.4) results in colloidal calcium phosphate (CCP) continuing to be solubilized from the inside of the casein particles, which causes a loosening of the network, coinciding with the appearance of whey. Below pH 5 gel firmness increases considerably and is maximal around the isoelectric pH, firmness continuing to increase with time.
2.3.2 Physicochemical Changes

Mathur (1991) observed stratification of fat during dahi fermentation, top layer being richer in fat with up to 90 per cent of total fat. He further reported that a decrease in charge on the fat globules brings them together which then rise to the surface.

Sindhu et al. (2000) studied that during fermentation of milk, LAB in the culture hydrolyse the lactose into lactic acid as a major product, which contributes to more than 90 per cent of the acidity. A portion of lactic acid combines with calcium to form calcium lactate. The casein devoid of calcium is coagulated on reaching its isoelectric point. Thus, fermentation is accompanied by gelling of solids, principally the protein and syneresis is manifested by appearance of a thin exudate of clear whey on the surface of the product. While fermentation of milk NPN, dialyzable nitrogen and ammonia nitrogen increase, protein nitrogen decreases while total nitrogen remains the same.

2.4 FERMENTED MILKS – GLOBAL TRENDS AND CONSUMPTION PATTERNS

Salminen et al., (1998) observed that present day consumers prefer foods that promote good health and prevent disease. Furthermore, these foods must fit into current lifestyles providing convenience of use, good flavor and an acceptable price-value ratio. Such foods constitute current and future waves in the evolution of the food development cycle. There are several principal reasons for the success of fermented dairy products, which relate to nutrition and health, versatility and marketing. Scientific and clinical evidence is also mounting to corroborate the consumer perception of health from fermented milks.

Chandan, (1999) reported that the increasing demand from consumers for dairy
products with 'functional' properties is a key factor driving value sales growth in developed markets. This led to the promotion of added-value products such as probiotic and other functional yoghurts, reduced-fat and enriched milk products and fermented dairy drinks and organic cheese. Another important global trend is the increasing demand for consumer convenience.

**Anon, (2003)** found that the manufacture of cultured dairy products represents the second most important fermentation industry (after the production of alcoholic drinks).

**Adwan, (2003)** stated that a dynamic category, fermented dairy drinks were reported to grow at six times the rate of total dairy growth between 1998 and 2003 in value terms, according to a recent market survey. Also, probiotic drinking yoghurt was the fastest growing dairy product sector between 1998 and 2003, followed by soy milk, (spoonable) probiotic yoghurt, flavoured milk drinks with juice and fermented dairy drinks.

### 2.5 INDIAN SCENARIO

**Rajorhia, (1998)** stated that fermented milk products are significant to the Indian Dairy Industry as they act as an outlet for dairy plant milk surplus and are seeking big markets abroad. Also they have tremendous traditional appeal throughout Indian masses especially the affluent consumer groups with regional preferences like shrikhand and misti doi becoming very popular. The demand for fermented milk products is increasing and it has been estimated that about 10 per cent of total milk produced in India is used for preparation of traditional fermented milk products and this has led to the increased large-scale commercial production. The Indian fermented milk products mainly include dahi, lassi, shrikhand, buttermilk and misti doi.

**Gupta, (2000)** reported that milk occupies an exalted position in India. Its
roots go back to some 6,000 years when milk animals were domesticated. Simple processes were developed to preserve milk’s nutritive goodness as a means to protect and promote health. The process of food fermentations was probably known to people inhabiting India in the Paleolithic and Neolithic times judging from the records of food habits.

**Gupta, (2000)** observed that a wide range of sweets was produced for consumption on festive occasions. They included *rasogolla, sandesh, burfi, peda, shrikhand, gulabjamun, lassi, misti doi and kheer* (rice pudding), combining delicious taste and flavor with fitness and health. These ethnic products constitute the world of traditional dairy products.

**Aneja et al., (2001)** stated that India is also the world’s largest and fastest growing market for milk and milk products. The indigenous dairy products are India’s largest selling and most profitable segment after liquid milk and account for 50 per cent of milk utilization of these fermented milk products constitute a major portion.

**Aneja et al., (2001)** found in their search for ways to prevent milk spoilage and find uses for surplus milk, a number of products were developed. They were curds (yoghurt-like fermented product), *makkhan* (butter), *khoa* (desiccated milk product), *chhana* and *paneer* (soft cottage cheese-like cultured product) and *ghee* (clarified butter).

**Anon, (2005a)** stated that India is the largest producer of milk in the world with over 50 million women and 15 million men involved in dairy enterprises. India contributes around 13 per cent to the global milk production with 70 million milk producers owning 90 million milking animals. The estimated production of milk in India in 2004-2005 was 91 million tonnes, projected to increase to 127 million tonnes by the end of 11th five year plan.

**Nagpal et.al., (2012)** found that dairy products are consumed not only for
meeting the nutritional requirements of the consumers, but also for their role in preventing various disorders such as obesity (Jaffiol, 2008), osteoporosis (Uenishi, 2006), dental caries (Shimazaki et al., 2008; Ferrazzano et al., 2008), poor gastrointestinal health (Pufulete, 2008), cardiovascular disease (Lamarghe, 2008), hypertension (Jauhiainen and Korpela, 2007), colorectal cancer (Weaver, 2009), bone ailments, ageing (Ginter, 2008) and others (Sharma and Rajput, 2006).

2.6 DAHI

PFA (1995) reported that dahi or curd is the product obtained from pasteurized or boiled milk by souring, natural or otherwise, by a harmless lactic acid or other bacterial culture. Dahi may contain additional cane sugar. It should have the same percentage of fat and solids not fat as the milk from which it is prepared.

Anon, (1997) stated that dahi or curd other than skimmed milk dahi is soldor offered for sale without any indication of the classes of milk, the standards prescribed for dahi prepared from buffalo milk shall apply. The technological developments have led to the commercialization of this product. More then 6.9 per cent of total milk produced in India is utilized for making dahi intended for direct consumption.

Rajorhia, (1998) found that dahi is age-old indigenous fermented milk of India, which has managed its popularity in Indian diet despite changing lifestyles and food habits. Dahi, whose history can be traced back to Vedic age, is known by various names in India. The important ones are Dadhi, Takra, Thyin, Perugu and Masinu. It has received great prominence in the Hindu religious rites and numerous references can be found in the Vedas and ancient Hindu scriptures.

Srilakshmi (2001) found that calcium and phosphorus content of curd are more easily assimilated. Curds contain more B vitamin than milk. Curd is prepared by initially boiling the milk to destroy viable organisms. It is cooled to the body temperature and 5 – 10 percent starter is added. Lesser quantities are needed during summer. After 6 -8 hours
an acidity of 0.9 – 1.1 acid is formed. Due to drop in pH the casein is coagulated and the curd is set. Curd is enjoyed as such as also used in the preparation of kadhi, raita, lassi and shrikhand.

Tomar and Prasad (2002) reported that the dairy products as a carrier of milk protein and lactic acid bacteria are equipped with great potential in prevention and cure of cardiovascular disease. Example hypertension, hyper-cholesterolemia and atherosclerosis.

Vatsyayan (2002) described that it as sweet and sour in taste and sour in the post digestive effect. Apparently one feels that curd might be cooling in effect, but it is just the opposite. While aggravating kapha and pitta, it has heavy and unctuous properties. The modern medicine attributes curd to be rich in protein, vitamins and minerals and says that it is cultured form of the milk where a bacteria called Lactobacillus bulgaricus turns it into coagulated form.

Verma et.al., (2012) stated that dahi is one of the most important products in the family of fermented milks. The total quantity of milk converted into milk products, about 15% is used for making dahi. Dahi is reported to have better nutritive value than milk. Through there is no increase in fat or protein content of milk during fermentation, the digestibility of dahi is better than that of milk.

2.6.1 Types of Dahi

Rangappa and Achaya (1974) classified dahi according to use into dahi for direct consumption, dahi for the production of chakka, shrikhand, lassi and buttermilk, dahi for the production of desi butter and ghee. On the basis of composition into Whole milk dahi, Skim milk dahi, dahi from special milks and according to flavour into Sweet dahi (Acidity not more than 0.7 per cent), Sour dahi (Acidity not less than 0.7 per cent) and Sweetened dahi.

2.7 LASSI
Tiwari, (1997) reported that Lassi is a ready to serve fermented milk beverage popular in India particularly in summer months. Lassi is conventionally prepared from dahi by mixing it with sugar in an earthen pot with the help of a wooden stirrer. Dahi may be liquefied by stirring vigorously or blending with water to yield lassi.

Aneja et al., (2001) found that it is a white to creamy white, cultured viscous fluid with a sweetish, rich aroma and has mild to high acidic taste. It is flavored either with salt/sugar and other condiments, depending on regional preferences. Sweetened yoghurt drinks available in the western world are comparable products to Indian lassi. Lassi making was earlier confined to cottage sectors or homes; it was mainly a rural product. Now a day it is being commercially prepared in several parts of the country.

Singh et.al., (2012) stated that cultured lassi is a product, made by blending yoghurt with water, salt, spices until frothy. Increasing awareness among consumers to ensure good health coupled with the change in the lifestyle has led to the concept of functional foods.

2.8 COMPOSITION OF DAHI AND FERMENTED DAIRY DRINK

Composition and quality of dahi vary widely in different geographical locations as it is being prepared under different domestic conditions and with milk having variable chemical and bacteriological quality. In a country as big as India, the consumers have different taste preferences for traditional products varying from region to region. Dahi is also made in different varieties with region specific tastes.

Rangappa and Acchaya, (1974) Rajhoria, (1998) observed that a number of workers have mentioned that good quality dahi should have a creamish white to creamish yellow color, smooth glossy appearance, sweet aroma, pleasing flavor, firm
body and weak gel texture along with negligible whey separation and absence of gas bubbles. Chemical composition of dahi approximates the milk from which it is prepared. There is an appreciable decrease in pH and lactose but a slight decrease in fat and TS. Acidity, volatile acids, lactic acid and dissolved calcium increase considerably. The chemical composition of whole milk dahi and skim milk dahi has been studied by Rangappa and Acchaya (1974) with fat, protein, lactose, lactic acid ranging from 5-8 per cent, 3.2-3.4 per cent, 4.6-5.2 per cent, 0.5-1.1 per cent and 0.05-0.1 per cent, 3.3-3.5 per cent, 4.7-5.3 per cent and 0.5-1.1 per cent, respectively.

Garg (1991) reported 0.7- 0.75 per cent ash in dahi with Ca and P content ranging from 0.12-0.14 and 0.09-0.11 per cent. A good quality dahi has a pH range of 4.6-5.0 and titratable acidity in the range of 0.8-1.0 per cent as lactic acid. Lactose is the chief C-source in milk and lactic acid is the major end product and accounts for more than 90 per cent of the total acidity, the rest being volatile acids.

Warsy (1992) stated that dahi samples obtained from shops in Karachi contained 4.7 per cent fat, 14.2 per cent total solids and 1.1 per cent lactic acid, with a pH of 3.80. In addition dahi samples collected from households and hotels in Bangalore showed considerable variation in consistency, flavour and acidity.

Aneja et al., (2001) found that the chemical composition of lassi depends upon the dahi from which it is prepared. It also varies with the initial composition of the milk, the degree of concentration of the milk solids and the quantity of sugar added. It has a characteristic pleasant acid flavor at 0.7-0.8 per cent (expressed as per cent LA) acidity. Lassi may contain milk fat varying from 1.5-3.8 per cent, 9.0 per cent milk solids, 13-20 per cent sugar, 0.5 per cent sodium dihydrogen phosphate, 0.5 per cent low methoxy pectin and minimum 0.7 per cent acidity expressed as lactic acid. Smooth consistency of lassi is obtained by homogenization of the mix. Flavor may also be added before packaging.
Antia and Philip (2002) reported that nutritive value of curd per 100 ml as shown in table. 2.2

<table>
<thead>
<tr>
<th>Types of curd</th>
<th>Weight (g)</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
<th>Carbohydrate (g)</th>
<th>Energy (kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curd (buffalo’s milk)</td>
<td>200</td>
<td>8.0</td>
<td>14.0</td>
<td>6.3</td>
<td>182</td>
</tr>
<tr>
<td>Curd (Skim milk)</td>
<td>200</td>
<td>8.4</td>
<td>0.2</td>
<td>6.3</td>
<td>69</td>
</tr>
<tr>
<td>Butter milk buffalo</td>
<td>200</td>
<td>2.7</td>
<td>4.6</td>
<td>2.1</td>
<td>62</td>
</tr>
<tr>
<td>Butter milk cow</td>
<td>200</td>
<td>7.1</td>
<td>9.4</td>
<td>0.4</td>
<td>114</td>
</tr>
</tbody>
</table>

Soomro et al. (2003) studied the physicochemical composition of dahi samples obtained from 3 different sources and found that the pH, titratable acidity, fat and TS varied from 4.26 – 4.31, 0.85 – 0.91 per cent, 4.6 – 5.07 per cent and 13.39 – 13.81 per cent, respectively.

2.9 FACTORS AFFECTING QUALITY OF DAIRY DRINK

The quality of fermented milks depends on the compositional and processing parameters as well as the subsequent handling and storage of the product. Industrial dairy drink preparation essentially involves 3 major steps i.e. preparation of dahi, liquefaction of dahi by blending with sugar syrup or salt, spices and packaging of lassi thus obtained. The most important step for lassi making is thus dahi preparation and quality of final lassi obtained depends largely on the quality of dahi prepared.

2.9.1 Quality of Raw milk

Riber, (1995) found that milk for fermented milk manufacture should be of
excellent bacteriological quality, free from mastitic organisms with low SPC, somatic cell count and psychrotrophic count. It should be free from antibiotics and sanitizer residue or any other inhibitory substances or late lactation milk.

Tiwari (1997) advocated that milk for lassi making should be free from lipolytic rancidity, residual antibiotics, germicides and bacteriophage contamination.

Tamime and Robison, (1999) observed that liquid milk may contain cellular material like epithelial cells and leucocytes that originate from udder of bovine animal, and is, in some instances due to carelessness during milk production. The milk is prone to further contamination with straw, leaves, hair, soil, seeds etc. The primary objective of a milk processor is to remove such contaminants from milk in order to ensure a better quality end product.

Patnaik, (2003) found that the raw milk quality of any food product is reflected in the final product quality thus in case of fermented milks, the raw milk should be of extremely good quality. Milk stored too long prior to inoculation leads to poor flavor and broken curd.

Gopalan et.al. (2004) reported the nutritive value of milk /100 ml as shown in table.2.3

<table>
<thead>
<tr>
<th>Type’s of milk</th>
<th>Moisture (g)</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
<th>Mineral (g)</th>
<th>Carbohydrate (g)</th>
<th>Energy (kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk buffalo’s</td>
<td>81.0</td>
<td>4.3</td>
<td>6.3</td>
<td>0.8</td>
<td>5</td>
<td>117</td>
</tr>
<tr>
<td>Milk cow’s</td>
<td>87.5</td>
<td>3.2</td>
<td>4.1</td>
<td>0.8</td>
<td>4.4</td>
<td>67</td>
</tr>
<tr>
<td>Milk goat’s</td>
<td>86.8</td>
<td>3.3</td>
<td>4.5</td>
<td>0.8</td>
<td>4.6</td>
<td>72</td>
</tr>
<tr>
<td>Skimmed milk (liquid)</td>
<td>92.1</td>
<td>2.5</td>
<td>0.1</td>
<td>0.7</td>
<td>4.6</td>
<td>29</td>
</tr>
<tr>
<td>Skimmed milk (powder cow’s)</td>
<td>4.1</td>
<td>38.0</td>
<td>0.1</td>
<td>6.8</td>
<td>51.0</td>
<td>357</td>
</tr>
</tbody>
</table>
Sharma and Rajput (2006) stated that milk and fermented milk should be consumed not only for meeting nutritional requirements but also for their role in prevention of disorders leading to obesity, osteoporosis, dental caries, poor gastrointestinal health, cardiovascular disease, hypertension and colorectal cancer.

2.9.2 Type of Raw Milk

Sharma and Jain (1974) observed that dahi made from buffalo milk had higher titratable acidity (TA) as compared to cow milk dahi and skim milk dahi showed more whey separation than whole milk dahi.

Bhandari (1985) established technical feasibility for preparing lassi from skim milk (9 per cent SNF) by agitation during fermentation.

Balasubramanyam et al. (1988) reported that dahi prepared from experimental samples containing up to 60 per cent recombined milk compared favourably with dahi made from fresh milk. There was no difference in the firmness of the curd and no whey expulsion was observed in any of the samples. Although the taste and flavour were found to deteriorate with increasing proportion of recombined milk, the difference was marginal.

Patidar and Prajapati (1998) reported that mixed cow milk and buffalo milk gave lassi with better flavor and texture.

Aneja et al., (2001) stated that compositional differences in milk from various
species and breeds affect the rheology and flavor profile of dahi. Dahi forms a weak gel when prepared from cow milk, whereas buffalo milk yields a firm gel owing to its high TS. Dahi is generally made from cow milk, buffalo milk or mixed milk.

Khetra et al., (2011) reported that nutritional functions of fermented milks involve supply of macronutrients including carbohydrate, fat and protein in easily digestible form and micronutrients including calcium, phosphorous, magnesium and zinc and certain water soluble vitamins. Fermentation enhances the absorption of vitamins and minerals. Calcium, phosphorous and iron are better utilized by consuming fermented milks. The reason could be the release of phospho-peptides by hydrolysis of casein that promote absorption. Fermentation also reduces the lactose content of milk which is beneficial for lactose intolerant population.

2.9.3 Standardization of Milk

Robinson and Tamime, (1975) obtained that the composition of milk is of great importance not only from the viewpoint of obtaining a satisfactory coagulum, but also in relation to the nutritional value of the product.

Chawla (1985) concluded that buffalo milk with 3.0 per cent fat and 10.0 per cent SNF was optimum for getting good quality yoghurt.

Nila et al. (1987) found that prepared fruit yoghurt using fresh cow milk standardized to the Fat: SNF ratio of 1: 3 by adding required amount of water and SMP. Milk of 3 per cent fat and 10 per cent SNF was found to be optimum for yoghurt preparation on basis of sensory scores.

Patidar and Prajapati (1998) mixed standardized buffalo milk with skim cow milk to obtain milk of 2.8 per cent fat and 10 per cent TMS for preparing lassi.

Aneja et al., (2001) reported that the fat and solid not fat (SNF) contents of the
milk are standardized and fortified to ensure compliance with existing legal standards. Several workers have given methods for preparation of lassi with fat and SNF content ranging from 0.5-4.0 per cent and 8.5-9.0 per cent, respectively.

2.9.3.1 Effect of fat

Chawla and Balachandran (1993) reported that higher fat content in yoghurt helped to reduce yoghurt setting time. Curd tension was maximum in low fat (0.05 per cent) and minimum in yoghurt with 1.5 per cent fat. An increase in fat level resulted in decrease of penetration value but increase in viscosity. Higher fat content gave yoghurt with superior flavor and appearance scores however, statistically flavor scores of yoghurts with 3, 4.0 and 6.0 per cent fat were not different.

Becker and Puhan (2005) observed that yoghurt made from whole milk did not show any whey separation. However, in case of skim milk out of 63 yoghurt samples, 15 showed a whey layer on the surface after 14 days of storage, especially those with low TS.

Barrantes et al. (2006) compared spontaneous whey separation in yoghurts containing either milk fat or one among 4 types of vegetable oils. On average, WHO was found to be higher in yoghurt containing milk fat than in yoghurts made from milk filled with vegetable oils.

Pandya (2007) concluded that increasing fat content in milk resulted in improved firmness of curd and reduced wheying off.

2.9.3.2 Effect of total solids

Rithcher et al., (1979); Aneja et al. (2001) found that the level of total solids also has a prominent effect on rheological as well as sensory attributes of fermented milks.
Tamime and Deeth (1980) reported that an increase in total solids may be achieved by various methods including: milk powder addition, concentration and whey powder addition. The common commercial practice of milk powder addition may sometimes cause excessive acid production and some taste deviations.

Harwalkar and Kalab (1993) found that yoghurt made from reconstituted nonfat dry milk was proportional to TS content, and at 20 per cent TS, the spontaneous whey drainage was stopped. This was attributed to the fact that higher TS increased the concentration of casein particles, which led to the enhancement of interactions between particles. They further reported an increase of yoghurt firmness of 2 to 3 times when the TS content in milk base was increased from 10 per cent to 15 per cent and 20 per cent, respectively.

Chawla and Balachandran, (1994) found that an increase in SNF, milk curd tension and viscosity increased whereas penetration value decreased. An increase in SNF of milk also leads to increase in protein content which in turn may contribute to refinement in taste of yoghurt with improved consistency, viscosity and reduced whey separation.

Chawla and Balachandran (1994) found that excessive addition of SMP to increase the SNF may adversely affect the yoghurt quality as higher culture activity was found at higher SNF levels. UF concentrates could be used to raise the protein levels without substantially raising the lactose levels. Use of caseinate powders for fortification was suggested as another alternative for increasing protein without increasing lactose. The added casein additionally enhanced the hydrophilic nature of the protein in the mix and acted as a stabilizer, thus increasing the viscosity and reducing the problem of syneresis.

2.9.4 Homogenization
Samuelsson and Christiansen, (1978) found that milk base homogenization is a common practice in yoghurt manufacture. It has been considered to prevent fat separation during fermentation and storage, improve consistency, increase whiteness and reduce whey separation. Homogenization is carried out to obtain a uniform distribution of fat globules and prevent separation of fat. It may lead to improvement in viscosity of resultant fermented milk, tend to reduce syneresis and increase water holding capacity.

Tamime (2002) reported the advantageous physical – chemical changes caused by homogenization of the milk base during the manufacture of fermented milk, include:

(a) A reduction in the diameter of fat to <2 mm, these small globules being less inclined to coalesce into larger units and rise to the surface;

(b) Milk becomes whiter in colour due to enhanced light reflectance and

(c) An increase in viscosity of the product due to interaction and/or adsorption of the fat globules onto the casein micelles; and

(d) A decrease in syneresis of the gel due to increase in its hydrophilicity and water-holding capacity as a result of the interaction(s) of the proteins.

2.9.5 Heat Treatment

The rationale of heat treatment to dahi mix is the destruction of undesirable microorganisms, pathogens and the inactivation of enzyme systems. A suitable heat treatment is applied to milk to make it free from most of vegetative cells of microorganism associated with raw milk. Reduced microbial population ensures that milk will provide good media for starter organisms.

Garg and Jain (1980) observed that heating milk at 82.2°C for 16-20 min led to a better consistency of dahi due to greater hardness and gumminess.

Walstra et al., (1999) stated that typical pasteurization does not necessarily include the destruction of bacterial spores or certain enzymes. Originally a batch process,
the pasteurization of milk encompasses a wide range of acceptable temperatures and times. For instance, a low temperature, long time process would involve processing the milk at 145°F (62.8°C) for 30 minutes. A high temperature, short time production, such as commonly used in continuous processing, would involve the application of temperatures at 161°F (71.7°C) for 15 seconds. In addition to the pasteurization of the milk, these conditions also affect the properties of the milk intended for fermented milk manufacture, as well as for the starter cultures.

Sinha and Sinha (2000) stated that domestically, milk is boiled at home before consumption or preparation of dahi but commercially it is pasteurized at 72°C for 15 s. For good quality dahi a heat treatment of 85°C/30 min or 90°C/5-15 min was recommended as it improves textural characteristics and water binding capacity due to denaturation of whey proteins and its interaction with casein fraction.

Aneja et al. (2001) briefly summarized the four-fold effect of heat treatment includes:

a) Development of relatively sterile media for exclusive growth of starter culture;

b) Removal of air from the medium and creation of a more conducive medium for the growth of microaerophillic lactic cultures;

c) Thermal breakdown of milk constituents especially proteins, releasing peptones and –SH- groups that provide nutrition and anaerobic conditions for starter;

d) Denaturation and coagulation of milk albumins and globulins that enhance viscosity and consistency of the product.

Tamime, (2002) observed that different temperatures are used for the heat treatment of the milk base during the manufacture of fermented milks and can vary depending on the time and temperature combinations. Some examples are: (a) 85°C for 30 min; (b) 90 – 95°C for 5-10 min; and (c) 105°C for 10 s. Boiling is the most
common heat treatment employed for the milk intended for dahi manufacture and even a few seconds of boiling can destroy 99.8 per cent of the microflora of milk.

Oliveira et al. (2002) found that prepared good quality fermented lactic beverages containing probiotic cultures by giving a heat treatment of 90°C for 10 min to the milk mix.

2.9.6 Starter Culture

Aneja et al., (2001) stated that the role of microbes in producing fermented dairy products has evolved from a chance discovery to a highly elaborated process involving the production of specialized "starter" of bacteria that function consistently in large cultures. The primary function of almost all starter cultures is to develop acid in the product. The secondary effects of acid production include coagulation, expulsion of moisture, texture formation and initiation of flavor production.

Batish et al., (2001) observed that in addition to these, starters also help in imparting pleasant acid taste, conferring protection against potential pathogens and providing a longer shelf life to the product. LAB chiefly convert approximately 1 per cent of lactose in milk to lactic acid with very little byproducts such as acetic acid, ethanol, CO2 etc. and normally with no substances causing taints and hence leading to a clean and wholesome milk souring.

2.9.6.1 Starters for dahi

Tiwari, (1997) tradition dictates that the production of dahi involves fermentation of milk by a mixed lactic culture containing various lactic organisms. Dahi is traditionally made by using artisans’ culture of undefined nature, which is maintained by transferring into heat-treated milk.

Rajorhia, (1998) stated that till date, small dahi manufacturers use previous day dahi as inoculum for fermentation. The normal microflora of dahi includes streptococci
and lactobacilli, although in market samples in addition to above organisms, yeasts are also found to be present as contaminants. A good starter for preparing *dahi* should be free from contaminants and the quantity of starter added to milk depends on the incubation temperature, acidity of the culture as well as the desired duration of incubation. The quantity of starter added generally varies from 1-5 per cent v/v.

### 2.9.7 Culturing Conditions

**Towler (1984)** reported that sedimentation in cultured milk beverages tends to reduce with longer culturing time. He also mentioned that reconstituted milk culture at 43°C exhibited some wheying off whereas a continuous coagulum resulted at 37°C.

**Bhandari (1985)** concluded that higher incubation temperature and higher quantity of inoculum favored rapid acid development. He also reported that higher whey separation occurred in lassi samples incubated at 30°C as compared to those at 20°C.

**Batish et al., (2001)** observed that the performance of LAB during milk fermentation can be influenced by a number of factors. Hence, adequate precautions are required to be taken to get the optimal activity of these organisms during the preparation of fermented milk products. Certain important factors affecting the growth and activity of lactic starter cultures include: temperature, pH, strain compatibility, growth medium, inhibitors, presence of bacteriophages, incubation period, heat treatment of milk, degree of aeration, effect of carbon dioxide and storage conditions. Although different types of LAB have different optimal temperatures for their growth, the majority of lactic starters like *L. lactis ssp lactis*, *L. lactis ssp cremoris* etc. grow optimally at 27-32°C. On the other hand *S. thermophilus* and some lactobacilli grow best in temperature range of 37-42°C. However, lueconostocs have their optimal temperature between 20-30°C.

**Aneja et al., (2001)** stated that culturing conditions especially, incubation time and temperature significantly affect the rate of acid and aroma production alongwith
the texture of final product. The heated milk base is cooled to the desired incubation temperature of the product; some examples include: (a) yoghurt at 40 – 45°C for up to 3 h, at 30°C for 18 h or 5 h when using direct-to-vat inoculation (DVI) starter culture; (b) probiotic products at 37°C for a few hours or up to 5 – 7 days depending on the organism(s) used; (c) buttermilk at 20 – 30°C for up to 10 – 20 h; (d) kefir at 22°C for 16 – 24 h depending on the type of kefir grains used (Tamime & Marshall, 1997; Wszolek et al., 2001) and (e) dahi at 20-28°C for 14-16 hours.

2.9.8 Addition of Stabilizers

Harris, 1990; (Imeson, 1997) stated that stabilizers have been used in food products for a variety of purposes, including thickening, aiding stability and improving mouthfeel.

Kumar and Solanky (1997) found that guar gum @ 0.05 per cent to be a better stabilizer for lassi as compared to CMC and sodium alginate. Sodium alginate and guar gum together gave much higher sensory scores and minimum whey separation as compared to gum acacia or guar gum when used alone for making lassi. The properties, functionality and quantity of these ingredients may all affect the mouthfeel and acceptance of fermented milks. Depending on their functional properties and concentration, they may jellify or simply thicken fermented milks, contributing to a better structuring, limited whey syneresis, and smooth texture.

Early, 1998; Tamime and Robinson, 1999; Phillips and Williams, (2000) In this capacity, the hydrocolloids, that can improve the viscosity, maintain the yoghurt structure, inhibit syneresis, alter the mouthfeel, and, in the case of yoghurt with added fruit, help keep the fruit in suspension.

Tamime and Robinson, (1999) found that stabilizers can be categorized according to the manufacturing process. Hydrocolloids can either be of natural, modified, or synthetic origin. Selection of the stabilizer or stabilizer combination to
be used in a food system greatly depends on several variables. Functional properties of the stabilizer, intended use and outcome, interactions with other ingredients and legal aspects are only a few considerations.

Tamime and Robinson, (1999) stated that numerous stabilizers like gelatin, CMC, pectin, starches, agar, locus bean gum, alginates, guar gum etc. have been studied for their use in fermented milks. The primary aim of adding stabilizer to cultured milk products is to enhance and maintain body and texture, viscosity, consistency, appearance and mouthfeel. They prevent whey separation by preventing flocculation of proteins.

Koksoy and Kilic, (2004) found that hydrocolloids have been widely used in textural stabilization of fermented milk products. In yoghurts, stabilizers are added for 2 main reasons: as thickening or gelling agents and to stabilize the yoghurt matrix.

2.9.9 Shearing of Dahi to Obtain fermented dairy drink

In the manufacturing of fermented dairy drink, the dahi (curd gel) is mixed, pumped, cooled, and packaged after the incubation stage. The protein network of the gel is thus broken, and gel pieces are formed. Breakdown depends on stirring temperature and intensity.

Arshad et al.,(1993) found that the texture of stirred yoghurt greatly increases just after the stirring through a mechanism called rebodying. Thus, a restructuration of aGDL- acidified gel broken down in a rheometer occurs during the first day of storage with complex viscosity increasing from 1.7 Pa.s to 3 Pa.s (76 per cent gain), which constitutes the stirred yoghurt.

Afonso and Maria (1999) found that stirred yoghurt has a lower ability to retain serum after high-speed mechanical stirring and reducing the intensity of shearing
could improve consistency.

2.9.12 Cooling

Tamime and Robinson, (1999) stated that fermented dairy drink production is a biological process and cooling is one of the popular methods to control metabolic activity of the starter culture and its enzymes.

Afonso and Maria, (1999) found that the elastic character of the stirred yoghurt increases during the first hours of storage. This increase in texture depends on the speed of the yoghurt cooling. Slow cooling permits an enhanced texture, evaluated by flowing properties and firmness.

Aneja et al., (2001) observed that the yoghurt organisms show limited growth activity around 100°C, the primary objective of cooling is to drop the temperature of coagulum from 30-450°C to below 100°C (best around 50°C) as quickly as possible so as to control the final acidity of the product.

2.9.13 Packaging

Shukla (1982) found that type of packaging material did not show a marked effect on the quality of yoghurt. In India dairy drink is generally available in tetra packs as well as polyethylene pouches.

Patidar and Prajapati, (1998) found that various workers have advocated glass bottles to be a better packaging material as compared to pouches or polystyrene cups for products like stirred yoghurts and dairy drink.

Tamime and Robinson, (1999) stated that proper packaging is mainly required to provide protection, ease of handling and to provide a message. A wide range of packaging materials can be used for cultured milk products like glass bottles,
earthenware vessels, metal cans, aluminium foil laminated pouches, flexible plastic containers, laminated paperboard cartons, polyethylene pouches etc.

2.10 CEREALS

Chaven and Kadam, (1989) reported that dried cereal grains constitute living cells that respire, when kept in an appropriate environment; whole grains can be stored for many years. In 1996, world cereal production amounted to more than two billion metric tons. Major cereal crops produced worldwide include wheat, rice, maize and barley. Other major cereal crops produced include sorghum, oats, millet and rye. Asia, America, and Europe produce more than 80 percent of the world’s cereal grains. Wheat, rice, sorghum, and maize are produced in large quantities in Asia; corn and sorghum are principal crops in America, and barley, oats and rye are major crops in the former USSR and Europe.

Charalampopoulos, (2002) stated that the global importance of cereal crops to the human diet and moreover to the written history of man and agriculture cannot be overstated. Cereal grains are the fruit of plants belonging to the grass family (Gramineae). Cereal crops are energy dense, containing 10,000-15,000 kJ/Kg, about 10-20 times more energy than most succulent fruits and vegetables. Nutritionally, they are important sources of dietary protein, carbohydrates, the B complex of vitamins, vitamin E, iron, trace minerals, and fiber.

MAIZE

Bhat and Puri, (1971) stated that maize is consumed mainly in the form of roti, sattu, dalia, phullae, etc. in India. It is used also as an important industrial ingredient for the manufacture of starch, glucose – syrup, dextrose, high fructose syrup, industrial alcohol, beer and whisky.

Deosthale and Pant, (1971); Reddy et. Al., (1991) reported that maize crop has a special place in Indian agriculture and is staple food of people of Utter Pradesh, Punjab, Rajasthan, especially for low socio economic group.
Kent, (1976) observed that maize flour is also used for the manufacture of cereal products, snack foods, cornflakes, instant foods, biscuits, wafers, crackers supplementary foods etc.

UNIDO (1986) found that the typical corn kernel (Zea mays L.) contains approximately 70-73 percent starch, 9-10 percent protein, 4-5 percent fat, 1-2 percent ash, 2 percent sugar and 3 percent crude fibre.

FAO, (1992) and CIMMYT, (1997) reported that maize (Zea mays L.) is an important coarse grain cereal crop holding third position in world production next to wheat and paddy. The pre-eminence of corn is due to its wide diversity of uses and highly useful products into which it can easily be transformed. Maize was domesticated in Central America 6,000 to 10,000 years ago. It spread to the rest of the world in the 16th to 18th centuries.

Prasanna et. Al., (2001) observed that maize is a major cereal crop for both livestock feed and human nutrition, worldwide. With its high content of carbohydrates, fats, proteins, some of the important vitamins and minerals, maize acquired well deserved reputation as a poor man’s nutricereal’. Several million people, particularly in the developing countries, derive their protein and calorie requirements from maize.

Cornflakes

Kellogg’s, (1896) found that cornflakes are a popular breakfast cereal originally manufactured by Kellogg’s through the treatment of corn (maize). A patient for the product was filed on May 31, 1895 and issued of April 14 1896.
Shanti’s, (2007) observed that breakfast is the most important meal of the day as it replenishes our body’s energy stores after an all night fast. A healthy breakfast significantly improves mental and physical performance of both children and adult. Essentially the breakfast should be low in fat cholesterol and high in vitamins and minerals. Corn flakes are made precisely as per the requirements of an ideal Breakfast for each morning.

Kellogg, (2007) described the accidental legacy of cornflakes goes back to the late 19th century, when a team of seventh-day Adventists began to develop new food to meet the standards of their strict vegetarian diet. Members of the group experimented with a number of different grains, including wheat, oats, rice, barley and of course corn. The idea for corn flaks began by accident when Dr. Kellogg and his brother, left some cooked wheat to sit while they attended to some pressing matters at the sanitarium. When they returned, they found that the wheat had gone stale, but being on a strict budget, they decided to continue to process by forcing it through rollers, hoping to obtain long sheets instead were flakes, which they toasted and served to their patients. This event occurred on August 8, 1894 and a patent for “Flaked Cereals and Process of Preparing Same” was filed on May 31, 1895 and issued of April 14, 1869.

Wikipedia (2007) stated that corn flakes are a popular breakfast cereal originally manufactured by Kellogg’s through the treatment of corn. A patent for the product was registered on May 31 1894 under the name Granose. A former patent of the Battle Creek Sanitarium named C. W. Post started a rival company, as well as the major other brand of corn flakes in the United States, called Post Toasties. Australia’s Sanitarium also manufactures their own brand of corn flakes called Skippy corn flakes. In addition there are many generic brand of corn of corn flakes produced by various manufacturers.
Table 2.4 Nutritive Constitutes of corn flakes / 100 gm

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>366 kcal</td>
</tr>
<tr>
<td>Protein</td>
<td>8 gm</td>
</tr>
<tr>
<td>Total Fat</td>
<td>0.7 gm</td>
</tr>
<tr>
<td>Minerals</td>
<td>1 gm</td>
</tr>
<tr>
<td>Dietary Fibres</td>
<td>2 gm</td>
</tr>
<tr>
<td>Total Carbohydrates</td>
<td>84.5 gm</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>300 µm³</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>67 mg</td>
</tr>
<tr>
<td>Thiamine ( Vit B1 )</td>
<td>1.0 mg</td>
</tr>
<tr>
<td>Riboflavin ( Vit B2 )</td>
<td>1.2 mg</td>
</tr>
<tr>
<td>Niacin ( Vit B3 )</td>
<td>13.4 mg</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td>1.7 mg</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>0.3 µg</td>
</tr>
<tr>
<td>Folate</td>
<td>84 µg</td>
</tr>
<tr>
<td>Iron</td>
<td>23.3 mg</td>
</tr>
</tbody>
</table>

Wikipedia, (2007) (Kellogg India PVL LTD.)
2.10.1 NUTRITIONAL QUALITY OF CEREALS

Chaven and Kadam, (1989) stated that cereals, together with oil seeds and legumes, supply a majority of the dietary protein, calories, vitamins, and minerals to the bulk of populations in developing nations.

Phillips, (1997) found that cereal grains are low in total protein compared to legumes and oilseeds. Lysine is the first limiting essential amino acid for man; although rice, oats and barley contain more lysine than other cereals. Corn protein is also limiting in the essential amino acid tryptophan, while other cereals are often limiting in threonine. The annual global yield of essential amino acids from major cereals has been compared to a hypothetical population of 3 billion adults and 2 billion children. Accordingly, if all cereals were effectively and fully utilized for human consumption they would more than meet man’s needs for essential amino acids. Barley, sorghum, rye and oat proteins are less digestible (77- 88%) than rice, maize and wheat (95-100%).

The nutritional profile of some common cereals is summarized in Table 2.2.
<table>
<thead>
<tr>
<th>FACTOR</th>
<th>Wheat</th>
<th>Maize</th>
<th>Brown rice</th>
<th>Barley</th>
<th>Sorghum</th>
<th>Oat</th>
<th>Pearl millet</th>
<th>Rye</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available CHO (%)</td>
<td>69.7</td>
<td>63.6</td>
<td>64.3</td>
<td>55.8</td>
<td>62.9</td>
<td>62.9</td>
<td>63.4</td>
<td>71.8</td>
</tr>
<tr>
<td>Energy (kJ/100g)</td>
<td>1570</td>
<td>1660</td>
<td>1610</td>
<td>1630</td>
<td>1610</td>
<td>1640</td>
<td>1650</td>
<td>1570</td>
</tr>
<tr>
<td>Digestible energy(%)</td>
<td>86.4</td>
<td>87.2</td>
<td>96.3</td>
<td>81.0</td>
<td>79.9</td>
<td>70.6</td>
<td>87.2</td>
<td>85.0</td>
</tr>
<tr>
<td>Vitamins (mg/100 g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thiamin</td>
<td>0.45</td>
<td>0.32</td>
<td>0.29</td>
<td>0.10</td>
<td>0.33</td>
<td>0.60</td>
<td>0.63</td>
<td>0.66</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.10</td>
<td>0.10</td>
<td>0.04</td>
<td>0.04</td>
<td>0.13</td>
<td>0.14</td>
<td>0.33</td>
<td>0.25</td>
</tr>
<tr>
<td>Niacin</td>
<td>3.7</td>
<td>1.9</td>
<td>4.0</td>
<td>2.7</td>
<td>3.4</td>
<td>1.3</td>
<td>2.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Amino acids (g/16 g N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lysine</td>
<td>2.3</td>
<td>2.5</td>
<td>3.8</td>
<td>3.2</td>
<td>2.7</td>
<td>4.0</td>
<td>2.7</td>
<td>3.7</td>
</tr>
<tr>
<td>Threonine</td>
<td>2.8</td>
<td>3.2</td>
<td>3.6</td>
<td>2.9</td>
<td>3.3</td>
<td>3.6</td>
<td>3.2</td>
<td>3.3</td>
</tr>
<tr>
<td>Met. &amp; Cys.</td>
<td>3.6</td>
<td>3.9</td>
<td>3.9</td>
<td>3.9</td>
<td>2.8</td>
<td>4.8</td>
<td>3.6</td>
<td>3.7</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>1.0</td>
<td>0.6</td>
<td>1.1</td>
<td>1.7</td>
<td>1.0</td>
<td>0.9</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Protein quality (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>True digestibility</td>
<td>96.0</td>
<td>95.0</td>
<td>99.7</td>
<td>88.0</td>
<td>84.8</td>
<td>84.1</td>
<td>93.0</td>
<td>77.0</td>
</tr>
<tr>
<td>Biological value</td>
<td>55.0</td>
<td>61.0</td>
<td>74.0</td>
<td>70.0</td>
<td>59.2</td>
<td>70.4</td>
<td>60.0</td>
<td>77.7</td>
</tr>
<tr>
<td>Net protein utilization</td>
<td>53.0</td>
<td>58.0</td>
<td>73.8</td>
<td>62.0</td>
<td>50.0</td>
<td>59.1</td>
<td>56.0</td>
<td>59.0</td>
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<tr>
<td>Utilization protein</td>
<td>5.6</td>
<td>5.7</td>
<td>5.4</td>
<td>6.8</td>
<td>4.2</td>
<td>5.5</td>
<td>6.4</td>
<td>5.1</td>
</tr>
</tbody>
</table>

Adapted from Chavan & Kadam (1989)
2.10.3 CEREAL BASED DAIRY PRODUCTS
FERMENTED PRODUCTS

2.10.3.1 Rabadi

Dhankher, (1985) found that rabadi is a traditional fermented food consumed on regular basis. It is an indigenous natural lactic acid fermented beverage popular in North-Western semi-arid regions of India. At homes, rabadi is prepared by mixing and fermenting the flour of wheat, barley, pearl millet, sorghum or maize with home butter milk in earthen or metallic vessel in hot summer days in open sun or at room temperature (35-45°C), kept for 4-6 h, followed by boiling, salting to taste and cooling before consumption.

Dhankher and Chauhan, (1987); Kurmann et al., (1992) observed that rabadi is commonly used by low and average income rural populations in the millet producing regions. It is important staple food for millions of Indians. This traditional method of making rabadi carries with it certain nutritional advantages. The fermentation brings about partial removal of the antinutrients, phytic acid and polyphenols normally occurring in the pearl millet, thus enhancing the bioavailability of minerals. Improved digestibility of proteins and carbohydrates is also claimed, and the blending of cereals and milk proteins brings about complementary of all essential amino acids.

2.10.3.2 Pearl millet rabadi

Modha, (2006) developed a technology for manufacture of pearl millet based rabadi-like fermented milk beverage. The manufacturing procedure involves, skim milk heated to 40°C followed by the addition of flour at 5.29% on skim milk basis. The mixture was heated to 90°C for 5 min, cooled to 37°C, inoculated with dahi culture (NCDC 167) at 3%, and incubated at the same temperature for 8 to 10 h. Water at 72% of
the curd was heated to 60°C followed by the addition of pectin with continuous agitation. The spices such as cumin (0.285%), black pepper (0.057%) and salt (0.85%) were added. The mixture was pasteurized at 75°C for 30 sec, cooled to 30°C and blended with the curd obtained previously, filled in bottles, crown corked and stored at refrigeration temperature. The final product contained 8.743% total solids, 0.65% fat, 2.24% protein and 1.28% ash (including spices and salt) and the shelf-life of the product was limited to a week at refrigeration temperature. After 7 days of storage, there was an increase in sedimentation, acidity and wheying off and decrease in flavour and viscosity.

2.10.3.3 Trahanas

Haard et al., (1999) reported that tarhana has an acidic and sour taste with a strong yeasty flavour, and is a good source of protein and vitamins. While tarhana soup can be used as a part of any meal, it is often eaten for breakfast. The practical nutritional importance of tarhana is the improvement of the basic cereal protein diet by adding dairy protein in a highly acceptable form. The low pH (3.8–4.2) and low moisture content (6–9%) make tarhana a poor medium for pathogens and spoilage organisms. In addition, tarhana powder is not hygroscopic and it can be stored for 1–2 years without any sign of deterioration.

Blandino et al., (2002) found that Trahanas is prepared from wheat flour and curd (1:1 ratio) produced by lactic acid fermentation of cow, sheep and goat milk. Str. lactis, Str. diacetylactis, Leuc. cremoris, L. lactis, L. casei, L. bulgaricus and L. acidophilus are the major acid and aroma producing organisms involved in fermentation. The whole fermentation lasts for about 50 h. The temperature of fermentation usually ranges from 30-40°C. In addition to milk and wheat flour, salt, tomato juice or puree, red pepper, onion, sesame, Oliver oil etc. may be added in various percentages and combinations to improve the product acceptability. The nutrient content and sensory attributes of trahanas depends upon curd and wheat flour ratio as well as other added materials the fermented matter is dried and stored in the form of biscuits.
2.10.4 DIETARY FIBER FORTIFIED DAIRY PRODUCT

Hoyda et al., (1990) developed a method for the manufacture of fiber-enriched yoghurt using selected sources of fiber which include soy fiber, oat fiber and gum Arabic by adding up to 6 g and 3.5 g of fiber per 8 ounces (~ 240 ml) of product in plain and fruit yoghurts respectively.

Annison, et al., (1993) stated that milk and most dairy products are devoid of dietary fiber. With the growing interest in dietary fiber and its health benefits, dairy industry has geared up for fortifying the dairy products with fiber. The main criteria that will affect both the dietary value and performance of dietary fiber in food product are the ratio between soluble and insoluble NSP. The soluble NSP will influence the water absorption and its activity during processing and storage of the food. The particle size of NSP is also important because it will affect the ability to absorb water as well as influence the texture and mouthfeel. If the fiber ingredient is too coarse, it can produce a harsh or gritty texture. On the other hand, if it is too fine its water holding capacity may be reduced. For most food formulations a bland flavour and neutral colour NSP is desirable.

Fiszman and Salvador, (1999) stated that yoghurt is one of the dairy products whose sales continues to increase due to diversification in the range of yoghurt-like products, including reduced fat content yoghurts, yoghurt shakes, drinkable yoghurts, yoghurt mousse, yoghurt ice cream, etc.

Chandrakant, (2002) found that dahi, lassi and other dairy products have been fortified with fruit and commercial dietary fiber to give the benefits of dietary fiber.

Patel and Arora, (2005) stated that in India, there are few traditional dairy products that contain significant quantities of fiber e.g., gajar-pak (carrot halwa), ghiya-ka-halwa (bottle gourd halwa), doda-burfi, and kaju-burfi. Traditional made cereal based
milk dessert like kheer and dalia dessert are other dairy food sources of dietary fiber in Indian diets.

Arora, (2006) found that screened various soluble and insoluble fiber preparation for their suitability in milk and reported that Microcrystalline cellulose (MCC), wheat fiber (WF- 200), Oat fiber (HF-600) and Oat bran among the insoluble fibers, and Psyllium and Inulin among the insoluble fibers were the most desirable from the point of view of their compatibility with milk. Further, it was reported that two blends of fiber viz. Blend-1 (0.27% psyllium, 0.36% Oat fiber (HF-600), 0.84% MCC and 4% Inulin) and Blend-2 (0.3% psyllium, 0.2% WF-200, 1% Oat bran and 4% Inulin) were developed using response surface methodology for their incorporation in fiber-enriched rice kheer and fiber-fortified sweetened set-type yoghurt.

Kantha and Kanawjia, (2007) developed low fat paneer using Response Surface Methodology and reported that milk with 2.5% fat and 0.56% soy fiber yielded a paneer similar to that prepared from full cream milk (6% fat) in respect to sensory quality.

2.11 SALT AND SPICES

Black salt

Black salt also known as sulemani namak, kala namak, black Indian salt, is a salty and pungent smelling condiment used in South Asia. The condiment is composed largely of sodium chloride with several impurities lending the salt its colour and smell.

Lachu, (2005) observed that black salt is used extensively in South Asian cuisines of Bangladesh, India and Pakistan as a condiment or added to chaats, chutneys, all kinds of fruits, raitas and many other savory Indian snacks.

Mark, (2010) found that black salt is considered a cooling spice in ayurvedic medicine and is used as alaxative and digestive aid. It is also believed to relive intestinal gas and heartburn. It is used in Jammu to cure goiters.
**Black pepper**

Black pepper (piper nigrum) is a flowering vine in the family Piperaceae, cultivated for its fruits, which approximately 5 millimeters (0.20) in diameter, dark red when fully mature and like all drupes contains a single seed.

Steven (2004) reported that black pepper is native to south India, and is extensively cultivated there and elsewhere. Drier ground pepper has been used since antiquity of both its flavour and as a medicine. Black pepper is the world’s most traded spice. It is ubiquitous in the modern world, often paired with salt.

**Cumin seed**

Cumin is the dried seed of the herb Cuminum cyminum, a member of the parsley family. The cumin plant grows to30- 50 cm. tall and is harvested by hand. The fruit is alataral fusiform or ovoid achene 4 – 5 mm. long containing a single seed. Cumin seed resemble caraway seeds, being oblong in shape, longitudinally ridged and yellow – brown in colour.

Zohar and Maria, (2000) found that cumin seeds are used as a spice for their distinctive flavour and aroma. It is globally popular and an essential flavouring in many cuisines, particularly South Asian, Northern African and Latin American cuisines. Cumin can be used ground or as whole seeds. It helps to add an earthy and warming feeling to food, making it a staple in certain stews and soups, as well as spiced gravies such as chili.

USDA (2011) one table spoon of cumin spice contains. 22 (Kcal) Calories, 1.34 g. Fat, 2.63 g. Carbohydrate, 0.6 g. Fiber, 1.07 g. protein.