th the improved quality, colour, safety and ) besides making them r (**Note :** Most foods are herefore as such are not year). In addition, modern s also take into account people.

## D FOODS

nted foods is variable. cal region, availability and food habits of the

mushrooms (Chapter 29).

A selected few of the fermented foods with special reference to their production are described briefly in this chapter.

## CHEESE

Cheese production is the largest dairy industry in the world. There are around 1,000 types of different cheeses. Th are broadly of two types — ***unripened cheeses*** (cottage cheese with low fat, cream cheese with high fat) and ***ripened cheeses*** (hard cheese e.g. chedder, blue cheese; soft cheese e.g. limburger, camembert). Irrespective of the type of the cheese, all of them are invariably ***made from the casein of milk***, that is produced after separating

**Table 28.1 A selected list of fermented foods along with the raw materials and fermentiag organisms**

| Fermented food/food product (country) | Raw material (substrate) | Fermenting organism(s) |
|---|---|---|
| **Dairy products** | | |
| Cheese (worldwide) | Milk | *Streptococcus* sp<br>*Penicillium roquefortii*,<br>*P. camembertii* |
| Yogurt (worldwide) | Milk | *Streptococcus thermophilus*<br>*Lactobacillus bulgaricus* |
| Kefir (Russia) | Milk | *Lactobacillus* sp, *Candida* sp |
| **Vegetarian products** | | |
| Cocoa beans (worldwide) | Cocoa fruit | *Candida krusei*, *Geotrichum* sp |
| Coffee beans (worldwide) | Coffee cherries | *Edwinia dissolvens*, *Saccharomyces* sp |
| Tempeh (Indonesia) | Soy beans | *Rhizopus oryzae*, *Lactobacillus delbrueckiia* |
| Soy sauce (worldwide) | Soy beans | *Aspergillus orzyae*, *A. soyae* |
| Sauekraut (Europe) | Cabbage | *Leuconostoc mesenteroides*, *L. plantarum* |
| Breads (worldwide) | Wheat flour | *Saccharomyces cerevisiae* |
| Rolls, cakes (worldwide) | Wheat flour | *Saccharomyces cerevisiae* |
| Idli (India) | Rice and black gram | *Leuconotoc mesenteroides* |
| **Non-vegetarian products** | | |
| Dry sausages (worldwide) | Beef, pork | *Pedicoccus cerevisiae* |
| Fish sauces (worldwide) | Small fish | *Halophilic* sp, *Bacillus* sp |
| Country-cured hams (worldwide) | Pork, hams | *Aspergillus* sp, *Penicillium* sp |

the whey (liquid portion of milk). Milk from different animals can be used e.g. sheep, cow, goat, buffalo.

## Historical perspective

The use of animal stomachs for carrying liquids is centuries old. When milk was transported in this fashion, the formation of solids (that were tasty) was observed. The solids were concentrated after draining liquids. These solids were salted and consumed later. A good example of food preservation, long long ago! We now know that this solid portion is the cheese. It is produced by the combined action of enzymes (rennet) of the stomach living and the bacterial contamination.

## Production process

As already stated, cheese is produced from milk. This is carried out by a process of dehydration wherein casein (milk protein) and fats are concentrated 5–15 fold. Cheese production is very complicated, and broadly involves four stages- acidification of milk, coagulum formation, separation of curd from whey and ripening of cheese.

1. **Acidification of milk :** By employing lactic acid bacteria (*Streptococcus lactis*, *Lactobacillus lactis*) the sugar of milk (lactose) can be converted to lactic acid. This lowers the pH to around 4.6, and thus acidifies milk.

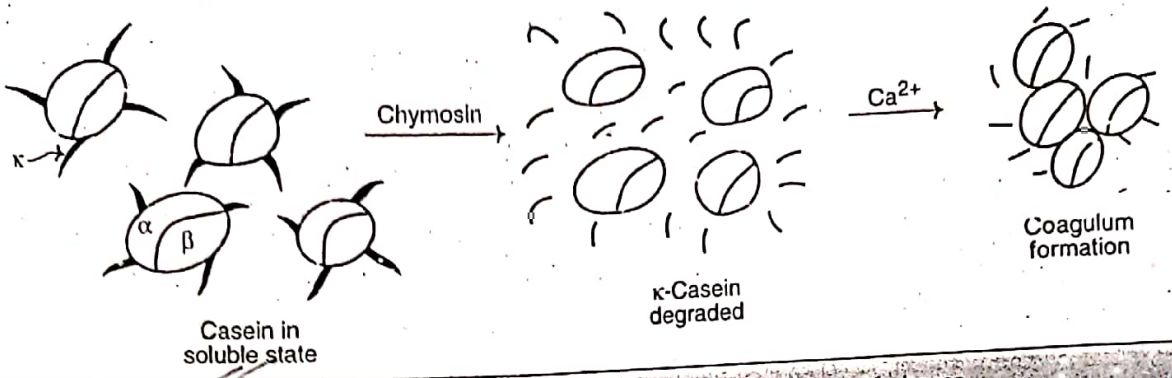


*Fig. 28.1 : Formation of coagulum (curd) in the production of cheese.*

2. **Coagulum formation :** When the acidified milk is treated with **rennet** (i.e. the enzyme chymosin of animal or fungal origin), casein gets coagulated. Casein mainly consists of three components-insoluble α and β caseins and a κ-casein that keeps them in soluble state. By the action of chymosin, κ-casein is degraded. Consequently, α and β caseins and the degraded products of κ casein combine to form a coagulum (curd) (***Fig. 28.1***). This process of coagulation is dependent on calcium ions.

3. **Separation of curd from whey :** When the temperature of the coagulum is raised to around 40°C; the coagulum (curd) and whey (fluid portion) get separated. The separated curd is cut into blocks, drained and pressed into different shapes.

4. **Ripening of cheese :** The flavour of raw cheese (with rubber texture) such as ***cheddar*** is bland. Ripening imparts flavours, besides making changes in its texture. The procedures adopted for ripening (or maturation) are highly variable depending on the type of cheese to be prepared. The blocks of curd separated are subjected to the action of proteases and/or lipases. Alternatively, they may be inoculated with certain fungi (e.g. *Penicillium roquefortii*). The hydrolysis of proteins and fats (either by enzymes or microorganisms) results in certain compounds which imparts flavour to the cheese. Mild hydrolysis of fats (or cheese), usually carried out by lipases or *Aspergillus niger* or *Mucor maihai* results in butyric acid formation with characteristic flavour.

A diagrammatic representation of cheese production is depicted in ***Fig. 28.2***.

**Sources of chymosin for cheese production**

There are several sources of rennet (chymosin enzyme) for cheese production. These include calves, adult cows, pigs and fungal sources. Fortunately, the fungal (e.g. *Mucor meihei*) sources of chymosin are almost comparable to the animal sources and are widely used in some countries. However, some people always prefer animal rennet used cheese due to its slight superior flavour.

**Genetically engineered microorganisms for chymosin :** Some workers could successfully clone the genes of animal chymosin and transfer the same into microorganisms. The chymosin so produced by genetic manipulation is very widely used these

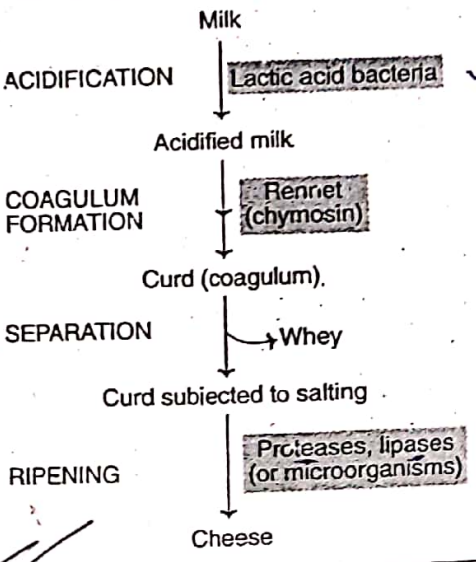


*Fig. 28.2 : A diagrammatic representation of cheese production.*

days in some countries. The taste of cheese manufactured by microbial chymosin (i.e. genetically engineered) and the animal chymosin are identical. Public as well as the vegetarian societies in some countries have accepted the cheese produced by the genetic manipulation of the enzyme, chymosin.

## YOGHURT

Yoghurt is produced ***by fermenting whole milk*** by employing a mixed culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. While *L. bulgaricus* produces acetaldehyde that imparts a characteristic taste, *S. thermophilus* results in the formation of lactic acid to give acid flavour. In addition, both these bacteria produce extracellular polymers that increase the viscosity of the fermented milk. Yoghurt is very delicious and in fact frozen yoghurt is becoming popular as an alternative to ice cream.

## SAUEKRAUT

Sauekraut is prepared in most western countries. It is a ***fermented and preserved form of cabbage***. The shredded cabbage is mixed with salt (approximately at 2.5% concentration) and packed anaerobically. High salt concentration promotes leakage of sugars from the cabbage while reducing the water activity. As the growth of the lactic acid bacteria occurs, the pH is lowered. At this low pH, the putrifying bacteria cannot grow. In this way, sauekraut can be preserved for long. Sauekraut is nutritious as well as delicious.

***The traditional pickles (mango, lemon, etc.) in India are also good examples of fermentation and preservation, based on the principles of biotechnology.***

## BREAD

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