

# Basic Principles of Cheese Making

- 1. Cheese consists of a concentration of the constituents of milk (fat, casein and insoluble salts) together with water in which small amounts soluble salts, lactose and albumin are found.**
- 2. Milk is coagulated either by means of lactic acid produced by bacteria or by addition of rennet or by both. A portion of water is removed by cutting, cooking, stirring or draining the curd or by mechanical application of pressure.**
- 3. May or may not be ripened (depends on variety of cheese).**

# Common steps of cheese manufacture

**Souring of milk**



**Clotting by rennet or a similar enzyme preparations**



**Cutting or breaking up of the coagulum to release the whey**

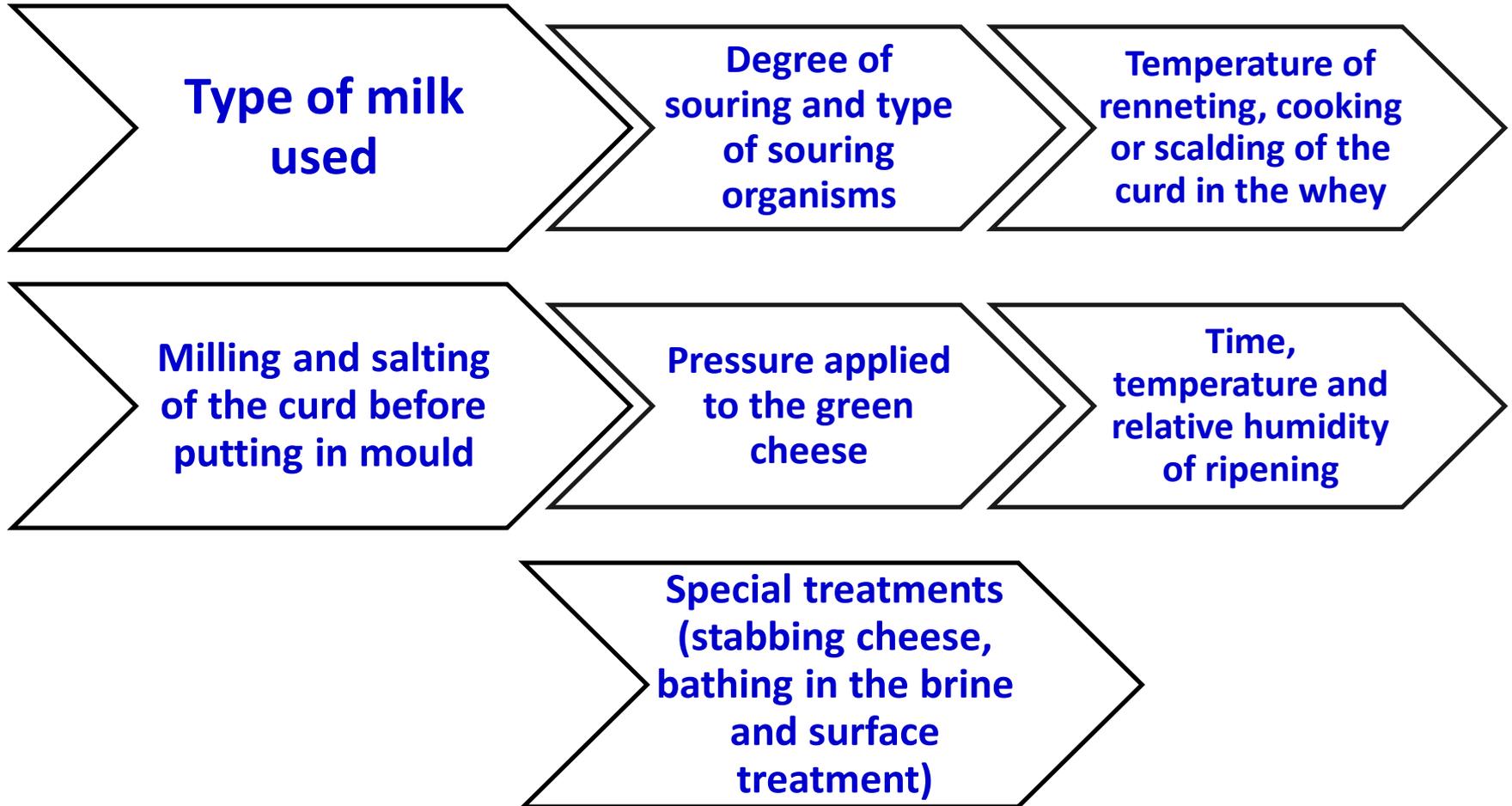


**Matting of the curd**



**Maturing**

# Chief factors responsible for differences in final cheese

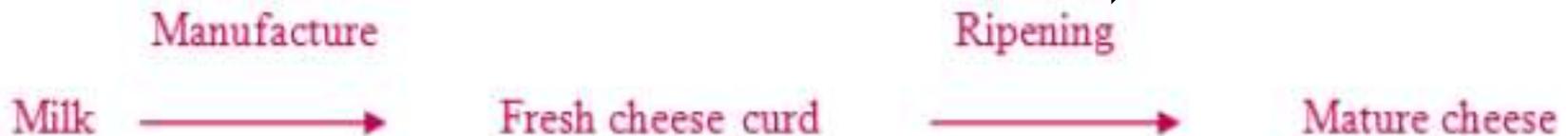
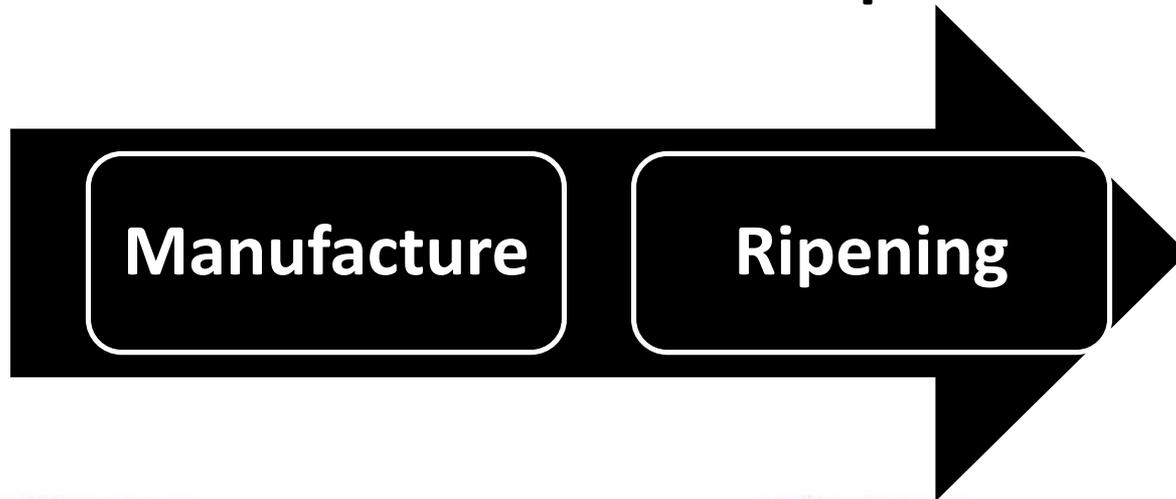


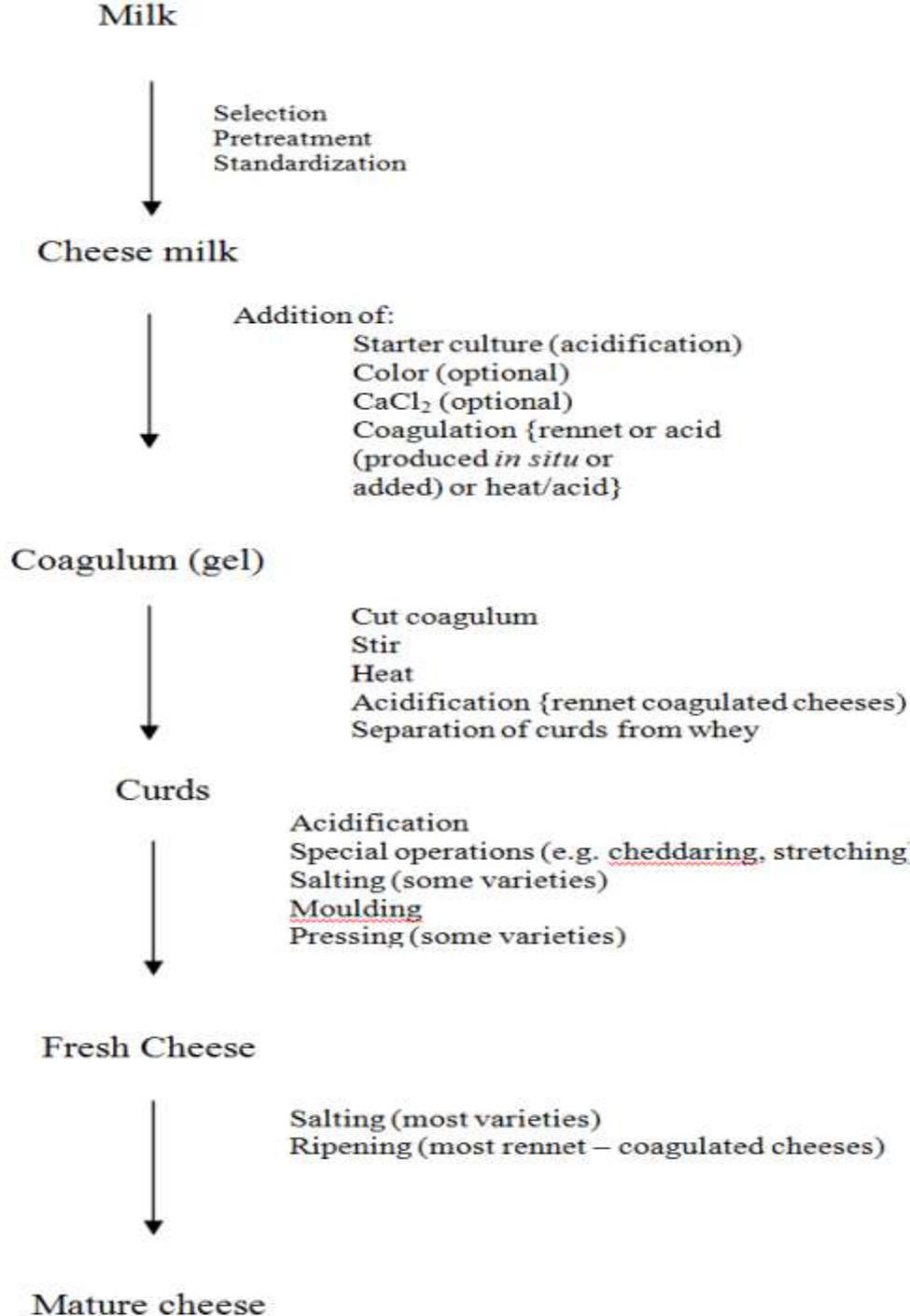
# Outlines of cheese manufacture

Cheese manufacture involves the controlled syneresis of the rennet milk coagulum, the expulsion of moisture being affected:

- i) Acid development (pH 6.6-5.0) due to *L. lactis* subsp. *lactis* and subsp. *cremoris*
- ii) Warmth, temperature being raised to about 31°C for renneting and 38°C for scalding the curd.

**Production of cheese requires**





1. During dehydration process, fat and casein in milk are concentrated between 6-12 fold.
2. Degree of dehydration is regulated by extent and combination of acidification, coagulation, dehydration, shaping and salting with chemical composition of milk.
3. Levels of moisture, salt, pH and cheese microflora regulate and control the biochemical changes that occur during ripening and determine the flavor, aroma and texture of finished product.

## **Selection of milk.....**

- 1. Composition of cheese is strongly influenced by the composition of the milk (content of fat, protein, calcium and pH).**
- 2. Constituents and composition of milk are influenced by species, breed, individual variations, nutritional status, health and stage of lactation (early or late stage of lactation should be avoided).**
- 3. Leucocyte count is a useful index of quality.**
- 4. Firmness of rennet coagulum/cheese curd is enhanced by acidity, high calcium and high casein content. Reduced by alkalinity, low casein, high albumin, globulin and sodium.**
- 5. Mastitis leads to weak curd formation.**
- 6. Milk should be free of taints of chemicals and free fatty acids that cause off-flavors in the cheese, antibiotics that inhibit bacterial cultures, good microbiological quality, pasteurized or free of pathogenic, food poisoning and spoilage bacteria.**

7. Variation in the characteristics of cheese depends on the species of dairy animals. Cattle, buffalo, sheep and goats produce 85%, 11%, 2% and 2% of commercial milk respectively.
8. Goats and sheep milk is used mainly for the production of fermented milks and cheese in Mediterranean.
9. World famous cheeses (Roquefort, Feta and Romano) are produced from sheep's milk and traditional Mozzarella made from buffalo milk.
10. Caseins of tyrogenic milk (capable of being converted into cheese) are same, fats of this milk may differ significantly in the proportions of the fatty acids in the triglycerides. The medium chain ( $C_6-C_{10}$ ) fatty acids liberated during ripening are more peppery in flavor (Roquefort) than short ( $C_2-C_4$ ) or longer ( $C_{12}-C_{18}$ ) fatty acids.

# Inhibitory substances in milk..... (Exclude the milk)

**1.**

- Lactenin may inhibit the growth of streptococci (two components, L1 is present in colostrum and is inactivated by heating to 70°C for 20 min and L2 present in mid-lactation milk and is inactivated by heating to 70°C for 20 min)

**2.**

- Presence of antibiotics (Penicillin) in milk is a major cause of trouble in cheese making by inhibiting growth of starter organisms.

**3.**

- Formalin, hypochlorite, quaternary ammonium compounds present in milk may inhibit growth of starter organisms.

# Storage of chilled milk.....



## Standardization of milk.....

1. Composition of cheese is prescribed in “Standards of Identity’ with respect to moisture and fat, which in effect defines protein:fat ratio.
2. Fat and casein together with moisture left in the curd control cheese yield, but fat also has a marked influence on appearance and feel of the curd and cheese.
3. Ratio of casein to fat is high, curd is more leathery and final cheese does not acquire the mellow, velvetiness of a whole milk cheese.
4. Casein:fat ratio (C/F ratio) in milk should be about **0.7** for good quality cheese. Depending on ratio required, it can be modified by removing some fat by centrifugation, adding skim milk, cream, milk powder, evaporated milk etc.
5. Such additions increase the total solids content of milk hence, increasing the yield of cheese curd per unit volume.

## Heat treatment of milk.....

**Cheese made from raw milk is more intense flavor than that produced from pasteurized milk, but less consistent and poses a public health risk.**

### **Thermization of cheese milk**

- **Reduce the microbial load**
- **Extend the storage period**

### **Pasteurization of cheese milk**

- **Public health reasons**
- **Milk supply of more uniform bacteriological quality**

**Pasteurization alters the indigenous microflora and facilitates manufacture of cheese of uniform quality, but may damage the rennet coagulability and curd-forming properties of milk.**

**Cheddar cheese made from pasteurized milk develops less intense flavor and ripens more slowly than raw milk cheese.**

**Several heat induced changes, e.g. inactivation of indigenous milk enzymes, killing of indigenous microorganisms, denaturation of whey proteins and their interaction with micellar  $\kappa$ -casein, destruction of vitamins could be responsible for these changes.**

**Sub-pasteurization temperature is preferred to heat cheese milk (Thermization-65°C/15 s) on arrival to factory and done to control psychrotrophs.**

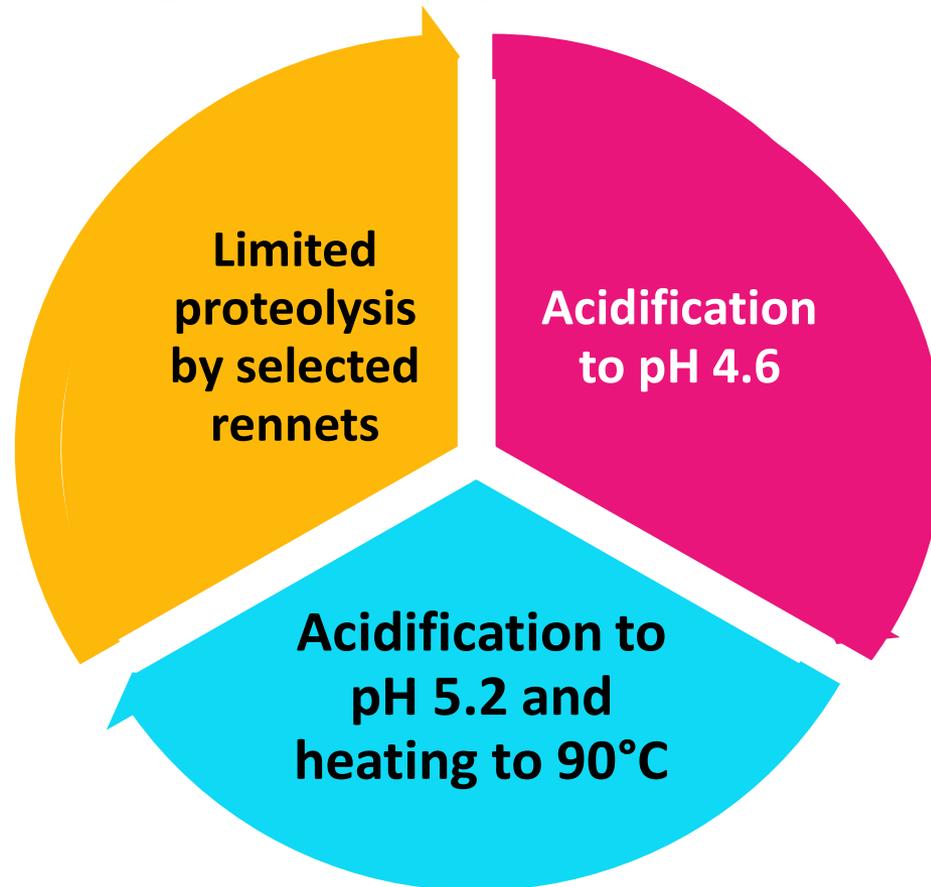
# Ripening of milk.....

1. Increase in acidity in milk to be used for cheese making known as “ripening” is usually brought about by starter culture.
2. Acidity developed inhibits the growth of undesirable organisms and influences the rate of coagulation.
3. When desired acidity (0.01% increase) is reached, most varieties of cheese require the addition of rennet to the ripened milk in order to obtain a curd of the desired characteristics.
4. Acidification is normally via. *in situ* production of lactic acid, although preformed acid or acidogen (gluconic acid- $\delta$ -lactone) are now used to directly acidify curd for some varieties (Mozzarella and Cottage).
5. Mixed microflora has unpredictable rate of acid production and leading to the production of gas and off-flavors. Selected LAB to pasteurized cheese milk achieve a uniform and predictable rate of acid production.
6. Cheese cooked to not more than 40°C (*L. lactis* subsp. *lactis* and/or *cremoris* is normally used) and mixed culture (*S. salivarius* var. *thermophilus*, *Lactobacillus* spp. (*L. bulgaricus*, *L. helveticus*, *L. casei*) is used for cheeses cooked to higher temperature (Swiss).

# Coagulation.....

**Essential step in the manufacture of all cheese varieties involves coagulation of casein of milk to form a gel, which entraps the fat.**

**Coagulation may be achieved by:**



**75% of total cheese are produced by rennet coagulation**

**Acid coagulated varieties (Quark and Cottage cheese)**

**Cheese produced by thermal evaporation of water from a mixture of whey and skim milk, whole milk or cream and crystallization of lactose (Mysost)**

- 1. Rennin is milk-curdling enzyme, which is usually obtained from the fourth stomach (abomasum) of suckling calves. In other animals, the proteolytic enzyme, pepsin, substitutes rennin.**
- 2. Rennin prepared commercially for use in cheese making as a salt extract of dried calf stomach. Such an extract containing the enzyme is called rennet or rennet extract.**
- 3. Rennin is an extremely powerful clotting enzyme; one part of pure rennin can clot more than five million parts of milk.**
- 4. Optimum pH for rennin action on milk is 5.4 and for pepsin is 2.0. Function very powerfully as a clotting agent at almost neutral pH (6.2-6.4).**
- 5. The ratio of clotting to proteolytic power is very high in rennin, but is lower in pepsin (bitter taste) and other proteolytic enzymes tried in cheese making.**
- 6. For Cheddar, usually about 2.5 g of commercial rennet powder is used for 100 L of milk.**

- 7. The formation of curd depends upon the coagulation of the casein in milk. With rennet this occurs in two steps:**
  - Calcium caseinate in milk is first changed to the paracasein, which then combines with the calcium ions present in the milk to form an insoluble curd. This curd is elastic and when heated/pressed it will shrink, squeezing out most of the retained whey.
  - Slow development of curd may be due to too little rennet or to the use of overheated milk. Addition of small amount (0.02%) of  $\text{CaCl}_2$  to that milk will restore calcium ion balance and permit the normal functioning of rennin.
- 8. Rennet extract is diluted up to 20-30 times with clean potable water before adding to cheese milk. After addition of rennet, the milk is stirred for about two minutes to distribute the rennet thoroughly, and then currents are stopped in the milk with a paddle or rake. Vibration of the vat must be prevented during setting. Milk then left undisturbed for the curd to form, and after about 30 min the milk is set with a firm curd.**

# Post-Coagulation Processing Operations.....

Great interest in studying rennet coagulation **is to optimize the gel cutting time**. When coagulum is firm enough, it is cut by mechanical knives in both the horizontal and vertical directions to produce curd particles. In cheese making, the cutting range between 20 and 50 mins depend on:

Concentration of rennet used (20 ml of single strength rennet/100 L milk)

$\text{CaCl}_2$  is added, as this accelerates clotting (Legal level-0.2%)

Coagulation temperature (coagulation occurs faster at higher temperature)

pH (activity of chymosin decreases with an increase in pH)

Seasonal changes in milk composition (late-lactation milk can be slow to clot due to high pH and hydrolysis of casein within mammary gland by plasmin).

# Cutting the coagulum.....

- 1. Rennet gel is quite stable if maintained under quiescent conditions but if it is cut or broken, syneresis occurs rapidly, expelling whey.**
- 2. Syneresis concentrates the fat and casein of milk by a factor of about 6.012. Rate and extent of syneresis are influenced by milk composition especially  $\text{Ca}^{++}$  and casein, pH of whey, size of cutting of cubes, cooking temperature, rate of stirring of curd-whey mixture and time.**
- 3. Coagulum is ready to cut after a period of 25 min-2 h.**
- 4. Cheesemakers plunge the hand, rod or thermometer stem below the surface layer and lift the coagulum causing it to break in a cleavage line. A clear cleavage with green whey at the base of the cleft indicates that the curd is ready to cut. Soft irregular cleavage with white whey indicates that the curd is too soft. Sides of the cleft show the quality of the curd. Granular curds indicate that the curd is too firm. If the coagulum becomes too firm, knives or curd breakers crush the curd rather than cut it cleanly. When curd is ready for cutting, it is first cut horizontally and then vertically.**

5. The curds, which have been cut cleanly, will heal or join up the cut fibrils on the new curd surfaces and thus prevent loss of fat and other milk components.
6. Size of curds after cutting depends on type of cheese to be manufactured. Curds, which need to be scalded to higher temperatures, are cut into smaller pieces, while curds which are scalded to lower temperatures, can be left in large pieces.
7. Mechanically operated curd knives are larger than the manual knives and use either blades or wires. Edges of the blades are kept sharp enough to cut cleanly. Heavy gauge wires tend to tear the curd more than steel knives. Cutting the coagulum lengthwise once manually in the long rectangular vats normally cut by mechanically operated knives prevents crushing of the soft curds during the first mechanical cutting. The rotating knives in round or oval vats do not crush the curd against the vat sides. Speed of rotation in some equipment can be controlled. The angle of the blade presented to the curd is such that if the rotation of the knife is reversed it stirs rather than cuts the curd.

## Cooking.....

- 1. The curd, when first cut, is soft and the coat surrounding the particles is open.**
- 2. Stirring the curd gently until the first flush of whey has left the curd particles is necessary to prevent undue crushing and loss of fat and curd dust.**
- 3. Once the curd coat becomes more membrane-like, the agitation rate can be increased.**
- 4. Cooking or scalding the curd causes the protein matrix to shrink and expel more whey. Increase in temperature also speeds up the metabolism of bacteria enclosed within the curd. Lactic acid production increases, pH declines, and acidity assists in shrinking the particles to express more whey.**

5. Cheesemaker has control over lactose in the curd, therefore, the amount of lactic acid formed, through the size of the curd particles, scald temperature and rate of rise of temperature of the curds. **Two methods of reducing the amount of lactose in the cheese curds:**

- Shrinkage of the curds brought about by heat and lowering of the pH owing to development of lactic acid in the curd.
- Addition of water to the whey, which increases the osmotic effect across the curd membranes and thus extracts the lactose from the curd moisture into the diluted whey.

- 6. Aim of scalding the curd is to shrink the curd to expel moisture and so firm up the curd to a state for texture formation, pressing or salting.**
- 7. Variation of scalding rates is carried out according to the acidity and under the control of cheesemaker. A high rate of scald will shrink the coat of the curd particles so much that the membrane is so firm that moisture is locked in the curd. The resultant cheese is acid, harsh texture, crumbly and eventually dry.**

## **Curd treatment.....**

- 1. The acidity of the curd continues to increase and its body becomes firmer due to decrease in its content of whey.**
- 2. If a soft high moisture cheese is made, the curd is removed from the vat quickly and the whey is drained. For some varieties, the curd is cut and stirred in the whey while it is being heated. In Cheddar cheese, the curd is heated in the whey and allowed to form continuous mass, which is then cut and milled into small pieces before further processing.**

# Whey is drained from the curd varies with the kind of cheese:

**Cream cheese is prepared by placing the curd on cloths which allow the whey to drain away**

**Brick cheese is prepared by placing curd in hoops put on mats which allow the whey to drain**

**In Cheddar cheese, curd is allowed to sink in the vat and the supernatant whey is drawn off**

**In Swiss cheese, curd is separated by placing a cloth under the curd and lifting it out of the vat or kettle**

## Pressing.....

- 1. Last portion of the whey is removed from the curd by pressing.**
- 2. Curd is composed of a matrix of protein enclosing fat globules, moisture, lactose, salts, non-protein nitrogenous substances, peptides, air and CO<sub>2</sub> (so that while it is warm it is springy, elastic and soft).**
- 3. Salt may or may not be applied and salt will dissolve some of the casein surfaces, and also releases water. So, surface layer of casein may be rendered hard and horny if the salt is not allowed to dissolve freely into the warm curd.**
- 4. Pressing the curd should be gradual at first, because high pressure at first compresses the surface layer of the cheese and can lock moisture into pockets in body of cheese. Temperature of curd before pressing should be below 23.9°C in summer and 26°C in winter.**

- 5. Since the cheese curd holds a volume of air before pressing, Cheddar requiring very closed curds have been pressed under a vacuum of 85-95 kN/m<sup>2</sup>.**
- 6. The vacuum applied for only a short time (2-3 h), also assists in cooling the curd.**
- 7. Pressures have been applied for 2-3 days to Cheddar cheese, but block cheese pressing limited to 24-36 h and with vacuum pressing (10-15 h). Cheese presses are either spring, dead weight, pneumatically or hydraulically operated.**

## Treatment of rind.....

- 1. Cheddar and Swiss cheese are given a smooth and uniform surface or rind by pressing the curd while warm, and curing the cheese under conditions that allow the moisture to evaporate from surface.**
- 2. Activity of organisms on surface is prevented in Swiss cheese by frequently cleaning the rind. For Cheddar cheese, this is done by coating the cheese with paraffin wax and holding it in cool room with low humidity.**
- 3. Holding them in cool, moist environment encourages growth of mold on Camembert and Roquefort cheese, and growth of yeasts and bacteria on Brick and Limburger cheese.**

- 4. Soft types of cheese acquire rind during ripening, often as a result of growth of molds and bacteria. Later, evaporation of moisture hardens the rind so that it is more rigid to handle.**
- 5. Sometimes, rind is kept clean by repeated washing with a salt impregnated cloth (Emmental) or repeated brushing to remove mold growth (Cantal). When these cheeses are ripe and ready, the rind is simply coated with vegetable oil, which may be colored brown or black (Parmesan).**
- 6. Smoking of cheese also gives the coat a fatty layer and due to phenolic compounds from the smoke.**
- 7. Spices used on coats of some cheese impart flavor to curd.**
- 8. Gorgonzola is also coated with "Plaster of Paris" as a protective coat inside a woven basket. The plaster is not completely airtight and allows cheese to breath and mold to remain blue.**

# Salting.....

Common salt is an ingredient of variety of cheese. Added to subdivide cheese curds (Cheddar), or apply by immersion of the formed cheese in brine (Gouda, Swiss). For some, the salt is rubbed on the surface after moulding is complete.

1.

- Draws the whey out of the curd

2.

- Suppresses the proliferation of unwanted microorganisms

3.

- Regulates the growth of desirable organisms

4.

- Promotes physical and chemical changes in maturing cheese

5.

- Directly modifies taste and controls acidity

- 1. Salt in cheese is held in solution in aqueous phase and its concentration in solution is a strong determinant of much of the biological and biochemical changes that occur during cheese maturation.**
- 2. Actual level of salt in cheese varies with type, ranging from 0.5-3% (w/w) but this range is amplified by the wide differences in water content between cheese varieties, concentration of NaCl in aqueous phase may range from <1% to about 8%.**

- 3. Dry salted cheese (Cheddar) should have uniform salt levels throughout body within just few hours after salting. In brine-salted cheese, there is marked difference between salt content of surface and interior, which persists for many days or weeks, depending on the dimensions of cheese.**
- 4. Rapid attainment of salt uniformity within dry salted cheese curds generally stops fermentation of residual lactose, leaving pool of fermentable carbohydrate to support growth of salt-tolerant starter and non-starter lactic acid bacteria (NSLAB).**

# Method of Salting.....

**1.**

- **Mixing of dry salt crystals with subdivided cheese curds prior to moulding/pressing stage of manufacture**

**2.**

- **Immersion of moulded cheese in a brine solution**

**3.**

- **Application of dry salt or salt slurry to the surface of formed cheese**

# The salting time depends primarily on the desired salt content and further influenced by:

1.

- Brine temperature (Diffusion rate increases with temperature)

2.

- Salt concentration (Higher concentration gives faster salt uptake)

3.

- Cheese dimensions (Smaller and flatter cheeses take up salt more rapidly; spherical cheeses take up salt more evenly)

4.

- Cheese moisture and pH (Higher moisture and pH both lead to more rapid salt intake)