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# Factors Affecting the Composition, Flavour and Textural Properties of Ghee*

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■ Our present knowledge of the composition of milk fat or ghee has revealed that milk fat is one of the most complex of fats and it has a unique composition as compared to other fats. The areas in which research work is being carried out on the compositional aspects of milk fat or ghee can be broadly divided as follows:

1. Glyceride structure of milk fat-pattern of distribution of fatty acids in the triglycerides of milk fat.
2. Minor components of milk fat: carbonyl compounds, glyceryl ethers and lactones.
3. Mechanism of variation of fatty acid composition of milk fat due to feed.
4. "Protected fat feeding" to increase poly-unsaturated fatty acids in milk fat.
5. Flavour studies of milk fat and ghee.
6. Comparative studies of cow and buffalo milk fat compositions.
7. Effect of composition on quality of ghee: (*i*) Keeping quality and (*ii*) Grain formation.

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## Gross composition of ghee

Bulk of ghee of both cow and buffalo milk fat is made up of triglycerides (98%). The other classes of lipids which are present in minor quantities in ghee are: (*a*) diglycerides (1–2%), (*b*) monoglycerides (0.1–0.2%) (*c*) free fatty acids (1 to 10 mg/100 g), (*d*) phospholipids (0 to 80 mg/100 g) (*e*) sterols—mainly cholesterol (*f*) fat soluble vitamins (*g*) carbonyls (4 to 6 $\mu g/g$) (*h*) glyceryl ethers (0.8 $\mu M/g$) and (*i*) alcohols (1.8–2.3 $\mu M/g$). The levels of diglycerides, monoglycerides and free fatty acids vary due to breakdown of triglycerides by hydrolysis during storage of ghee. The concentration of phospholipids in ghee increases with time and temperature used during clarification of butter or cream into ghee. The concentration of vitamin A, carotene and tocopherols, within certain limits, depends directly on the levels of these components in the ration of the animal.

## Fatty acid composition

At present, presence of about 500 different fatty acids in milk fat has been reported However, the major ones are from $C_4$ to $C_{18}$

of even numbered carbon chain length. The fatty acid composition of buffalo ghee is distinctly different from that of cow ghee. The amount of butyric acid (4:0) is significantly higher in buffalo than in cow ghee. The levels of other short chain fatty acids caproic to myristic (6 : 0 to 14 : 0) are significantly higher in cow than in buffalo ghee. The levels of palmitic (16:0) and stearic acid (18:0) are higher in buffalo than in cow ghee. The oleic acid content is similar in both cow and buffalo ghee.

### Poly-unsaturated fatty acids

The total proportion of polyunsaturated fatty acids is only 3-4% in ghee. The fatty acids with 4 and 5 double bonds are significantly higher in buffalo than in cow milk fat. Although their concentrations are very low they can play a significant role in starting autoxidation reactions which lead to spoilage of ghee during storage. The proportions of polyunsaturated fatty acids are not much affected by the feed as the feed lipids are mostly hydrogenated in the rumen. However, the levels of polyunsaturated fatty acids in milk fat can be increased upto 25% by a method known as "protected fat feeding" in which hydrogenation of the unsaturated fatty acids of feed fat is prevented.

### Relationship between feed of the animal and biosyntheses of fatty acids

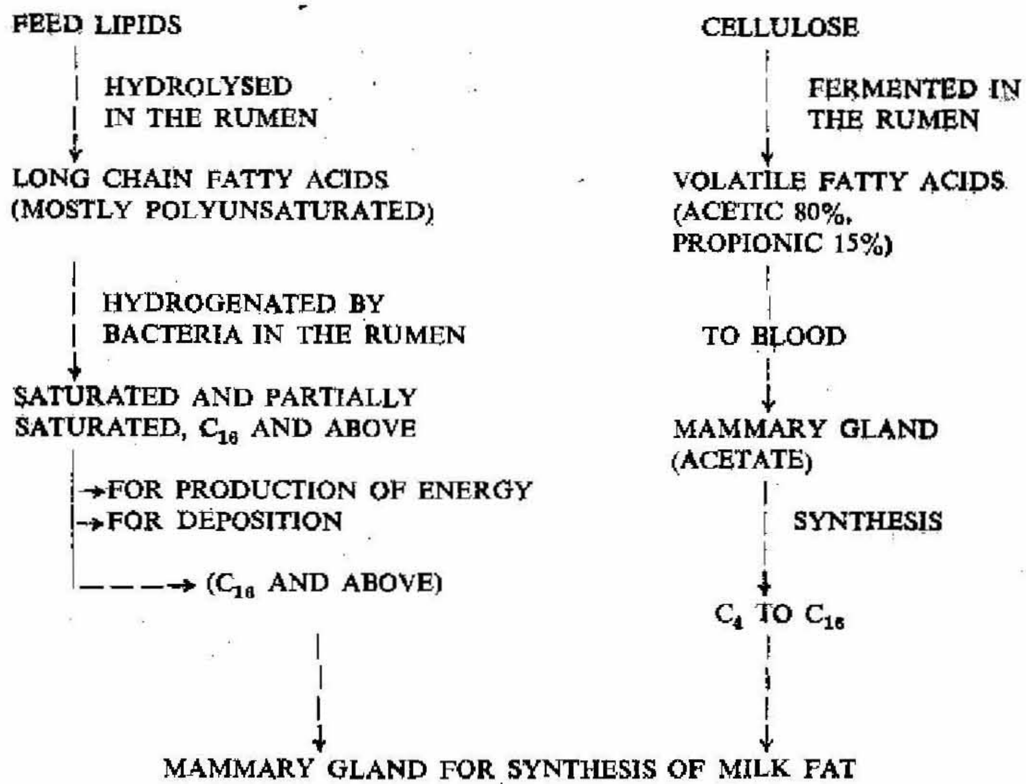
Feed is the main factor affecting variation in fatty acid composition of milk fat. In order to understand the mechanism of variation due to the feed the biosynthesis of fatty acids which go into the formation of milk fat in the mammary gland should be understood. The roughages in the animal feed, which mainly consists of cellulose, contribute to the formation of fatty acids of 4 to 16 carbon chain lengths($C_4$ to $C_{16}$) and the lipid content of the feed contributions to the formation of long chain fatty acids of $C_{16}$ and above. A brief scheme of bio-synthesis of milk fat is shown in the Figure.

### Effect of various feeds on fatty acid composition of milk fat

Low roughage diets to the animals have been reported to cause a decrease in short chain fatty acids ($C_4$ to $C_{14}$) and an increase in long chain fatty acids, $C_{18}$ and above. Pasture grass, which is rich in linolenic acid ($C_{18}$:3), causes an increase in the levels of $C_{18}$:3 acids in milk fat by about 0.5 to 1.0%. Hay or silage, which is rich in palmitic acid and low in $C_{18}$:3 acid causes an increase in palmitic acid content of milk fat. Feeding oils or fats has been shown to cause a general decrease in short chain fatty acids accompanied by an increase in long chain fatty acids. Certain specific fatty acids present in the feed lipids may also appear in milk fat. For instance, when rape seed oil, which typically contains erucic acid ($C_{20}$:1), is fed to the animal, this fatty acid appears in milk fat. Similarly coconut oil which is rich in lauric and myristic acids, causes an increase in the levels of these fatty acids in milk fat. Feeding cottonseed, soya oil and groundnut oil increase unsaturation of milk fat in addition to the general changes mentioned above.

Addition of urea, to replace 20% of digestible proteins, has been found to decrease butyric ($C_4$:0) and Caproic ($C_6$:0) fatty acids (10—30%) and increase in $C_8$:0 to $C_{16}$:0 fatty acids. The physical nature of the feed can affect fatty acid composition of milk fat through the changes in rumen bacterial flora. For example it has been demonstrated that feeding cattle with ground and pelletted roughages decreased the level of short chain fatty acids in milk fat.

Fig. SCHEME OF MILK FAT SYNTHESIS




**Glyceride composition of ghee**

The structure or pattern of arrangement of fatty acids in the triglyceride molecule is an important aspect of compositional studies of ghee or milk fat. The glyceride structure greatly influences the physico-chemical properties of a fat. It has been seen that glyceride composition of cow ghee is distinctly different from that of buffalo ghee. The proportion of high-melting triglyceride is much higher in buffalo (ave. 8.7%) than in cow ghee (Ave. 4.9%). This is because buffalo ghee has larger proportions of long chain saturated fatty acids—palmitic and stearic acids. For the same reason buffalo ghee is distinctly harder than cow ghee. The content of long chain triglycerides is higher in cow (ave. 62%) than in buffalo ghee (ave. 55%). On the other hand the proportion of short chain triglycerides is higher in buffalo (ave. 45%) than in cow ghee (38%). This is because buffalo ghee contains higher amounts of butyric acid than cow ghee. The levels of trisaturated glycerides are similar in cow and buffalo ghee (21 to 43%).

**Falvour of ghee**

Ghee is greatly valued in our country for its characteristic flavour. The flavour of pure milk fat, as observed in the case of fresh butter oil, is termed as 'bland' in comparison with the typical flavour of ghee. The flavour varies, depending upon the conditions of manufacture, which is described as 'mild' to 'intense' or 'high heated' or 'cooked'. There are regional preferences to the type of flavour. Ghee obtained by clarification of butter or cream at a temperature of not more than 100°C is mild and that produced at about 120°C is intense. This difference is not one of "quantitative" but rather of "qualitative" because at high temperature of clarification certain new compounds are formed as a result of heat induced chemical changes. The Chemistry of "ghee" flavour" is not understood well. The flavour of pure milk fat is attributed to the presence of several carbonyl compounds naturally present in milk fat. The composition of carbonyls is not altered by the manufacturing conditions such as temperature of clarification and ripening of cream or butter. On the other hand temperature of clarification and ripening have significant effect on the flavour development in ghee. Ripening of cream or butter gives intense "ghee flavour", provided the temperature of clarification reaches around 120°C. It has been observed that ghee prepared under the above conditions contained more of lactones, free fatty acids and alcohols than did pure milk fat. It has been reported that butter oil when heated with skim milk dahi acquired "ghee flavour."

It can be concluded that "ghee flavour" may be due to a combination of carbonyls, free fatty acids, lactones, alcohols and other compounds generated due to higher temperatures of clarification.

**Texture of ghee**

A good grainy texture of ghee is very much appreciated by consumers. Ghee or milk fat has a unique property of forming grains because it is made up of a wide variety of triglycerides with varying melting points. There are a number of factors which affect the formation of grains in ghee:

(1) *Temperature of clarification:* Size and quantity of grain is better at 28°C (24 h) than at 30 or 32°C.

(2) *Rate of cooling:* Slow cooling (2-3 h) to incubation temperature (28°C) gives better grain size.

(3) *Cow vs buffalo:* Buffalo ghee forms bigger size crystals (0.31 mm) than cow ghee (0.24 mm).

(4) *Temperature of clarification:* Higher temperature of clarification gives better grain size and quantity.

(5) *Method of preparation:* Butter ghee gives better grain than cream-ghee.

(6) *Free fatty acids:* Presence of free fatty acids increases the grain size markedly but the quantity of grains is increased only to a small extent.

(7) *Seeding:* Seeding (1–3%) with grains of ghee gives grains of good appearance. The grain shape is needle like as compared to those of spherical ones obtained without seeding.

(8) *Keeping quality:* Seeded ghee shows less autoxidative stability than unseeded ghee. A good grainy gnee develops less rancidity than ghee kept in liquid condition. ● ●