Technews

National Dairy Development Board

For Efficient Dairy Plant Operation

Jan- March 2020 **Issue No. 99**

Technology of Ghee manufacturing

This bulletin includes technical information based on latest developments on products, systems, techniques etc. reported in journals, companies' leaflets and books and based on studies and experience. The technical information in different issues is on different areas of plant operation. It is hoped that the information contained herein will be useful to readers.

The theme of information in this issue **"Technology of Ghee manufacturing"** It may be understood that the information given here is by no means complete.

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Introduction

Ghee is one of the oldest and important traditional milk products of India. *Ghrita* (ghee) was produced in ancient India as far back as 1500 BC and in ancient India, it was the preferred cooking medium *(Achaya, 1997)* and used in *Ayurvedic* system of medicine. According to Ayurveda, ghee promotes longevity and protects the body from various diseases *(Tirtha, 1998).*

The products similar to ghee have been available in other parts of the world probably since equally ancient times and known as *samna* in Egypt, *samin* in Sudan, *maslee* in Middle East, *rogan* in Iran and *samuli* in Uganda. Ghee is also gaining popularity in Australia, Arabian countries, the United States, the United Kingdom (UK), Belgium, New Zealand, Netherlands and many other African and Asian countries.

A major portion of ghee in India is utilised for culinary purposes, for example, as a dressing for various foods and for cooking and frying of different foods. It is considered as the supreme cooking or frying medium. Almost the entire range of Indian sweets, prepared with admixtures of milk, cereals, fruits, vegetables and nuts, are preferably cooked using ghee as the medium. In its table use, ghee is served in hot melted form and used for garnishing rice or spreading lightly on *chapatis*.

Codex Alimentarius (FAO/WHO, 1997, 2006) and FSSR 2011, define ghee as 'a product exclusively obtained from milk, cream or butter by means of processes, which result in almost total removal of water and non-fat solids, with an especially developed flavour and physical structure'.

Composition of Cow and Buffalo ghee

Ghee is made up of a combination of saturated (~65%) and unsaturated (~5%) fat and monounsaturated fat (~25%).Its saturated fat is primarily made up of the easy-to-digest short chain fatty acids (89%). Both saturated and unsaturated fat play an important part in a healthy diet.

Ghee contains fat soluble vitamins A, D, E and K, small amounts of essential fatty acids (arachidonic acid & linoleic acid), charred casein and traces of calcium, phosphorus, iron and zinc. Free fatty acid is limited to 3.0 % (as % oleic acid) (FSSR standard).

Ghee shall conform to the following requirements				
	FSSR	**AGMARK-schedule III A**		
Parameter		**Special**	**General**	**Standard**
Baudouin test	Negative	Negative	Negative	Negative
Butyro-refractometer reading at 40°C	As per FSSR	40 - 43	40 - 43	40 - 43
Reichert Meissl value	As per FSSR	Not lessthan 28	Not lessthan 28	Not lessthan 28
Polenske value	-	1 - 2	1 - 2	1 - 2

Moisture content, max.,%	0.5	0.3	0.3	0.3
FFA as Oleic acid, max., %	3	1.4	2.5	3
*color of lettering of grade	NA	Red	Green	Chocolate
*color of circular border of label	NA	Red	Green	Chocolate

Cow ghee contains nearly 5% less saturated fats than buffalo ghee. It also contains carotenoids which imparts yellow colour to the product. On the contrary, buffalo ghee lacks carotenoids but contains biliverdin and bilirubin responsible for its greenish tint *(Achaya, 1997).*

Characteristics	**Cow milk Ghee**	**Buffalo milk Ghee**
Milk fat (% by weight)	99-99.5	99-99.5
Moisture (% by weight)	<0.5	<0.5
Carotene (mg/g)	3.2-7.4	-
Vitamin A (IU/g)	19-34	17-38
Cholesterol (mg/100g)	302-362	209-312
Tocopherol (mg/g)	26-48	18-37
FFA (% oleic acid)	1-3	1-3

(Aneja et al., 2007).

Compositionally ghee is made up of:-

A. Triglycerides:

- The long-chain triglycerides is higher in cow's ghee (62.4 g 100 g−1*)* than in buffalo ghee (54.7 g 100 g−1*)*
- The proportion of short-chain triglycerides is higher in buffalo ghee (45.3 g 100 g−1) than in cow ghee (37.6 g 100 g−1); this is because buffalo ghee contains higher amounts of butyric acid than cow ghee *(Ramamurthy & Narayanan, 1975*)
- Buffalo ghee contains higher (40.7 g 100 g−1) tri saturated glycerides than cow ghee (39.0 g 100 g−1)
- The average proportion of high-melting triglyceride is much higher in buffalo ghee (8.7 g 100 g−1) than in cow ghee (4.9 g 100 g−1); this is because buffalo ghee has larger proportions of long-chain saturated fatty acids – palmitic and stearic acids

Hence, buffalo ghee is distinctly harder than cow ghee. Levels of unsaturated glycerides are high in buffalo ghee (56.0 g 100 g−1) compared with cow ghee (54.5 g 100 g−1), which makes the former more prone to autoxidation.

Fatty acid composition of ghee (g 100 g−1)		
Fatty acid	**Cow**	**Buffalo**
C4:0	3.6	6.7
C6:0	3.1	3.0
C8:0	2.0	1.1
C10:0	3.2	3.4
C10:1	0.6	0.4
C12:0	3.9	3.6
C12:1	0.1	-
C14:0 (br)	0.3	0.2
C14:0	12.9	13.9
C14:1	1.0	1.0
NI	1.2	1.3
C15:0	2.2	1.0
C16:0 (br)	0.4	0.1
C16:0	23.8	28.4
C16:1	1.0	0.2
C17:0	0.8	0.9
C18:0	11.8	12.1
C18:1	25.5	20.5
C18:2	1.2	0.9
C18:3	0.8	0.8
C20:0	0.2	0.1

(br), branched chain; NI, not identified

Data compiled from Ramesh & Bindal (1987)

Effect of feed on fatty acid profile:

Feed significantly affects the composition of ghee. Feeding cottonseed or groundnut cake increases the unsaturation of milk fat and decreases the lower chain fatty acids. Low roughage diet to the animals have been reported to cause a decrease in short-chain fatty acids

(C4:0–C14:0*)*, and an increase in long-chain fatty acids, C18 and above. Pasture grass, which is rich in linolenic acid (C18:3*)*, causes an increase in the levels of C18:3 acids in milk fat by about 0.5 to 1.0 g 100 g−1. Hay or silage, which is rich in palmitic acid and low in C18:3 acid causes an increase in palmitic acid content of milk fat.

Feeding oils or fats to milch animals, 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 (C20:1*)*, 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 and groundnut oils increases unsaturation of milk fat.

B. Phospholipids:

- Buffalo ghee, on average, contains slightly higher amounts (42.5 mg 100 g−1*)* of phospholipids than cow ghee (38.0 mg 100 g−1*)*
  Note: also influenced by the method of preparation
- Ghee prepared by direct heating of butter at 120°C contained less phospholipids than the ghee prepared by pre-stratification and subsequent heating of the fat and serum at 120°C *(Pruthi et al., 1972a). This is*

because moisture gets effectively removed in pre-stratification process and heating of ghee in boiler causes liberation of excessive phospholipid from phospholipid-protein complex.

- Ghee filtered at 110°C contains more phospholipids than when filtered at 60°C
- Increasing the momentary heating temperatures from 120°C to 150°C results in a 12-fold increase in the phospholipids content, probably due to the combined effect of liberation of phospholipids from the phospholipid–protein complex, and the more efficient removal of moisture *(Pruthi, 1980)*
- Heating time also influences the phospholipids content of ghee, which increases by about 13 times when heating time at 120°C is increased from 0 to 90 minutes.

Note: On further heating, however, there is a progressive decrease in the phospholipid content of the ghee due to thermal oxidation resulting in de-phosphorylation. Heating ghee for 40 min and more at 120°C results in the development of a deep dark brown colour and a fishy odour, probably due to interaction of amino groups of phosphatidyl ethanolamine and phosphatidyl serine with aldehydes *(Kuchroo & Narayanan, 1977).*

- Ghee prepared from ripened cream or stored butter contained more phospholipids than when prepared from fresh material. The acidity developed during ripening or storage appeared to facilitate removal of moisture from the ghee residue, forcing more phospholipids into the oil phase *(Rajput & Narayanan, 1968)*

C. Unsaponifiable constituents:

- Cow ghee contains higher free cholesterol than buffalo ghee (283 mg 100 g−1 against 212 mg 100 g−1*)*, whereas esterified cholesterol is higher in buffalo ghee).
- The method of preparation of ghee also affects its cholesterol content. Cow ghee made by the Butter method contains significantly lower (292 mg 100 g−1*)* total cholesterol than ghee prepared by the Direct Cream method (306 mg 100 g−1*).*
- Mastitic Milk Fat contains much more cholesterol (cow 729 and buffalo 625 mg 100 g−1*)* than normal milk and clarification temperature has no effect on the cholesterol content of ghee *(Bindal & Jain, 1973c)*
- The minor unsaponifiable constituents (μg g−1 fat) of cow ghee and buffalo ghee are lutein (4.2 and 3.1), vitamin A (28.3 and 39.83 IU 100 g−1 fat), squalene (59.2 and 62.4) and ubiquinone (5.03 and 6.51), respectively. The buffalo ghee contains higher vitamin A, squalene and ubiquinone than cow ghee, whereas the concentration of lutein is significantly higher in cow ghee.
- Lanosterol content (mg 100 g−1) ranges between 5.8 and 13.0 in cow ghee and between 4.8 and 12.1 in buffalo ghee *(Bindal & Jain, 1973d)*

Methods of ghee preparation

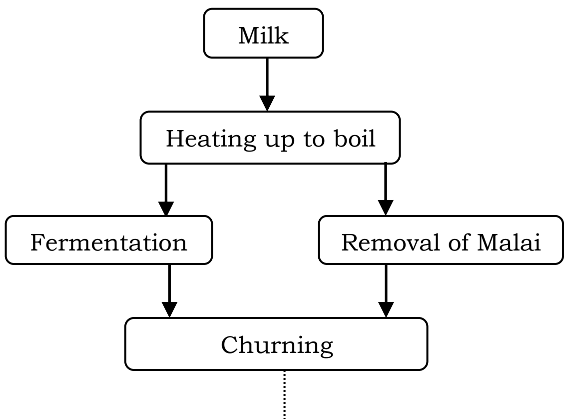
The principle involved in ghee preparation include;

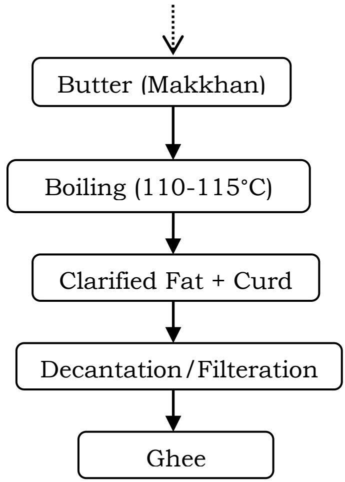
- Concentration of milk fat in the form of cream or butter.
- Heat clarification of fat rich milk portion and thus reducing the amount of water to less than 0.5%.
- Removal of the curd content in the form of ghee residue

There are five methods of ghee making:

1. Desi or Indigenous Method
2. Direct Cream Method
3. Creamery Butter Method
4. Prestratification Method
5. Continuous Method

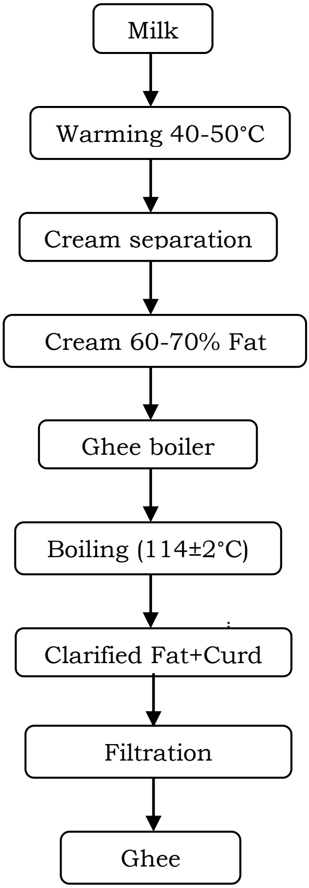
1. Desi method:





This is the practice from age-old days in rural areas where excessive milk is cultured and kept overnight for fermentation. Resultant curd is churned using hand driven wooden beaters to separate the milk fat in the form of desi butter. (Some follow slightly different method wherein milk is heated continuously to about 80°C, the malai (creamy layer) that forms over the surface is collected manually. This malai is then churned to get the desi butter.) After collection of desi butter over a period of time, the butter is melted in a metal pan or earthenware vessel on an open fire. Extent of frothing is an index to judge when to terminate heating. Heating should be stopped when sudden foaming appears and leave the contents undisturbed after heating. Curd particles settle down over a period of time. Decant the clear fat carefully. In this method it is possible to recover only up to 85% fat.

2. Direct cream method:



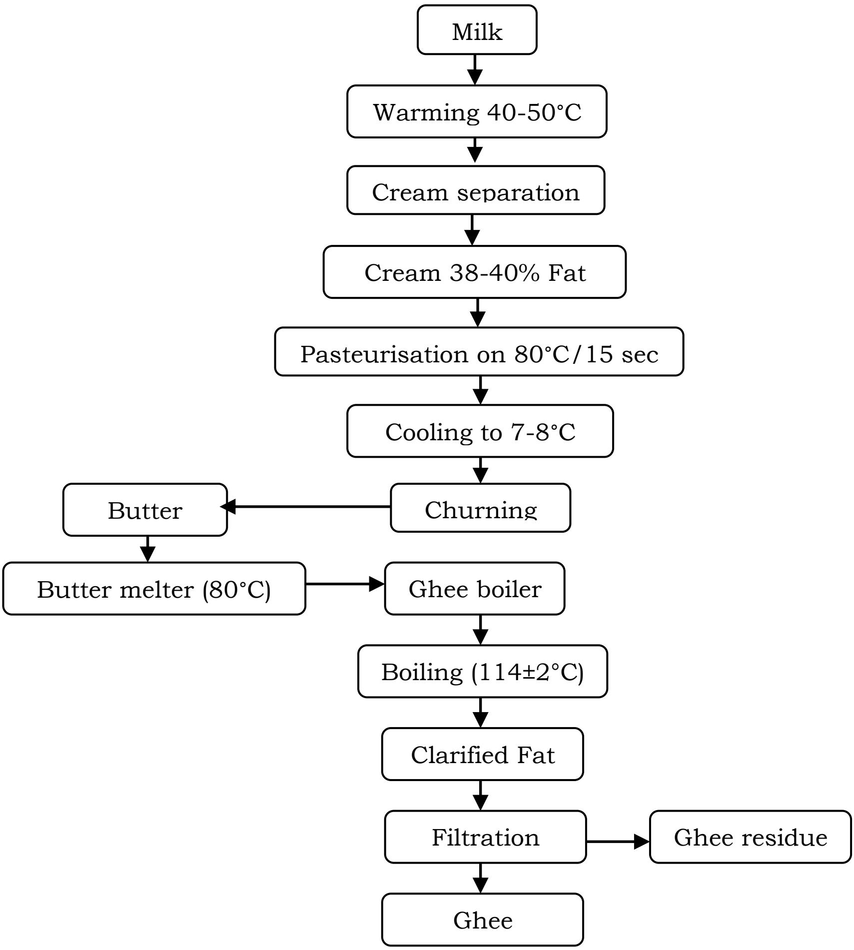
This method involves separation of cream of 60 to 70% fat from milk by centrifugation process, fresh cream or cultured cream is heated to 114±2°C in a stainless steel, jacketed ghee kettle. This kettle is fitted with an agitator, steam control valve, pressure and temperature gauges. A movable hollow stainless tube centrally bored for emptying out the contents (alternatively provision can be made for tilting device on the ghee kettle to decant the product). Heating is discontinued as soon as the colour of the ghee residue turns to golden yellow or light brown. Usually, initially plenty of effervescence accompanied by a crackling sound is heard in the preliminary stages of boiling but both gradually subside as the moisture content decreases. When almost all the moisture is evaporated, the temperature of the liquid medium suddenly spurts up and care has to be exercised at this stage to control the heating. The end point is indicated by the appearance of second effervescence, which is subtler than the first one accompanied by the browning of curd particles. At this stage the typical ghee flavour emanates and this indicates that the preparation of ghee is complete. Advantages of this method is there is no need for butter production prior to manufacturing of ghee.

Limitations:

- Long heating time to remove the moisture.
- High content of serum solids in the cream may also produce a highly caramelized flavour in the ghee.
- 4 – 6% loss of butter fat in the ghee residue & during the handling operations.

- So, 70 – 80% fat cream is recommended to minimize both fat loss and steam consumption.

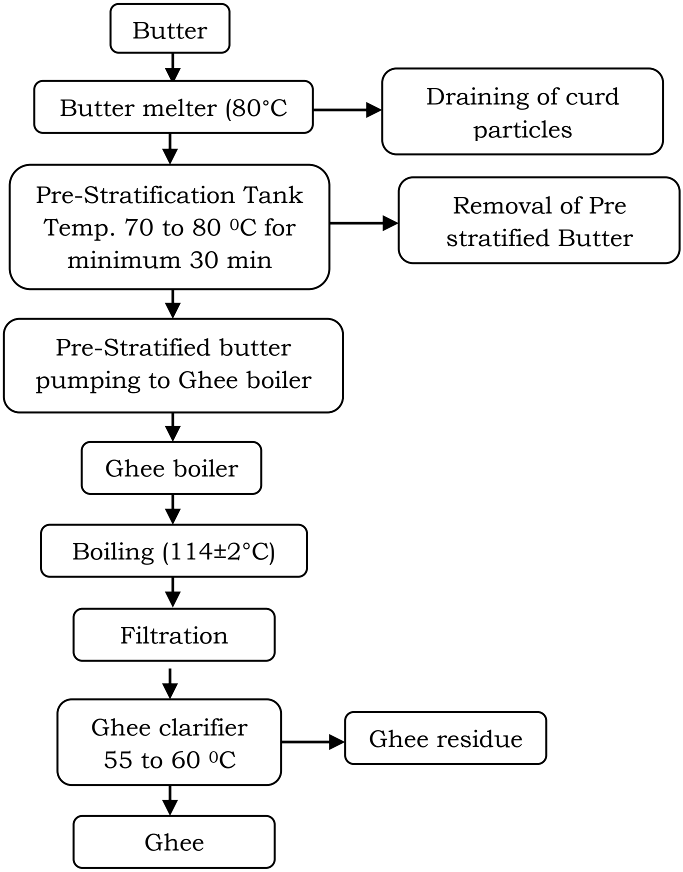
3. Creamery butter method:



This is the standard method adopted in most of the organized dairies. Unsalted or white butter is used as raw material. Butter mass or butter blocks are melted at 60°C to 80°C in butter melter. Molten butter is pumped into the ghee boiler where final heating will be done using steam as heating medium. Increase the steam pressure to raise the temperature. Scum which is forming on the top of the surface of the product is removed from time to time with the help of perforated ladle. Moment of disappearance of effervescence, appearance of finer air bubbles on the surface of the fat and browning of the curd particles indicates to stop heating. At this stage typical ghee aroma is produced. Final heating temperature is adjusted to about 114±2°C. To get the cooked flavour, heating beyond this temperature is also being in practice. Ghee is filtered via oil filter into the settling tank.

4. Pre-Stratification Method

Butter is produced from aged cream of 38 to 40% fat using continuous butter making machine or batch churn. Butter is then transferred to butter melter, and melt at 80°C. This molten butter is kept undisturbed in a ghee kettle or boiler at a temperature of 80-85°C for 30 min. Here, in ghee kettle, stratification of mass takes place, product stratifies into 3 distinct layers. Denatured protein particles (curd particles) and impurities are collected on top layer and floats on surface. Middle layer consists of clear fat and bottom layer consists of buttermilk serum carrying 80% of moisture and 70% of solids-not-fat contained in butter.



The bottom layer is then carefully removed without disturbing the both top and middle layers. Middle layer, largely consists of fat is heated to 114±2°C along with top layer of floating curd particles and denatured protein. This step is necessary to develop characteristic ghee aroma.

Milder flavour ghee can be produced, since most of the curd content is removed before final clarification temperature of ghee.

Advantages of pre-stratification method:

- Removal of buttermilk (bottom layer) eliminates prolonged heating for evaporation of the moisture
- Formation of significantly low quantity ghee residue
- Low quantity of ghee absorbed into ghee residue so less fat loss along with ghee residue
- Production of ghee with lower FFA and acidity

5. Continuous method

This method was developed to meet the requirement of high volume production and to overcome the limitation of batch method.

Limitations of batch method are as follows:

- Requires high energy, due to low heat transfer co-efficient.
- Cleaning and sanitation of equipment's, not satisfactory.
- Equipment's and process unsuitable for large volume of production.
- Floor becomes slippery due to ghee spillage.
- Handling losses are more.

On the other hand, continuous method has following benefits;

- Better control on quality of the product.
- Only small hold-up of raw material in the plant at any time and hence no chance for whole batch getting spoiled.
- Contamination due to foreign objects can be minimised.
- No foaming of the product during production.

Punjrath (1974) described the development of two prototype continuous ghee making plants.

I. The first process uses three successive stages of scraped surface heat exchangers (SSHE), followed by flashing into vertical vapour separators. Molten butter is pumped through the successive stages. Ghee leaving the final stage is passed through a centrifugal clarifier to remove residue, and the clarified ghee is stored in a tank for final packing.

II. Another continuous process for manufacture of ghee from cream involves concentration of the fat and breaking of the fat-in-water emulsion mechanically with the help of centrifugal force in the clarifixator and concentrator. The use of heat is limited to the development of flavour and removal of traces of moisture. The plant requires low energy input and can be adapted for much larger volumes.

The process also results in lower SNF losses and better fat recovery; the separated SNF by concentrating the cream is used for milk standardisation or for the manufacture of skimmed milk powder.

III. Abichandani et al. (1995) developed a continuous 'ghee' making system comprising (a) a continuous butter melting unit and (b) a straight sided horizontal thin film SSHE for converting the molten butter into ghee.

- The butter melting unit, which can be hooked up with a continuous ghee making machine, works on the principle of tank-type heat exchanger.
- It is a jacketed shell where the solid material is fed at one end, and is mechanically conveyed along the length of the heat exchanger having condensing steam in its jacket.
- The heat transfer is very rapid due to the turbulence created by the rotor, and the molten butter is then passed onto a thin film SSHE.
- The heat exchanger utilises steam to heat the inner shell of the jacket, which is in direct contact with the product.
- The centrifugal action of the rotor blades causes the product to spread uniformly as a thin film on the inner shell of the heating surface. It results in rapid evaporation of water from the product.

- The vapour is removed through an outlet, and may be reused for pre-heating the butter.
- Ghee is drawn from a 'well' located at the bottom of the downstream end of the SSHE and led to a balance tank.
- The ghee residue is clarified by pumping the product through a centrifugal clarifier. The clarified ghee is then stored in a tank for final packing.

A comparison of various ghee manufacturing methods:

Particulars	Indigenous	Cream-butter	Direct cream	Pre-Stratification	Continuous
Fat recovery %	88-90	88-92	92	93	93
Aroma	Strong nutty	Pleasantly rich	Mild & milky	Pleasantly rich	Mild
Flavour	Acid	Normal	Cooked	Normal	Flat
Texture	Packed coarse grain	Slushy fine grain (cow) packed fine grain (Buffalo)	Mostly liquid with slight granulation	Fine grains	Greasy
Clarification using heat	Easy, economic, pre-stratification possible	Easy, economic, pre-stratification possible	Difficult, slow& pre stratification not possible	Easy & economic	Easy & economic
Essential equipment's	Butter churn	Cream separator & butter churn	Cream separator	Cream separator & butter churn	Scraped surface heat exchanger
By product produced	Butter milk & ghee residue	Skim milk, Butter milk & ghee residue	Skim milk, Butter milk & ghee residue	Skim milk, Butter milk & ghee residue	Skim milk, Butter milk & ghee residue
Adaptability	Small scale	Large scale	Large scale	Large scale	Very Large scale

Source: Rajorhia (1993) and Aneja, et, al (2002)

The yield of ghee from cream or butter is influenced by fat content of raw material.

I. Factors influencing the yield of ghee:

- Method of production: The fat recovery in indigenous method is lowest (80-85%), follows by the creamery butter method (88-92%) and highest in direct cream method (90-95%).
- The fat content of the raw material used: Higher the fat content higher will be the yield and vice versa.
- Quality of milk or cream: If the acidity of milk or cream intended to use in ghee production is higher, then fat losses in ghee residue will be higher, thus it reduces the yield.
- Fat recovery from ghee residue: Scientific reports suggest to extract as much as fat from ghee residue by dissolving ghee residue in hot water followed by filtration and centrifugation. By this method, it is possible to extract the fat from ghee residue and that fat can be reused.

II. Factors influencing the flavour formation in ghee:

Free fatty acids, carbonyls and lactones are the major groups of compounds contributing to ghee flavour. The flavour profile is affected by method of preparation temperature of clarification and storage period.

1. **Carbonyls:** The quantity of carbonyls is directly proportional to the temperature of clarification and found to increase during storage.

Components	Cow Ghee	Buffalo ghee
Total carbonyls (μM g−1) Alkan-2-ones=90% Alkanals=6% Alk-2-enals=2% Alka-2,4 dienals=2%	7.2	8.64
Volatile carbonyls (μM g−1)	0.33	-
Head-Space carbonyls (μM g−1)	0.035	0.027

2. **Lactones:** The lactone level in buffalo ghee has found to be higher than that in cow ghee. It was the highest in direct cream (DC) ghee, followed by creamery butter (CB) and lowest in desi ghee. Clarification butter at 100-120°C doubles the lactones level from butter. The lactone level in ghee showed a significant rise on storage.

3. Formation of flavour components are due to:
   - Heat interaction between the native carbohydrates and protein system of cream.
   - Due to heat effect on the unfermented residue as well on fermented metabolic products formed by ripening process.

4. Flavour in ghee is the resultant of four different mechanisms;

   i. Hydrolysis – Free fatty acid formation

ii. Oxidation – Saturated and unsaturated aldehyde, ketones, alcohols and hydrocarbons.
iii. Decarboxylation – Alkan-2-Ones
iv. Dehydration and Lactonization – Lactones

III. Factors influencing texture in ghee:

When ghee is stored at room temperature, it crystallizes into three distinct fractions or layers, (i) Oily (ii) granular semi-solid at the bottom and (iii) hard flakes portion floating on the surface and sticking to the sides of the container.

According to *Singhal et al.* Layer formation in ghee could be prevented by storing it at 20°C or below immediately after preparation. Ghee thus solidified could subsequently be stored at higher temperature without formation of layer. The liquid portion of ghee varies with storage temperature, shape and size of container, repeated heating and agitation, ripening of cream/butter, storage and handling, external seeding etc.

Ghee therapeutic values

Anticarcinogens: The various milk fat components, such as CLA, sphingomyelin, butyric acid, β-carotene and vitamin A and D, have anticarcinogenic potential. (Jahereis et al., 1999; Parodi, 1999; Alkalin and Tokusoglu, 2003; Khanal and Olson, 2004).

1. **Conjugated Linoleic Acid (CLA):** Milk fat is the richest natural source of CLA with reported values ranging from 2.4 to 28.1 mg/g (Riel, 1963). The CLA content of milk fat is influenced by feeding practices. Feeding of fresh fodder increases the secretion of CLA in milk.
   - CLAs reportedly suppress carcinogens, inhibiting proliferation of leukemia and cancers of the colon, prostate, ovaries, and breast.
   - Antiatherogenic effects, altered nutrient partitioning, improved lipid metabolism, antidiabetic action (type II diabetes), immunity enhancement, and improved bone mineralisation (Sabikhi, 2007).

2. **Sphingomylein:** In bovine milk, phospholipids account for 0.2 to 1.0 g/100 g of total lipids, where they are associated with the milk fat globule membrane.

   - These are highly bioactive moleculeswith multiple beneficial effect on human health, e.g., cancer inhibition and immunomodulatory activities, as well as inhibition of cholesterol adsorption.
   - It plays an important role in transmembrane signal transduction and cell regulation

   - **Phospholipids** have antimicrobial effect.

3. **Butyric acid:** In bovine milk, about one third of milk triglycerides contain one molecule of butyric acid, its amount in cow and buffalo ghee varies between 10-12 per cent

- It is a well-known modulator of gene function and may also play a role in cancer prevention.
- it promotes histone acetylation that may benefit DNA repair, suppresses the expression of various proto-oncogenes, and stimulates expression of tumor suppressor genes (Parodi, 1996 and Parodi, 1997).
- It acts as anticarcinogen by regulating cell growth and inducing cell differentiation in a wide variety of neoplastic cell lines (Prasad, 1980 and Merrill, 1991).
- It inhibits cell growth and induces differentiation in a wide spectrum of cancer cell lines including those of the breast and colon, where butyric acid can induce apoptosis (the death of cells which occurs as a normal and controlled part of an organism's growth or development) and may prevent metastasis to the liver (McBain, 1997, Parodi, 1996, Velazquez, 1996).
- Another important property is the down-regulation of estrogen receptors in breast cancer cells (Planchon, 1991).

- **Lauric acid** is a potent antimicrobial and antifungal agent.

- **DHA (Docosahexaenoic acid)** contributes to reduced risk of diseases like heart attack, cancer, insulin resistance and arthritis.

Distribution of selected Omega6 and Omega3 fatty acids in *Ghee* prepared by traditional method and direct cream method (*n*=3)

Fatty acid % distribution	**Ghee prepared by traditional method**	**Ghee prepared by direct cream method**
Linoleic acid	5.1± 0.544	6.2± 1.29
Arachidonic acid	0.218± 0.096	0.169± 0.95
Alpha linolenic acid	3.66± 0.88	3.0± 0.7
Docosahexaenoic acid	0.083*± 0.003	0.062± 0.002

*Values are Mean±SEM,*valuesignificant withP≤0.05. Ref: journal of Ayurveda and Integrative medicine 2014 Apr-Jun5(2), pg-85-88*

Ghee has been recognised as Indian medicine in Ayurveda and is being used for treatment of various disorders from time immemorial. There are about 55–60 medicated ghee types reported in *Ayurvedic* literature. Medicated ghee is always prepared with selective fortification with herbs so as to acquire all the required fat-soluble therapeutic components of the herbs (Saxena & Daswani, 1996). One such study has revealed that the effect of herbs and herb extracts were high when used along with ghee as compared to its usage in powder or tablet form (Joshi, 1998).

The claims on the efficacy of some of the medicated ghee, such as *Bramhi Ghrita* for treatment of learning and memory disorders (Achliya *et al.*, 2004a), hepatoprotective effect of *Amalkadi Ghrita* against hepatic damage (Achliya *et al.*, 2004b) and the immunomodulatory activity of

Haridradi Ghrita (Fulzele *et al.*, 2003) have been validated in experimental animals. Significant reduction in scaling, erythema, pruritus and itching in psoriasis patients with marked improvement in the overall appearance of skin has also been reported using medicated ghee (Kumar *et al.*, 1999b).

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