

**PROXIMATE COMPOSITION AND SENSORY EVALUATION OF
CULTURED AND NON-CULTURED GHEE**

By

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Dissertation submitted in partial fulfillment of the requirements for the degree of
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CERTIFICATE

This is to certify that the dissertation entitled “Proximate Composition and Sensory Evaluation of Cultured and Non-Cultured Ghee” is the bona fide record of research work done by Ms Izzah Shafiqah binti Md Suhaini during the period from October 2025 to January 2026 under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfillment for the degree in Nutrition with Honors.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at USM or other institutions. I acknowledged that the research work and collection of data belong to Universiti Sains Malaysia.

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LIST OF MEASUREMENTS

°C	Celsius
g	Gramme
kcal/g	Kilocalories per Gramme
mg	Milligram
mL	Milliliter
rpm	Revolutions per minute

LIST OF SYMBOLS

<	Less than
>	More than
%	Percentage
±	Plus-minus
N	Normality
n	Number of replicates
HCl	Hydrochloric acid

LIST OF ABBREVIATIONS

ANOVA	One-way Analysis of Variance
AOAC	Association of Official Analytical Chemists
BC	Before Christ
CG	Cultured Ghee
CLA	Conjugated Linoleic Acid
DVS	Department of Veterinary Services Malaysia
FSSAI	Food Safety and Standards Authority of India
HDL	High-Density Lipoprotein
HREC	Human Research Ethics Committee
LDL	Low-Density Lipoprotein
NCG	Non-Cultured Ghee
PPSG	School of Dental Sciences
PPSK	Pusat Pengajian Sains Kesihatan
PPSK	School of Health Sciences
PPSP	School of Medical Sciences

QR	Quick Response
rTFA	ruminant Trans Fatty Acid
SD	Standard deviation
SPSS	Statistical Package for the Social Sciences
USA/US	United States of America
USD	United States Dollar
USDA	United States Department of Agriculture
USM	Universiti Sains Malaysia
USMKK	Universiti Sains Malaysia Kubang Kerian

KOMPOSIS PROKSIMAT DAN PENILAIAN SENSORI MINYAK SAPI KULTUR DAN BUKAN KULTUR

ABSTRAK

Minyak sapi digunakan secara meluas di Asia Selatan dan Malaysia kerana rasanya, sifat masakan, serta manfaat kesihatannya. Walau bagaimanapun, kajian saintifik yang membandingkan minyak sapi kultur dan minyak sapi bukan kultur di Malaysia masih terhad, terutamanya dari segi kaedah pemprosesan dan sumber susu terhadap kualiti pemakanan dan sensori. Kajian ini membandingkan komposisi nutrisi dan ciri sensori empat jenis minyak sapi, iaitu minyak sapi kultur daripada susu tempatan (A), minyak sapi kultur daripada susu import (B), minyak sapi bukan kultur daripada susu tempatan (C), dan minyak sapi bukan kultur daripada susu import (D). Analisis nutrisi menunjukkan perbezaan signifikan dalam kandungan kelembapan, abu, protein dan tenaga ($P < 0.05$), manakala kandungan lemak tidak menunjukkan perbezaan signifikan antara sampel ($P > 0.05$). Minyak sapi bukan kultur daripada susu tempatan mempunyai kandungan lemak (99.70%) dan tenaga tertinggi (897 kcal/100 g), menunjukkan ketulenan dan kepadatan tenaga yang tinggi. Minyak sapi bukan kultur juga menunjukkan kandungan kelembapan dan abu yang lebih tinggi. Sebaliknya, minyak sapi kultur daripada susu import mempunyai kandungan protein tertinggi (0.72%) dan kelembapan terendah (0.10%). Keputusan ini menunjukkan minyak sapi bukan kultur lebih kaya dengan lemak, manakala minyak sapi kultur mengekalkan lebih banyak protein serta mempunyai kandungan kelembapan yang lebih rendah. Penilaian sensori menggunakan skala hedonik 7 mata menunjukkan perbezaan signifikan dalam penampilan, aroma, tekstur, rasa dan penerimaan keseluruhan ($P < 0.05$), kecuali warna. Minyak sapi bukan

kultur daripada susu tempatan menerima skor tertinggi bagi kebanyakan atribut sensori, manakala minyak sapi bukan kultur daripada susu import kurang digemari. Secara keseluruhan, kaedah pemprosesan dan sumber susu mempengaruhi kualiti minyak sapi, dengan sumber susu memberi kesan yang lebih ketara terhadap penerimaan sensori. Minyak sapi yang dihasilkan daripada susu tempatan menunjukkan kualiti nutrisi dan sensori yang lebih baik dalam konteks Malaysia.

PROXIMATE COMPOSITION AND SENSORY EVALUATION OF CULTURED AND NON-CULTURED GHEE

ABSTRACT

Ghee is widely used in South Asian and Malaysian households for its flavor, cooking properties, and perceived health benefits. However, scientific evaluation comparing cultured and non-cultured ghee in Malaysia is limited, particularly regarding how processing methods and milk sources affect nutritional and sensory qualities. This study compared the nutritional composition and sensory characteristics of four ghee types: cultured ghee from local milk (A), cultured ghee from imported milk (B), non-cultured ghee from local milk (C), and non-cultured ghee from imported milk (D). Nutritional analysis showed significant differences in moisture, ash, protein, and energy content ($P < 0.05$), while fat content was similar across samples ($P > 0.05$). Non-cultured ghee from local milk had the highest fat (99.70%) and energy content (897 kcal/100 g), indicating high purity and caloric density. Non-cultured ghee also had higher moisture and ash, whereas cultured ghee from imported milk contained the highest protein (0.72%) and the lowest moisture (0.10%). These results indicate that non-cultured ghee is richer in fat, while cultured ghee retains more protein and has lower moisture. Sensory evaluation using a 7-point hedonic scale revealed significant differences in appearance, aroma, texture, taste, and overall acceptability ($P < 0.05$), though colour did not differ significantly. Non-cultured local ghee received the highest scores for appearance (5.28), texture (4.76), taste (4.78), and overall acceptability (5.06), while non-cultured imported ghee was least preferred. Cultured local ghee was particularly appreciated for its taste and aroma. Overall, both processing method and milk source influenced ghee quality, with

milk source having a stronger impact on sensory acceptance. The study highlights that ghee produced from local milk, whether cultured or non-cultured, demonstrated more favorable nutritional and sensory properties compared to ghee made from imported milk. These findings provide valuable insights into ghee quality assessment in the Malaysian context.

CHAPTER 1: INTRODUCTION

1.1 Background of Study

Ghee is widely used as a popular traditional dairy product in the Indian subcontinent and the Middle East (Saha et al., 2023). Over the past decade, the USA, Argentina, and Paraguay have been the main producers from the American continent, increasing cow ghee production by between 3,000 and 12,000 tonnes per year (Pena-Serna & Restrepo Betancur, 2020).

Ghee, also known as clarified butter, is prepared by heating milk, cream, or butter from various animal species to remove water and non-solid fats. It is a high-fat dairy product containing 98.9% lipids, 0.3% water, and less than 0.9% non-fat solids. It is also highly valued for its rich flavour, high smoke point, and potential health benefits. Vitamins A and E, as well as conjugated linoleic acid (CLA), a ruminant trans fatty acid (rTFA), can also be obtained by consuming ghee, as it provides a good source of lipophilic vitamins. Health benefits associated with ghee consumption include anti-obesity, anti-carcinogenic, anti-atherogenic, anti-diabetic, anti-mutagenic, anti-hypertensive, immunomodulatory, apoptotic, and osteosynthetic effects (Pena-Serna & Restrepo Betancur, 2020).

Despite these benefits, Peña-Serna and Restrepo-Betancur (2020) report that the connection between fat intake and coronary disease risk is partly related to the lipophilic characteristics of ghee and the rising trend of ghee consumption in Western countries. Pervaiz et al. 2022 further highlight that ghee carries notable cultural and dietary importance, especially within South Asian communities in Malaysia.

In Malaysia, there is no recent publicly available data specifically reporting the annual production of cow ghee. This gap is largely due to Malaysia's limited dairy sector, where domestic raw milk production remains extremely low and accounts for only a small fraction of the country's overall dairy supply. As a result, Malaysia relies heavily on imported dairy fats, including butter, milk fat oils, and related dairy fat products (Nurul Aini & Nurshuhada, 2023). As ghee is classified under the same import categories as butter and other milk-derived fats, available trade statistics do not distinguish ghee from these other products. This makes it difficult to quantify the exact volume of ghee consumed in Malaysia.

While specific production or consumption figures for cow ghee in Malaysia are unavailable, it has been found that Malaysia imports a large quantity of fat derived from milk to meet local demand. In 2023, Malaysia imported approximately 24.6 thousand tonnes of butter and related dairy fats, a category that likely includes products used as ghee. This suggests that the supply of cow ghee in Malaysia is mainly import-driven (World Bank, 2023). Given the limited local production and reliance on imports, understanding the nutritional composition and sensory characteristics of available ghee products is important, particularly for consumers who prefer either cultured or non-cultured variants.

Despite the lack of precise figures, ghee clearly holds cultural and dietary significance, especially among South Asian households in Malaysia. A cross-sectional survey conducted in South Asia revealed that around 38% of participants consumed ghee at least once a week, and 17% more frequently (Pervaiz et al., 2022). This suggests the potential for regular ghee consumption in similar communities abroad. Additionally, Malaysian consumers are increasingly conscious of food quality, nutrition, and product origin.

Roslan et al. (2023) stated that this increasing trend is reflected in consumer expectations for food safety and transparency. Meanwhile, Lim et al. (2024) showed that more consumers depend on nutritional labeling and health indicators when making decisions on products to purchase. In this context, understanding the compositional differences in ghee based on processing methods and milk sources can help consumers make informed choices, particularly those concerned with health and product quality. Research by Roslan et al. (2023) further suggests that with clear information about supply chains, it improves consumers' trust and helps them make decisions related to their health. Therefore, studying the two types of ghee samples, cultured and non-cultured, in Malaysia is relevant, as it aligns with the increasing consumers' demand for quality and nutritional value and product transparency.

As consumers become more health- and environment-conscious, the present study aims to characterise cultured and non-cultured ghee in terms of proximate composition and sensory characteristics, providing a basis for analysis and discussion regarding ghee consumption and its benefits or risks to human health and nutrition.

This study investigated four types of ghee, categorised as cultured and non-cultured. Two types of cultured ghee were prepared using the same processing methods but with two different milk sources: local cow's milk and imported cow's milk. Similarly, two types of non-cultured ghee were prepared using the standard processing method with the same two milk sources: local cow's milk and imported cow's milk. The primary differences between these categories are their processing methods and the type of milk used.

Both types of ghee were prepared using fresh milk from local cows in Malaysia and from imported cow's milk. Local cow's milk typically comes from Malaysian dairy cow breeds such as Mafriwal, Friesian-Sahiwal, and Friesian-Jersey crossbreeds, which are well adapted to the tropical conditions in Malaysia (Department of Veterinary Services Malaysia

[DVS], 2013; Malaysian Journal of Veterinary Research, 2023). Meanwhile, the imported cow's milk used in some local ghee production is sourced from New Zealand (Department of Veterinary Services Malaysia [DVS], 2013).

Previous studies have examined cultured and non-cultured ghee or evaluated ghee prepared from different cow milk sources. However, many of these studies focus on selected nutritional parameters or processing aspects, rather than providing a comprehensive evaluation that simultaneously considers processing method, milk origin, and a complete set of proximate composition and sensory attributes. Limited research has systematically compared cultured and non-cultured ghee produced from different milk sources, particularly in the Malaysian context. Furthermore, studies integrating both proximate composition and sensory evaluation of locally prepared ghee remain scarce.

In this study, both cultured and non-cultured ghee are produced through homemade or small-scale local processing methods. The ghee samples were considered pre-commercial formulations, developed by a small local enterprise that has not yet performed proximate or sensory quality assessments. Despite its widespread use in domestic kitchens and small-scale production, both types of ghee remain understudied, particularly regarding their nutritional composition and sensory characteristics. Therefore, this study aims to analyze the proximate composition and sensory characteristics of both cultured and non-cultured ghee.

1.2 Problem Statement

Ghee has a significant cultural and dietary impact, particularly in South Asian households. According to a global market analysis by Persistence Market Research (2025), the ghee market is projected to grow from USD 51.2 billion in 2025 to USD 77.9 billion by 2032, with South Asia remaining a major contributor due to its cultural and culinary uses. This suggests that ghee is already integrated into daily life because of its flavour, cooking properties, and health benefits. In Malaysia, ghee is available in various forms, including cultured ghee, which is manufactured using cultured cream, and non-cultured ghee, typically produced using cream without fermentation (Bhattarai et al., 2013).

A small enterprise currently develops both types using local and imported cow's milk. However, these products are at a pre-commercial stage and have not undergone scientific compositional or sensory evaluation. Furthermore, comparative research assessing cultured and non-cultured ghee, especially using different milk sources and processing methods, remains limited. Understanding their differences in proximate composition and sensory characteristics can support more informed decision-making for both household consumers and commercial producers. Therefore, this study aims to compare the proximate composition and sensory characteristics of cultured and non-cultured ghee, contributing to a better understanding of how processing method and milk source affect ghee quality.

1.3 Study Rationale

This study aims to evaluate the nutritional composition and sensory characteristics of cultured and non-cultured ghee, particularly those produced by a small-scale enterprise using local and imported cow milk. Cultured ghee, typically made from fermented cream, and non-cultured ghee, produced from fresh cream, differ in processing methods and milk sources, which may significantly affect their nutritional and sensory profiles (Bhattarai et al., 2013). However, these differences have not been well characterised, particularly in ghee produced by small Malaysian enterprises using local or imported cow milk.

This research is motivated by several key factors, including the growing consumer interest in food quality, nutrition, and product origin, including products such as ghee. Studies and literature indicate that rising consumer demands for food safety and transparency greatly influence purchasing decisions. A study in Bangladesh found that consumer understanding and perception of food labels are key factors affecting how individuals interpret and use nutritional information to make healthier choices (Islam et al., 2024). A similar survey in Malaysia found that trust in certification labels and expert opinion is fundamental in advising consumers about food safety, as most consumers consider these major factors when purchasing different foods (Mazuki et al., 2025). In addition, Liu (2024) noted that navigating complex food labelling, including health claims and nutrition facts, affects consumer awareness and enables more informed choices. Collectively, these findings underscore the importance of product transparency, credible labelling, and accessible nutritional information in supporting consumer decision-making.

1.4 Research Questions

1. Are there any differences in the proximate composition between cultured and non-cultured ghee?
2. Are there any differences in the sensory characteristics between cultured and non-cultured ghee?

1.5 Objectives

1.5.1 General Objective

To investigate the proximate composition of cultured and non-cultured ghee and its sensory characteristics among undergraduate students in USMKK.

1.5.2 Specific Objectives

1. To compare the proximate composition of cultured and non-cultured ghee.
2. To compare the sensory characteristics of cultured and non-cultured ghee.

1.6 Hypothesis

1.6.1 Null Hypothesis, H_0 :

There is no significant difference in the proximate composition and sensory characteristics between cultured and non-cultured ghee.

1.6.2 Alternative Hypothesis, H_A :

There is a significant difference in the proximate composition and sensory characteristics between cultured and non-cultured ghee.

1.7 Conceptual Framework

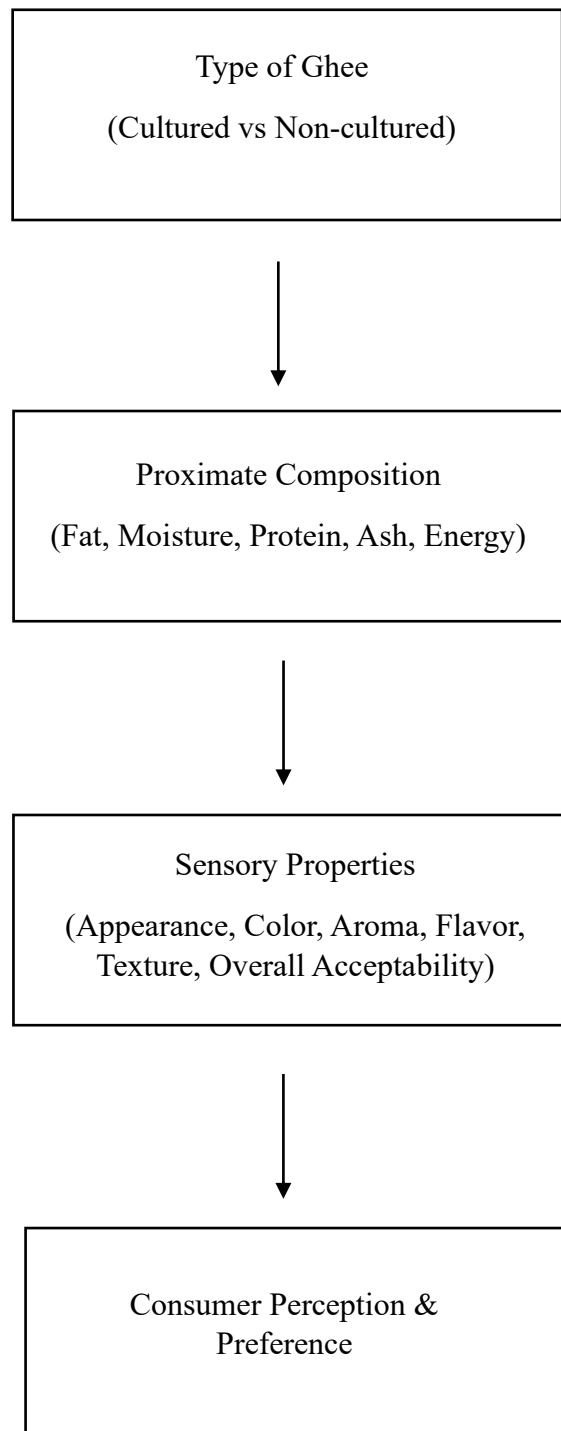


Figure 1.1: Conceptual framework showing how the ghee type, production method, and milk source influences proximate composition and sensory attributes

Figure 1.1 illustrates the types of ghee, including differences in production method and milk source, which influence its proximate composition and, subsequently, its sensory properties, such as appearance, aroma, flavor, texture, color, and overall acceptability. These sensory attributes are key determinants of consumer perception and preference, measured through hedonic evaluation. This framework guided the study in systematically evaluating how variations in ghee type and composition shape sensory quality and consumer acceptance.

CHAPTER 2: LITERATURE REVIEW

2.1 Overview of Ghee

The term ghee was derived from the ancient Sanskrit word *ghṛ*, which means brightness or shining. Ghee (*Ghṛta* in Sanskrit) referred to clarified butter, also known as anhydrous milk fat, and was a fat-rich dairy product (Kumbhare et al., 2021). According to Bumbadiya et al. (2024), ghee was commonly known by other names, such as butteroil, Indian butteroil, anhydrous milk fat, butterfat and clarified butter, and Indian ghee. It provides important nutrients, including lipids, fat-soluble vitamins, essential fatty acids, and growth-promoting compounds (Saha et al., 2023). Owing to its nutritional richness and versatility, ghee is regarded as one of the most valued fat-rich dairy products in the Indian subcontinent (Ahmed et al., 2020).

Ghee was primarily produced from cow's milk, buffalo's milk, or a mixture of both. Smaller quantities are obtained from the milk fat of goats, sheep, mares, or camels (Saha et al., 2023). Industrially, white butter is the most commonly used raw material (Kumbhare et al., 2021). Ghee can also be made from milk or other fat-rich milk products (Deep et al., 2023). Both ripened and unripened cream were used for ghee production (Ahmed et al., 2020). The production process involves heating milk, cream, or butter to remove water and non-fat solids, resulting in a smooth, homogeneous, semi-solid product with a golden-yellow colour in cow ghee (Pena Serna, Gomez Ramirez, & Zapata Lopez, 2019). According to Kumbhare et al. (2021), ghee was thermally processed and derived solely from milk or milk-based products, without any preservatives or colouring agents.

According to Codex Alimentarius, ghee was obtained exclusively from milk, cream, or butter, processed to remove almost all water and non-fat solids while developing a distinctive flavour and texture (National Dairy Development Board, 2020). Ghee contains approximately 98.9% fat (Ulambayar et al., 2024). Meanwhile, Kwak, Ganesan, & Al

Mijan (2013) reported that ghee was typically specified to contain a minimum of 99.6% milk fat, 0.4% free fatty acids, and no more than 0.1% moisture. Natural antioxidants or functional ingredients may be added to improve shelf life (Kumbhare et al., 2021).

Ghee was one of the oldest traditional milk products of India. Records indicate that ghr̥ta was produced as early as 1500 BC and was the preferred cooking medium. It was also used in the Ayurvedic system of medicine (National Dairy Development Board, 2020). References suggest its consumption as early as 3000 BC during the time of Lord Krishna (Ulambayar et al., 2024). In Indian culture, ghee was associated with wealth, purity, and prosperity (Koshidgewar, 2024). In recent times, ghee has gained popularity in Australia, Arabian countries, the United States, the United Kingdom, Belgium, New Zealand, the Netherlands, and many other African and Asian countries (National Dairy Development Board, 2020).

Ghee was widely produced and consumed in India, Sudan, Ethiopia, and the Middle East (Pena-Serna & Restrepo Betancur, 2020). Kumbhare et al. (2021) reported that India was one of the largest producers and exporters of ghee. Around 9 million tonnes of ghee are marketed annually (Kumbhare et al., 2021). Ghee was the second most consumed dairy product in India after liquid milk (Lodh, Khamrui, & Prasad, 2018). Global consumption of ghee has increased moderately since 2007 (Indexbox Inc., 2019). Approximately 30–34% of India's milk production was converted into ghee (Lodh, Khamrui, & Prasad, 2018). Annual production has exceeded 800,000 tonnes, mostly for culinary purposes (Kwak, Ganesan, & Al Mijan, 2013).

Although ghee has been extensively studied internationally, there was limited research on the production and quality characteristics of cultured versus non-cultured ghee in the Malaysian context. Similarly, sensory evaluation data involving Malaysian

consumers are scarce, highlighting the need for localised studies to inform dietary guidance and product development.

2.2 Classification of Ghee

A key distinction in ghee production lies in the use of cultured versus non-cultured butter. Cultured ghee was produced from cultured butter, obtained by fermenting collected

milk fat with lactic acid bacteria, while non-cultured ghee was prepared from dairy butter without prior fermentation (Bhattarai et al., 2013).

Increasing health awareness among the general population has contributed to a growing demand for functional foods, defined as foods that provide health benefits beyond basic nutrition (Kumbhare et al., 2021). Despite this interest, studies comparing fermented and non-fermented ghee produced from different milk sources remain limited in the Malaysian context. Therefore, the general objective of this study was to investigate the proximate composition of cultured and non-cultured ghee and their sensory characteristics among undergraduate students at USMKK.

2.2.1 Cultured Ghee

Cultured ghee was produced using the fermented cream–butter method, in which the primary raw material was fermented with lactic acid bacteria (Kataria & Singh, 2025). It is similar to Western butter but differs due to its fermented origin and traditional preparation. The inclusion of fermented dairy components has been reported to influence the appearance, texture, and flavour of cultured ghee (Halder et al., 2020). Throughout the fermentation process, lactose was converted into lactic acid, resulting in improved digestibility for individuals with lactose intolerance (Kondrotiene et al., 2023). Although both cultured and non-cultured ghee have a long shelf life, cultured ghee generally exhibits superior storage stability and can be kept at room temperature without refrigeration (Rajta et al., 2023).

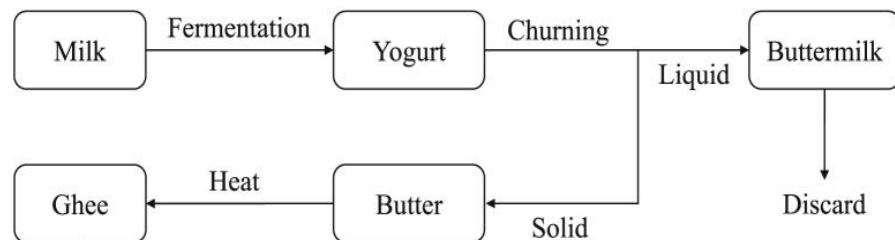


Figure 2.1: Cultured Ghee Process. Adapted from Upadhyay et al. (2017)

2.2.2 Non-cultured Ghee

Non-cultured ghee was produced using the direct cream method, in which the cream was not subjected to ripening or fermentation (Kataria & Singh, 2025). As fermentation was absent, the formation of flavour-enhancing compounds was limited, resulting in ghee with less pronounced flavour characteristics (Bhattarai et al., 2013). Compared with butter, ghee exhibited a longer shelf life and a lower tendency to develop rancid off-flavours (Kwak, Ganesan, & Al Mijan, 2013). This observation was further supported by Akhgar et al. (2023), who reported that ghee contains very low levels of moisture and milk solids (approximately 0.5%), allowing it to be stored at room temperature for 6 to 8 months.

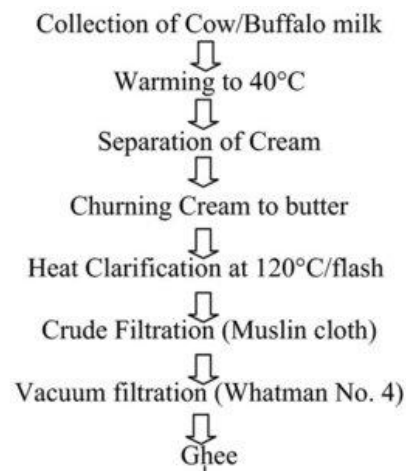


Figure 2.2: Non-cultured Ghee Process. Adapted from Lamsal et al. (2020)

2.3 Nutritional and Functional Properties of Ghee

Ghee was a traditional clarified dairy fat with significant value in both culinary and nutritional contexts (Lamsal et al., 2020). It was highly prized for its rich flavour, pleasant aroma, and high smoke point, making it especially suitable for frying and other high-temperature cooking applications. Due to its unique flavour, ghee was widely consumed across all age groups (Kumbhare et al., 2021). Ghee was regarded as the supreme medium for cooking and frying. Almost all types of Indian sweets, prepared using mixtures of milk, cereals, fruits, vegetables, and nuts, were preferably cooked in ghee (National Dairy Development Board, 2020). In some religious rites, ghee was considered a sacred item.

As a rich source of energy, fat-soluble vitamins, and essential fatty acids, and with a long shelf life at room temperature, ghee was extensively used in both culinary applications and confectionery items. It was often consumed during formal occasions, such as religious ceremonies (Saha et al., 2023). Its characteristic aroma and flavour make it one of the most valued dairy products. Consumer acceptance of ghee or butter depends on the manufacturing method and the quality maintained during storage (Bumbadiya et al., 2024). Moreover, Kataria & Singh (2025) noted that the culinary, nutritional, and therapeutic properties of ghee were believed to depend on both the source of milk and the processing method used to produce it.

Fat was the main component of ghee, comprising more than 98% of its total mass (Ulambayar et al., 2024). It consisted of approximately 65% saturated fat, 25% monounsaturated fat, and 5% unsaturated fat. The saturated fat mainly comprised easily digestible short-chain fatty acids, which accounted for 89% of the total saturated fat. Both saturated and unsaturated fats played important roles in a healthy diet. Ghee also contained

fat-soluble vitamins, including A, D, E, and K, as well as small amounts of essential fatty acids (National Dairy Development Board, 2020).

The high fat content of ghee contributed to its energy density, oxidative stability, and long shelf life (Modi et al., 2025). Although the moisture content was generally low, it remained a critical factor affecting ghee's susceptibility to microbial growth and oxidation. To improve stability during storage, it was recommended that the moisture content be kept below 0.5% (Akhgar et al., 2023). Proteins in ghee were usually minimal due to the removal of most proteins during the clarification process. However, trace amounts might remain and were sometimes analysed for nutritional labelling and quality control (Akhgar et al., 2023). Ash content, which reflected the total mineral content, was present in small quantities and was important for assessing the inorganic composition of ghee and detecting possible adulteration or contamination (Ulambayar et al., 2024).

2.4 Influence of Milk Source on Ghee Quality and Composition

Globally, cow milk accounts for the largest share of milk production, contributing approximately 81% of total output (Food and Agriculture Organization of the United Nations, 2022). The physicochemical, nutritional, and sensory properties of ghee produced from different animal species have been reported to vary, largely due to differences in the inherent composition of milk among species (Koshidgewar, 2024). These variations influence consumer preferences and the associated health benefits of ghee derived from different species (Koshidgewar, 2024).

The composition of milk, which directly affects the final quality of ghee, was influenced by several environmental factors, including geographical breeding location, climate, seasonal conditions, and the growth stage and quality of pasture grasses. For instance, in yak ghee production, the nutritional composition of yak milk plays a decisive role in determining the quality and composition of the resulting ghee (Wang et al., 2024). Most existing literature on cultured and non-cultured ghee originated from India and other countries. However, studies conducted in Malaysia remained limited, leaving differences related to milk sources, processing practices, and consumer preferences insufficiently explored. This lack of local data highlights the need for the present study.

2.4.1 Animal Breed and Genetic Factors

Milk was recognised as a widely consumed food source that provides a broad range of essential nutrients. However, its nutritional composition was influenced by multiple factors, among which the breed of the milk-producing animal plays a particularly important role. At present, most cow milk was produced by hybrid or crossbred cattle (Kataria & Singh, 2025).

The breed of dairy cattle has been shown to significantly affect milk fat and protein contents, which were considered critical determinants of both ghee yield and final product quality. For instance, milk obtained from Simmental cows contains a higher fat percentage, contributing to increased ghee yield, whereas Bokane cows produce milk with elevated protein levels that influence browning reactions and residue formation during ghee processing (Hermiz & Hadad, 2020). Genetic factors account for approximately 55% of the variation in milk composition, while the remaining 45% was attributed to environmental influences such as feeding practices and farm management. This distribution emphasises the strong effect of breed on milk quality, with lactose content reported as the main exception.

According to Rezagholivand et al. (2021), Holstein cows were recognised as the most widely bred dairy breed globally and recorded the highest milk production levels. Jersey cows, for example, consistently exhibited higher concentrations of fat, protein, and total solids compared with Holstein and Simmental breeds, indicating greater suitability for ghee production (Hermiz & Hadad, 2020).

Differences in research findings were observed regarding the influence of breed on milk components. While Hermiz and Hadad (2020) reported significant breed effects on both fat and protein contents, Mishra et al. (2022) identified a significant effect on fat content only. Studies involving synthetic and crossbred cattle, including Ethiopian Ogaden cattle and crosses with Jersey, Horro, and Holstein Friesian breeds, demonstrated significantly higher milk fat levels, whereas pure Holstein Friesian cattle showed the lowest fat content. In contrast, no significant breed-related differences in protein and lactose contents were detected (Hermiz & Hadad, 2020; Mishra et al., 2022).

2.4.2 Cow Diet and Feeding Regime

Feeding regimes also affected overall milk composition. The composition of milk fat, in turn, influenced the characteristics of ghee (National Dairy Development Board, 2020). Milk fat content was highly sensitive to diet and feeding practices. Although the type of dietary fat generally had little effect on increasing milk fat content, supplementation with fat was shown to enhance both milk fat percentage and total fat yield. For example, adding 2% yellow grease to the diet of Holstein cows increased milk fat content and total fat yield more effectively than hydrogenated palm oil. The use of rumen buffers, such as sodium bicarbonate with or without magnesium oxide, also helped maintain proper rumen function, supported digestive health, and further improved milk fat percentage, particularly in cows fed diets high in fermentable fibre (Olika, 2021).

Milk protein, although less responsive to dietary changes than fat, could still be influenced by feeding strategies. Adjusting the forage-to-concentrate ratio, for instance, was reported to increase milk protein content by up to 0.4 percentage units. Modifying the

energy and protein content of the diet produced smaller increases of 0.05 to 0.15 percentage units. However, the choice of fat source sometimes affected protein content differently, with certain dietary fat supplements leading to slight declines in milk protein (Olika, 2021). Manzocchi et al. (2021) found that milk from hay-fed cows contained higher protein and total solids compared to milk from silage-fed cows. Additionally, fresh grass feeding was associated with an increase in beneficial fatty acids and a reduction in saturated fatty acids in milk fat.

2.4.3 Milk Composition and Its Effect on Ghee Properties

The fat content of milk was a key factor determining ghee yield as well as its physicochemical characteristics. Since ghee was composed primarily of milk fat, variations in fatty acid composition influenced its melting behaviour, texture, flavour, and nutritional quality. Several studies have reported that the fatty acid profile of ghee depends on the milk source, which is influenced by breed, diet, and geographical conditions. For example, Wang et al. (2024) found that yak milk and ghee produced at different altitudes on the Qinghai–Tibet Plateau exhibited distinct fatty acid profiles, with higher unsaturated fatty acid contents observed at greater altitudes, thereby affecting both the nutritional value and oxidative stability of the ghee.

Milk proteins also play an important role in the flavour and colour development of ghee during processing. Protein content has been reported to influence free fatty acid levels in ghee, which are critical for determining shelf life. Veena et al. (2021) highlighted that protein concentrations vary according to lactation stage and seasonal factors, and these variations affect the physicochemical properties of ghee produced from crossbred cows.

Moreover, Khastayeva et al. (2021) reported that milk protein, in particular, serves as a key indicator of milk quality, reflecting the energy status of the cow and acting as an energy barometer for the herd.

In addition, mineral content, particularly calcium and phosphorus, has been shown to impact the stability and texture of ghee. Ulambayar et al. (2024) observed that variations in mineral composition across ghee from different animal origins influence both its nutritional and physicochemical properties. The composition of cow's milk was influenced by several factors, including diet and breed. As the quality of dairy products depended largely on the composition of raw milk, understanding the factors that caused changes in milk composition and its physicochemical properties was considered essential (Khastayeva et al., 2021).

2.5 Health Benefits of Ghee

Ghee has been valued for centuries not only as a culinary ingredient but also as a substance with purported health-promoting properties. In Ayurveda, cow ghee, often called ‘amrita’ (nectar), was considered a natural oil that supported all internal body mechanisms (Mahakalkar et al., 2014). It was highly valued for its nourishing and rejuvenating properties, contributing to overall health and well-being. Beyond general nourishment, ghee was recognised for its functional and therapeutic properties in traditional Ayurvedic medicine. Approximately 21% of references to ghee in Ayurvedic texts related to cognitive and neurological health, where it was credited with enhancing memory, improving intelligence, and assisting in the management of conditions such as epilepsy and insanity (Kataria & Singh, 2024). In Ayurvedic classification, ghee was considered a Rasayana, a rejuvenating substance believed to nourish body tissues, strengthen the immune system, and support longevity and vitality. Ghee was also shown to have therapeutic potential in managing autoimmune and inflammatory diseases (Kumar et al., 2024). Ayurveda further recognised ghee as promoting growth and detoxification, making it a highly valued ingredient (Koshidgewar, 2024).

Some traditional claims have been supported by modern research. For example, Kalyanaka Ghrita, an herbal ghee formulation, was shown to enhance memory and reduce oxidative stress and neuroinflammation in animal studies (Singh et al., 2023). These effects were attributed to ghee’s bioactive lipid profile, which was associated with anti-inflammatory and neuroprotective properties. Ghee was also valued for gastrointestinal health (Kataria & Singh, 2024). Its high butyric acid content, a short-chain fatty acid, supported digestion by reducing gut inflammation and promoting the growth of beneficial gut bacteria (Pena Serna, Gomez Ramirez, & Zapata Lopez, 2019). Studies indicated that