The Pharma Innovation Journal 2023; 12(4): 423-426

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(4): 423-426

www.thepharmajournal.com
Received: 02-02-2023
Accepted: 06-03-2023

Ankit Deep
Scientist, Dairy Engineering Division, ICAR-National Dairy Research Institute, Karnal, Haryana, India

Manos Sarkar
M. Tech. Scholar, Dairy Technology Division, ICAR-National Dairy Research Institute, Karnal, Haryana, India

Writdhama Prasad
Scientist, Dairy Technology Division, ICAR-National Dairy Research Institute, Karnal, Haryana, India

Kaushik Khamrui
Head & Principal Scientist, Dairy Technology Division, ICAR-National Dairy Research Institute, Karnal, Haryana, India

Corresponding Author:
Ankit Deep
Scientist, Dairy Engineering Division, ICAR-National Dairy Research Institute, Karnal, Haryana, India

Quality evaluation of ghee obtained using different methods

Ankit Deep, Manos Sarkar, Writdhama Prasad and Kaushik Khamrui

Abstract
Ghee, a form of heat clarified butterfat, is one among the principal indigenous dairy products consumed in India because of its unique pleasing flavour. About 30% of the total milk produced in India is converted into *ghee* by different methods *viz*., indigenous (*desi*), direct cream, creamery butter and pre stratification method. Further, *ghee* prepared from fermented cream (or fermented white butter) is more preferred as compared to fresh cream (or white butter) because of the volatiles generated as a result of starter propagation. Most of the Indian dairy industries use white butter as a raw material for *ghee* making and often employs pre-stratification method. However, direct cream method is most commonly employed for *ghee* preparation from fermented cream. *Ghee* preparation from fermented requires fermentation of fresh cream using lactic starters to ferment the cream and develop the acidity to desired level. This is followed by heat clarification of the contents to obtain *ghee*. The present work was undertaken with an objective to compare the *ghee* (clarified butter fat) obtained using different methods for physico-chemical attributes and energy requirement during their preparation. *Ghee* obtained using all the employed methods complied with the FSSR (2022) requirements for moisture and free fatty acids content. Sensory evaluation revealed that *ghee* obtained using creamery butter method was most preferred, followed by pre-stratification method and direct cream method. Energy determination study revealed that highest amount of energy was required for *ghee* preparation using direct cream method followed by creamery butter method and least was by pre-stratification method.

Keywords: Energy consumption; free fatty acids; moisture content; sensory evaluation

Introduction
Ghee (or clarified butter fat) could be defined as a thermally processed purified fat-rich product derived solely by milk or solely milk based products. In India, approximately 30-34 percent of milk produced is converted into *ghee* (Lodh *et al*., 2018) [3]. Chemically, ghee is a complex mixture of different triacylglycerol's, free fatty acids, phospholipids, sterols, burnt caseins and minerals. Ghee is different from anhydrous fat and butter oil (other solely milk fat based products) in terms of method of preparation and its unique flavour profile. Ghee could be prepared using milk or milk based fat rich products, however white butter is the most commonly used raw material at the industrial scale for ghee preparation. One of the common step in all the ghee making methods is a thermal treatment of white butter at 110-115 °C for 10-20 minutes, during which the heat catalysed reactions results into generation of distinctive volatile aromas that imparts the distinctive flavour to ghee. Because of the unique rich flavor, ghee is consumed by large populace of all age categories and it is also used for frying and preparation of different sweetmeats (Lodh *et al*., 2022; Kumbhare *et al*., 2022; Wani *et al*., 2022a; Prasad *et al*., 2022a; Shende *et al*., 2022; Badola *et al*., 2022) [4, 2, 6, 6, 8, 1].
Ghee is conventionally prepared using white butter through creamery butter or pre-stratification method. However, certain small and large scale enterprises still employs direct cream method for ghee preparation. Ghee obtained using these methods vary in terms of sensory and other attributes because of the extent of heat treatment provided to the contents. In addition, energy required to prepare ghee using the three methods also appears to be different because of the differences in the moisture content of the raw material used in these methods. However, no literature is available to quantify this information. Considering this, the present investigation was performed to evaluate the sensory and chemical attributes of ghee produced using direct cream, creamery butter and pre-stratification method. In addition, energy consumed during the ghee preparation using these methods was also compared to make the study more applicable to the dairy industries.

Materials and Methods

Materials

Fresh cream (75% fat) and white butter (86% fat) was collected from Experimental Dairy, ICAR-National Dairy Research Institute, Karnal. Jacketed steam kettle was used for ghee preparation from different sources. The kettle was provided with steam trap and condensate valve to collect the condensate obtained using ghee preparation. Glass pre-stratification assembly (M/S Labco., Ambala, India) was used for pre-stratification of melted creamery butter. All chemicals used during the investigation were AR grade and obtained from standard suppliers.

Preparation of ghee samples

Ghee was prepared using three procedures, *viz*, direct cream, creamery butter and pre-stratification method as provided by Kumbhare *et al*. (2022) [2]. For direct cream method, cream of 75% fat was directly transferred to the jacketed steam kettle and heated to 110 °C for 10 minutes with continuous stirring. Once the required time of 10 minutes was achieved, the steam supply to the kettle was stopped and contents were left undisturbed for cooling and settling of ghee residue particles. At 70-75 °C, the contents were filtered using double layered muslin cloth to separate the ghee residue and obtain ghee. For creamery butter method, white butter instead of cream was used as the raw material and all the remaining steps were kept unchanged. For pre-stratification method, the white butter was first melted by heating the contents to 80 °C and then they were transferred to the stratification assembly and left undisturbed for 1 hour. After an hour, the contents lower aqueous layer was carefully removed to minimize the fat losses and the remaining contents were transferred to jacketed steam kettle for ghee preparation as followed in case of direct cream method.

Analysis of the samples

Moisture content in the sample was determined using the gravimetric method as per the method provided by Meena *et al*. (2021) [5]. Sensory evaluation of the samples obtained during the course of investigation were analysed by trained panellists from the scientific faculty of ICAR-NDRI, Karnal using the scorecard prescribed by Bureau of Indian Standards as per the method provided by Lodh *et al*. (2022) [4]. Energy required to prepare the samples was calculated measuring the amount of condensate collected after preparation of ghee through different methods individually. Steam pressure was maintained at 1.5kg/cm^2 throughout the operation. Energy requirement was calculated using the formulae:

$$Energy = m.h_{fg}$$

Where,
m = mass of the condensate;
h_{fg}: enthalpy of evaporation of water at 1.5 kg/cm^2 gauge pressure (2181.1 kJ/kg)

Free fatty acid (FFA) content in the samples was measured using the method provided by Wani *et al*. (2022b) [7]. In brief, a 10g of sample was taken in a 250mL conical flask and mixed with previously neutralized ethyl alcohol. The contents were shaken vigorously and brought to boil. While the contents were still boiling, they were titrated against 0.1N Noah solution using phenolphthalein indicator till the colour change persisted for at least 15 seconds. The FFA content was presented as % oleic acid and calculated using the following formula:

$$FFA\ (\%\ Oleic\ acid) = T * 2.82 / M$$

Where,
T = volume of 0.1 N alkali required for titration in ml;
M = mass (in grams) of *ghee* sample taken

The data obtained during the present investigation were statistically analysed using one way analysis of variance (ANOVA) to evaluate the significant difference between different treatments. Also, Turkey's comparison test was performed to group the significantly different results at 5% level of significance (p<0.05) using SPSS software of M/s. IBM Corporation.

Results and Discussion

Moisture content in the samples ranged from 0.19 to 0.22 (Table 1). Highest moisture content was observed in the sample obtained using direct cream method and the least moisture content was obtained using creamery butter method, however there was no significant difference (p>0.05) among the three samples. It is also important to observe that although the ghee sample obtained using different methods had different moisture content, y*et al*l of the samples complied with the maximum permissible limit of moisture content (0.5%) laid down by the FSSR (2022). Decrease in the moisture content during ghee preparation could be attributed to heating step (>100 °C) and minor differences among the different samples could be due the amount of ghee residue produced and the SNF part in the raw material (Prasad *et al*., 2022b; Badola *et al*., 2022; Wani *et al*., 2022b) [7, 1, 7].

Free fatty acids in the sample ranged from 0.11 to 0.12% oleic acid. No significant difference (p>0.05) was obtained between the samples for free fatty acids content. This could be due to the boiling (heat treatment) step and the ghee residue which might have efficiently eliminated the free fatty acids from the sample owing to the polarity difference (Kumbhare *et al*., 2022; Wani *et al*., 2022a) [2, 6]. In addition, similar to the moisture content, ghee samples produced using the three methods complied with the maximum permissible limit (2.0%) of free fatty acids laid down by the FSSR (2022).

Energy requirement is an important point of discussion these days. Almost all of the processing steps are relooked to minimize the energy consumption and decrease the associated carbon emission. Energy consumption in all the three methods was determined using the amount of condensate obtained during the ghee boiling step and the results are presented in Table 1. It could be seen that highest amount of energy (1684.69KJ/Kg raw material) was required to prepare ghee using direct cream method, while the least amount of energy (605.8169KJ/Kg raw material) was required to prepare ghee using the pre-stratification method. Ghee preparation using creamery butter method required 910.4969KJ of energy per kg raw material. Significant difference (p<0.05) was observed among the three methods for energy requirement during ghee boiling step. This could be attributed to the amount of moisture present in the raw material. Direct cream method used cream as the raw material which contained about 22.35% moisture; while white butter contained 12.82% moisture.

Ghee obtained using the three methods were also compared for sensory attributes so as to ascertain the consumer acceptability of these samples and the results are presented in Table 2. All the samples obtained more than 80 scores, which indicated that all the samples are liked by the panellists. Highest flavour score (45.19) was obtained by the ghee sample prepared using creamery butter method, followed by direct cream method (44.84) and pre-stratification method (43.72). Body and texture score of the sample ranged from 22.46 (for pre-stratification method) to 24.19 (for creamery butter method). Colour and appearance score ranged from 8.55 (direct cream method) to 8.74 (creamery butter method). All the samples had perfect score of 10 for 'freedom from impurities' attributes, which indicates that efficient filtration of ghee was performed after the boiling step and the filtered samples were free from impurities (ghee residue). Total score of the samples were 86.88 for direct cream method, 88.12 for creamery butter method and 84.80 for the ghee obtained using pre-stratification method. Significant difference ($p<0.05$) among the samples was obtained for the flavour and total score attribute. This could be attributed to the amount of SNF that was present in the ghee boiler in addition to the total amount of heat employed to the system. The SNF comprises of proteins and lactose, which contributes to the *ghee* flavour compounds. Hence, lower amount of SNF in pre-the raw material for stratification method might have resulted into lower flavour score in it. Lesser score in the sample obtained using direct cream as compared to creamery butter method could be attributed to the higher amount of heat treatment subjected to the contents, which not only led to higher energy consumption, but also to lower flavour score of the sample.

Table 1: Chemical attributes and energy consumption during *ghee* preparation by using different methods

Method of *ghee* preparation	Moisture (%)	Free fatty acids (% oleic acid)	Energy consumed (kJ/kg of raw material)
Direct cream	0.19±0.02[a]	0.12±0.01[a]	1684.69±18.42 [a]
Creamery butter	0.21±0.03[a]	0.12±0.01[a]	910.49±12.44[b]
Pre-stratification	0.22±0.02[a]	0.11±0.01[a]	605.81±27.09[c]

Data are presented as means ± SD (n=3)
Means with different superscript in the same column for the same attribute differ significantly ($p<0.05$)

Table 2: Sensory attributes of ghee prepared using different methods

Sensory attributes	*Ghee* preparation method		
	Direct cream	Creamery butter	Pre-stratification
Flavour	44.84±2.55[a]	45.19±2.83[a]	43.72±2.43[b]
Body & Texture	23.49±1.66[a]	24.19±1.88[a]	22.45±1.83[a]
Colour & Appearance	8.55±1.20[a]	8.74±1.06[a]	8.63±1.18[a]
Freedom From Impurities	10.00±0.00[a]	10.00±0.00[a]	10.00±0.00[a]
Total Score	86.88±1.86[ab]	88.12±1.62[a]	84.80±1.22[b]

Data are presented as means ± SD (n=3)
Means with different superscript in the same row for the same attribute differ significantly ($p<0.05$)

Conclusion

The present study was undertaken to compare the ghee obtained using direct cream, creamery butter and pre-stratification method for sensory and chemical attributes. In addition, energy consumed during the boiling step of these methods was also measured. Ghee obtained using the three methods complied with the FSSR (2022) requirements for ghee for moisture and free fatty acids content. Sensory evaluation revealed that ghee obtained using creamery butter method was most preferred, followed by ghee obtained using direct cream method and pre-stratification method. Energy consumption during ghee boiling step in the three methods was significantly different from each other. Highest energy was consumed in direct cream method of ghee preparation, followed by creamery butter method and least energy was consumed in pre-stratification method of ghee preparation.

Declaration

The authors have no conflict of interest to disclose.

Acknowledgment

The authors are thankful to Director, ICAR-National Dairy Research Institute, Karnal for providing the research and all other research facilities to perform this work.

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