Volume 10, Issue 4, 2020, 5755 - 5759 ISSN 2069-5837

Biointerface Research in Applied Chemistry

www.BiointerfaceResearch.com

https://doi.org/10.33263/BRIAC104.755759

Original Research Article **Open Access Journal**

Received: 07.03.2020 / Revised: 27.03.2020 / Accepted: 28.03.2020 / Published on-line: 01.04.2020

Development and characterization of novel spreadable dairy butter via incorporation of low-melting point fat from ghee

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ABSTRACT

Butter is value added fat rich dairy product having unique aroma and flavour. Table butter is very firm and has low spreadability at refrigerated conditions and needs thawing before consumption. In the present study, table butter was prepared via incorporation of low melting fat fractions from ghee after triple fractionation at 25°C, 20°C& 15°C. All these fractions after incorporation in dairy butter significantly affect the butter characteristics. They not only increase the spreadability of butter but also enhance the color characteristics, texture and sensory characteristics. Low melting fat fractions from ghee can be utilized for the development of acceptable butter with improved spreadability. This novel butter does not need thawing and can be easily used just after removal from the refrigerator.

Keywords: *Butter; spreadability; ghee; low-melting fat; firmness.*

1. INTRODUCTION

Milk and milk products are very popular among all age groups. Butter, butter-oil and ghee are fat rich dairy products which are main ingredient in many recipes [1-5]. Development of novel value added dairy products is in great demand by today's consumers. Recently, scientists focused on the development of value added and functional dairy products [6-17]. Butter is value added product prepared via churning of dairy cream and is liked by consumers for its unique aroma and flavour [18].

Low spreadability or high firmness of butter at refrigerated temperature is a common problem faced by butter consumers which leads to its lower acceptability at refrigerated temperature [19]. Hence, the thawing of butter to room temperature is essential to make it soft and spreadable on bread or toast. This high firmness and low spreadability of dairy butter at refrigerated conditions (i.e. around 7 °C) are linked with crystal structure of milk fat which behaves differently at different temperature conditions. Portion of milk fat remains crystallized in temperature range of 5 to 25 °C. Fatty acids composition of milk fat which differs in chain length, molecular weight and degree of saturation are responsible for crystallization of milk fat. Milk fat is composed of around 400 types of fatty acids [20].

Melting temperature range of milk fat is very broad i.e. -40 to 40 °C, which is due to the difference in degree of saturation and chain length of fatty acids. The crystal network of fat in liquid phase is responsible for the firmness characteristic of butter. More crystallized structure of milk fat in butter is responsible for higher firmness and lower spreadability in butter [21].

Polymorphic stability and firmness of butter are related to the crystal structure of milk fat. Polymorphism in milk fat crystals (i.e. α, β and β′) is time and temperature dependent irreversible phenomenon in which α-form (less stable) changes to β-form (stable). Milk fat having β′-type crystals are softer and provide softness and spreadability to butter and margarine type products.

Numerous studies have been reported in literature related to development of butter with low firmness and more spreadability [22-23]. Physical characteristics of butter can be controlled by changes in aging temperature of cream, cooling rate and storage condition of butter [24-25]. These conditions result in increased spreadability of butter via influencing the size, shape and orientation of crystal in liquid phase. Ripening of cream via warm-cold-warm conditions leads to production of butter with low firmness and more spreadability less liquid fat is entrapped in developed crystal laminate structure [26]

Other possible methods for controlling the firmness and spreadability of butter are alteration in animal feeding, addition of unsaturated fats, milk fat inter-esterification and milk fat fractionation [27-30].

Milk fat can be separated in different fractions having distinct physico-chemical properties. Dry fractionation method is suitable method for this purpose on an industrial scale. In dry fractionation method, first fat is melted to erase the crystal history of the fat which is followed by partial crystallization of milk fat via slow cooling with constant agitation which leads to separation of two fractions- solid fraction (stearin fraction) and liquid fraction (olein fraction). Solid or stearin fraction is composed of fats having a greater melting point and this fraction remain solid at room temperature whereas liquid or olein fraction is composed of fats having lower melting point and are liquid at room temperature. Stearin and olein fraction have the capability to alter structure and texture of butter and related dairy and food products. Olein (low melting fat) fraction provides spreadability and reduces firmness in butter [31].

Addition of low melting fats in cream used for butter making not only leads to production of soft butter from dairy fat but also provide nutritional benefits to consumer because of their easy absorption and metabolization due to their low molecular weight [32]. Olein or low melting fat fraction also contains a higher amount of carotenoids, fat-soluble vitamins and flavor compounds which makes it more nutritional as compared to normal milk fat.

Present study was designed to study the effect of low melting fat fraction separated from buffalo milk ghee at three different temperatures i.e. 25°C, 20 °C & 15 °C, on physiochemical and textural properties of butter.

2. MATERIALS AND METHODS

2.1. Materials.

Cream, ghee samples were obtained from Dudhsagar Dairy, (India) and stored at refrigerated conditions until use.

2.2. Separation of low-melting fat from ghee.

The triple fractionation of buffalo milk ghee (BMG) was performed using a 1 l flask in shaking incubator equipped with speed and temperature controller. Firstly, BMG was melted at temperature of 65°C for 15 minutes duration for the eradication of the any crystals history. Separation of milk fat in different fractions was carried out in a shaking incubator at agitation speed of 80 revolutions per minute and the rate of cooling was kept at 5°C per minute, just changing temperature of fractionation for different milk fat fractions. Firstly, crystallization temperature was kept at 25 °C for 20 hours for stabilization of fat crystals. The derived fractions were separated by centrifugation and named as SBMG25 (solid fraction) and LBMG25 (liquid fraction).

The next fractionation step was initiated using fraction LBMG25 and the rest procedure remained same as previously described, using 20°C temperature for crystallization. Fat fractions obtained from this step were titled as SBMG20 (solid fraction) and LBMG20 (liquid fraction). The fraction LBMG20 was then used in the third fractionation, following the same procedure previously described, but at temperature of crystallization of 15°C. The fat fractions obtained in this fractionation step were titled as SBMG15 (solid fraction) and LBMG15 (liquid fraction). The fractions LBMG25, LBMG20 and LBMG15 were used in this study.

2.3. Analysis of ghee and low-melting ghee fractions.

Ghee, LBMG25, LBMG20 and LBMG15 were characterized for fat content, moisture, free fatty acid, Reichert-Meissl (RM) value, peroxide value, Butyro-Refractometer (BR) reading at 40°C using standard methods of analysis.

2.4. Preparation of control and spreadable dairy butter.

Cream having 40% fat was used for making control butter sample. Butter with addition of LBMG25, LBMG20 and LBMG15 was manufactured using cream and LBMG25, LBMG20 and LBMG15 in the ratio of 50:50, having same fat level as in the cream which was utilized in making of control butter samples. An emulsion of skim milk and LBMG was first prepared and then mixed with cream (40% fat). For the pre-emulsion, LBMG fractions and skim milk were subjected to homogenization carried out at a temperature of 50 °C using rotary stirrer. After homogenization, the prepared emulsion was subjected to cooling (40 °C) and it was kept in refrigerator (5 °C) for 12 hours duration. The cooled cream was churned at 8 °C temperature, using a planetary stand mixer. Inversion of phase from oil-in-water to water-in-oil occurred and the butter grains were formed followed by separation of butter-milk. After this washing of butter grains were carried out using water which was pasteurized and chilled (8 °C). Later, washed water was removed and 2.5 % refined salt was added, followed by kneading (8 min) step. This kneading step leads to adjoining of butter grains for joining butter grains and the left over water was removedControl and spreadable butter samples were preserved for further analysis at refrigerated conditions at 10 °C temperature.

2.5. Characterization of butter.

After 24 hours of storage at 10 °C, the control butter sample and butter containing LBMG were characterized for fat content, moisture, solids not-fat, salt, peroxide value using standard methods. Hunterlab colorimeter was used for measurement of color values of the butter samples in which color of the samples is characterized or described by L* value (lightness) and a* and b* value (chromaticity coordinates). In this system, the positive value of a* corresponds to red color whereas the negative value of a* corresponds to green color and the positive value of b* corresponds to yellow color whereas negative value of b* corresponds to blue color.

2.6 Textural analysis of the control and spreadable dairy butter.

The firmness of butter samples was assessed after 24 hours of storage at 10 °C via cone-penetration test (45°) usingtexture analyzer (TAXT2i). Three replications were deteremined. Performing criteria used were: length (10 mm), speed (2 mm/s), time (5 s). Penetration force was considered as measure of firmness Soft butter requires lower penetration force.

2.7 Sensory analysis.

Sensory analysis of butter samples was performed by nine-point Hedonic scale. Total 30 panelists were selected for sensory analysis of butter samples. The selection criteria of the panelist were his/her knowledge and past experience of sensory analysis of butter and fat rich dairy products samples. Sensory scores for color & appearance, spreadability, firmness, flavor and overall acceptability were given by sensory panel members. Butter samples (10±1°C) in coded containers were presented to the panelist in random order just after removal from refrigerator. For evaluation of the spreadability of the butter samples, panelists were also provided with bread slices. Water for mouth rinsing was also made available to panelist for sensory evaluation.

3. RESULTS

3.1. Characterization of ghee & ghee fractions.

The physicochemical analysis of buffalo ghee and ghee fractions (LBMG25, LBMG20, LBMG15) of buffalo ghee are presented in Table 1. Results revealed that butyro-refractometer (BR) reading of all the ghee fractions were lower than the BR reading of buffalo ghee. Reichert Meissl (RM) value of ghee and ghee fractions ranged 29.14 to 33.99. RM value of buffalo ghee was lower than the ghee fractions. Polenske value of ghee and ghee fractions ranged 1.55 to 1.7. Polenske value of buffalo ghee was higher as compared to ghee fractions. Free fatty acids (FFA) content in the ghee and ghee fractions ranged 0.2 to 0.24. FFA content of buffalo ghee fractions was higher as compared to the native buffalo ghee. This might be due to the temperature treatment and dissolved oxygen during fractionation process. Moisture content of all the ghee factions was similar i.e.0.12% and was lower as compared to native buffalo ghee (0.16%). This was also due to heat treatment given to ghee fractions during fractionation procedure.

3.2 Characterization of butter.

Physicochemical parameters of control and spreadable butter samples containing low melting ghee fractions are presented in Table 2. The moisture content in control butter sample (B1) was 13.47% while that of butter sample B2, B3 and B4 were 11.35, 11.19 and 11.20, respectively.

Moisture content of butter samples containing low melting ghee fractions was lower as compared to control butter which reveals that former were unable to retain more moisture as compared to control butter. Butter samples containing low melting ghee fractions also showed higher fat content (84.31-84.75%) as compared to control butter (82.50%). Salt content in control butter and butter with added low melting ghee fractions were similar.

Table 1. Analysis of ghee and ghee fractions.

Parameters	Ghee	LBMG25	LBMG20	LBMG15
Butyro-Refractometer (BR) Reading	42.10	41.90	41.70	41.70
Reichert Meissl (RM) Value	29.14	30.80	32.67	33.99
Polenske Value (PV)	1.55	1.60	1.65	1.70
Free Fatty Acids (FFA)	0.20	0.21	0.24	0.24
Moisture (%)	0.16	0.12	0.12	0.12

Note: Results are average values of determinations made in triplicate

SNF content in control butter and butter with added low melting ghee fractions were ranged 1.30 to 1.41 %. SNF content of butter with added low melting ghee fractions was higher as compared to control butter sample. Peroxide value of butter samples ranged 0.7 to 1.14. Peroxide value of butter samples with added LBMG fractions was higher as compared to control butter sample. Peroxide value represents oxidation of fat. Higher peroxide value of butter samples with added LBMG fractions may be due to heat treatment given to the ghee fractions and exposure to oxygen during fractionation procedure of ghee.

Table 2. Physicochemical parameters of control and spreadable butter.

Parameters	B1	B2	B3	B4
Moisture (%)	13.47	11.35	11.20	11.19
Fat (%)	82.50	84.75	84.37	84.31
Salt (%)	2.40	2.40	2.41	2.41
SNF (%)	1.30	1.40	1.41	1.41
Peroxide Value (PV)	0.70	1.09	1.13	1.14

Note: Results are average values of determinations made in triplicate
B1- control butter; B2- butter containing LBMG25;
B3- butter containing LBMG20; B4- containing LBMG15

Table 3. Texture analysis of control and spreadable butter.

Butter	Firmness (g)	Firmness (N)
B1	2398.37	23.52
B2	2280.09	22.36
B3	996.26	9.77
B4	807.62	7.92

Note: Results are average values of determinations made in triplicate
B1- control butter; B2- butter containing LBMG25;
B3- butter containing LBMG20; B4- containing LBMG15

3.3. Butter firmness.

The results of the texture analysis of control and spreadable butter are presented in Table 3. The results of the texture analysis revealed that the firmness of the butter decreased with the addition of LBMG fractions. The lowest firmness value 807.62 g was reported in the B4 butter sample with added LBMG fraction (15°C) whereas control butter sample (B1) showed the highest firmness value i.e. 2398.37 g. LBMG fraction (15°C) does not completely solidify even at refrigerated conditions, thus the butter remains less firm and spreadability of the butter increases.

3.4 Butter color.

Color of the butter samples was characterized by L* value (lightness) and a* and b* value (chromaticity coordinates). All color parameters i.e. L*, a* and b* value of control and spreadable butter samples containing low melting ghee fractions showed significant differences from each other (Table 4). L* value of control and spreadable butter samples containing low melting ghee fractions ranged 75.24 to 82.18. B2 butter sample (containing LBMG25) showed lowest whereas B1 (Control) sample showed the highest L* value. All the butter samples showed negative a* value. a* value of control and spreadable butter samples containing low melting ghee fractions ranged -1.79 to -3.92.b* value of control and spreadable butter samples containing low melting ghee fractions ranged 21.45 to 27.47. The highest b* value was recorded for B4 butter sample (containing LBMG15). Positive b* value denotes yellow color and higher b* value of butter samples means more yellowness. This yellowness in milk fat is mainly caused by carotenoids [33]. Dark yellow color of butter samples containing LBMG fractions in comparison to control butter samples might be due to more extraction of carotenoids in LBMG fractions which leads to dark yellow color.

Table 4. Color values of control and spreadable butter.

Characteristics	B1	B2	B3	B4
L*	82.18	75.24	79.71	79.81
a*	-1.79	-3.68	-3.87	-3.92
b*	21.45	26.67	26.79	27.47

Note: Results are average values of determinations made in triplicate
B1- control butter; B2- butter containing LBMG25;
B3- butter containing LBMG20; B4- containing LBMG15

Table 5. Sensory analysis of control and spreadable butter.

Characteristics	B1	B2	B3	B4
Color & Appearance	7.7	7.7	7.6	7.6
Spreadability	5.8	7.6	8.2	8.3
Softness	5.3	6.7	7.3	7.6
Flavor	6.7	6.5	6.1	5.6
Overall Acceptability	6.4	7.1	7.3	7.0

B1- control butter; B2- butter containing LBMG25;
B3- butter containing LBMG20; B4- containing LBMG15

3.5 Sensory analysis.

The sensory analysis of the butter samples was carried out on a nine point hedonic scale. The results of the sensory analysis are presented in Table 5. Color and appearance of the butter samples were similar. However, spreadability, softness and flavor values of butter samples showed significant differences. Spreadability scores of butter samples ranged from 5.8 to 8.3. Softness scores of butter samples ranged from 5.3 to 7.6. At sensory evaluation temperature i.e. 10°C, the control butter sample was very firm and received lowest score for softness whereas butter sample containing LBMG15 fraction received the highest score for softness. The scores of the sensory analysis of control and spreadable butter revealed that the softness and spreadability of B4 butter sample were highest. These results are in concordance with the results obtained by texture analysis of the butter samples. Low score for flavor parameter of butter samples (B2, B3 and B4) as compared to B1 was due to more ghee flavor and less buttery flavor in these samples.

4. CONCLUSIONS

It is concluded from this research study that the firmness of the butter can be decreased by the addition of the different liquid buffalo milk ghee fractions- i.e. liquid ghee fraction at 25°C, 20°C and 15°C. Thus, butter with improved spreadability, low firmness can be produced with the addition of liquid ghee fractions without sacrificing the sensory characteristics. Overall sensory acceptability suggests that LBMG20 fraction is most suitable for enhancing softness and spreadability of butter.

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6. ACKNOWLEDGEMENTS

Authors acknowledge Executive Director, MIDFT, Mehsana & Managing Director, Dudhsagar Dairy, Mehsana for providing facilities for this research work.