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Effect of milk fat (white butter) and vegetable fat (Shortening) on the sensory, colour and textural attributes of Eggless muffins

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Abstract
Muffins are sweet bakery products characterised by good taste and soft spongy texture which was attributed to the function of fat in combination with emulsifier and egg. Fat play most important role in the flavour and texture of the muffins. Fat from either milk origin (butter) or vegetable origin (shortening) or both in combinations were used for the study. Samples were evaluated for sensory, instrumental colour and textural attributes. It was observed that the best muffins were prepared by using 16% shortening alone in combination with other ingredients. Although the difference was not significant (p>0.05) compared to control but the samples prepared with shortening scored maximum for sensory attributes as well as desired colour and textural attributes values.

Keywords: Eggless muffin, shortening, sensory evaluation, colour values, textural attributes

1. Introduction
Wheat based bakery products are one of the most important segment of processed food industry. Bread, biscuits, cakes and muffins are essential part of our diet as these are considered as impulse food items and mostly consumed to satiate the palate. Bakery products are considered as products of mass consumption primarily due to their richness in nutrients and lower price. Rapid economic growth, establishment of food chains and changing eating habits have created huge popularity among masses. With upsurge in economy and establishment of eating, joints demand for bakery products such as bread, buns, pizza base, cakes, muffins, cookies etc. has increased tremendously. A significant proportion of Indian population comprises of children and youths, who prefer to eat away from home and fond of products like burgers, pizza, muffins, frozen desserts and beverages. Therefore, the demand for these products is increasing day by day.

Muffins are characterized by a typical porous structure and high volume which confer a spongy texture (Martinez-carvera *et al*., 2012) [1]. A muffin batter is a complex mixture of interacting ingredients; which is consisted of high level of sugar and variable levels of fat, flours, eggs and baking powder. Other minor or optional ingredients are emulsifiers, stabilizers, preservatives and milk powders. For getting a desired spongy texture, stable batter containing many small air bubbles are required. The bubbles are produced during the mixing process, which will act as nuclei and grow in size when the carbon dioxide generated by the baking powder leavens the product during baking. Egg solids, particularly egg white to a lesser extent, milk proteins are important foam stabilizers, slowing down the coalescence of air bubble. Shortening and oil are used to give a softer structure and avoid a dry mouthful. During the baking of muffins, starch present in flour gets gelatinized and denaturation of proteins set the structure of cake (Baixauli *et al*., 2003) [2]. Emulsifiers are used in the manufacture of bakery products particularly to improve textural quality and check staling, one of the major issue related to their storage stability. In cake making, emulsifiers aid the incorporation and subdivision of air into the liquid phase to promote uniform dispersion of fat that contain entrapped air cells, thereby providing more sites for the expansion of gas, resulting in greater volume and soft texture (Manisha *et al*., 2012) [1].

Eggless muffins were prepared by using the combination of whey protein concentrate-70 (6%) and skim milk powder (2%) in place of egg. These were reconstituted before adding to the batter to get the desired body and texture of muffins. Fat is major ingredient in cake or muffin which plays significant important role in texture formation, palatability and storage stability of these products (Kumari *et al.*, 2011) [4]. Shortening, margarine, butter, ghee etc.

are used for the preparation of muffins. It provides softer and stable body and texture, good mouthful, richness of fat flavour and enhances the appearance of the product. It binds other components and makes the stable matrix during the batter preparation because the fat was dispersed in batter as irregularly shaped particles. It also plays an effective role at the time of baking to increase the loaf volume due to the melting of fat crystals into oil droplets throughout the continuous aqueous phase (Pyler, 1988) [5]. Previously many researchers (Baixauli *et al.,* 2007; Jyotsna *et al.,* 2007; Baixauli *et al.,* 2008; Hussain and Al-Oulabi, 2009; Ahluwalia *et al.,* 2014; Ambigaipalan and Shahidi, 2015; Goswami *et al.,* 2015; Marcet *et al.,* 2015; Martínez-Cervera *et al.,* 2015; Shevkani *et al.,* 2015; Nambiar *et al.,* 2016; Singh *et al.,* 2016; Struck *et al.,* 2016; Wyrwisz *et al.,* 2016; Alvarez *et al.,* 2017; Beegum *et al.,* 2017; Hussain *et al.,* 2017; Karp *et al.,* 2017; Lim *et al.,* 2017; Pérez-Carrillo *et al.,* 2017; Singh *et al.,* 2017; Soumya *et al.,* 2017; Umashankar *et al.,* 2016; ur Rehman *et al.,* 2017) [6-29]. worked on the processing variables, quality improvement, nutritional significance and preservation of the control (muffins containing eggs) and eggless muffins. In the present study we selected the most desirable fat source and there level for the preparation of muffins with desired characteristics. Butter and shortening were used in the study for the sample preparation.

2. Materials and method

2.1 Materials

The research work was carried out at Dairy Technology Division, ICAR-National Dairy Research Institute (NDRI), Karnal, Haryana (India). White butter was procured from Experimental Dairy of the Institute. Whey protein concentrate (WPC-70) containing 70% protein and spray dried skim milk powder (SMP) were purchased from M/s Modern Dairies Ltd., Karnal (Haryana). Good quality white crystalline food grade cane sugar (Brand name-Trust classic), refined wheat flour (Brand Name: Rajdhani) contained 9% protein, double acting baking powder and cake gel were procured from the local market of Karnal. Cake gel was mixture of emulsifiers: INS 471 (Mono and diglycerides of fatty acids) and INS 477 (Propylene glycol esters of fatty acids) and humectants: INS 1520 (propylene glycol) and INS 422 (Propylene glycol esters of fatty acids). Bakery shortening (Brand Name: Marvopride) was procured from Bunge India Pvt. Ltd., Mumbai (India).

2.2 Methodology

Eggless muffins were prepared as per the method described by Singh *et al.* (2017). The following proportions of white butter and shortening were used at the rate of 16 percent in eggless muffin formulation: T_1= 100 percent shortening, T_2=100 percent white butter, T_3= 25 percent shortening and 75 percent white butter, T_4= 50 percent shortening and 50 percent white butter, T_5= 75 percent shortening and 25 percent white butter.

2.3 Sensory evaluation of eggless muffins

The eggless muffin samples were analysed for sensory parameters using a composite sensory evaluation score card (9- point hedonic scale). The sensory parameters evaluated for eggless muffins were flavour, body and texture, colour and appearance, sweetness, and overall acceptability. The samples were served to a panel of 10 trained judges and research scholars to evaluate the product by using score card.

2.4 Colour analysis of eggless muffins

The surface colour of milk-coconut sweet was measured using a "Colorflex" colorimeter supplied by Hunterlab (Hunter Associates Laboratory, Inc., Reston, VA, USA) following the protocol described by Gomez *et al.* (2010) [30].

2.5 Texture profile analysis (TPA)

Texture profile analysis of samples of muffins were carried out at 25 °C by subjecting them to uniaxial compression to 70% of the initial sample height using a Stable Micro System Texture Analyzer, Model TAXT2i, as described in Martinez-carvera *et al*. (2012) [1].

2.6 Statistical analysis

The data obtained during the study was subjected to various statistical analyses using different software. One-way analysis of variance (ANOVA) was carried out by using the general linear model of SPSS software (version 20.0).

3. Result and discussion

3.1 Selection of fat source for muffin formulation

On the basis of preliminary trials 16 percent shortening level was standardized for preparation of eggless muffins. Shortening used in present investigation was made by partial hydrogenation of wide variety of oil blends (palm oil, palm kernel oil, coconut oil, rice bran oil, sesame oil and palmolein) having melting point in the range of 37-41^{0}C. However, panellists reported that the muffins prepared with shortening must be compared with muffins prepared with butter or in combination of both (butter+ shortening) for their effect on quality of resultant muffins. Prepared eggless muffins are shown in Fig. 1. Samples were evaluated for sensory attributed on 9-point hedonic scale, instrumental colour and texture profile analysis. Results obtained are discussed hereunder.

Fig 1: Eggless muffins

3.2 Effect of different combinations of fat source on the sensory attributes of eggless muffins

Table 1: Effect of type of fat and their blend on sensory attributes of eggless muffins

Sensory attributes					
Samples	**CA**	**BT**	**Sweetness**	**Flavour**	**OA**
Control	$7.86^{a}\pm 0.09$	$8.07^{a}\pm 0.07$	$7.79^{a}\pm 0.21$	$8.00^{a}\pm 0.13$	$8.00^{a}\pm 0.07$
T_1	$7.60^{a}\pm 0.22$	$7.70^{ab}\pm 0.15$	$7.68^{a}\pm 0.16$	$7.70^{ab}\pm 0.18$	$7.70^{ab}\pm 0.15$
T_2	$7.57^{ab}\pm 0.20$	$7.07^{c}\pm 0.07$	$7.20^{ab}\pm 0.15$	$6.89^{c}\pm 0.17$	$7.12^{c}\pm 0.14$
T_3	$7.50^{ab}\pm 0.31$	$7.57^{b}\pm 0.23$	$7.64^{a}\pm 0.21$	$7.57^{ab}\pm 0.17$	$7.55^{bc}\pm 0.22$
T_4	$7.64^{a}\pm 0.18$	$7.43^{bc}\pm 0.20$	$7.43^{a}\pm 0.20$	$7.29^{bc}\pm 0.29$	$7.43^{bc}\pm 0.23$
T_5	$6.93^{b}\pm 0.13$	$7.07^{c}\pm 0.13$	$7.20^{a}\pm 0.10$	$7.20^{bc}\pm 0.10$	$7.10^{c}\pm 0.09$

Mean±SE, abcd: mean value with different superscript within a column differ significantly (P<0.05). CA: colour and appearance, BT: body and texture, OA: overall acceptability, T_1-shortening, T_2-butter, (Shortening: Butter, 75:25- T_3), (Shortening: Butter, 50:50- T_4), (Shortening: Butter, 25:75 -T_5)

It is evident from Table 1 that there was no significant difference for all the sensory attributes between the control and eggless muffins made with shortening, although average sensory scores of control muffin were higher than eggless muffin (T_1) prepared with shortening. Increasing the proportion of butter in blend resulted in lowering of body and texture, sweetness, flavour and overall acceptability scores. Muffins containing butter reported to have denser body, predominant cooked milk fat flavour and appearance of liquid fat on the surface and within the crumb. No adverse quality defects were observed in eggless muffins prepared with shortening. Application of shortening might have assisted in air incorporation during the creaming process involved in complexing of starch and protein molecules and emulsification of aqueous phase that contributes towards the crumb texture, tenderness and moisture retention; which resulted in better sensory scores. Similarly, Puranik (1997) [31] used shortening for preparing eggless cakes.

3.3 Effect of different combinations of fat source on the colour attributes of eggless muffins

Instrumental analysis of colour showed that the lightness (L*) value of control muffins was higher than the eggless muffins. The L* value of eggless muffin containing equal proportion of shortening and butter (T_4) differed non-significantly (p>0.05) from control muffin.

Table 2: Effect of type of fat and their blend on instrumental colour values of eggless muffins

Colour attributes			
Sample	**L***	**a***	**b***
Control	$69.20^{a}\pm 0.02$	$3.92^{a}\pm 0.01$	$24.05^{a}\pm 0.01$
T_1	$69.46^{a}\pm 0.05$	$4.16^{b}\pm 0.01$	$28.21^{d}\pm 0.01$
T_2	$62.90^{c}\pm 0.06$	$6.91^{e}\pm 0.03$	$21.36^{b}\pm 0.03$
T_3	$64.10^{d}\pm 0.02$	$5.65^{d}\pm 0.02$	$27.66^{c}\pm 0.03$
T_4	$63.34^{b}\pm 0.01$	$6.44^{f}\pm 0.01$	$27.20^{c}\pm 0.02$
T_5	$62.80^{c}\pm 0.04$	$6.76^{c}\pm 0.04$	$22.93^{b}\pm 0.02$

Mean±SE, abcde: mean value with different superscript within a column differ significantly (P<0.05). T_1-shortening, T_2-butter, (Shortening: Butter, 75:25- T_3), (Shortening: Butter, 50:50- T_4), (Shortening: Butter, 25:75 -T_5)

In general eggless muffin made with butter (T_2) or higher level of butter in blend (T_5) were darker in colour and there was no significant difference among them (P>0.05). Redness (a^*) value of control muffin was significantly lower (p<0.05) than eggless muffins. Redness (a^*) value of eggless muffin made with shortening was 4.16 unit which was significantly lower than the one made with butter (6.91 unit) Table 2. All the shortening-butter blend based eggless muffins too differ significantly (P<0.05) among themselves for redness value (a^*). Yellowness (b^*) value of eggless muffin prepared with butter was lowest (T_2) followed by control muffins and eggless muffin with shortening (T_1). The variation in colour values of muffins could be attributed to the number and size of air cells formed, and the uniformity of crumb which in turn depends on air incorporation in muffin batter during creaming, subsequent mixing steps and also their retention during baking process.

3.4 Effect of different combinations of fat source on the textural attributes of eggless muffins

The hardness, gumminess, springiness and chewiness of eggless muffin with butter fat (T_2) were significantly (p<0.05) higher than with shortening (T_1) shown in Table 3. Fats in baked products contributed to tenderness, moistness and mouthfeel. A positive correlation between level of fat and tenderness of cakes was observed by Bennion and Bamford (1997) [35]. Sanz *et al.* (2009) [33] suggested that the fat reduction in bakery products often caused an increase in hardness due to greater and stronger gluten development since fat coated the flour, reducing gluten hydration.

Table 3: Effect of type of fat and their blend on instrumental textural attributes of eggless muffins

Textural attributes					
Sample	**Hardness**	**Cohesiveness**	**Gumminess**	**Springiness**	**Chewiness**
Control	$17.17^{e}\pm 0.15$	$0.31^{ab}\pm 0.02$	$5.31^{d}\pm 0.31$	$0.76^{a}\pm 0.02$	$4.05^{d}\pm 0.36$
T_1	$17.56^{e}\pm 0.25$	$0.31^{ab}\pm 0.02$	$5.77^{d}\pm 0.20$	$0.37^{d}\pm 0.01$	$2.11^{e}\pm 0.10$
T_2	$33.84^{a}\pm 0.23$	$0.34^{a}\pm 0.00$	$11.59^{a}\pm 0.13$	$0.68^{b}\pm 0.01$	$7.74^{a}\pm 0.10$
T_3	$23.75^{d}\pm 0.27$	$0.29^{b}\pm 0.00$	$7.31^{c}\pm 0.55$	$0.63^{c}\pm 0.00$	$4.77^{cd}\pm 0.07$
T_4	$26.57^{c}\pm 0.18$	$0.31^{ab}\pm 0.00$	$7.61^{c}\pm 0.07$	$0.65^{bc}\pm 0.00$	$4.97^{c}\pm 0.45$
T_5	$29.50^{b}\pm 0.32$	$0.33^{a}\pm 0.01$	$9.28^{b}\pm 0.13$	$0.67^{bc}\pm 0.00$	$6.01^{b}\pm 0.08$

Mean±SE, abcde: mean value with different superscript within a column differ significantly (P<0.05). T_1-shortening, T_2-butter, (Shortening: Butter, 75:25- T_3), (Shortening: Butter, 50:50- T_4), (Shortening: Butter, 25:75 -T_5)

Replacement of oil with dietary fibre increased hardness Grigelmo-Miguel *et al.* (2001) [34]. The role of fat particles as 'active filler' in a protein network was reported as they interacted with the proteins of the network and influenced the texture of the gel (Anton *et al.*, 2001; Kalkani *et al.*, 2007) [37-37]. The greater crumb softness of cake was responsible for finer fat dispersion. Similarly in present findings, fresh white butter when used to replace shortening on weight basis in formulation, the effective fat content in eggless muffin containing butter lowered as butter contained almost 15 percent moisture and about 84 percent fat whereas shortening had only 0.10 percent moisture, might be responsible for higher hardness value in muffin containing butter. The hardness was also increased with a decrease in air incorporation. Moreover, air incorporation in cake batter is influenced by the solid fat index (SFI), crystal structure and size of fat (Ghotra *et al.*, 2002) [32]. Milk fat comprise of appreciable amount of unsaturated fatty acids and thus have low SFI value, which might have resulted in lower entrapment of air during creaming with sugar causing cake with decreased volume and harsh crumb.

4. Conclusion

Eggless muffins with shortening exhibited a better sensorial attributes, desirable colour and textural properties as compared to eggless muffin with butter fat. Addition of shortening at 16% level in eggless muffin provided similar sensorial properties as control muffin and hence it was concluded that the shortening is better ingredient for preparation of eggless muffins.

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