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Fat replacement in soft dough biscuits: Its implications on dough rheology and biscuit quality

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Abstract

In order to develop low calorie soft dough biscuits, fat in the biscuit formulation was reduced from 20% (control) to 10%, 8%, and 6% levels, respectively. Changes in the rheological properties of the dough due to fat reduction were studied using research water absorption meter (RWAM), Brabender Farinograph and Texture analyzer. As the fat level decreased, the dough hardness increased and the extrusion time of biscuit dough, as measured in RWAM, increased from 43 s (20%) to 167 s (6%) and the farinograph biscuit dough consistency increased from 180 to 540 Brabender Units (BU). The texture analyzer showed an increase in dough hardness from 20.78 N to 44.08 N. Replacing fat with equal quantities of maltodextrin and polydextrose reduced the dough consistency and dough hardness, to some extent. Addition of glycerol mono stearate and guar gum had a positive effect on dough consistency and hardness. Effect of fat reduction had a negative effect on biscuits texture. Biscuit texture improved significantly, when fat was replaced with maltodextrin. Further improvement in biscuit texture was noted when either glycerol mono stearate or guar gum was used along with maltodextrin.

Keywords: Biscuit dough; Soft dough biscuits; Fat replacement; Dough rheology; Farinograph; Texture analyzer

1. Introduction

Flour, sugar, fat, water and salt are the main components in a soft dough biscuit formulation (Maache-Rezzoug, Bouvier, Allaf, & Patras, 1998). Fat in a biscuit formulation has a multifaceted function. Fat is the principle ingredient responsible for tenderness, keeping quality, grain and texture and it adds a rich quality to cookies (O'Brien, 2003). Mechanical properties of biscuits are largely dependent on the fat component of the formulation (Baltsavias, Jurgens, & van Vilet, 1999). Fat interacts with other ingredients to develop and mould texture, mouthfeel and overall sensation of lubricity of the product (Giese, 1996; Stauffer, 1998). Fat also influences the rheological properties of cookie dough (Jissy & Leelavathi, 2007).

High fat intake is associated with various health disorders such as obesity, cancer, high blood cholesterol, and coronary heart disease (Akoh, 1998). This awareness has prompted consumers about the amount of fat in their diet (O'Neil, 1993). Due to this reason, in spite of the important role played by fat, there have been continued efforts to reduce the fat content in food products and replace it with various fat replacers.

At present, a wide variety of ingredients are employed as fat replacers to capitalize on the unique properties and qualities of each bakery product. However, the important point is the consideration of the functionality of these replacers in a variety of products to obtain products with similar quality parameters (Kamel & Rasper, 1988). The most difficult part of reformulating with these fat substitutes is obtaining the mouthfeel, texture, taste and lubricity equivalent to that found in the conventional products.

Maltodextrin and polydextrose are two of the most popular carbohydrate based fat replacers. Carbohydrate

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based fat replacers form a gel-like matrix in the presence of substantial levels of water, resulting in lubricant and flow properties similar to those of fats (Yackel & Cox, 1992). Maltodextrin, a non-sweet starch hydrolysate is a bulking agent having no undesirable side reaction (Alexander, 1992). Polydextrose is a complex carbohydrate made from glucose, sorbitol and citric acid and its relatively high viscosity in solution contributes to the mouthfeel and creaminess of fat reduced formulations including biscuits (Mitchell, 1996).

The objective of the present work was to study the effect of fat replacement with either maltodextrin or polydextrose on rheology of biscuit dough and on the quality of biscuits. Secondly, effect of emulsifiers namely, glycerol mono stearate and sodium sterolyl lactylate and a hydrocolloid (guar gum) on the rheology of low fat biscuit dough and the biscuit quality was also studied.

2. Experimental

2.1. Raw materials

Commercially available wheat flour, having moisture, protein and ash contents of 11.48%, 9.65% and 0.5%, respectively, was used in the study. Commercially available emulsified bakery fat 'marvo' (Hindustan Lever Ltd., India), sugar powder and non fat dry milk were used in the formulation. Sodium chloride, sodium bicarbonate, ammonium bicarbonate, and dextrose syrup used in the biscuit formulation were all of food grade. Maltodextrin (DE < 20) was procured from M/s Indras Agencies, Ltd, India. Polydextrose (Litesse II) was procured from Cultor Food Science Inc., Xyrofin GmbH, Germany. Commercially available food grade emulsifiers, namely, glycerol monostearate, sodium steroyl lactylate and food grade guar gum were procured from local markets for use in the studies.

2.2. Preparation of soft dough biscuits

Soft dough biscuits were prepared according to Leelavathi and Haridas Rao (1993). The biscuit formulation consisted of wheat flour 100 g, sugar powder 30 g, fat 20 g, dextrose syrup 2 g, non fat dry milk 2 g, sodium chloride 1 g, sodium bicarbonate 0.4 g, ammonium bicarbonate 1.5 g and water 17% (by volume). For the preparation of low fat biscuits, fat content in the biscuit formulation was reduced by 50%, 60% and 70%, respectively. The corresponding biscuit dough therefore contained 10%, 8% and 6% fat in their respective formulations. Water used in the above three formulations were 19.0%, 21.0% and 22.5%, respectively. Water used in the preparation of maltodextrin, polydextrose, emulsifier and guar gum gels was taken into consideration during dough preparation. Fat and sugar powder were creamed in a Hobart mixer (model N 50, North York, Ontario, Canada) at speed 1 (61 rpm) for 1 min and continued creaming at speed 3 (178 rpm) for 4 min. Dextrose syrup, milk powder made into suspension in water, baking chemicals and sodium chloride dissolved in water were transferred to the above cream and mixed at speed 1 (61 rpm) for 2 min with further mixing for 2 min at speed 2 (125 rpm) to get a smooth cream. Wheat flour was transferred to the above cream and mixed for 2 min at speed 1 (61 rpm) to get the biscuit dough. The dough was sheeted to a thickness of 3.5 mm and cut into round shapes using a 52 mm diameter dough cutter. The cut dough was transferred to aluminum trays and placed in a baking oven and baked at 205 °C for 8 min.

Maltodextrin, polydextrose, glycerol mono stearate, sodium steroyl lactylate and guar gum were added in gel-form during fat-sugar creaming whenever included in the formulation. One volume of emulsifier was transferred to 3 volumes of water heated to 80–85 °C, cooled and stirred into smooth gel. Same method was followed for the preparation of maltodextrin and polydextrose gels, except that water was heated to 45–50 °C and used at a ratio of 1:1. Guar gum was made into gel form in water heated to 40–42 °C at a ratio of 1:2.

2.3. Measurement of biscuit dough consistency

2.3.1. Farinograph studies

Consistency of the biscuit dough was measured using a Brabender Farinograph (CW Brabender Instruments, Duisberg, Germany), according to the method of Olewnik and Kulp (1984). A 300 g capacity mixer bowl was used in the experiment and the third lever position was used to measure the biscuit dough consistency. The mixing speed of the farinograph was 61 rpm. Three hundred grams of biscuit dough pre-mixed in a Hobart mixer was transferred to the farinograph bowl and the instrument was run for 20 min and the farinogram pattern was studied. Biscuit dough consistency and farinogram bandwidth was recorded at 0 min mixing.

2.3.2. Research water absorption meter studies

Studies on the biscuit dough consistency using a Henry Simon RWAM was carried out according to Chandra Shekara, Haridas Rao, and Shurpalekar (1985) with slight modifications. Forty-five grams of biscuit dough was cut into small pieces and packed gently into the dough holder of the instrument. The dough holder was later fixed to the RWAM and a pressure of 2.4 kg was applied to the dough. The time taken by the RWAM to move a distance of 1 cm was recorded in seconds.

2.3.3. Texture analysis of biscuit dough

The texture properties of the biscuit dough were measured in an 'Instron' Universal Testing machine (Model 4301) using an aluminum plunger with 6.0 cm diameter. The load cell used was 50 kg and the crosshead speed was 10 mm / min with a clearance of 1.5 cm. Biscuit dough was sheeted to a thickness of 1 cm and cut to 4 cm diameter and was used for texture measurement. The texture profile analysis was carried out according to Bourne (1978). The biscuit dough was applied 80% compression two times in a reciprocating motion. Based on the above force–time curve, hardness (1st bite), cohesiveness, adhesiveness and springiness of the biscuit dough were measured.

2.4. Physical evaluation of biscuits

Biscuits were evaluated for spread, thickness and spread ratio. Breaking strength of the biscuits was measured in a Texture Analyzer (TA-HDi, Stable Micro Systems, UK) according to a triple beam snap technique described by Gains (1991). A crosshead speed of 10 mm/min with a load cell of 50 kg was used in the studies. The force required to break 8 biscuits individually were recorded and the average value reported.

2.5. Sensory evaluation of biscuits

The biscuits were evaluated for color, appearance, texture, taste, flavor and overall acceptability on a 9-point hedonic scale by a panel of 6 judges according to the method of Hooda and Jood (2005).

2.6. Statistical evaluation

Results were analyzed statistically following Duncan's Multiple Range Test (Duncan, 1955).

3. Results and discussion

3.1. Effect of fat reduction on biscuit dough properties

Table 1 shows the effect of fat reduction on the biscuit dough properties as measured in the RWAM, farinograph and texture analyzer. Measurement of consistency using the RWAM showed that the biscuit dough became hard when fat content in the formulation was reduced. The time taken for extrusion of dough in the RWAM is directly related to its consistency (Chandra Shekara et al., 1985). The control biscuit dough containing normal fat level (20%) required 43 s for extrusion while it increased to 122 s for the dough containing 50% less fat (10%), requiring almost 3 times more time to extrude the dough. The RWAM values further increased to 167 s when fat content was reduced by 70%. The above result shows that the biscuit dough was loosing its lubricant properties hence requiring more time for its extrusion. Fat, if present in sufficient amounts, coats the surface of the flour particles inhibiting the development of the gluten proteins. The free fat therefore disrupts the gluten network resulting in softer doughs (Menjivar & Faridi, 1994). Water uptake by the flour, in the absence of sufficient fat, would therefore result in dough hardness (O'Brien, Chapmen, Neville, Keogh, & Arendt, 2003). Incidentally, in the above experiment biscuit dough containing less fat required more water for the formation of the dough. Spies (1990) reports that if fat level is high, the lubricating function in the dough is so pronounced that little water is required to achieve a desired consistency.

Farinograph dough consistency, which was 180, BU for the control biscuit dough, increased to 300 BU when 50% fat was reduced in the formulation. Further increase in its consistency was observed when fat was reduced by 60% and 70%. The Farinograph bandwidth, which denotes the elastic properties of the dough, was narrower and smoother for the dough containing normal fat level and became wider and erratic when the fat was reduced (Fig. 1). This again infers that in the absence of sufficient fat there is increased tendency for the development of gluten proteins resulting in increased dough consistency. Maache-Rezzoug et al. (1998) working on the rheological properties of the biscuit dough explained that when fat content in the biscuit formulation is decreased it results in an increase in total specific energy during mixing with an increase in consistency and wide oscillation amplitudes.

Measurement of biscuit dough texture in the texture analyzer showed that the hardness value increased when fat content in the biscuit formulation was reduced. O'Brien et al. (2003) reported increased dough hardness when fat in the biscuit formulation was replaced with microencapsulated fat. Reduction in fat level also increased the cohesive properties of the biscuit dough. Rotary mold cookie dough contains lower water levels and has a crumbly dough and develops cohesive properties only after pressure has been applied (Hoseney & Rogers, 1994). Much of the cohesiveness of the dough comes from the plastic shortening used in the biscuit formulation

Table 1
Effect of fat reduction on biscuit dough consistency

Fat (g)	RWAM (s)	Farinograph dough		Texture[a]			
		Consistency (BU)	Bandwidth (BU)	H (N)	C	S (mm)	A (N)
20	43 ± 0.82	180	30	20.8 ± 0.16	0.39 ± 0.03	0.60 ± 0.02	0.34 ± 0.02
10	122 ± 2.83	300	80	26.6 ± 0.22	0.57 ± 0.01	0.84 ± 0.01	1.20 ± 0.2
8	145 ± 2.83	540	160	37.7 ± 0.24	0.51 ± 0.01	1.06 ± 0.04	1.86 ± 0.1
6	167 ± 4.24	540	200	44.1 ± 0.36	0.48 ± 0.02	1.58 ± 0.1	2.26 ± 0.1

N: Newton, H: hardness (peak force during first compression cycle – first bite), C: cohesiveness (ratio of the positive force area during the second compression to that during the first compression), S: springiness (distance food recovers in height between the end of first bite and the start of the second bite), A: adhesiveness (negative force area of the first bite).

[a] Using texture analyzer.

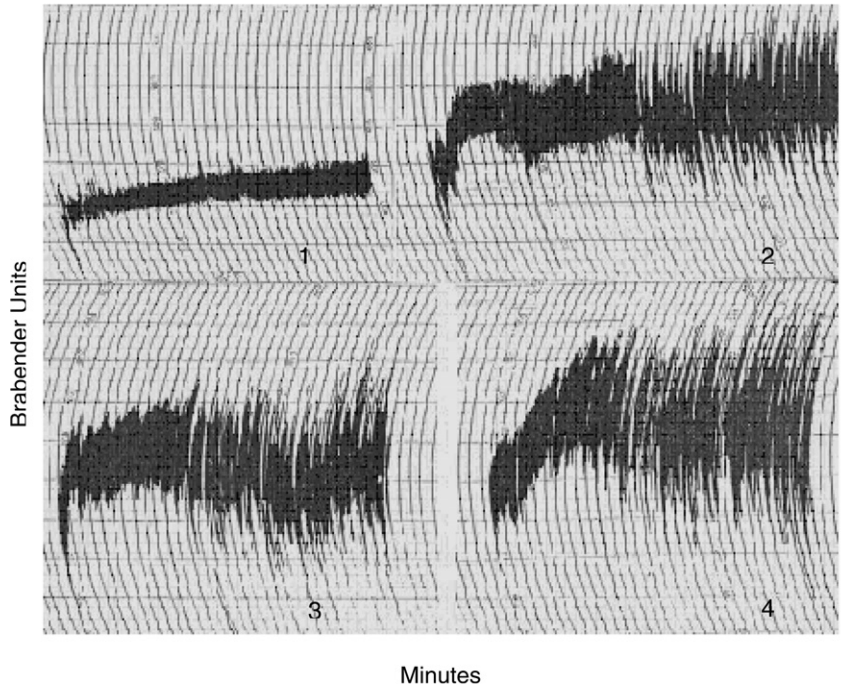

Fig. 1. Effect of 1:0%, 2:50%, 3:60%, 4:70% fat reduction on farinograph consistency of biscuit dough.

(Hoseney, 1986). The increase in cohesive properties of the dough observed could be attributed to the absence of normal fat level in the formulation. When fat is mixed with the flour before hydration it prevents the formation of a gluten network and produces a less elastic dough (Maache-Rezzoug et al., 1998). Besides, other flour components such as starch and lipids along with sucrose can also affect the distribution of water in a biscuit dough (Assifaoui, Champion, Chiotelli, & Verel, 2006). Yamazaki and Lord (1971) explain that cohesive matrix of the dough is due to development of viscoelastic protein fibrils and is undesirable in cookie dough, as it leads to product toughness. The results further showed that springiness or elastic properties of the biscuit dough increased when fat content in the formulation was reduced. The result also showed an increase in the adhesiveness of the biscuit dough with fat reduction.

3.2. Effect of maltodextrin (MD) and polydextrose (PD) on biscuit dough properties

MD and PD are amongst the several fat replacers used in bakery products. In the present study fat was reduced by 50%, 60% and 70% levels, respectively and was replaced with either MD or PD gels such that total weight was kept constant at 20 g, which was equivalent to the amount of fat present in the control biscuit dough. The RWAM values showed that the biscuit dough containing either MD or PD was harder than their counterparts containing no MD or PD (Table 2). For example, the RWAM value for the dough that had 8 g fat (60% reduction) was 145 s while that containing 8 g fat and 12 g MD (total 20 g) was more than 300 s. This was probably because in the presence of fat replacers the amount of fat present in the respective doughs became further diluted leading to reduction in its lubricant properties.

Farinograph consistency of dough containing MD was relatively lower than the corresponding dough that did not contain MD (Table 2). Similarly, bandwidth of the farinograms containing MD was much narrower than the ones not containing MD, especially at higher levels of replacements. On the other hand, the farinograph consistency and bandwidth of biscuit dough containing PD were lower than those containing corresponding levels of MD. In both the cases, lower consistency could be due to the presence of more water in the dough.

Replacement of fat at 10% level either with MD or PD did not show much effect on dough hardness as measured in the texture analyzer (Table 2). However, when fat was reduced to 8% and 6%, respectively and replaced with MD or PD, a decrease in dough hardness was observed. Similarly, when fat was replaced with either MD or PD, cohesiveness of the dough decreased to some extent. But it was still considerably more than the control biscuit dough containing normal fat level. The springiness of the dough that had increased when fat was reduced increased further with replacement of fat with either MD or PD. This can once again be related to development of gluten proteins leading to an increase in elastic or springiness properties. Elastic properties in a biscuit dough is not a desirable property. On the other hand, the adhesive properties of the dough, which had increased with fat reduction, decreased significantly when fat was replaced with either MD or PD. Since effect of MD and PD on dough properties was

Table 2
Effect of fat replacement with MD and PD on biscuit dough consistency

Fat + MD + PD (g)	RWAM (s)	Farinograph dough		Texture[a]			
		Consistency (BU)	Bandwidth (BU)	*H* (N)	*C*	*S* (mm)	*A* (N)
20 + 0 + 0	43 ± 0.82	180	30	20.8 ± 0.16	0.39 ± 0.3	0.60 ± 0.02	0.34 ± 0.02
10 + 10 + 0	138 ± 8.0	265	80	26.6 ± 1.2	0.49 ± 0.13	1.28 ± 0.3	0.46 ± 0.08
8 + 12 + 0	>300	340	100	29.4 ± 0.8	0.43 ± 0.05	1.61 ± 0.08	0.38 ± 0.11
6 + 14 + 0	–	380	100	39.4 ± 1.2	0.48 ± 0.11	1.91 ± 0.09	0.75 ± 0.07
10 + 0 + 10	153 ± 6.0	200	80	27.6 ± 0.8	0.49 ± 0.12	1.31 ± 0.14	0.46 ± 0.04
8 + 0 + 12	>300	260	80	30.4 ± 0.9	0.48 ± 0.06	1.74 ± 0.06	0.58 ± 0.08
6 + 0 + 14	–	260	80	41.4 ± 1.6	0.53 ± 0.07	1.99 ± 0.26	0.79 ± 0.14

N: Newton, *H*: hardness (peak force during first compression cycle – first bite), *C*: cohesiveness (ratio of the positive force area during the second compression to that during the first compression), *S*: springiness (distance food recovers in height between the end of first bite and the start of the second bite), *A*: adhesiveness (negative force area of the first bite).
[a] Using texture analyzer.

more or less similar further experiments were carried out using only MD in the formulation.

3.3. Effect of emulsifiers on biscuit dough containing maltodextrin

Two emulsifiers, namely, glycerol mono stearate (GMS) and sodium steroyl lactylate (SSL), were selected to study their effect on biscuit dough containing reduced fat levels replaced with MD. Emulsifiers are known for their shortening sparing action in bakery products (Flack, 1996). Since the RWAM was giving very high values for dough containing low fat levels, in the present study therefore, only the Farinograph and the texture analyzer were used. Effect of GMS and SSL on biscuit dough containing MD is shown in Table 3. With the addition of both GMS and SSL (0.5% on flour basis) a decrease in Farinograph dough consistency was observed. Measurement of dough texture in the texture analyzer showed that there was a decrease in dough hardness when GMS or SSL was present. There was also a reduction in cohesiveness of the dough in the presence of emulsifiers. The cohesive properties of the dough containing 10% and 8% fat along with MD in the presence of GMS were almost similar to that of control biscuit dough. Adhesive properties decreased in the presence of both the emulsifiers. GMS seemed to be more effective than SSL, at the level used, as far as the texture of biscuit dough was concerned. Hutchinson, Baiocchi, and Del Vecchio (1977) reported that SSL was more effective in the reduced fat cookie when used at lower levels (0.25%) and had poor effect at 0.5% level.

3.4. Effect of guar gum on biscuit dough containing maltodextrin

Guar gum (GG) as a source of galactomannans can give low fat products the softness and moistness associated with higher fat products (Setser & Racette, 1992). Even though, this property of GG is more suitable for use in bakery products having higher moisture content, in the present study we tried to use it at 0.2% level along with MD to replace fat. The results showed not much improvement in Farinograph consistency of the dough containing MD and GG. However, presence of GG reduced the hardness and cohesiveness of the biscuit dough (Table 3).

Table 3
Effect MD, GMS, SSL and GG on consistency of biscuit dough containing reduced fat levels

Fat + MD (g)	Farinograph dough		Texture[a]			
	Consistency (BU)	Bandwidth (BU)	*H* (N)	*C*	*S* (mm)	*A* (N)
20 + 0	180	30	20.8 ± 0.16	0.39 ± 0.3	0.60 ± 0.02	0.34 ± 0.02
10 + 10 + 0.5 (GMS)	220	10	25.3 ± 0.4	0.38 ± 0.08	1.48 ± 0.08	0.31 ± 0.02
8 + 12 + 0.5 (GMS)	310	120	29.1 ± 0.3	0.41 ± 0.04	1.12 ± 0.12	0.30 ± 0.03
6 + 14 + 0.5 (GMS)	315	80	32.5 ± 0.7	0.43 ± 0.03	1.69 ± 0.19	0.40 ± 0.02
10 + 10+ 0.5 (SSL)	270	80	26.4 ± 0.5	0.38 ± 0.05	1.50 ± 0.2	0.44 ± 0.04
8 + 12 + 0.5 (SSL)	240	90	31.3 ± 0.5	0.40 ± 0.01	1.59 ± 0.12	0.56 ± 0.07
6 + 14 + 0.5 (SSL)	340	60	33.0 ± 2.0	0.45 ± 0.05	1.73 ± 0.21	0.63 ± 0.04
10 + 10+ 0.2 (GG)	280	80	25.40 ± 0.8	0.36 ± 0.09	1.50 ± 0.08	0.39 ± 0.06
8 + 12 + 0.2 (GG)	300	80	30.3 ± 0.8	0.40 ± 0.02	1.59 ± 0.14	0.42 ± 0.05
6 + 14 + 0.2 (GG)	360	80	33.0 ± 4.0	0.45 ± 0.05	1.69 ± 0.09	0.58 ± 0.07

N: Newton, *H*: hardness (peak force during first compression cycle – first bite), *C*: cohesiveness (ratio of the positive force area during the second compression to that during the first compression), *S*: springiness (distance food recovers in height between the end of first bite and the start of the second bite) *A*: adhesiveness (negative force area of the first bite).
[a] Using texture analyzer.

3.5. Effect of fat reduction on physical and sensory qualities of biscuits

Changes in the physical properties of biscuits on fat reduction are shown in Table 4. The spread of the biscuits reduced significantly when fat was reduced in the formulation. Biscuits containing normal fat level had a spread of 55.5 mm, which reduced to 50.5 mm when 70% fat was reduced in the formulation. Similarly, there was also significant increase in the thickness of these biscuits from 6.3 mm to 6.9 mm. The microstructure studies of Flint, Moss, and Wade (1970) have demonstrated the lack of gluten development in short sweet doughs, both after mixing and after processing (Wade, 1988). However, in the present study, earlier observations had showed that biscuit dough increase in its elastic properties in the absence of sufficient fat. This elastic nature of the dough would be responsible for the adverse effect on the spread and thickness of the respective biscuits. The results also showed that reduction in fat level increased the breaking strength of the biscuits (Fig. 2). The hardness in biscuits as a result of fat reduction was highly correlated to hardness of biscuit dough ($r = 0.993$). Force required to break biscuits containing 70% less fat was almost three times more than that required to break the control biscuits. Fat is utilized in biscuit production to trap and hold air incorporated during the creaming stage which in turn results in a crisp or crunchy product (Given, 1994).

Table 4
Effect of fat reduction on physical quality of biscuits

Fat (g)	Width (W) (mm)	Thickness (T) (mm)	Spread ratio (W/T)	Breaking strength[A] (kg f)
20	55.5[a]	6.3[a]	8.80[a]	1.03[a]
10	53.6[b]	6.6[b]	8.12[b]	1.72[b]
8	51.6[c]	6.6[b]	7.82[c]	2.49[c]
6	50.5[d]	6.9[c]	7.32[d]	3.28[d]

Figures followed by different letters in the same column are significantly different from each other ($p \leqslant 0.05$ by DMRT).
[A] Using texture analyzer.

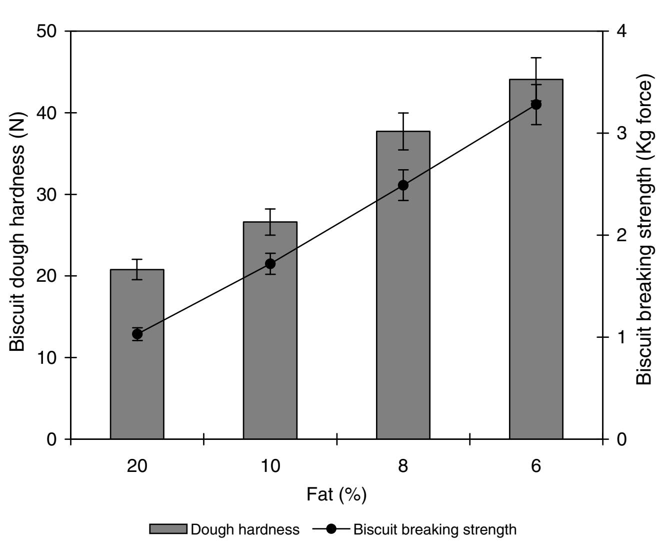

Fig. 2. Effect of fat reduction on biscuit dough hardness and on breaking strength of biscuits.

Table 5 shows the sensory properties of biscuits containing reduced fat levels. The crust color of the biscuits did not alter much up to 60% fat reduction and became pale at 70% fat reduction. The sensory scores for the appearance of the biscuits decreased significantly with fat reduction. The surface of the control biscuit was smooth and as the fat level was reduced, especially at 60% and 70% levels, the surface was uneven and looked shrunk. The sensory parameters that were greatly affected by fat reduction were texture, taste and flavor of the biscuits. The biscuits became hard, developed dry mouthfeel, lacking the lubricity and moistness imparted by fat. Biscuits containing lower fat levels also lacked their wholesome flavor and taste.

3.6. Effect of maltodextrin (MD) and polydextrose (PD) on physical and sensory qualities of biscuits

Replacement of fat with MD at all three levels had improving effect on the spread of the biscuits (Table 6). In comparison, PD seemed less effective in increasing the biscuit spread. There was no improving effect, however, on the thickness of the biscuits with the addition of either MD or PD. One benefit that was very conspicuous with the addition of MD was significant improvement in the texture of biscuits. Biscuits that had become hard due to the reduction in fat level improved in its texture when it was replaced with MD (Fig. 3). For some reason, MD seemed to be more effective than PD in improving the texture of biscuits containing reduced fat levels.

Sensory evaluation of biscuits containing MD and PD comparing them to control biscuits is shown in Table 7. Results show that the color and appearance of the biscuits improved when fat was replaced with MD and PD at 50% and 60% levels. At 70% fat replacement, not much improvement was observed. Even though, a considerable reduction in the breaking strength of the biscuits was noted in the texture analyzer, subjective analysis showed that there was not much improvement in texture of biscuits containing either MD or PD. A small improvement in the taste and flavor of the biscuits were noted in the sensory evaluation. These results showed that it was not easy to replace the lubricity, flavor or taste imparted by fat in a short dough biscuit formulation by replacing it with either MD or PD. Under the present experimental conditions MD seemed to be a better fat replacer than PD in the soft dough biscuit formulation.

3.7. Effect of emulsifiers and GG on the physical and sensory qualities of biscuits containing MD

Table 8 shows the overall quality of the biscuits containing MD along with the two emulsifiers and guar gum. The most important improvement that was observed was a significant decrease in the breaking strength of the biscuits

Table 5
Effect of fat reduction on sensory quality of biscuits

Fat reduction (%)	Color	Appearance	Texture	Taste	Flavor	Overall acceptability
0	7.38[a]	7.72[a]	7.79[a]	7.80[a]	7.88[a]	7.63[a]
50	7.29[b]	7.58[b]	7.11[b]	7.43[b]	6.75[b]	7.27[b]
60	7.29[b]	7.20[c]	6.12[c]	6.82[c]	5.63[c]	6.63[c]
70	7.13[c]	6.92[d]	5.55[d]	5.55[d]	4.65[d]	5.97[d]

Figures followed by different letters in the same column are significantly different from each other ($p \leqslant 0.05$ by DMRT).

Table 6
Effect of maltodextrin (MD) and polydextrose (PD) on the physical quality of biscuits

Fat + MD + PD (g)	Width (*W*) (mm)	Thickness (*T*) (mm)	Spread ratio (*W*/*T*)	Breaking strength[A] (kg f)
20 + 0 + 0	55.5[d]	6.3[a]	8.8[d]	1.03[a]
10 + 10 + 0	56.1[e]	6.8[b]	8.3[c]	1.48[b]
8 + 12 + 0	55.5[d]	6.8[b]	8.2[c]	1.72[c]
6 + 14 + 0	55.5[d]	7.5[d]	7.4[a]	2.05[d]
10 + 0 + 10	54.4[a]	6.3[a]	8.7[d]	2.37[e]
8 + 0 + 12	54.8[b]	7.0[c]	7.8[b]	3.19[f]
6 + 0 + 14	55.1[c]	7.0[c]	7.9[b]	3.44[g]

Figures followed by different letters in the same column are significantly different from each other ($p \leqslant 0.05$ by DMRT).
[A] Using texture analyzer.

when either GMS or GG was used along with MD. However, the breaking strength of none of these biscuits was comparable with that of control biscuits. Incidentally,

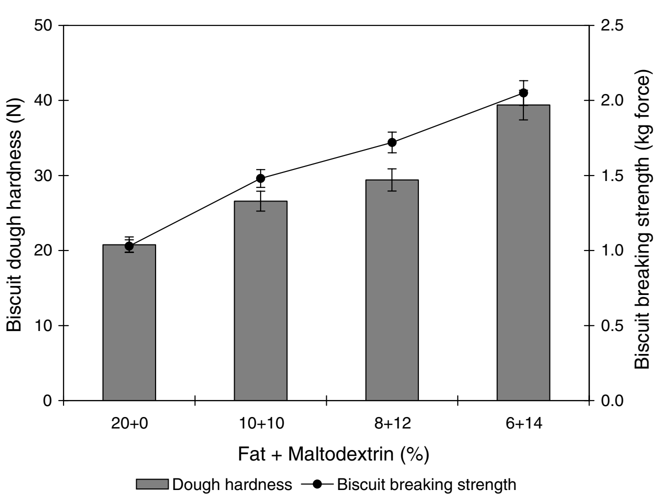

Fig. 3. Effect of MD on the biscuit dough hardness and its effect on biscuit breaking strength.

SSL did not show the improving effect of GMS on the biscuit texture. Emulsifiers are known to enhance the incorporation of air, creating great numbers of air bubbles, aid in dispersing the shortening in sufficiently small particles and produce the maximum number of effective nucleating sites (Kamel, 1994). In the present context, in the presence of very limited fat content, GMS with its lypophilic nature (Kamel & Ponte, 1993), was probably more efficient in providing many nucleating sites for the water vapour to expand during baking thus resulting in an improvement in the texture of the biscuits. GG, on the other hand, has been reported to stabilize the viscosity by strong associations with amylose molecule during pasting (Christianson, Hodge, Osborne, & Detroy, 1981). Gómez et al. (in press) working on the role of hydrocolloids in a cake system explained that this increase in viscosity slows down the rate of gas diffusion and allows its retention during the early stages of baking. In all probability, in the biscuit system also, GG perhaps helped in the retention of gas during baking thereby improving its texture. Effect of GMS, SSL and GG on the dough hardness was also reflected in the breaking strength of their respective biscuits (Fig. 4).

Table 7
Effect of maltodextrin (MD) and polydextrose (PD) on the sensory quality of biscuits

Fat + MD + PD (g)	Color	Appearance	Texture	Taste	Flavour	Overall acceptability
20 + 0 + 0	7.38[a]	7.72[a]	7.79[a]	7.80[a]	7.88[a]	7.63[a]
10+10 + 0	7.34[a]	7.50[b]	7.09[b]	7.05[bc]	6.89[b]	7.18[b]
8 + 12 + 0	7.42[a]	6.89[d]	6.37[c]	6.53[de]	5.90[e]	6.69[cd]
6 + 14 + 0	6.82[e]	6.22[e]	5.77[e]	6.41[de]	4.95[g]	6.12[f]
10 + 0 + 10	6.89[e]	6.75[d]	6.98[b]	6.79[bcd]	6.44[c]	6.80[c]
8 + 0 + 12	7.27[abcd]	7.27[c]	6.07[d]	7.09[b]	6.15[d]	6.69[cd]
6 + 0 + 14	7.27[abcd]	7.27[c]	6.15[d]	6.00[f]	5.25[f]	6.33[e]

Figures followed by different letters in the same column are significantly different from each other ($p \leqslant 0.05$ by DMRT).

Table 8
Effect of GMS, SSL and GG on quality of biscuits containing MD

Fat + MD (g)	GMS (0.5%[A])			SSL (0.5%[A])			GG (0.2%[A])		
	Breaking Strength (kg)	Spread ratio (W/T)	Overall quality (9)	Breaking Strength (kg)	Spread ratio (W/T)	Overall quality (9)	Breaking Strength (kg)	Spread ratio (W/T)	Overall quality (9)
20 + 0 (Without additives)	1.03[a]	8.80[a]	7.63[a]	1.03[a]	8.80[a]	7.63[a]	1.03[a]	8.80[a]	7.63[a]
10 + 10	1.26[b] (1.48)	8.46[b] (8.3)	6.98[b] (7.18)	2.50[b] (1.48)	8.46[b] (8.3)	6.30[b] (7.18)	1.63[b] (1.48)	8.58[b] (8.3)	6.78[b] (7.18)
8 + 12	1.51[c] (1.72)	8.27[b] (8.2)	6.64[c] (6.69)	2.65[b] (1.72)	8.46[b] (8.2)	6.24[b] (6.69)	1.63[b] (1.72)	8.92[a] (8.2)	6.67[b] (6.69)
6 + 14	1.89[d] (2.05)	8.34[b] (7.4)	6.47[c] (6.12)	2.96[c] (2.05)	8.88[a] (7.4)	5.46[c] (6.12)	1.66[b] (2.05)	8.46[b] (7.4)	6.47[c] (6.12)

Figures followed by different letters in the same column are significantly different from each other ($p \leqslant 0.05$ by DMRT). Figures in parenthesis are those for fat replacement with MD only.
[A] On flour weight basis.

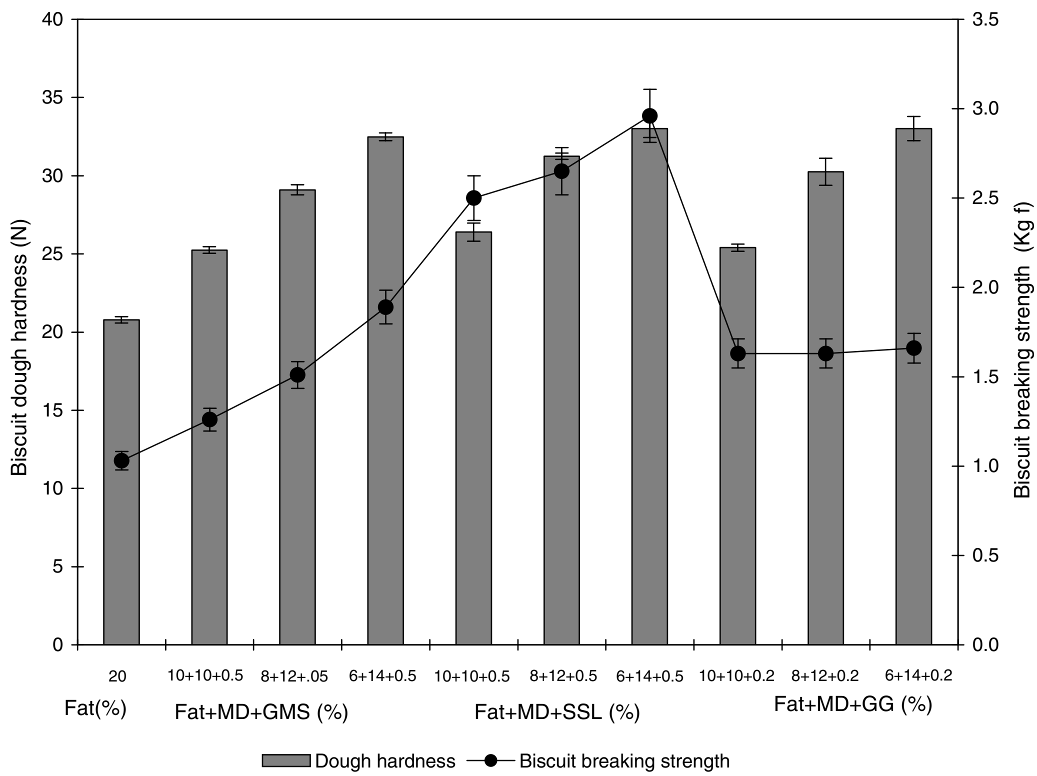

Fig. 4. Effect of glycerol mono stearate (GMS). sodium steroyl lactylate (SSL) and guar gum (GG) on hardness of biscuit dough and on biscuit breaking strength.

Hardness of dough containing GMS, SSL or GG along with MD had an improving effect on the spread ratio of the biscuits. As discussed earlier replacement of fat with MD alone had led to a decrease in spread and an increase in the thickness of the biscuits. The spread ratio of the biscuits, to some extent, could be achieved in the presence of all the three additives.

The overall quality of the biscuits did not seem to improve much when emulsifiers or guar gum was included in the formulation. The scores for overall quality of the biscuits were lower compared to those biscuits that did not contain the additives.

4. Conclusions

When fat in a biscuit formulation is reduced the resultant dough becomes hard, and increases in its cohesive, elastic and adhesive properties. The present study showed that the biscuit dough properties could be enhanced by replacing fat with either MD or PD. Further improvement in dough characteristics was possible with the addition of GMS and GG. Accordingly, the texture aspect of the biscuit could be significantly improved by replacing fat with MD or PD along with GMS and GG. The study showed that the texture of biscuit was greatly dependent on the texture of the biscuit dough. Besides being responsible for a soft dough and crisp biscuit texture, fat also imparts flavour, taste, mouthfeel, and lubricity to the product. The present study showed that in spite of significant improvement achieved in dough and biscuit texture, it was a challenge trying to achieve the other functionalities of fat in the soft dough biscuit formulation.

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