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Functional Ingredients as Fat Replacers in Cakes and Pastries

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RESEARCH REPORT NO 41

Contents

FUNCTIONAL INGREDIENTS AS FAT REPLACERS IN CAKES AND PASTRIES

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CONTENTS

SUMMARY

For specific health concerns, consumers want fat taken out of food without the flavour and texture being adversely affected. Novel ingredients were investigated for use in the formulation of reduced fat bakery products.

Formulations were developed for reduced fat muffins, madeira cake and shortcrust pastry by replacing some of the fat in the recipes with combinations of novel ingredients. The aim was to achieve at least a 25% fat reduction in the products while maintaining quality, texture, taste and consumer acceptability. Focus groups were used to ascertain consumers' preferences for the reduced fat bakery products to determine which, if any, recipes had greatest potential for further development.

The best quality and most acceptable muffins were produced with the bakery pre-blend Beatrim Bakelo. A combination of the pre-blend, additional recipe water and 25% margarine reduction gave results closest to the quality of full fat muffins produced from a standard recipe. Fat reduction achieved in the final product was 20% compared with the standard recipe.

In madeira cake production, reducing the margarine content by 25% in combination with the addition of either N-Lite D, Beatrim Bakelo or Gelite, gave cakes with an acceptable external and internal appearance, colour and crumb. All cakes were acceptable to a taste panel. However fat reduction achieved was only 16-20%.

Higher levels of fat reduction (35–42%) in madeira cakes were achieved by replacing half the margarine with carbohydrate-based fat replacers in combination with other ingredients. The use of N-Lite D and an emulsifier (Ovalett) gave better appearance, volume, texture and acceptability.

An increased level of Beatrim Bakelo plus additional recipe water, or the addition of inulin (Raftiline) in conjunction with Gelite and Ovalett, improved overall cake quality, including crust colour, cake volume, crumb texture and acceptability.

Reduced fat pastry doughs containing Pectose Paste or Gelite were pliable and easy to knead and sheet whereas dough with N-Lite D was slightly brittle.

Shrinkage and eccentricity values after baking, of both sweet and savoury reduced fat pastry with N-Lite D were similar to the control, whereas those of pastry containing Pectose Paste or Gelite were greater than the control. A taste panel judged pastries containing Gelite and higher levels of Pectose Paste as being excessively hard; however, no preferences were indicated for either appearance or flavour of all reduced fat pastries.

Consumer Focus Groups suggested that the reduced fat pastry containing Gelite had potential for further development and the reduced fat madeira cakes had commercial potential.

INTRODUCTION

Public awareness about the health risks relating to fat intake has increased and the substitution of high fat foods by reduced fat alternatives can significantly reduce the amount of energy that consumers derive from fat. Consumers, however, want fat taken out without the flavour and texture of the food being adversely affected. Fat contributes to texture and pleasing mouthfeel and imparts flavour intensity to a baked product, so as bakers strive to meet consumer demands to reduce fat, they must identify systems that mimic fat's attributes without its disadvantages.

A major function of fat in baked goods is to improve eating quality. When fat is included in a recipe, it becomes dispersed throughout the mix in the form of irregularly sized droplets and it also coats some of the surfaces of the flour particles. In this way it interrupts the continuity of the gluten chains that form when flour proteins become hydrated, by creating areas of weakness in the structure. The result is that the baked product becomes softer and generally, the more fat there is, the more crumbly the product.

In cake-making fat has the property of air entrapment, which is of vital importance. The basis of the cake structure is formed during mixing when a myriad of minute air bubbles are incorporated into the batter. These expand as the temperature rises during baking and eventually, just as the batter is setting, they burst into one another to form the familiar, porous structure of

the cake crumb. Without some form of stabilisation, the air bubbles trapped during mixing would rapidly coalesce and rise to the surface of the batter to be lost. In cakes this function is performed by the fat. Any reduction in fat in the recipe will result in less air being mixed into the batter, resulting in a muffin or madeira cake which is smaller in volume, with denser and drier texture and shorter shelf life due to premature staling.

In shortcrust pastry-making, fat is used in the recipe as the shortening agent, interrupting and preventing continuous gluten development. This results in dough that is stiff in order to permit rolling and flattening. Removal of fat from a pastry recipe will allow the gluten to develop resulting in a pastry that is hard and leathery to eat instead of being soft and crumbly.

To make a reduced fat claim on packaging, it is recommended that a 25% reduction in fat of the original product is made (UK Food Advisory Committee, 1991). In products such as spreads and milk, reduced fat alternatives are both widespread and acceptable to the consumer, while other sectors such as bakery lag behind in producing successful alternatives. Reduced fat bakery products are not widespread in the market place and in this sector there are technical and economic barriers to providing quality reduced fat products.

In terms of technical barriers, reduced fat bakery products have different dough handling properties, fewer suitable ingredients for fat replacement and limited technical knowledge about the effect of fat reduction on the functionality of ingredients. The economic barriers include manufacturing difficulty due to different dough handling properties and shorter production runs. New product development is complex, know-how is fragmented and difficult to locate and may be witheld for commercial reasons. These factors add to production costs of reduced fat products.

The project therefore aimed to:

- develop formulations for acceptable reduced fat cakes and pastry by replacing fat in the recipe with combinations of novel ingredients;

- achieve a minimum 25% fat reduction in the products while maintaining quality, texture, flavour and consumer acceptability;
- determine the influence of novel ingredients on flour doughs and batters.

MATERIALS AND METHODS

Materials

To reduce fat in flour confectionery products, a range of ingredients was identified that could possibly be used to replace some of the fat in the recipes, either individually or in combination. These included:

(i) Beatrim Bakelo (Kerry Ingredients, Beloit, USA), a spray-dried blend of emulsifiers and stabilisers to control moisture in high volume cakes, biscuits and muffins without the starchiness associated with some low-fat formulations. The emulsifiers/stabilisers include mono and diglycerides, propylene glycol esters of monoglycerides, and diacetyl tartaric esters of monoglycerides. The product also contains modified corn starch, maltodextrin, non fat milk, corn syrup solids, sodium caseinate, guar gum, sodium stearate and disodium phosphate.

(ii) Gelite (D.D. Williamson (Ireland) Ltd.) contains glycerine, glucose syrup, maltodextrin, water and carrageenan and functions as a fat reducer / replacer in cakes, muffins and yeast-leavened baked goods.

(iii) N-Lite D (National Starch & Chemical Ltd., Manchester, UK) is a modified food starch (maltodextrin) used as a fat mimetic for dairy systems in which a rich mouthfeel is desired.

(iv) Sodium caseinate.

(iv) Ovalett (Irish Bakels Ltd.) is a high performance cake and sponge emulsifier and stabiliser.

(vi) Raftiline (Orafti Food Ingredients, Belgium) contains about 92% inulin while about 8% is a glucose, fructose and sucrose mixture. It can be incorporated into a variety of baked goods, especially in reduced fat products to improve eating quality and shelf-life.

(vii) Pectose Paste (D.D. Williamson (Ireland) Ltd.) is a blend of fructose, dried glucose syrup, water and pectin. This ingredient functions as a fat replacer and shelf-life extender in baked goods such as pastries.

Methods

The methods used to investigate the production of reduced fat bakery products were baking, sensory (including consumer evaluation), chemical and rheological tests.

Baking tests : Standard recipes (Appendix 1) were reformulated in the production of reduced fat muffins, madeira cakes and shortcrust pastry. The standard full fat recipes were used as controls. The margarine content of the recipes was reduced by 25 and 50% and other ingredients incorporated to maintain physical and sensory properties of a full-fat product. Muffins were produced by the sugar batter method and madeira cakes by the blending method. For pastry production, all the dry ingredients were mixed initially in a Hobart mixer for 1 minute at a low speed i.e. speed 1, followed by 30 seconds at speed 2. Recipe water was then added and ingredients mixed for a final 20 seconds at speed 1. Batter for muffins was scaled at 65g and for madeira cakes at 380g. Products were baked at 190°C for 30 minutes (muffins) or 40 minutes (madeira cakes). Pastry dough was sheeted to a thickness of 3mm and discs (60mm diameter) cut out and baked at 215°C for 12 minutes. All products were baked in a Chandley deck oven.

Baked products were evaluated after 24 hours storage. Tests on muffins and madeira cakes included volume, specific volume, moisture, crumb softness (VEB Feinmess penetrometer), crumb and crust colour (measured with a Hunter Colour Difference Meter as L, a and b values) and overall appearance including crumb structure. Batter specific gravity was also estimated. Pastry discs were evaluated using physical tests. Surface colour was measured with a Hunter Colour Difference Meter and expressed as L and b values. Maximum and minimum diameters of the pastry discs from each treatment were measured and the mean calculated to give a value for pastry disc diameter. Shrinkage of the pastry was calculated as the difference between the mean external area of the top surface of baked pastry discs and the internal area of the cutter expressed as a percentage of the latter. Eccentricity is a measure of

the distortion of the shrinkage. It is calculated as the difference between the mean maximum and mean minimum diameters of the baked pastry discs expressed as a percentage of the former. Pastry hardness was measured as the maximum force required to break each pastry disc using a Kramer shear press system. A texture analyser (Stable Micro Systems) was used to examine the pastry dough for hardness, springiness and cohesiveness.

Sensory tests : A panel of 20 tasters was used for muffins, madeira cakes and pastry. Paired comparison taste panels compared reduced fat muffins with the control muffin. In the case of madeira cakes and pastry, three samples were presented to the panellists who were asked to rank them for preference in decreasing order from 1 to 3. Madeira cakes were also ranked for acceptability on a 5-point scale of +2 (very acceptable) to –2 (very unacceptable).

Two consumer focus groups (one male and the other female) were held in Dublin to ascertain consumers' preferences for the reduced fat bakery products and to determine which recipes had potential for commercial development. Consumers were asked to taste madeira cakes, muffins and shortcrust sweet pastries. A control (the full fat product) was included each time. Participants were asked if they liked/disliked the samples giving reasons for their answers in terms of texture, flavour and appearance. Participants were also asked to rank the products in order of preference. The differences between the samples were explained at the end of the tasting session and there was a brief general discussion on the participants' use of reduced fat products.

Rheological and chemical tests : Rheological quality refers to the machining properties of dough and batter and includes elasticity, resistance, extensibility, development time, stability, degree of softening, water absorption of dough, and viscoelastic characteristics of batter. Rheological properties of dough were measured using a Chopin alveograph (ICC Standard No. 121), a Brabender extensograph (ICC Standard 114/1), and a farinograph (ICC Standard 115/1) and of batter using a Bohlin VOR controlled strain rheometer in the oscillatory mode. The rheometer viscosity measurements were carried out in the linear region using a 86.2g cm torque bar and a 25C cup and bob.

The alveograph differs from the extensograph in that the dough sample is subjected to biaxial extension rather than uniaxial extension i.e. a dough piece in the former is inflated to give a bubble while in the latter it is stretched by a hook. Alveograph measurements include resistance to deformation (P), measured abscissa to rupture or extensibility (L), and deformation energy (W). Resistance to stretch (R) and extensibility (E) of the dough were measured using the extensograph.

Fat content of baked products was estimated by an acid hydrolysis method (Kent Jones and Amos, Cereal Chemistry, 1967).

RESULTS AND DISCUSSION

In baked goods the function of fat is to assist in aerating the batter and increasing the batter viscosity. This is critical in the development of a fine cell structure. Fat also imparts richness and tenderness to the bakery products as well as preventing starch retrogradation. The latter is a process that occurs when starch chains begin to reassociate in an ordered structure after baking and cooling, resulting in staling of the product. Reducing the fat content of muffin, madeira cake and pastry recipes without the addition of a fat replacer gave products of inferior and unacceptable quality. The quantity of fat replacers in the recipes are expressed as percentages of flour weight.

Single fat replacer in reduced fat muffins (less 25% margarine)

Reducing the margarine content in the muffin recipe by 25% gave muffins which were paler, tougher and had lower specific volume than those produced from the standard recipe. A range of ingredients was screened as potential fat replacers with most emphasis on Beatrim Bakelo. The other ingredients were oat fractions and the dairy powders, sodium caseinate and whey protein concentrate (35% protein).

The best quality muffins were produced when Beatrim Bakelo was used. Beatrim Bakelo was added at 2.1 and 4.5% in combination with four levels of additional recipe water (0, 20, 40 and 60%) in a muffin recipe with 25% less

margarine. Level of Beatrim Bakelo and additional water both had a major effect on muffin quality, with a combination of 2.1% Beatrim Bakelo and 20% additional water producing results closest to full-fat muffins (Figures 1-3). A 20% fat reduction was achieved for these muffins.

Sodium caseinate or whey protein concentrate (WPC), when used as replacements for 25% of the margarine in the recipe, produced different effects on muffin quality. The dairy powders were added at a level of 9% in

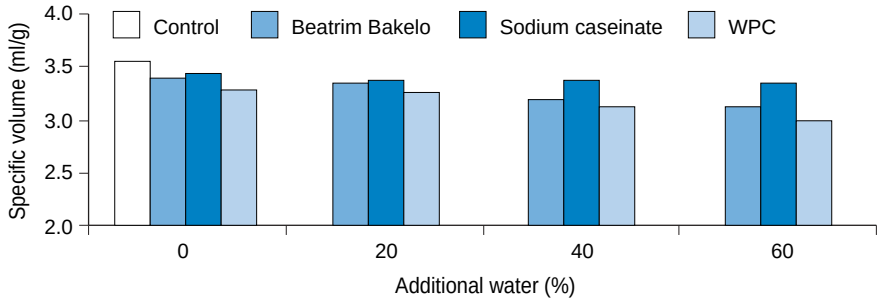

Figure 1: Effect of Beatrim Bakelo (2.1%), sodium caseinate (9%), whey protein concentrate (9%) and level of additional water on volume of reduced fat (-25%) muffins.

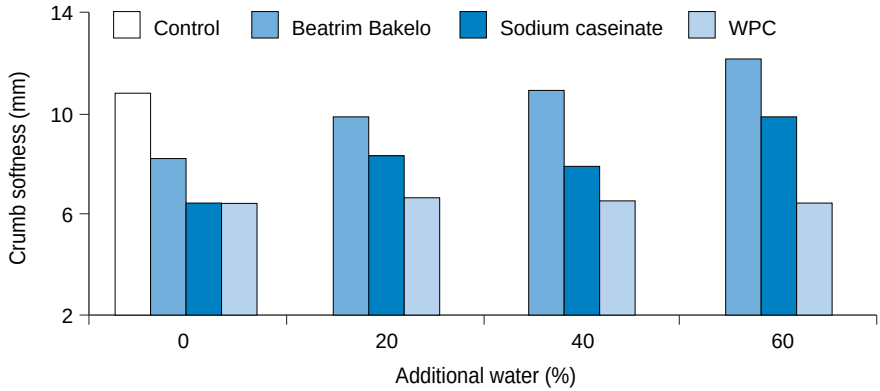

Figure 2: Effect of Beatrim Bakelo (2.1%), sodium caseinate (9%), whey protein concentrate (9%) and level of additional water on crumb softness of reduced fat (-25%) muffins.

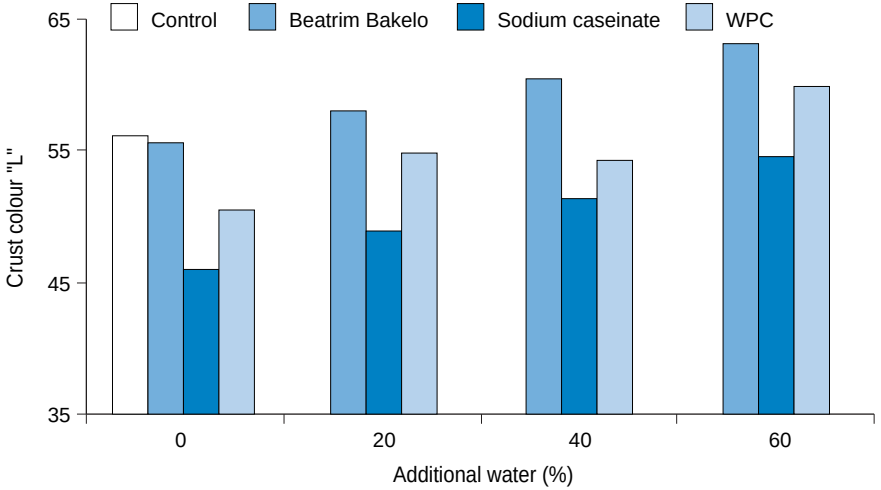

Figure 3: Effect of Beatrim Bakelo (2.1%), sodium caseinate (9%), whey protein concentrate (9%) and level of additional water on colour of reduced fat (-25%) muffins.

combination with different levels of additional recipe water (0, 20, 40 and 60%). Inclusion of sodium caseinate and 60% additional water produced muffins with volume, crumb softness and crust colour closest to those produce by the standard recipe (Figures 1-3). However the top surface appearance of the muffins was not as good as the control muffins. A 24% fat reduction was achieved for these products. Muffins containing WPC were inferior in quality to the control muffins (Figures 1-3).

Replacing 25% of the margarine in the recipe with oat fractions at a level of 9% in combination with additional water (0, 20, 40 and 60%) indicated that neither oatflour, oatbran or whole oatflour under these conditions produced muffins of a quality similar to the control.

Sensory analysis of the muffins revealed that there was no significant difference in preference between the control muffin and muffins containing

(a) Beatrim Bakelo (2.1%) and additional recipe water (20%) or

(b) sodium caseinate (9%) and additional recipe water (60%).

Single fat replacer in reduced fat madeira cakes (less 25% margarine)

Reducing the margarine content in the madeira cake recipe by 25 and 50% indicated that as the fat reduction increased, the batter specific gravity increased (Figure 4). This was due to less air being mixed into the batter. This in turn resulted in reduction in cake volume, crumb softness and deterioration of overall cake and crumb appearance compared with the control (Figures 5 & 6). Ingredients screened as fat replacers when the margarine content in the

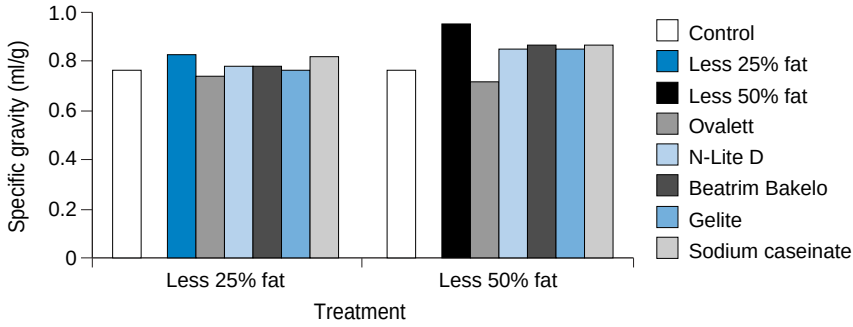

Figure 4: Effect of added ingredients on batter specific gravity of reduced fat (-25 & -50%) madeira cakes.

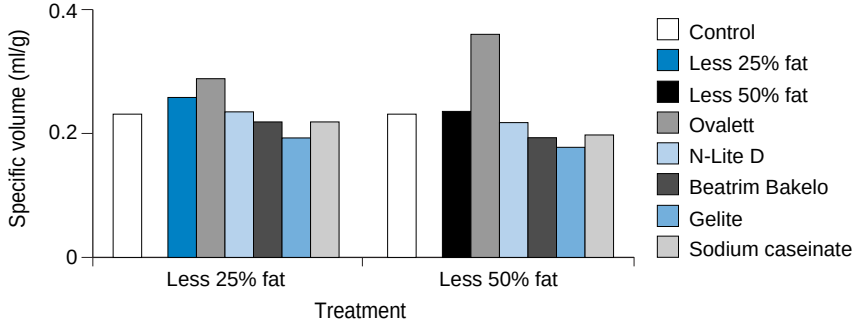

Figure 5: Effect of added ingredients on volume of reduced fat (-25 & -50%) madeira cakes.

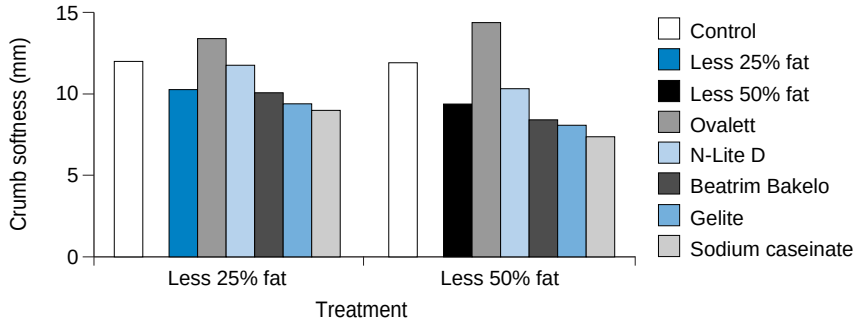

Figure 6: Effect of added ingredients on crumb softness of reduced fat (-25 & -50%) madeira cakes.

recipe was reduced by 25% were Ovalett, N-Lite D, Beatrim Bakelo, Gelite and sodium caseinate.

The emulsifier Ovalett, at the recommended level of 9%, was included in the reduced fat recipes to enhance aeration and to maintain cake volume. The resulting cakes had higher volumes, softer crumbs (Figures 5 & 6) and crumb structures similar to the control. When using the emulsifier on its own, the overall appearance of the cakes was not as good as the control.

N-Lite D addition (2.5%) gave reduced fat cakes which were similar to the control in overall external and internal appearance, in volume (Figure 5), colour and crumb structure; a 20% fat reduction was achieved.

Cakes with Beatrim Bakelo (4%) or Gelite (6.5%), had an acceptable external and internal appearance and were similar to the control in colour and crumb structure; fat reduction achieved was 16 and 20% respectively.

Sodium caseinate at 9% inclusion in a reduced fat recipe resulted in unacceptable cakes. The batter specific gravity was higher, the cake volumes lower and the crumb texture very firm with an open crumb compared with the control (Figures 4-6).

Sensory analysis indicated that cakes containing Beatrim Bakelo, Gelite or N-Lite D with 25% less margarine in the recipe were acceptable and similar to the control. Also there was no significant difference in tasters' preference for

cakes with either Beatrim Bakelo or N-Lite D and the control. Cakes containing Gelite, on the other hand, were slightly preferred to the control.

Fat replacer mixtures in reduced fat madeira cakes (less 50% margarine)

The aim was to maintain maderia cake quality when the margarine content in the recipe was reduced by 50% especially cake volume and crumb texture. Ingredients investigated as mixtures to act as possible fat replacers were N-Lite D, Beatrim Bakelo, Gelite, sodium caseinate, Ovalett, oatbran and Raftiline.

N-Lite D addition (2.5%) on its own gave a batter specific gravity higher than the control (Figure 4) and this was reflected in lower cake volume and a firmer crumb texture (Figures 5 & 6). Addition of the emulsifier Ovalett, at 4%, in combination with N-Lite D, significantly improved overall quality and resulted in madeira cake with appearance, volume and texture similar to the control (Figures 8 & 9); a fat reduction of 39% was obtained.

Beatrim Bakelo at 4% gave batters with higher specific gravity and cakes with lower volume and firmer crumb than cakes produced by the standard recipe (Figures 4-6). However, doubling the level to 8% with the inclusion of 20% additional recipe water, resulted in improved quality of the madeira cakes and a 37% fat reduction. Overall there were no significant differences in volume, texture (Figures 8 & 9) or colour between these cakes and those produced from the standard recipe.

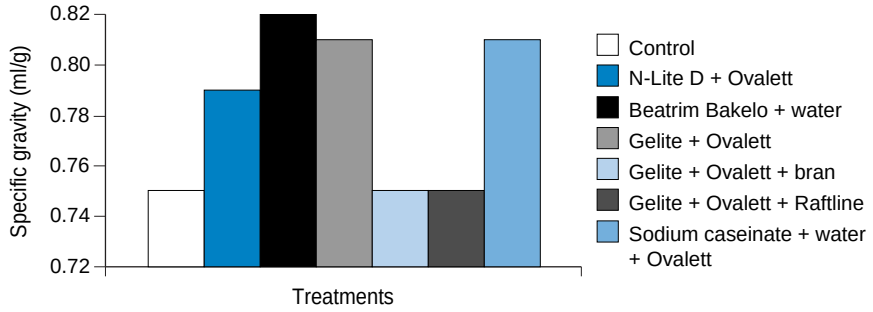

Figure 7: Effect of ingredient mixtures on batter specific gravity of reduced fat (-50%) madeira cakes.

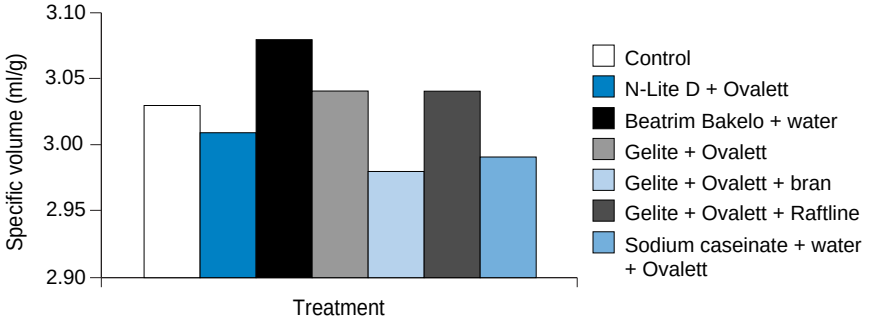

Figure 8: Effect of ingredient mixtures on volume of reduced fat (-50%) madeira cakes.

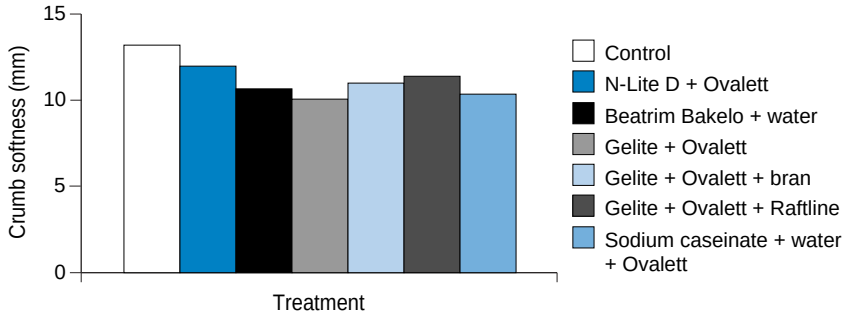

Figure 9: Effect of ingredient mixtures on crumb softness of reduced fat (-50%) madeira cakes.

Gelite on its own at 6.5% in the madeira cake recipe, produced batters with higher specific gravity and cakes with lower volume, firmer crumb (Figures 4-6) and darker crust colour than the control. To try and overcome these defects, the emulsifier Ovalett was included in the recipe at 2 and 4% in combination with Gelite. The external appearance of the resulting cakes was not improved. However Ovalett (at 4%) produced cakes with volume (Figure 8) and an internal appearance similar to the control; a fat reduction of 35% was also obtained.

Mixtures of Gelite (6.5%) and Ovalett (4%) in combination with oat bran at 10% or Raftiline at 5% were used in reduced fat (-50%) madeira cakes.

External appearance of the cakes was not improved by oat bran and the internal crumb structure was coarser and more open than for the standard recipe. Also there was a significant difference between the treatments for cake volume and crumb texture (Figures 8 & 9). Raftiline addition on the other hand, in combination with Gelite and Ovalett (at 4%) improved batter specific gravity, crust colour, cake volume and crumb texture (Figures 7-9) and values were similar to the control; a 42% fat reduction was achieved.

Madeira cakes containing 9% sodium caseinate had lower volumes and a firmer crumb texture than the control (Figures 5 & 6). Inclusion of 60% additional recipe water in combination with 2% Ovalett improved cake volume (Figure 8). However, crumb texture was still significantly firmer (Figure 9) and crust colour significantly darker when compared with the control. A 42% fat reduction was achieved for these cakes.

Sensory analysis revealed that the madeira cakes were only of intermediate quality when the margarine content was reduced by 50%, with and without the addition of a fat replacer. These cakes were also least preferred by the taste panellists when compared with the control or cakes with 25% less margarine plus the fat replacer as described in the previous section. However, when additional ingredients were introduced with the fat replacers, the acceptability and preference ratings for the cakes improved. The ingredients included Ovalett, oatbran, Raftline and in some instances extra recipe water. The optimum taste panel ratings were obtained for cakes with:

(a) Beatrim Bakelo (8%) and extra recipe water (20%),

(b) Gelite (6.5%), Ovalett (4%) and Raftiline (5%) or

(c) N-Lite D (2.5%) and Ovalett (4%).

Single fat replacer in reduced fat shortcrust pastry (less 25% margarine)

In shortcrust pastry production, reducing the margarine content in the recipe by 25% resulted in pastry that was tougher and required more force to break it compared with the full fat control (Figure 10). Ingredients screened as fat replacers in shortcrust sweet and savoury pastry were N-Lite D, Gelite or Pectose Paste.

Rheological characteristics of dough are important in pastry as they influence the machinability as well as the quality of the finished product. As expected, handling properties of the different pastry doughs (i.e. control and reduced fat recipes) showed marked differences especially during the sheeting stage. Reduced fat dough with no fat replacer was fragile and difficult to knead and sheet. Doughs containing 2.5% N-Lite D or 5% Pectose Paste were slightly brittle whereas doughs with 10% Pectose Paste or 5% Gelite were more pliable and easier to knead and sheet. However, results obtained for dough cohesiveness as measured by a texture analyser appear to contradict what was observed when the dough was physically handled. This indicated that although the pastry doughs were cohesive, their sheeting properties still lacked the cohesion of the full fat dough.

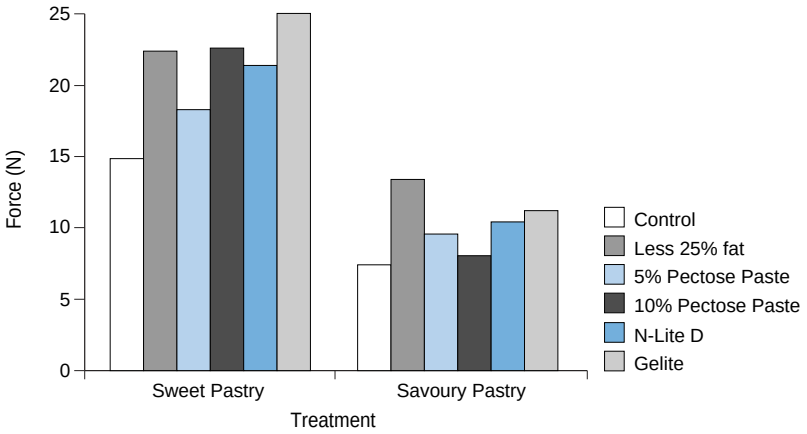

Figure 10: Effect of N-Lite D, Pectose Paste or Gelite on texture of reduced fat (-25%) sweet and savoury pastry.

Although the production process (especially sheeting) was the same, some batches produced pastry discs after baking that were very different in appearance. Doughs with 10% Pectose Paste or Gelite produced pastries that were oval in appearance compared with the control discs which were round. Significant differences were found between treatments. Discs with the highest results for mean diameter were obtained from the control and the reduced fat pastry with N-Lite D irrespective of whether the shortcrust pastry was sweet or savoury (Figure 11). Pastries containing Pectose Paste or Gelite had significantly lower values for mean diameter. In this instance, therefore, the N-Lite D fat replacer was better at simulating the fat in the reduced fat sweet or savoury pastry.

Shrinkage takes account of changes in the shape of the pastry discs during baking. Only pastry with N-Lite D had shrinkage properties similar to the control whereas batches with Pectose Paste and Gelite were significantly higher. This applied to both sweet and savoury shortcrust pastry (Figure 12). However, for all treatments, shrinkage of savoury pastry was slightly lower than for the sweet pastry.

Eccentricity measures unevenness of shrinkage. The pastry containing N-Lite D and the control produced the lowest percentage eccentricity values for both

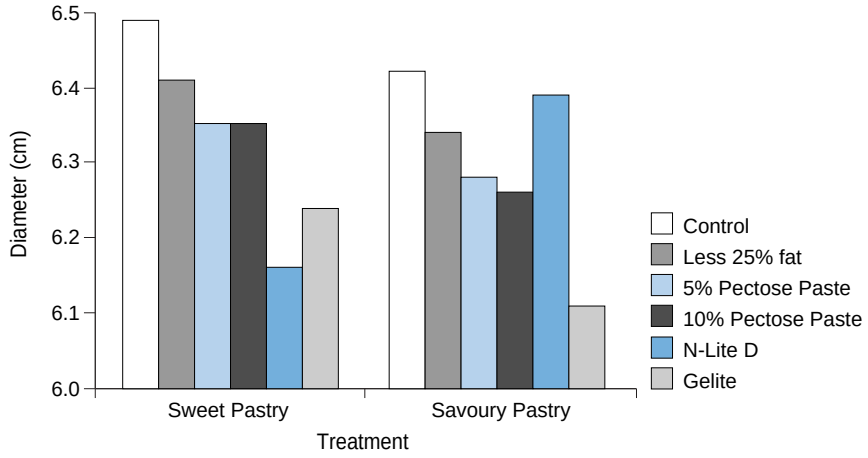

Figure 11: Effect of N-Lite D, Pectose Paste or Gelite on diameter of reduced fat (-25%) sweet and savoury pastry discs.

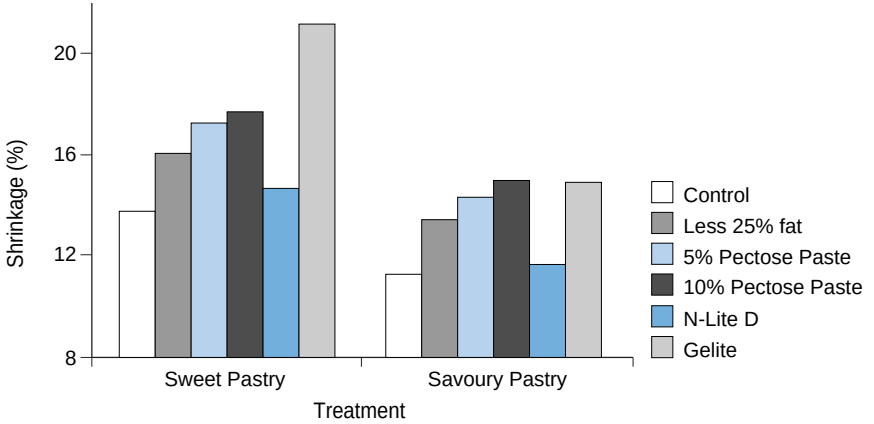

Figure 12: Effect of N-Lite D, Pectose Paste or Gelite on shrinkage of reduced fat (-25%) sweet and savoury pastry discs.

sweet and savoury pastry. Reduced fat doughs with Pectose Paste and Gelite had significantly higher values than the control (Figure 13). This may be due to the composition of the different fat replacers. N-Lite D was incorporated in the form of a powder whereas the Pectose Paste and Gelite were added as a gel or a liquid. The extra moisture from these ingredients most likely evaporated during the baking process, disrupting the structure of the baked product.

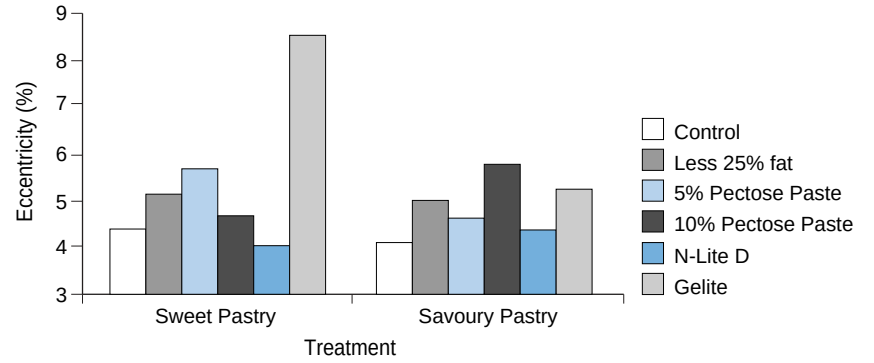

Figure 13: Effect of N-Lite D, Pectose Paste or Gelite on eccentricity of reduced fat (-25%) sweet and savoury pastry discs.

Texture measured on a Kramer shear press gives an indication of the hardness/brittleness of the pastry. Only pastry with 5% Pectose Paste had texture similar to the control. Reduced fat shortcrust sweet pastries with Gelite or 10% Pectose Paste were hardest and slightly harder than the reduced fat pastry with no fat replacer (Figure 10). However, taste panellists did not find these harder pastries to be inferior to the control. The fracturability of the pastry was largely influenced by the shrinkage of the discs during baking. A similar trend in shortcrust savoury pastry was observed; however the force required to fracture the pastry discs was lower for all treatments due to the absence of added sugar in the recipe.

In general, surface colour of the pastry did not vary with the exception of pastry containing 10% Pectose Paste which was significantly darker. This was to be expected, as the Pectose Paste ingredient contains a large quantity of sugar and caramelisation and Maillard browning reactions occurred during baking, resulting in a darker appearance of the baked products. Overall, a fat reduction of 25% or more was achieved for the reduced fat pastry.

Sensory panels ranked the pastry on the basis of overall acceptability with respect to appearance, hardness and flavour. When asked to rank the hardness of the samples, the reduced fat pastry with no fat replacer and the samples containing Gelite and 10% Pectose Paste were classified as being undesirably hard. No preference was given for flavour.

Consumer focus groups

Two consumer focus groups were held in Dublin, one group comprised females, the other males. The purpose was to ascertain consumers' preferences for the three types of reduced fat bakery products and determine which, if any, recipes had potential for commercial development.

For the madeira cakes, the reduced fat product containing N-Lite D was preferred but the product with Beatrim Bakelo was also highly rated. All the products were considered favourably. The texture was the main difference between them. The reduced fat products were sufficiently well rated to suggest they have commercial potential.

None of the muffins were particularly liked although the control was preferred. It was suggested that if dried fruit or chocolate chips were added, the muffins would possibly be more moist and would have better flavour so it would be easier to compare samples with commercial muffins.

In general, all the pastry products were liked but the control was the most favoured. However, the product containing Gelite was also well liked and it was concluded that it had potential for further development.

In the discussions that followed, the participants were somewhat agreeably surprised that they had tasted reduced fat products. Men don't usually think about reduced fat products and would not be really influenced by reduced fat claims on packaging. They expect cakes to be high in fat anyway. The women were generally interested in reduced fat products and would like to see more such products available in the market place.

Effect of fat replacers on dough rheological properties

The ingredients Beatrim Bakelo, Gelite and N-Lite D were examined for their effect on the rheological properties of high-ratio flour dough at levels of 2 and 4%. The flour/ingredient blends were mixed in a farinograph or alveograph bowl prior to testing with the exception of Gelite which, due to its viscous nature, was incorporated with some of the dough water.

The farinograph revealed that the addition of increasing levels of Beatrim Bakelo to the flour increased, and Gelite decreased, the water absorption and N-Lite D had no effect (Table 1). Dough development time and dough stability were not significantly affected by the ingredients. However, degree of softening was increased by the ingredients' addition (Table 1). Extensograph water absorption followed the same trend as the farinograph results. Maximum resistance and extensibility of the dough also increased with increasing levels of ingredients (Table 2). The effects of the ingredients as measured by the alveograph indicated that N-Lite D addition, especially at a level of 4%, had the most significant impact on dough rheological properties. The dough's resistance to deformation (P) decreased significantly as did dough extensibility (L) and deformation energy (W) (Table 2). Beatrim

Table 1: Farinograph characteristics of flour/ingredient[1] blends.

Flour	Water absorption[2] (%)	Development time (min)	Stability (min)	Degree of softening (Fu)
F[3]				
100:0	56.2	3.0	2.5	205
F+Beatrim Bakelo				
100:2	58.5	2.5	2.5	215
100:4	60.5	2.5	2.0	235
F+Gelite				
100:2	55.1	3.5	3.0	222
100:4	54.3	3.5	3.0	227
F+N-Lite D				
100:2	56.2	3.0	3.0	230
100:4	56.2	3.0	3.0	237

[1] At 2 and 4% of flour weight
[2] At 600 Farinograph units
[3] Control

Bakelo addition (2 and 4%) also resulted in a decrease in P values compared with the control.

Reducing the amount of fat causes batter instability and a reduction in aeration with a resulting deleterious effect on cake quality. Madeira cake batters were investigated using a rheometer to determine the effects of the different ingredients used (as described in Materials section i-vi) to replace 25 and 50% of the fat in the recipe. Batters were investigated ex mixer and contained fat replacers at the levels used in the baking trials. In a batter with 0, 25, or 50% fat reduction without the addition of fat replacers, as fat reduction increased, the values for the solidity of the batters (n*) increased (n*=0.373 and 0.466 respectively) indicating that the batters were less firm (i.e. had less aeration) compared with the control batter (n*=0.296). Results

Table 2: Extensograph and Alveograph characteristics of flour/ingredient[1] blends.

Flour	Extensograph R (EU)	Extensograph E (mm)	Extensograph R/E	Alveograph P (mm H_2O)	Alveograph L (mm)	Alveograph W (J)
F[2]						
100:0	626	755	0.83	87.5	21.5	81.5
F+Beatrim Bakelo						
100:2	678	810	0.84	80.0	22.5	79.0
100:4	511	860	0.60	70.5	29.5	85.0
F+Gelite						
100:2	650	795	0.82			
100:4	654	840	0.78			
F+N-Lite D						
100:2	658	810	0.82	74.5	22.0	73.0
100:4	684	810	0.84	64.0	18.0	51.0

[1] At 2 and 4% of flour weight

[2] Control

R= maximum resistance; E= extensibility; P= resistance to deformation; L= measured abscissa to rupture or extensibility; W= deformation energy

also indicated that the addition of Beatrim Bakelo (n*=0.260), Gelite (n*=0.316) or N-Lite D (n*=0.335) counteracted the effects of 25% fat reduction in cake batters. However, this was not the case at 50% fat reduction where the n* values ranged from 0.338 to 0.460. At the higher levels of fat reduction in order to produce a batter and cake in line with the quality of the control, the use of Gelite or N-Lite D required the addition of an emulsifier (Ovalett at 4%)(n*=0.316 and 0.365). Also, the quantity of Beatrim Bakelo had to be increased to 8% (in combination with 20% extra recipe water)(n*=0.312) and it was necessary to add Ovalett (2%) (in combination with 60% extra recipe water) with sodium caseinate (n*=0.338). The rheometer test is a good indicator of batter and final baked product quality.

CONCLUSIONS

- Carbohydrate based fat replacers and emulsifiers are good combinations for replacing 25 to 50% of margarine in muffin and madeira cake recipes. In the case of shortcrust pastry it was possible to replace 25% of recipe fat with carbohydrate based fat replacers.
- For muffins a combination of Beatrim Bakelo (2.1%), additional recipe water (20%) and 25% less margarine in the recipe gave results closest to the quality of the full fat product.
- Madeira cakes with the addition of either N-Lite D (2.5%), Beatrim Bakelo (4%) or Gelite (6.5%) to the 25% reduced fat formulation resulted in all cakes having an acceptable external and internal appearance, colour and crumb. All cakes were acceptable to a taste panel.
- It was possible to reduce the margarine content in the madeira cake recipe by 50% and maintain quality. The combination of N-Lite D (2.5%) and Ovalett (4%), Beatrim Bakelo (8%) plus 20% additional recipe water or the addition of Gelite (6.5%) and Ovalett (4%) in conjunction with Raftiline (5%) resulted in cakes with acceptable qualities.
- Consumer focus groups found the reduced fat bakery products had potential for commercial development.
- The Bohlin rheometer test is a good indicator of batter and baked madeira cake quality.

RECOMMENDATIONS TO INDUSTRY

In a madeira cake recipe where the margarine content is to be reduced by 25%, product quality can be retained when a carbohydrate-based fat replacer is incorporated in the mix. However, 50% margarine replacement necessitates the addition of an emulsifier with the carbohydrate-based fat replacer to produce a quality product.

Some adjustments in recipe water addition may be necessary depending on the type of fat replacer used and whether it is in powder, gel or liquid form.

In shortcrust pastry production where the margarine content has been reduced by 25%, it is possible to overcome machinability problems by the inclusion in the recipe of carbohydrate-based fat replacer.

Companies are invited to avail of expertise at The National Food Centre on flour technology, especially in areas of product development, flour functionality, ingredients, test milling, test baking and food analysis.

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APPENDIX 1: STANDARD RECIPES

Table 1: Muffin standard recipe.

	%
High-ratio flour	100.0
Sugar	56.0
Water	44.8
Cake margarine	37.3
Eggs	29.9
Milk powder	6.7
Baking powder	4.5
Salt	1.5

Table 2: Madeira cake standard recipe.

	%
High-ratio flour	100.0
Sugar	110.0
Eggs	67.0
Cake margarine	50.0
Water	35.0
Milk powder	10.0
Baking powder	4.5
Salt	2.0

Table 3: Shortcrust pastry standard recipes.

	Sweet %	Savoury %
Soft flour	100.0	100.0
Cake margarine	50.0	
White shortening		50.0
Sugar	25.0	
Salt		1.25
Water	12.5	22.5

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