DAIRY PRODUCTS RESEARCH CENTRE

MOOREPARK

END OF PROJECT REPORT 2000 DPRC No. 41

Dairy Ingredients for the Baking Industry

M.K. Keogh, D. Neville and C. Stanton

Shortenings (baking fats), microencapsulated using dairy ingredients and milk protein hydrolysates, were produced for testing in a variety of baked products. The powders were evaluated for their functionality as powdered baking fats, as potential replacers of synthetic emulsifiers, as ingredients capable of improving baking performance or as potential health-enhancing ingredients.

These studies provide the technology for the dairy industry to enter the specialised food ingredients sector with a siftable, non-greasy, free-flowing powdered fat for the baking industry.

Teagasc
The Science of Farming and Food

Functional Additives in Cereal-based Consumer Foods

(Dairy Ingredients for the Baking Industry)

Armis No. 4518

Project Team:
Dr. M.K. Keogh (Leader)
Mr. D. Neville
Dr. C. Stanton
Mr. M. Auty
Mr. R. Kennedy
Dr. E. Arendt *
* Dept. Food Technology, University College Cork

The Dairy Products Research Centre
Moorepark, Fermoy, Co. Cork.

Teagasc acknowledges with gratitude grant aid under the Food Sub-programme (Sub-Measure 3 (ii) - Institutional R&D) of the Operational Programme for Industrial Development. The Programme was managed by the Department of Agriculture and Food supported by EU and national funds.

Teagasc gratefully acknowledges the use of the baking facilities of the Food Technology Department, University College Cork in the course of these studies.

ISBN 1 84170 181 5
DPRC No. 41

Teagasc 19 Sandymount Avenue
Ballsbridge Dublin 4

EUROPEAN UNION
European Regional Development Fund

Summary and Conclusions

Microencapsulated high fat powders provide a convenient alternative to fats or shortenings which are usually used in cereal-based baked products. Powdered fats, in common with other baking ingredients, are flowable compared to block fats and they also increase the overall protein content of baked goods, which provides certain functional benefits. The main objective of this project was to evaluate the performance of microencapsulated high fat powders in a range of baked products.

Milk protein hydrolysates have well-established nutritional properties, but their functional effects in baked goods have not been quantified. Hence, the functional and physicochemical characteristics of some casein hydrolysates generated by a range of food-grade enzymes were evaluated to determine their suitability for use in baked products. Pilot-scale production of hydrolysates were undertaken and the spray dried products were evaluated in baked products.

Main Conclusions and Achievements

** Microencapsulated fat powders were developed and optimised to suit various baking applications. These powders performed satisfactorily in the baked goods in which they were assessed in terms of a) alternatives to block fats, b) dough conditioners and c) functional substitution of traditional ingredients.*

** The influence of microencapsulated high fat powders on the physical, physicochemical and sensory properties of bread, biscuits and cakes was determined. Whey protein concentrate (WPC-75) was selected as microencapsulating agent for its functionality, flavour and cost.*

Free fat was found to have the greatest effect on the properties of the bread.

The optimum powder gave similar dough rheological properties and loaf volume yield compared to a standard loaf with added shortening. Increasing the scale of production of the powder (using the Niro Tall-Form spray dryer) improved the mechanical and physical properties of the powder. The powder performed well in pilot-scale baking trials and on assessment by baking end-users.

A high fat cake powder with WPC-75 was successfully incorporated into Madeira cake as a complete replacement for margarine and egg. The cake with the high fat powder was found to be superior to a commercially produced Madeira cake.

* *Caseinate hydrolysates were prepared in spray-dried powder form and were evaluated as suitable protein-rich ingredients in bread making applications.*

A sodium caseinate hydrolysate of limited degree of hydrolysis (DH) which exhibited superior in-vitro functional properties, and an extensively hydrolysed hydrolysate prepared from acid casein, with inferior in-vitro functional properties to unhydrolysed sodium caseinate were prepared in spray-dried powder form.

Results of these studies showed that there was no correlation between the positive in-vitro functional properties observed for the sodium caseinate hydrolysate and performance in bread making applications.

The bread made using the sodium casein hydrolysate (at 1 and 4% w/w) was generally of inferior quality to the control. However, the bread made using the extensively hydrolysed acid casein hydrolysate was equivalent or of superior quality to the control. Therefore, this ingredient may have applications in the development of protein-enriched bread.

* *The project was very successful in understanding the effects of the selected milk components (milk fat, milk protein type/level and lactose) and homogenisation conditions on the functional properties of spray-dried powders (free fat and whey protein denaturation) relevant for baked products.*

This provides the technology for the dairy industry to enter the specialised food ingredients sector with a siftable, non-greasy, free-flowing powdered fat suitable for the baking industry.

Fundamental knowledge was gained on the influence of protein hydrolysates on the quality of baked products, and processing procedures were modified with a view to enhancing quality.

Research and Results

Microencapsulated High Fat Powders

Microencapsulated high fat powders (70% fat) ranging in free fat content from 2 to 60 g /100 g fat were produced.

The free fat content decreased significantly as the homogenisation pressure and added sucrose level in the powders increased. Fat type (milk fat or hydrogenated vegetable fat), protein type (whey protein concentrate or sodium caseinate) and protein level (5 to 20%) did not significantly affect free fat. Wettability, which is a measure of the reconstitution properties of the powders ranged from 30 to 133 seconds. Wettability was poorer at the higher protein level (20%), which increased the wetting time by 17 seconds.

Microencapsulated fat powders made with whey protein concentrate (WPC-75) rather than sodium caseinate were selected for further study because of functionality, flavour and cost reasons, based on their evaluation in baked products.

In a second stage, microencapsulated powders were produced using WPC-75 or WPI (90% protein) at levels of 5 - 20% w/w of powder protein and at varying levels of homogenisation pressure (40 - 400 MPa). Hydrogenated vegetable shortening was used as the fat source.

Increasing the homogenisation pressure significantly decreased the fat globule size of the concentrate prior to drying. The particle size of the spray-dried powders was also significantly decreased. The free fat of the microencapsulated fat powders ranged from 8 to 80 g fat/100 g fat. Increasing the homogenisation pressure decreased free fat significantly while increasing the protein level from 5 to 20% increased the free fat significantly in the powders (Fig.1).

One of the primary objectives at this stage was to produce microencapsulated powders with a wide range of free fat contents, as it was found in stage one that free fat had the greatest effect on the properties of baked bread and dough. The processing and compositional variables that affected the properties of the microencapsulated powders also affected the baked bread properties.

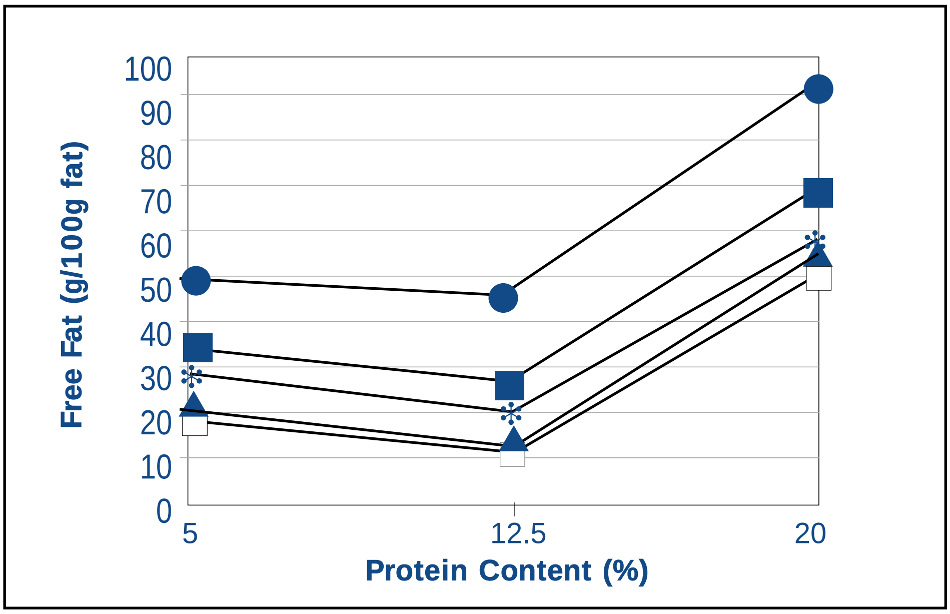

Fig. 1: Effect of protein content and homogenisation pressure on powder free fat at 4 MPa (●), 13 MPa (■), 22 MPa (▲), 31 MPa (❑) and 40MPa (❇).

Increasing the homogenisation pressure, which decreased the free fat of the powders, resulted in a significant decrease in loaf volume (Fig 2). Increasing the protein level in the powders significantly increased the hardness and chewiness of the breads. Increasing the homogenisation pressure significantly increased the dough rheological properties related to stiffness of the dough (tan δ and complex viscosity), making it more difficult to process and expand during baking.

A hydrogenated vegetable fat powder (70% fat) was produced using homogenisation at high pressure with 10% WPC as the emulsifying agent and 20% lactose as the filler. A hydrogenated vegetable fat powder (39% fat) was also produced with 38% WPC-75 and 22% sucrose at the same homogenisation pressure. The powders were spray dried using an Anhydro pilot-scale dryer and stored at 16ºC.

The 70% WPC-based microencapsulated powder was used as a complete replacer for egg, synthetic emulsifier and fat in English cake, while the 39% fat powder was used as a similar replacer in sponge cake. The expected benefit was to replace expensive egg proteins, synthetic emulsifiers and bulk fats normally used in cakes with one microencapsulated dairy ingredient. The powders produced were in the

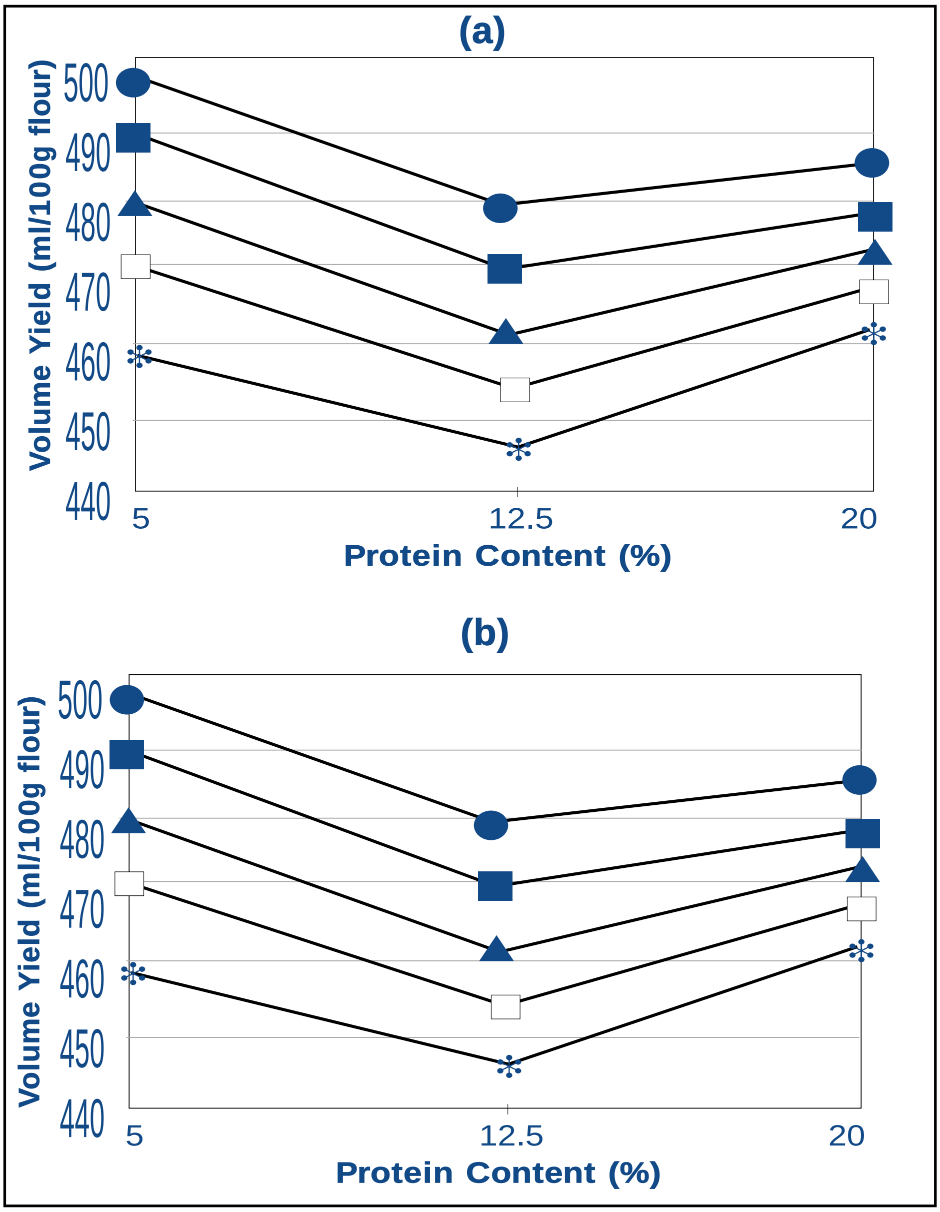

Fig. 2: Effect of protein content and homogenisation pressure on the volume yield of baked bread with added powders (5% w/w of flour) using (a) WPC-75 and (b) WPI at 4 MPa (●), 13 MPa (■), 22 MPa (▲), 31 MPa (❑) and 40 MPa (❇).

low free fat range, and the free fat of the 70% fat powder was greater than the 39% fat powder (7.0 v. 3.7 g free fat/100 g fat).

The properties of the cakes produced with egg and synthetic emulsifier were better than cakes produced with the microencapsulated fat powders and synthetic emulsifiers. However, the microencapsulated fat powders performed as well as egg in cakes produced without synthetic emulsifier in the recipes.

A further series of powders was produced with and without added synthetic emulsifier and substituted for egg and/or emulsifier in English cake.

It was found that the recipe used for cake manufacture did not produce a good control cake, but the cakes manufactured with the microencapsulated powder ingredient performed adequately in this recipe.

Commercial Scale Assessment of Dairy Ingredients for Baking

A whey protein-based high fat microencapsulated powder with optimum functionality in baked bread was manufactured on a commercial scale using a Niro Tall-Form spray dryer in Moorepark Technology Ltd.

The powder performed well in terms of its handling and flow properties during drying and the recovery of the powder was high. Increasing the scale of production of the powder improved the mechanical and physical properties of the powder. The powder performed well in baking trials and the powder and process were assessed by commercial milk powder manufacturers and baking end-users.

Puff pastry products are the primary outlets for hard milk fat fractions. Puff pastry was produced using hard milk fat fraction, winter milk fat and microencapsulated powders containing each of the fats.

Hard milk fat fraction performed better than winter milk fat when added as bulk fat or in microencapsulated powder form. The microencapsulated fat powders performed poorly in these trials. When the fat content in the powders was increased from 70 to 80%, puff pastry quality improved. The improvement could be attributed to the greater availability of fat during baking, as the free fat values increased 3-fold in the higher fat powder.

A Madeira cake (high ratio) formulation was used, into which a series of high fat cake powders was incorporated. The formulation and process for manufacture of cake powders was further modified by the inclusion of specific small molecular weight emulsifiers. The interaction between the whey protein/emulsifier system was assessed and optimised. An optimum powder was produced in terms of its performance in Madeira cake. A commercial milk powder manufacturer assessed the powder and process.

The powder produced a cake superior to a commercially produced Madeira cake product. This powder was manufactured on a commercial scale using the Niro Tall-Form spray dryer. The powder performed well in terms of its handling and flow properties during drying and the recovery of the powder was high.

Casein Hydrolysates

An evaluation of the functional and physicochemical characteristics of five casein hydrolysates, which were generated by a range of food-grade enzymes, was undertaken to determine their suitability for use in baked bread products. In all cases, sodium caseinate was hydrolysed to a limited degree (1% DH) by food-grade commercial enzyme preparations. This typically involved the use of 0.1 - 0.001% enzyme:substrate ratio for 2 - 4 hours at conditions of optimum temperature and pH for the particular enzyme.

The peptide size distribution of the five hydrolysates varied depending on the proteolytic enzyme used. *Protamex*, a *Bacillus* protease complex (Novo Nordisk), was the most proteolytic enzyme studied, generating a hydrolysate which consisted of 25% of total peptides of less than 5 kDa, while the other hydrolysates had between 14 - 21% of total peptides less than 5 kDa.

The emulsification, foaming/whipping and water-binding capacity of these casein hydrolysates were evaluated and compared to unhydrolysed sodium caseinate. Emulsification activity (EA), an indicator of the ability of the hydrolysate to form an emulsion, was measured at pH values ranging from 2.0 to 10.0.

For all hydrolysates, EA was higher at alkaline pH than at acid pH values.

Emulsion stability (ES) over 30 min was recorded from pH 2.0 - 10.0 and compared with unhydrolysed sodium caseinate.

ES was reduced at acidic pH values, and emulsions were most stable in the alkaline pH range, with the most stable emulsion being generated at pH 10.0 by the casein hydrolysate made using Alcalase.

Whipping and foaming properties of the hydrolysates and sodium caseinate were measured at pH 2.0, 7.5 and 10.0. Foams were prepared at 4% protein and foam expansion and percentage drainage quantified.

All hydrolysates exhibited superior foam expansion compared to unhydrolysed sodium caseinate at all pH values tested. Furthermore, there were no differences between the levels of foam expansion obtained between the five hydrolysates.

Unhydrolysed sodium caseinate had low drainage at pH 2.0, whereas at pH values of 7.5 and 10.0, greater than 95% drainage was observed. Interestingly, the hydrolysate made using Neutrase had low drainage at all pH values investigated, whereas all other hydrolysates exhibited high drainage (> 90%) at pH 2.0. Of the five casein hydrolysates, that made using Neutrase exhibited the lowest drainage at pH 7.5.

Water-binding capacity of sodium caseinate and the five casein hydrolysates (3% w/v) was measured and compared with commercial bakers flour, which yielded a value of 0.80 ml/g.

Unhydrolysed sodium caseinate exhibited higher water-binding capacity (0.88 ml/g) than the casein hydrolysates (0.76 - 0.87 ml/g).

The hydrolysate made using Neutrase exhibited improved foaming and whipping properties and had similar water binding capacity to unhydrolysed sodium caseinate, and was subsequently selected for incorporation into baked goods.

The performance of this hydrolysate was compared to an extensively hydrolysed acid casein hydrolysate, prepared with the enzyme Flavourzyme, in baking applications. The functional properties (e.g. emulsification and foaming/whipping) of the extensively hydrolysed acid casein hydrolysate were very poor.

Bread was produced to a standard procedure and the casein hydrolysates were incorporated at 1% and 4% (flour basis). Batches were also prepared without hydrolysate and with unhydrolysed material (also at 1% and 4% w/w). All bread batches were evaluated using standard balling tests, crumb firmness testing and crumb grain image analysis.

Bread made using the sodium casein hydrolysate was generally inferior in quality compared with the control, while the incorporation of the extensively hydrolysed acid casein hydrolysate resulted in bread of equivalent or superior quality to the control. Therefore, the results indicated that there was no correlation between such functional properties as foaming/whipping and bread making potential.

For further information please contact:
Dr. Kieran Keogh or Dr. Catherine Stanton

Publications

O'Brien, C.M., Grau, H., Neville, D.P., Keogh, M.K. and Arendt, E.K. (1998). Use of microencapsulated high fat powders in bread. Proceedings of *28th Annual Food Science and Technology Conference*, September, Cork, Ireland.

Neville, D.P. and Keogh, M.K. (1998). Microencapsulated high fat milk powders spray dried using sodium caseinate. Proceedings of *28th Annual Food Science and Technology Conference*, September, Cork, Ireland.

Neville, D.P. (1998). Development of a natural bacon fat flavoured ingredient using microencapsulation technology. Presentation for *The 1998 Food Ingredients Europe Research Award*, November, Frankfurt, Germany.

Neville, D.P. (1998). Microencapsulation technology for ingredient and flavour delivery in consumer foods. Dissemination Project Workshop on *Ingredients for Consumer Foods*, December, University College, Dublin.

Kenny, S., Wehrle, K., Stanton, C. and Arendt, E.K. (1998). Use of dairy powders as functional ingredients in wheat bread. I*nternational Dairy Journal* **8**, (5-6) (A), 576.

O'Brien, C.M., Grau, H., Neville, D.P., Keogh, M.K. and Arendt, E.K. (1998). Rheology of wheat bread doughs containing microencapsulated high fat powders. Proceedings of the *1998 Annual AACC Meeting*, Minneapolis, MN, USA.

O'Brien, C.M., Grau, H., Neville, D.P., Keogh, M.K. and Arendt, E.K. (1998). Functionality of microencapsulated high fat powders in wheat bread. *Journal of Cereal Science*. Submitted.

Neville, D.P., Kelly, P.M. and Keogh, M.K. (1999). A natural bacon fat flavoured ingredient developed by microencapsulation technology. *Farm & Food*, Winter 1998/99.

Kenny, S., Wehrle, K., Stanton, C. and Arendt, E.K. (2000). Incorporation of dairy ingredients into wheat bread: effects on dough rheology and bread quality. *Eur. Food Research Technol.* **210**, 391-316.

Crowley, P., Slattery, H., Arendt, E.K. and Stanton, C. (2000). Evaluation and Application of Casein Hydrolysates in Wheat Bread. *Irish J. Agricultural Food Research* **39**, 1, 149.

Neville, D.P., Keogh, M.K. and Auty, M.A. (2001). Spray dried high fat powders. *J. Food Science*. Submitted.

Neville, D.P., Keogh, M.K., Auty, M.A., O'Brien, C.M. and Arendt, E.K. (2001). Whey protein encapsulated high fat powders for application in wheat bread. *J. Food Science*. In Preparation.

Dr. Kieran Keogh

DAIRY PRODUCTS RESEARCH CENTRE
Moorepark, Fermoy, Co. Cork, Ireland
Tel: +353 (0) 25 42222 - Fax: +353 (0) 25 42340
E-Mail: reception@moorepark.teagasc.ie