



An Roinn Talmhaíochta,
Bia agus Mara
Department of Agriculture,
Food and the Marine

Food Institutional Research Measure

Final Report

Healthy to bake – ready to bake mixes containing flours generated from food processing by-products

DAFM Project Reference No: 13 FP 471

Start date: 01/04/14

End Date: 31/03/15

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Collaborating Research Institutions and Researchers: None

Please place one "x" below in the appropriate area on the research continuum where you feel this project fits

Basic/Fundamental	→	Applied	→	Pre Commercial		
1	2	3	4	5	6 X	7

Please specify priority area(s) of research this project relates to from the National Prioritisation Research Exercise* (NRPE) report;

Priority Area (s)	Food for Health (H); Sustainable Food Production and Processing (I)
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Key words: (max 4): Bakery mixes, by-products

1. Rationale for Undertaking the Research

This project aimed to add value, through further research to increase the commercial value/relevance of the outputs of a previously-completed FIRM project [Healthy cereal-based snacks from by-products of the milling, malting, brewing and cider industries (08RDTAFRC665)], and to elevate the technologies and the expertise developed during the previous FIRM project to a pre-commercial footing.

Healthy eating is a leading trend, and consumers still seek for their favourite foods to be enhanced nutritionally. When funding for this project was granted, bakeries in Ireland were struggling in the economic downturn, and their outlook was difficult and uncertain. Innovation and product diversity are key for boosting business, and 'health' and 'variety' have been identified as key market drivers in the bakery sector.

The project addressed the following current consumer and industry needs:

- Consumers' needs and demands for healthier food products with added functional ingredients.
- Industry's need to innovate to meet consumer demands and boost business.
- Food manufacturers' needs to deal with by-products in an efficient sustainable way.

The project also addressed the significantly growing trend of home baking. Buying individual ingredients is equally as popular as buying bake mixes. Bake mixes are perceived as cost effective, minimizing waste and unwanted ingredients and a convenient solution for inexperienced bakers or people with busy lifestyles. Innovation is of great importance in this area, and consumers wish to have their favourite baked goods with added 'good for you' health claims and ingredients. Also, ingredients with healthy connotations provide food manufactures with a distinct competitive advantage. Struggling bakeries in the Republic of Ireland are continually looking for ways to innovate and apply cost effective methods to attract consumers, plus with healthy eating remaining a top consumer trend, there is a clear market niche for novel, natural ingredients for baked goods. Finally, the project addressed the issue of food waste/sustainability, whereby the flours utilised in this project (orange, apple and brewer's spent grain) are healthy, novel and recovered directly from commercial waste streams.

2. Research Approach

In the original FIRM-funded project, the nutritional and technological properties of the food by-products were characterised and successfully incorporated into novel bakery formulations. The final step, which was carried during this Research Plus project was to bring this work to a pre-commercial level and make it more applicable and relevant to industry. To do this, the new formulations would be amalgamated and packaged in an easy to use, healthy, ready-mix form, which would be commercially exploitable by relevant industry. These flour mixes would produce baked products (sweet and savoury) requiring minimum addition of ingredients, equipment and time by the end user.

To complete the above, the following methodologies were used:

TASK 1 Optimisation of ready-to-bake flour mixes containing the by-product flours (apple, orange or brewer's spent grain):

- Finalising the lists of ingredients for each bakery mix product.
- Formalising the standard operating procedures (SOP) for the end users (home baking, commercial bakery, catering services).
- Compositional, sensory and nutritional analysis of the optimised flour mixes, which included: Moisture, aW, peroxide value, fibre, protein, fat, antioxidant, colour and volatile compounds.
- Baking assessments of the final products, including: Specific volume, texture, structure, sensory analysis, fibre, protein, sugar, fat and antioxidant capacity.

TASK 2 Storage stability of the ready-to-bake mixes:

- Assessing the storage stability of the bakery mixes. This was undertaken via packing the four flours [wheat flour, apple pomace (AP), orange pomace (OP), brewer's spent grain (BSG)] in three different packaging materials (plain paper, kraft paper and matt white) which had different barrier properties. Every month the flours were analysed for changes in moisture content, aw, colour, water binding capacity, total phenol content and oxidative rancidity. The flours were tested every 3 months (Days 0, 90, 180, and 240) for changes in volatile compounds and a microbial assessment also took place on these intervals.
- The stability of the ready-to-bake flour mixes were identified in terms of sensory and nutritional properties when they were baked into products. The optimised ready-to-bake mixes from Task 1 were packaged in the 3 types of packaging described above and used for baking every 3 months (Day 0, 90, 180 and 240 of storage). The packages were stored in room temperature and at -20°C also.
- Mixes of wheat flour and 10% OP, AP, and BSG flours were packaged in the same packaging material and were used every 3 months for baking. The following types of mixes/products were assessed:
 - BSG soda mix
 - BSG ready mix
 - OP cake mix
 - AP scone mix

The following parameters of the baked products were assessed: Specific volume, crumb colour, crumb texture, moisture, aW, structure, phenols, fat, fibre, micro counts.

3. Research Achievements/Results

TASK 1: Optimisation of ready-to-bake flour mixes containing the by-product flours (apple, orange or brewer's spent grain):

Flours from food by-products, namely apple pomace, orange pomace and brewer's spent grain were prepared and incorporated as baking ingredients into the following ready-to-bake-mixes:

- A soda bread mix containing 10% brewer's spent grain (BSG) flour (flour weight basis) and wheat flour.
- A yeasted brown bread mix containing 10% BSG and wheat flour.
- A scone mix containing 10% apple pomace (AP) flour and wheat flour.
- A cake/muffin mix containing 3.5% orange pomace flour (OP) and wheat flour. The amount of the OP flour was determined to replace 40% of the fat normally used in a cake recipe.

The baked products resulting from the above mixes were analysed to determine their baking quality. Results of the baking properties in terms of volume, colour, texture and crumb structure highlighted the good quality of these products. The baked products were deemed to be highly acceptable by panellists in terms of flavour, texture, appearance, aroma and overall acceptability.

BSG and AP flours were used as means of increasing the fibre content of the baked products. The results support the hypothesis and allow for sustaining a 'high fibre' claim for the ready-to-bake mix. The OP cake mix was prepared with 40% less fat than a normal recipe which could possibly sustain a claim of a 'lower in fat' product'.

TASK 2: Storage stability of the ready-to-bake mixes:

The four flours and the ready-to-bake mixes were stored in 3 packaging materials (with various barrier properties) over a period of 240 days at room temperature and relative humidity, to determine their stability and their shelf-life.

Changes in the physicochemical properties of the by-products flours were observed. Aw and moisture content increased with time, and the rate of increase was dependant on the barrier properties of the packaging material and the hygroscopicity of the flours. Colour was also affected in the case of OP flour; this was not dependant on the packaging material. The nutritional properties were not significantly affected by storage.

The baking properties of the four flour mixes were not affected by storage. However, in the case of yeasted BSG bread, the stability of the dried yeast was an issue and affected the proofing time and as a consequence the final volume and texture of the breads. Overall, the ready-to-bake mixes provided consistent results in terms of quality and nutritional value of the baked products.

The by-product flours were found to be suitable for incorporation into ready-to-bake mixes. These novel mixes offer a distinct advantage of producing baked products with enhanced nutritional quality (rich in dietary fibre and bioactive compounds) using natural functional ingredients.

Table 1: Composition of the flours

Sample	Protein (%)	TDF (%)	Fat (%)	Total Sugars (%)
Wheat flour	9.2	3.65	1.3	3.3
AP	2.5	43.20	0.4	54.9
OP	5.3	47.55	1.0	26.5
BSG	17.1	39.00	7.0	13.2

Table 2: Baking properties of the products

Samples	L*	a*	b*	Hardness (N)	Slice Area (mm ²)	Slice Brightness	Number of Cells	Wall Thickness (mm)	Cell Diameter (mm)	Specific volume (ml/g)
BSG soda	49.6	9.2	25.9	32.1	4999	74.5	3555	0.4	1.9	2.1
BSG yeast	46.6	8.6	24.8	11.7	5549	68.2	2872	0.5	2.9	2.9
OP cake	70.9	0.3	30.3	1.3	2442	133.9	1535	0.5	2.8	2.8
AP scones	60.8	5.7	28.8	4.4	1466	105.6	982	0.5	2.1	2.3

Table 3: Nutritional properties of the baked products

Samples	Protein (%)	TDF (%)	Fat (%)	Total Sugars (%)	Total phenols (mg Gallic acid /100 g of dry sample)
BSG soda	7.5	4.4	2.7	3.8	0.4
BSG yeast	9.3	5.4	2.0	3.8	0.5
OP cake	6.2	2.4	10.2	26.9	0.5
AP scones	7.1	7.0	11.2	11.9	0.5



Figure 1: Yeasted breads with 10% BSG baked using flour mixes stored for 240 days: (L-R):- matt white (L), kraft paper, and plain paper packaging, and at 0 days (R).



Figure 2: Soda breads with 10% BSG baked using flour mixes stored for 240 days: (L-R):- matt white (L), kraft paper, and plain paper packaging, and at 0 days (R).



Figure 3: Scones with 10% apple pomace baked using flour mixes stored for 240 days in plain paper packaging (L), kraft paper, and matt white (R) packaging and 0 days (D).



Figure 4: Cakes with 10% orange pomace baked using flour mixes stored for 240 days in plain paper packaging (L), kraft paper, and matt white (R) packaging and 0 days (D).

4. Impact of the Research

Outcomes and impact from Task 1 (Optimisation of ready-to-bake flour mixes containing the by-product flours (apple, orange or brewer's spent grain)):

Flours from food by-products (apple pomace, orange pomace and brewer's spent grain) were prepared and incorporated as baking ingredients into ready-to-bake-mixes. The formulations were optimised for improved sensory and nutritional properties, which were investigated in both the flours and the subsequent baked products. Compositional and nutritional properties of the flours were investigated and documented.

The results of the analysis undertaken on the baked products indicated that they were highly acceptable by panellists in terms of flavour, texture, appearance, aroma and overall acceptability. BSG and AP flours were used as means of increasing the fibre content of the baked products. The results support the hypothesis and allow for sustaining a 'high fibre' claim for the ready-to-bake mix. OP cake mix can be prepared with 40% less fat than a normal recipe which could sustain a claim of a 'lower in fat' product. The results from this task will also be used set the quality standards to which the properties of the flours and the baked products will be compared to, to establish the stability and shelf-life of the flours.

The three types of scones prepared with the flours from the three by-products had similar characteristics in terms of volume, texture and structure. As expected, the colour varied significantly with AP scones having a light red-brown colour, the OP scones having a bright yellow colour and the BSG scones having a similar appearance a wholemeal scone. The fibre content was 6.9, 7.9, and 7.3% respectively.

The end users have been identified as the baking and catering industry, ingredients companies, milling companies and the consumer. The results of this task will provide all the information necessary for the use of these flours as baking ingredients, the process required, and the nutritional benefit of using them. It will also provide the end user with established formulations and SOPs.

Characterisation and evaluation of the by-products as baking ingredients was carried out during the original FIRM project. The results of this task have added to the scientific knowledge base in terms of the characterisation of these novel flours. Volatile analysis on these flours was performed which provided information on the aromatic compounds identified. An existing method used to measure oxidative rancidity on meat, was modified to allow monitoring lipid oxidation occurrence in flours.

Outcomes and impact from Task 2 (Storage stability of the ready-to-bake mixes):

The four flours were stored in 3 packaging materials over a period of 240 days at room temperature and relative humidity. Changes in the physicochemical properties of the by-products flours were observed. Aw and moisture content increased with time, and the rate of increase was dependant on the barrier properties of the packaging material and the hygroscopicity of the flours. Colour was also affected in the case of OP flour; this was not dependant on the packaging material. The nutritional properties were not affected significantly by storage.

The baking properties of the four flour mixes were not affected by storage. However in the case of yeasted BSG bread, the stability of the dried yeast was an issue and affected the proofing time and as a consequence the final volume and texture of the breads. Overall the ready-to-bake mixes provided consistent results in terms of quality of the baked product and nutritional value.

The results of this task provide a comprehensive evaluation of the stability of novel by-products flours in different types of packaging. They are relevant to the end users as they provide evidence for their shelf-life and stability during storage. The research findings progress the new product development process and brings the ready-to-bake mixes to a pre-commercial level.

Food by-products and their use as functional ingredients is an area that is currently attracting much interest. Information available on the characteristics of food by-products is comprehensive; however information on the stability and shelf-life of food by-products and their flours in particular is very limited. Our research findings add to the scientific knowledge base and they are valuable to the scientific/research community and industry in the area of functional ingredients. It highlights the physicochemical properties that are susceptible to change, which will be of great value to future research work exploring new applications.

4(a) Summary of Research Outcomes

(i) Collaborative links developed during this research

A significant number of companies were in receipt of information on this project, particular at one of the Gateways Teagasc events in May 2015, where the project was showcased to the food industry. The total number of companies in receipt of information was approximately 80.

Also, a number of confidential one-to-one meetings took place with a number of individual companies.

(ii) Outcomes where new products, technologies and processes were developed and/or adopted

The following confidential innovations are currently being investigated by industry:

- Drying trials involving fruit 'waste'.
- Cereal formulations containing BSG.

(iii) Outcomes with economic potential

Highly trained / skilled scientist – who has since been offered and accepted a senior R&D position at a multinational food company.

Improved links / collaborations with industry have been established.

(iv) Outcomes with national/ policy/social/environmental potential

None to report.

4 (b) Summary of Research Outputs

(i) Peer-reviewed publications, International Journal/Book chapters.
Ktenioudaki, A., et al. (2015). Application of bioprocessing techniques (sourdough fermentation and technological aids) for brewer's spent grain breads. Food Research International, 73: 107–116.

(ii) Popular non-scientific publications and abstracts including those presented at conferences
BSc Thesis by a final year food science student from DIT: Investigating the nutritional value, shelf-life and baking potential of novel flours generated from food by-products. Supervisors: Prof. Nissreen Abu-Ghannam (DIT), Dr. Eimear Gallagher (Teagasc), Dr. Anastasia Ktenioudaki (Teagasc).
Received a first class honour's mark, April 2015.

(iii) National Report
None to report.

(iv) Workshops/seminars at which results were presented
Teagasc Gateways event, June 2015. The project was showcased to industry.

(v) Intellectual Property applications/licences/patents
None to report.

(vi) Other

5. Scientists trained by Project

Total Number of PhD theses: 0

Total Number of Masters theses: 0

Undergraduate Thesis: BSc Thesis by a final year food science student: Investigating the nutritional value, shelf-life and baking potential of novel flours generated from food by-products. Supervisors: Prof. Nissreen Abu-Ghannam (DIT), Dr. Eimear Gallagher (Teagasc), Dr. Anastasia Ktenioudaki (Teagasc).
Received a first class honour's mark, April 2015.

6. Permanent Researchers

Institution Name	Number of Permanent staff contributing to project	Total Time contribution (person years)
Teagasc	1	0.174
Total	1	0.174

7. Researchers Funded by DAFM

Type of Researcher	Number	Total Time contribution (person years)
Post Doctorates/Contract Researchers PhD students Masters students Temporary researchers	1	0.655
Other	1	
Total	1	0.655

8. Involvement in Agri Food Graduate Development Programme

Name of Postgraduate / contract researcher	Names and Dates of modules attended
-	-

9. Project Expenditure

Total expenditure of the project:	€78,812
Total Award by DAFM:	€95,535.70
Other sources of funding including benefit in kind and/or cash contribution(specify):	€0

Breakdown of Total Expenditure

Category	Teagasc	Total
Contract staff		
Temporary staff		
Post doctorates	€55,238.26	€55,238.26
Post graduates		
Consumables	€4,108.95	€4,108.95
Travel and subsistence	€1,277.06	€1,277.06
Sub total	€60,624.27	€60,624.27
Durable equipment		
Other		
Overheads	€18,187.28	€18,187.28
Total	€78,811.55	€78,811.55

10. Leveraging

An unpaid final year BSc student completed his undergraduate project at Ashtown. His thesis title was 'Investigating the nutritional value, shelf-life and baking potential of novel flours generated from food by-products' and the student obtained a first class honour's mark for the project.

The project co-ordinator is also involved in the current KIC (Knowledge and Innovation Communities) EU initiative, and in the compilation of the proposal for the EI Prepared Consumer Foods Technology Centre.

11. Future Strategies

1. Continued research work with industry:

Collaborative work with industry as outlined above will continue, particularly in the area of by-product valorisation and use in novel food formulations.

2. Application of outputs from the project in future projects:

The co-ordinator of this project is currently a partner in a recently funded FIRM project (SweetLow), where a number of the methods and control formulations will be carried forward from the current project. She has also included the methods in 2 project proposals that she co-ordinated in the recent FIRM funding call. It is anticipated that these will also feature in future national and EU project submissions.