Teagasc

AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY

FINAL REPORT

Project RMIS No. 4914

Development of Organic Breads and Confectionery

The National Food Centre

RESEARCH & TRAINING FOR THE FOOD INDUSTRY

RESEARCH REPORT NO 75

DEVELOPMENT OF ORGANIC BREADS AND CONFECTIONERY

Editor-in-Chief: Dr Gerard Downey

Authors:

Eimear Gallagher MSc PhD
Denise Keehan BSc MSc
The National Food Centre, Ashtown, Dublin 15

Francis Butler PhD
Biosystems Engineering, University College Dublin, Earlsfort Terrace, Dublin 2

ISBN: 1 84170 432 6
July 2005

Agriculture and Food Development Authority

National Development Plan

Teagasc Oak Park Carlow Co. Carlow

CONTENTS

SUMMARY

In recent years, concern for the environment and consumer dissatisfaction with conventional food has led to growing interest in organic farming and food. The demand has also been fuelled by highly-publicised food scares. Food safety and genetic modification issues have led some consumers to opt for organic food as a safer alternative.

Recently, there has been a significant increase in the number of launches of organic bakery products in Ireland. As a result, there is an increased need to identify suitable organic bakery ingredients for use in bread and confectionery formulations. However, only a limited number of scientific studies on the physical, chemical and functional properties of organic flours and ingredients exist. The effects of commonly-used ingredients in baking, *i.e.* organic improvers and fats, on the baking characteristics of organic products have not yet been reported and little is known about the influence of approved additives that may be beneficial to organic baking.

Arising from these gaps in the knowledge base on the use of organic flours and ingredients, the objective of this study was to evaluate the chemical, rheological and baking characteristics of white, wholemeal and confectionery organic flours and to assess the baking potential of organic bakery ingredients, in particular improvers, fats and additives. Ingredients and baked goods were compared to non-organic controls.

Main outcomes from the project were:

- No significant differences were found between the four organic and one non-organic strong white flour varieties in terms of protein content and this would suggest that the organic varieties were comparable in quality to the control (a non-organic flour). All organic flours tested were found to have excellent mixing qualities *e.g.* long stability and tolerance to overmixing.

- Overall, no differences in strong white flour compositional and rheological characteristics were large enough to have negative influences

on baking characteristics. The small differences in flour enzyme activity, dough mixing tolerances and crumb lightness and yellowness values did not affect baking quality or acceptability.

- The organic bread improver was darker and more yellow in colour than the non-organic improver and this contributed to crust and crumb colour (L* and b*) characteristics. Organic fat contributed to darker crust appearance whereas non-organic ingredients contributed to a more yellow crust colour.

- Although some differences were found between the organic and non-organic wholemeal flours (*i.e.* protein content and mixing characteristics), loaves from most of the organic wholemeal flours were of similar quality (crumb texture and sensory acceptability) to the control which was produced with conventional non-organic ingredients.

- The addition of organic skim milk powder (SMP) had some negative effects on baked product qualities of the organic flours including a lower loaf volume, a significant yellowing of the crumb, and a significantly firmer crumb texture throughout the staling profile. While the addition of organic gluten, non-GM lecithin and organic cider vinegar had positive influences on crumb hardness characteristics in comparison to the control, this was not reflected in sensory acceptability ratings.

INTRODUCTION

Organic foods are products of a farming system that avoid the use of man-made fertilisers, pesticides, growth regulators and livestock feed additives. Instead, the system relies on crop rotation, animal and plant manures, hand-weeding and biological pest control. A conventional farming system is characterised by the use of easily-soluble artificial fertiliser while in an organic farming system, green manure and soluble nutrients from a naturally-occurring source are used.

Concern for the environment and consumer dissatisfaction with conventional foods have led to growing interest in organic farming and food. The demand has also been fuelled by recent highly-publicised food scares. Food safety and genetic modification issues have led some consumers to opt for organic food as a safer alternative.

Organic flour characteristics

Due to the different husbandry practices of organic growing, there is a tendency for the characteristics of organically-grown wheat varieties to be different from those obtained with non-organic farming methods (Cauvain and Young, 2001). Good management is, therefore, a prerequisite to the successful organic farming of wheat. A major concern in the organic production of bread-quality wheats is the achievement of sufficient grain protein content (Gooding *et al.*, 1993). This is the single most important property of wheat flour, as bread volumes and other important baking characteristics are directly related to the quantity of protein present. Also, in Ireland, the moist climate predisposes cereals to fungal diseases and weed infestation that are more difficult to deal with using organic methods than is the case in cereal-growing areas in Europe and North America which have a warm, dry climate. However, due to the fact that there are a limited number of published studies on the intrinsic characteristics of organically-grown flours and ingredients, there is still a large gap in knowledge in this area.

Other organic ingredients for baking

Additives or improvers are commonly added to baking formulations to improve some aspect of dough behaviour or baked bread quality. However, the range permitted in organic baking is limited. Commonly-used preservatives and ingredients for enhancing shelf-life in conventional baking, such as mono- and di-glycerides of fatty acids, diacetyl esters of monoglycerides (DATEM), calcium propionate, calcium stearoyl lactylate, polysorbate 60, potassium bromate and potassium sorbate, are prohibited. The use of synthetic colourings and flavourings together with irradiated or GM ingredients and derivatives is also prohibited (Stauffer, 2000). Additives that are permitted in organic bakery formulations include organic SMP, organic gluten, non-GM lecithin and organic cider vinegar. The effect of these ingredients, however, remains widely unknown and this lack of knowledge formed the basis of a section of this study.

METHODS USED TO ASSESS ORGANIC FLOUR CHARACTERISTICS

- Flour protein content was measured using a Leco protein analyser. The analysis is based on the Dumas method for nitrogen combustion *i.e.* the amount of nitrogen contained within the sample. A factor of N x 5.7 was applied for wheat flour samples and results were given as percentage protein. An adjustment was applied to calculate flour protein content at 14g/100g moisture content as follows:

$$PC = N \times 5.7$$

$$P_{DM} = \frac{PC \times 100}{100 - MC}$$

$$PC_{14} = \left(\frac{\frac{P_{DM}}{100}}{100-14} \right)$$

Where: N= Nitrogen

PC = Actual flour protein content

MC = Flour moisture content

P_{DM} = Protein @ dry matter

PC_{14}= Protein @ 14g/100g moisture content

- Amylase activity was assessed using the Hagberg Falling Number method (ICC Standard Method No. 107).

- Starch damage was measured using the Farrand FTWG Method 0005 (FTWG, 1964).

- Gluten quality and quantity of flour was estimated using the Gluten Index (ICC Standard method No. 155).

- Moisture content of flour was obtained using the ICC Standard method No. 110/1.

- Rheological properties of flours were evaluated using the Brabender Farinograph (ICC Standard method No. 115/1, see Figure 1). Flour added (adjusted to 14g/100g moisture content) was calculated as follows:

$$M = M^1 \text{ x } \left(\frac{86}{100 - MC} \right)$$

Where: M^1 = Flour mass at actual moisture content (300g)

MC = Flour moisture content (%)

M = Flour added (g)

Measurements obtained from the Farinograph torque curve were flour water absorption, dough development time, dough stability and degree of softening.

Figure 1. The Farinograph measures flour water absorption

- Extensibility of the dough and its resistance to extension were measured after a rest period of 45 minutes using a Brabender Extensograph (ICC Standard Method 114/1, see Figure 2).

Figure 2. The Extensograph measures wheat dough extensibility and other empirical rheological properties

METHODS USED TO ASSESS ORGANIC BREAD QUALITY

- Loaf specific volume (cm^3) was measured using rapeseed displacement.
- Crust and crumb colour were measured with a Minolta Chroma Meter (Figure 3).

Figure 3: The Minolta Chroma Meter measures colour in numerical terms.

- A texture analyser (TAXT2*i)* was used to assess crust and crumb characteristics. Crust penetration (cylindrical probe; 6mm diameter) and crumb texture profile analysis (cylindrical probe; 20mm diameter) were carried out to assess the staling profile of baked products.

- Loaf moisture was measured by the AACC two-stage drying method (Standard methods no. 62-05 and 44-15A).

- Digital image analysis was performed on the crumb grain by capturing images of the sliced breads using a flatbed scanner. The images were scanned full scale at 300 dots per inch and analysed in grey scale. A 60 x 60 mm square field of view (FOV) was evaluated for each image. This FOV captured the majority of the crumb area of each slice. Twelve digital images were processed and analysed for each batch, giving a total of 60 images. Image analysis was performed using SigmaScan Pro software. Seven measurements were taken from this analysis including total number of cells, total number of small cells, total number of large cells, cells/cm^2, mean cell area, total cell area and cell-to-total area.

For all trials, sensory acceptability tests were carried out on the products at 24h post baking and involved twenty untrained panellists who marked their acceptability ratings on a 5 cm line (0 cm = very unacceptable and 5 cm = very acceptable). Samples to be assessed in each trial were uniform in size (quarter of a slice x 1cm thick), served at room temperature and randomly-presented with allocated codes to identify each sample.

TRIAL 1: FLOUR QUALITY AND BREAD-BAKING CHARACTERISTICS OF COMMERCIALLY-AVAILABLE ORGANIC WHITE FLOURS

Introduction

The characteristics of organically-grown wheat varieties are often different (*e.g.* lower protein content) from those that are obtained with non-organic farming methods due to the different husbandry practices used in organic farming (Cauvain and Young, 2001). Therefore, the objective of this trial was to source and evaluate the composition and baking potential of four commercial brands of organic strong white flour: Doves Farm 'Biobake strong white baker's flour'; Rank Hovis, 'organic white baker's flour'; Allied Mills, 'strong organic white flour'; and Shipton Mills, 'traditional organic white flour'. They are addressed as Doves, Ranks, Allied and Shiptons for convenience in this publication. All organic flours were milled in the UK as there are no commercially-available organic flours produced in Ireland. The flours comprise blends of wheat from Canada, the Czech Republic and the UK to ensure adequate breadmaking protein quality. An Irish-milled, non-organic strong white flour (Odlums) was used as a control. This flour consisted of wheat blends from Canada, North America, Germany, UK and Ireland. Four batches of flour were obtained from the five suppliers over a six-month period. Each of the batches of flour represented different dates of milling at the relevant supplier's manufacturing plant. Overall, the work was replicated four times using a different batch of flour for each replicate.

Materials and Methods

The ingredients for the control non-organic bread were added (g/100g flour) as follows: water as per water absorption value (Brabender Farinograph), (62.9g), salt (2g), bread improver (1g), emulsified bread fat (1g) and fresh compressed yeast (2.5g). The organic breads were formulated as follows: (g/100g flour weight): water as per water absorption value (Brabender Farinograph), (61.7 – 62.3g), sea salt (2g), organic bread improver (1g), organic deodorised palm oil (1g) and fresh compressed yeast (2.5g).

Ingredients were added to produce sufficient dough for the six 300g loaves required for testing. Mixing of the ingredients was carried out in a Stephan high speed mixer to a temperature of 30°C at 1500rpm. Mixing time ranged from 2 min 10 sec to 2 min 25 sec to reach the required temperature. The resulting dough was divided into six 340g pieces, moulded by hand (Figure 4), rested for 7 min, moulded into roll shapes (using a Mono-moulder) and placed into pre-greased 454g tins. The dough was proofed for 55 min at 40°C and 80 – 85% humidity and then baked in a rotating oven for 20 minutes at 230°C. Loaves were then cooled to room temperature, placed in polyethylene bags and left on a stainless steel bench at room temperature until required for testing.

Figure 4: Moulding wheat dough by hand

Results

1: Flour compositional and mixing characteristics

Ranks, Allied and Shipton organic white flours had significantly higher moisture content than the control (Table 1). However, none of the flours exceeded the recommended maximum 14g/100g moisture content level and were safe for storage. The protein content of all flours was within an acceptable range for breadmaking (11 – 13g/100g, Table 1). These results suggest that the organic fertilisers were as effective as conventional methods in producing flours of breadmaking quality which were similar in quality to the non-organic flours. No significant differences were found for wet and dry gluten contents or gluten index values between the control and the organic flours tested which indicates that they had similar gluten quality to the non-organic control (Table 1).

Alpha-amylase is important for the hydrolysis of starch. Falling Number (FN) values above 400 (s) indicate that flours are deficient in α-amylase and that they should be supplemented with a form of amylase to achieve the desired level of enzyme activity. Doves, Ranks and Allied organic white flours were found to have a significantly higher Falling Number value than the non-organic control, indicating that these had lower levels of cereal α-amylase present (Table 1). Shipton was the only organic flour that had acceptable enzyme activity present and was similar to the control. This study did not compensate for enzyme activity deficiency by adding fungal α-amylase or malt flour. This was done to limit variability between the formulations and also to determine if enzyme activity deficiency had an adverse effect on baking characteristics.

Table 1: Compositional analysis of the non-organic control white flour (Odlums) and four organic white flours (Doves, Ranks, Allied and Shipton)

	Flour type						
	Odlums	Doves	Ranks	Allied	Shipton	Significance	SED
Protein content (g/100g)	12.4	11.8	11.3	12.4	11.6	NS*	0.51
Wet gluten (g/100g)	31.5	28.8	26.6	32.5	29.9	NS	2.11
Dry gluten (g/100g)	11.1	10.3	9.4	11.6	10.2	P<0.05	0.62
Gluten index (units)	93.2	95.5	96.9	88.7	92.4	NS	2.84
Moisture (g/100g)	12.6	12.9	13.5	13.7	13.5	P=0.05	0.36
Falling No. (s)	340	454	433	423	347	P<0.001	20.5
Starch damage (g/100g)	28.5	24.5	33.0	25.0	26.0	P<0.001	1.59

*not significant at p=0.05

Results for water absorption did not reveal any significant difference between the organic and non-organic flours (Table 2) and all had acceptable water absorption levels for breadmaking. Dough development time (DDT) (the point at which the dough is optimally developed and best able to retain gas) was significantly higher for all organic flours when compared with the control (Table 2). Therefore, the time taken for the organic flours to reach maximum strength and peak development during mixing took longer than the non-organic control. However, all results for the organic flours were within the guidelines outlined by Mailhot and Patton (1988) for white breadmaking flours (6 – 8 min).

Resistance to extension (R_m) is a measure of the ability of properly-developed gluten dough to retain gas. A higher resistance to extension is desirable as good breadmaking dough must have an ability to retain gas during baking. Ranks flour had a lower R_m than all other flours tested (Table 2).

Table 2: Empirical rheological characteristics of the non-organic white flour (Odlums) and four organic white flours (Doves, Ranks, Allied and Shipton).

	Flour type						
	Odlums	Doves	Ranks	Allied	Shipton	Significance	SED
Water absorption (g/100g)[1]	62.9	61.7	62.3	62.1	62.1	NS[3]	1.20
Dough development (min)	2.9	7.7	6.9	7.9	6.8	$P<0.001$	0.64
Resistance to extension (R_m) (EU)[2]	636	645	505	526	539	$P<0.05$	52.4

[1]Farinograph units

[2]Extensograph units

[3]not significant at p=0.05

2: Bread quality

Loaf volume results showed no significant difference between the organic and non-organic flours (Table 3). However, even though differences were found in cereal α-amylase, starch damage, dough development and resistance-to-extension between the flours, these did not have a negative influence on loaf volume.

Crust colour measurements of the organic varieties were not significantly different from those of the control, indicating that they had a similar level of Maillard browning reactions during baking. However, all organic white flours had a darker (lower L*) and more yellow (b*) crumb colour than the control (Table 3). These differences were also evident on visual inspection of the organic varieties.

Table 3: Baking characteristics of breads made from a non-organic white flour (Odlums) and four organic white flours (Doves, Ranks, Allied and Shipton).

	Flour type						
	Odlums	Doves	Ranks	Allied	Shipton	Significance	SED
Loaf volume (cm^3)	1436	1325	1440	1379	1416	NS[2]	57.0
Crumb L*	79.9	77.4	77.5	77.1	76.8	$P<0.05$	1.04
Crumb b*	12.3	16.4	15.1	15.5	15.1	$P<0.001$	0.44
Sensory analysis[1]	3.24	3.16	3.34	3.04	2.99	NS	0.15

[1]Sensory acceptability scale is from 1 (very unacceptable) to 5 (very acceptable); [2] not significant

Bakery products undergo a progressive, time-related deterioration in quality. Moisture migration occurs from the high moisture crumb to the low moisture crust until an equilibrium is reached. This results in a firmer crumb and a softer crust with increased moisture content. Flour type had no significant effect on crumb or crust hardness but the values did fluctuate over the 72h testing period (Table 4). A deficiency in α-amylase and the longer dough development times associated with some of the organic flours did not have a negative effect on loaf quality (*i.e.* firmer crumb texture) in comparison to the non-organic bread. Water absorption has also been linked to crumb texture and the levels for the organic flours were similar. This result supports the crumb texture findings (Table 4) *i.e.* no differences in crumb hardness.

Table 4: Crumb hardness [g] of breads produced from a non-organic white flour (Odlums) and four organic white flours (Doves, Ranks, Allied and Shipton) over a 72 hour period.

	Flour type				
	Odlums	Doves	Ranks	Allied	Shipton
24 hours[1]	101	124	113	121	130
48 hours	134	174	147	174	145
72 hours	177	199	195	201	177

Flour:	NS;	SED 22.9
Time:	$p<0.001$;	SED 8.2
Flour x time interaction	NS;	SED 27.3

[1]Post-baking

Sensory acceptability ratings on the loaves from the organic and non-organic flours carried out 24h post-baking were not significantly different (Table 3). The average rating for all flours was 3.15 (63%) out of a maximum rating of 5 (very acceptable). This indicated that all samples were deemed acceptable. The differences in flour compositional characteristics were consequently not large enough to have a negative influence on sensory acceptability ratings. This agrees with the loaf volume and crumb/crust texture measurements.

Conclusions from Trial 1

There was little or no difference in protein content, protein quality or baking characteristics between the organic white flour and the non-organic flours.

- Three of the organic flours were deficient in cereal α-amylase and would require a form of amylase addition (*e.g.* fungal α-amylase) to boost enzyme activity levels. However, this deficiency did not affect the baking characteristics.

- All of the organic flours had excellent mixing qualities *e.g.* long stability and tolerance to over-mixing. The organic varieties had significantly longer dough development times (DDT). However, in the trial, mixing was kept at a constant rate to minimise variability. This did not affect the baking quality.

- Organic loaves had similar loaf volumes to the non-organic control loaves. They also had a significantly darker and more yellow crumb colour. This was due to the darker and more yellow colour characteristics of the organic improver and fats. Crumb hardness values showed that the loaves from organic flours were comparable to the non-organic flours and sensory acceptability ratings were also similar.

TRIAL 2: THE EFFECTS OF ORGANIC AND NON-ORGANIC (CONTROL) IMPROVERS AND FATS ON BREAD QUALITY

Introduction

To date, no work has been reported on the effects of organic ingredients, namely fats and improvers, on the quality of baked goods. Our objective was to evaluate the effects of organic fat and bread improver on dough and bread characteristics. Two commercially-available organic flours were selected for this study and a non-organic flour was used as a control. Non-organic fat and improver (Figure 5) were also used for comparative reasons and these are referred to as 'control' ingredients in the Results and Conclusions sections.

Figure 5: Organic improver and fat (top left, top right) vs conventional improver and fat (bottom left, bottom right).

Materials and Methods

A non-organic (control) commercial flour (Odlums) and two organic commercial flours [Shipton and Doves (these had similar flour protein contents)] were used in this study. The organic and non-organic fats and improvers (Table 5) were combined with the three flours to give an experimental design of (3 flours x 4 ingredient combinations x 3 replications). The flours used were from one 32kg bag (for each flour type) to minimise the effect of batch-to-batch flour variability. Bread formulation, baking and analysis were identical to the procedures used in Trial 1.

Table 5: Combinations of organic and non-organic fat and improver ingredients used in Trial 2

Combination No.	Ingredient Combination
1	Non-organic fat plus non-organic improver
2	Non-organic fat plus organic improver
3	Organic fat plus non-organic improver
4	Organic fat plus organic improver

Results

Effects of flour type, organic fat and organic improver on bread characteristics

Apart from affecting crumb colour characteristics, the organic and control improvers and fats had little influence on baking quality when used with the Odlums flour. With Shipton flour, the control fat increased loaf volume but when organic fat was used, both loaf volume and sensory acceptability scores were lower. With Doves flour, the control fat also had a positive influence on loaf volume characteristics and resulted in loaves with a firmer crumb texture (Table 6). Image analysis showed that the organic improvers and fats produced smaller sized cells in the breadcrumb of all three flours (Figure 6). These are positive effects as cell size and cell uniformity are important quality characteristics for bakers and consumers. A fine cell structure is desirable, with the majority of the cells being small-to-intermediate in size. Sensory acceptability scores were not affected.

The protein content of the flours had an important effect on crumb image analysis results. As the protein content of the flours tested decreased (Odlums 12.5%, Shipton 12.0% and Doves 11.2%) the influence of the ingredients on crumb grain characteristics increased. For example, neither fat nor improver type had a significant influence on loaf volume characteristics for the higher protein control Odlums flour, whereas organic fat reduced loaf volume when used with the organic flours. Zghal *et al.* (2001) hypothesised that bread quality is principally influenced by the flour protein content. The findings of the present trial are in agreement with this hypothesis.

Scanning electron microscopy of the different dough combinations showed similar microstructures *i.e.* small and large starch granules were homogeneously and loosely distributed throughout the dough structure. Patches of embedded small and large starch granules within the gluten matrix were also evident (Figure 7). The micrographs indicated that all of the flour and ingredient combinations produced similar dough microstructures.

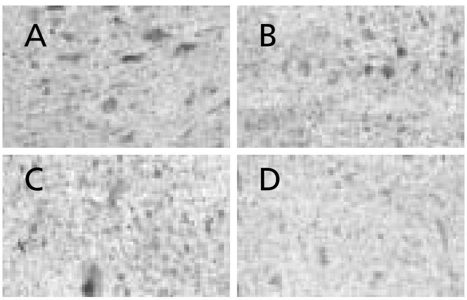

Figure 6: Sample images of bread crumb (using Odlums flour) containing non-organic ingredients (A); organic ingredients (B); organic improver plus non-organic fat (C); non-organic improver plus organic fat (D).

Table 6: Effect of flour (control: Odlums and two organic varieties: Doves and Shipton), fat and improver on the baking characteristics of white breads.

		Ingredient combination number			
		1	2	3	4
Loaf volume (cm^3)	Odlums	1434	1367	1404	1467
	Doves	1346	1334	1282	1291
	Shipton	1409	1391	1350	1349
Total number of cells	Odlums	3162	3310	3255	3417
	Doves	2911	3105	2845	3325
	Shipton	2915	2849	2859	3210
Crumb hardness (g) 24h[1]	Odlums	135	138	118	119
	Doves	133	140	132	140
	Shipton	151	149	158	160
48h	Odlums	167	180	171	177
	Doves	198	208	185	214
	Shipton	221	221	287	238
72h	Odlums	173	205	174	191
	Doves	239	223	207	257
	Shipton	274	250	303	242

[1]Post-baking

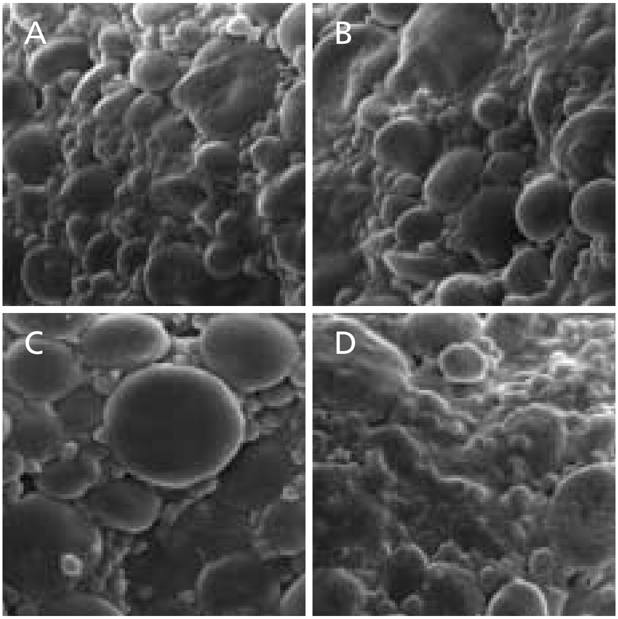

Figure 7: Scanning electron micrographs of dough (using Odlums flour) containing non-organic ingredients (A); organic ingredients (B); organic improver plus non-organic fat (C); non-organic improver plus organic fat (D).

Conclusions

- The different ingredients did not have a significant influence on loaf volume, sensory and textural characteristics when using three different flour bases.
- The organic bread improver was darker and more yellow in colour than its non-organic counterpart and this contributed to crust and crumb colour characteristics.
- Image analysis of the breadcrumb showed that cell numbers increased significantly and mean cell area decreased.

TRIAL 3: BREAD-BAKING CHARACTERISTICS OF COMMERCIALLY-AVAILABLE ORGANIC WHOLEMEAL FLOURS

Introduction

Recent years have seen a rapid increase in consumer demand for bread products with high dietary fibre content and a better nutritional image. This has led to a sharp rise in the production of high extraction flours *i.e.* wholemeal and other brown flours. A traditional wholemeal loaf has a low specific volume and a dense crumb structure (Galliard, 1986) largely due to the wheat bran component of the wholemeal and brown flours. However, recent developments in baking technology have produced loaves with a similar texture to the popular white, high-volume, soft-textured bread. These developments have also significantly increased consumer demand for wholemeal baked goods. Little research has been conducted on the flour and baking properties of organic wholemeal flours and there is limited availability of premium quality organic bread and baked goods in Ireland (Bord Bia Report, 2000). These factors prompted the current study with the dual objective of sourcing commercially-available organic and non-organic wholemeal flours in Ireland and evaluating the quality of these flours and characteristics of the resulting wholemeal bread.

Materials and Methods

Four commercial brands of organic strong wholemeal flour were sourced and are addressed as Doves, Ranks, Allied and Shipton for convenience in this trial. Flour protein and moisture analyses were carried out as described previously. Bran content was measured by sieving 100g of each flour type using a 500µm aperture (30-mesh) sieve and then weighing the bran that remained in the sieve. For bran particle size, 10g of bran from each of the flours with a higher bran content were sieved using sieves with apertures of 710µm (22-mesh), 1000µm (16-mesh) and 1680µm (10-mesh).

The formulation for the control, non-organic bread was based on a g/100g flour weight basis and was as follows: water added as per water absorption value measured with a Brabender Farinograph (71.1g), salt (2g), bread improver

(4g), emulsified bread fat (1g) and fresh compressed yeast (3g). The organic breads were formulated as follows: water added as per water absorption value (69.4 – 70.9g) (Brabender Farinograph), sea salt (2g), organic bread improver (4g), organic deodorised palm oil (1g) and fresh compressed yeast (3g). Loaves were produced and tested according to the methods described previously.

Results

1: Organic wholemeal flour compositional and mixing characteristics

The organic wholemeal flours had approximately 2g/100g less protein than the non-organic flour (Table 7). While Ranks and Allied flours had adequate protein content for breadmaking, the protein contents of Doves and Shipton organic flours were below (1g/100g & 0.7g/100g respectively) the breadmaking requirements as outlined by Mailhot and Patton (1988) (13.5 – 16g/100g). The different results with the wholemeal flour may be due to the protein contents of the flours which may in turn be due to a lower soil N content (Starling and Richards, 1993). Soil fertility (N availability) plays a major role in determining wheat and therefore flour protein content. A shortfall in protein content may be alleviated for these organic flours by adding non-organic gluten as part of the 5% non-organic ingredient level that is permitted when making organic bread. Gluten was not added to flours in the current study in order to limit variability. Organic wholemeal flours had a similar moisture content to the non-organic control flour. Dough development time (DDT) is the time at which the dough is optimally developed and best able to retain gas. Results for the wholemeal flours show that the DDT for the non-organic controls was increased significantly in comparison to the non-organic white flour studied in Trial 1 (see data in Table 1 and Table 7). According to Krishnan *et al.* (1987), the DDT is longer if coarser (larger bran particle size) wheat bran is used. This may explain the large difference between the non-organic white and wholemeal DDT results although the higher protein content of the wholemeal control flour may also increase DDT. Mixing criteria of wholemeal flours stipulate that a peak DDT should be reached within 7 – 9 min. Therefore, Ranks and Allied flours could be considered weaker with less gas-retaining potential.

2: Organic wholemeal bread quality

Odlums (control) wholemeal flour had a coarser bran particle size than the organic wholemeal flours and produced the highest loaf volumes due to the higher protein content of this flour. Doves flour had the finest particle size (and a low flour protein content) and the loaves had a lower volume than the control (Table 7). Loaves from Doves and Allied flours had a darker (lower L*) and more yellow (b*) crumb colour than the control while all of the organic loaves had a darker crust than the control.

Shipton loaves had a significantly softer texture (24 h post-baking) than the control despite the fact that the mixing characteristics of this flour were similar to the others tested (Figure 8). However, the protein content was below wholemeal flour standard requirements and the bran particle size was smaller than the control. These factors may explain the softer textural characteristics. Loaves from Allied organic flour had a significantly harder crumb and a lower volume; these may have arisen from the large bran particle size of Allied wholemeal flour and its low gas-retaining capability [as indicated by Farinograph DDT measurements (Table 7)]. Doves flour also produced loaves of low volume but the crumb texture was not firmer. This flour had a finer bran particle size and increased gas-retaining capability (longer DDT).

There was no difference in sensory acceptability between the organic and non-organic loaves (Table 7) and the differences in crumb and crust texture were not reflected in the sensory acceptability ratings

Scanning electron micrographs of all the doughs showed a similar pattern of small and large starch granules that were mostly covered and firmly embedded within the thick gluten matrix. There was also evidence of some loosely-distributed starch granules that were not covered by gluten film in both the organic and non-organic varieties. It is noteworthy that there was little evidence of the presence of bran particles in any of the micrographs of wholemeal doughs even though the doughs contained approximately 15% bran.

Table 7: Flour and bread characteristics from non-organic (Odlums) and organic (Doves, Ranks, Allied and Shipton) wholemeal flours measured 24 hours post-baking.

	Flour Type						
	Odlums	Doves	Ranks	Allied	Shipton	Sig.	SED
Protein content (g/100g)	14.8	12.5	13.4	13.5	12.8	p<0.01	0.31
Dough development (min)	9.3	7.3	5.8	5.3	8.8	p<0.001	0.29
Loaf volume (cm^3)	1244	1096	1200	1027	1233	p<0.001	35.3
Crust L*	44.9	40.1	36.3	41.3	38.5	p<0.001	1.38
Crumb b*	20.6	21.4	20.9	321.6	19.9	p<0.001	0.27
Sensory analysis (cm)[1]	2.78	3.24	3.47	3.33	3.66	NS[2]	0.37

[1]Sensory acceptability scale is from 1 (very unacceptable) to 5 (very acceptable)

[2]not significant at p=0.05

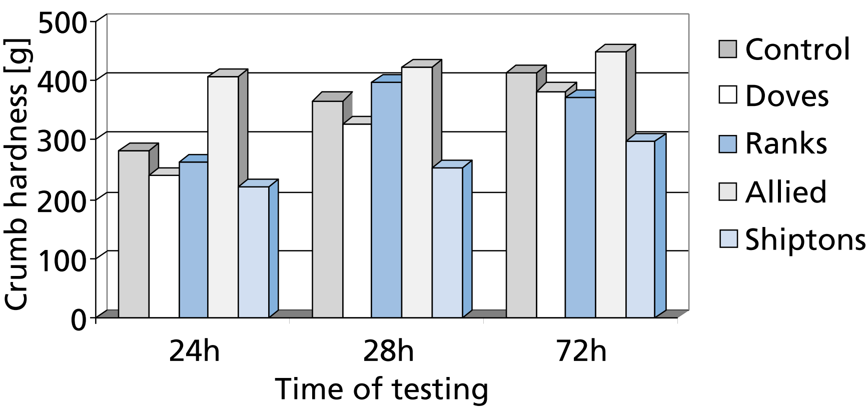

Figure 8: Bread crumb hardness values for Odlums non-organic and Doves, Ranks, Allied and Shipton organic wholemeal flours over a 72-hour period post-baking

Conclusions

- Although some differences were found between the organic and non-organic wholemeal flours (*i.e.* protein content and mixing characteristics), loaves from most of the organic flours (Doves, Ranks and Shipton) were of similar quality with regard to crumb texture and sensory acceptability.

- Allied flour contained larger bran particles and gave doughs with a lower gas-retaining capability and breads with a firmer crumb texture. The characteristics of this flour could be improved by milling the bran to a smaller particle size and by mixing to an optimum regime.

- The lower flour protein contents of the organic wholemeal flours could be alleviated by the permitted addition of non-organic gluten as part of the 5% non-organic ingredient level.

- Studies on dough microstructure showed similarities between organic and non-organic wholemeal dough structure.

TRIAL 4: EVALUATING THE EFFECTS OF ORGANICALLY-APPROVED ADDITIVES IN BREAD BAKING

The use of additives in baked products is increasing world-wide because of the advantages they offer such as improved dough handling properties, increased product volume, softer crumb texture, increased crumb shelf life and improved slicing characteristics of bread. Additives that are permitted in organic baking are limited. Common preservatives and ingredients used in conventional baking for extending shelf-life are prohibited. Inclusion of synthetic colourings and flavourings, irradiated or genetically-modified (GM) ingredients and derivatives in organic food are also prohibited. Therefore, due to these constraints, this trial studied the effects of adding approved organic additives (individually) to an organic white wheat bread formulation. The approved additives selected for study were: organic skimmed milk powder (SMP), organic gluten, non-GM lecithin and organic vinegar.

Materials andMethods

Two organic commercial flours (Shipton and Doves) were used in this study. The white bread formulation, baking and testing methods were identical to those used in Trial 1. Water absorption analysis was also carried out on the flour containing either the added SMP or gluten as these were in powdered form. This ensured that the bread formulation facilitated the additional water uptake by these ingredients. The organic improvers were added separately (based on 100g flour weight) as follows: organic skimmed milk powder (6g), organic gluten (2g), non-GM lecithin (0.4g) and organic cider vinegar (1g). The control loaves were baked from each of the two selected flour types but contained no organic additives.

Results

With Doves flour, the inclusion of either non-GM lecithin or organic cider vinegar produced breads with the highest volumes when compared with the control (Table 8). When using Shipton as the flour base, the addition of organic gluten produced significantly higher volume loaves than the control. The addition of lecithin and vinegar to the Shipton flour produced loaves which were not significantly different from the control.

Table 8: Effects of organic SMP, gluten, non-GM lecithin and organic vinegar addition on the loaf volume (cm^3) of breads made from Doves and Shipton organic flours

Flour	Added ingredient				
	None (control)	SMP	Gluten	Lecithin	Vinegar
Doves	1340	1286	1371	1448	1424
Shipton	1441	1266	1483	1452	1442

Flour	$p<0.001$;	SED 9.24
Added ingredient	$p<0.001$;	SED 14.61
Interaction	$p<0.001$;	SED 20.66

Crust and crumb colour results were similar following addition of the improvers to both flour types. All loaves with SMP had a darker crust colour than the control for both flour types (Table 9). This is due to the presence of approximately 40% of lactose in the milk solids. This sugar is not fermented by the yeast during baking but is available for a Maillard browning reaction between reducing sugars and amino groups during this process. The inclusion of the organic SMP also had a significant yellowing effect on crumb colour of the loaves produced with both types of organic flour. The inclusion of lecithin, vinegar and gluten to the bread formulation did not affect the crumb lightness values.

Table 9: Effects of organic SMP, gluten, non-GM lecithin and organic vinegar addition on loaf crust lightness (L*) values of breads made from Doves and Shipton organic flours

Flour	Added ingredient				
	None (control)	SMP	Gluten	Lecithin	Vinegar
Doves	52.6	42.5	48.7	43.8	44.0
Shipton	52.9	43.8	51.5	48.7	52.9

Flour	$p<0.001$;	SED 0.504
Added ingredient	$p<0.001$;	SED 0.798
Interaction	$p<0.001$;	SED 1.128

Skim milk powder addition produced a significantly harder crumb texture 24 h post-baking for the Doves and Shipton flours while lecithin inclusion resulted in loaves with a significantly softer crumb. The addition of organic gluten, lecithin or vinegar gave a softer crumb texture than the control. Callejo *et al.* (1999) reported that addition of gluten increased dough flexibility and reduced firmness and crumb staling of bread. Also, possible adsorption of the additives onto wheat starch granules may prevent the starch granules from taking up water released by the added gluten. Thus, more water is available to the crumb, thereby resulting in a softer crumb texture.

Similar sensory acceptability ratings were obtained for all breads containing additives irrespective of the type of flour used and the firmer crumb texture of loaves with organic SMP did not influence acceptability ratings.

Conclusions

- Addition of organic SMP had some negative effects on the baking characteristics for both organic flours including a lower loaf volume, a yellowing of the crumb and a firmer crumb texture throughout the staling profile.
- Organic gluten increased loaf volume by 2% and crumb hardness was reduced at 72h post-baking by 12% and 21% for Doves and Shipton organic white flours respectively.
- The addition of organic gluten, non-GM lecithin and organic cider vinegar improved crumb texture characteristics. However, these effects were not reflected in the sensory tests.
- There are some negative aspects in the use of these ingredients in baking. These include the extra expense and the handling difficulties within a bakery processing environment. Organic cider vinegar or acetic acid is also a corrosive ingredient and its presence may be undesirable in a bakery processing plant.
- This study showed that while the ingredients improved some quality attributes based on the physico-chemical tests, the effects were small in practical terms as indicated by the sensory acceptability ratings. This shows that the benefits are small and that their inclusion may not be worth the extra expense.

TRIAL 5: FORMULATION AND ASSESSMENT OF ORGANIC CONFECTIONERY

Small-scale tests were undertaken to assess the composition and baking potential of organic confectionery flours and ingredients. Only two organic confectionery flours (Shipton and Doves) could be sourced. Both organic flours had a longer DDT (a similar result to the strong white flours indicating that the flours were tolerant to mixing), lower flour moisture content and lower water absorption than the Odlums non-organic control confectionery flour. Therefore, before the baking trials commenced, water levels in the formulations were adjusted accordingly.

Baking trials for muffins and Madeira cakes were completed using the following combinations:

1: Odlums flour + non-organic ingredients (fat and improver) (this was considered the control formulation)
2: Odlums flour + organic ingredients
3: Doves flour + organic ingredients
4: Shipton flour + organic ingredients

Combinations 1 and 2 compared non-organic *vs* organic ingredients in a non-organic flour. Combinations 3 and 4 studied the effects of using different organic flours.

The baking tests gave similar results for the muffin and the Madeira trials. Muffins and Madeira cakes produced with the organic flours and ingredients were lower in volume, had a darker crumb colour and a firmer crumb texture than the Odlums flour. Texture profile analysis results showed that all

Table 10: Baking characteristics of Madeira cake made with non-organic and organic flours and ingredients.

Cake measurement	Ingredient combination			
	1	2	3	4
Volume (cm^3)	784	723	732	715
Crumb b*	27.74	26.87	27.46	25.98
Crumb hardness at 24h (g)	1066	1363	1083	1274
Crumb hardness at 72h (g)	1239	1634	1267	1427

products staled at a similar rate over the 72 h testing period (Table 10). Sensory acceptability tests revealed no significant differences between the samples despite the fact that the volumes and physical appearance of the organic products were notably different to their non-organic counterparts.

OVERALL CONCLUSIONS

- The organic flours tested had excellent mixing qualities *i.e.* long stability and tolerance to over-mixing. The organic varieties had significantly longer dough development times (DDT) than the non-organic flours. However, in these trials the mixing rate was kept constant to minimise variability.

- The differences in flour compositional and rheological characteristics were small and did not have a negative influence on baking characteristics. The small differences in flour enzyme activity, dough mixing tolerances and crumb lightness and yellowness values did not affect baking quality or acceptability.

- The organic bread improver was much darker and more yellow in colour than the non-organic and this contributed to different crumb and crust colour characteristics.

- Some differences were found between the organic and control (non-organic) wholemeal flours (*i.e.* protein content and mixing characteristics). However, loaves from Doves, Ranks and Shipton were of similar quality (*i.e.* crumb texture, and sensory acceptability) to the control. The mixing characteristics, in particular DDT and stability, and bran characteristics influenced the baking characteristics for these flours. Allied flour had a larger bran particle size and produced doughs with a lower gas-holding capability and this had a negative influence on baked loaf quality.

- The addition of organic SMP resulted in a reduced loaf volume, increased yellowing of the crumb and gave a firmer crumb texture throughout the staling profile for both flour types. The addition of organic gluten, non-GM lecithin and organic cider vinegar had a crumb softening effect over the 72h shelf life tests.

- Organic confectionery flours and ingredients produce muffins and Madeira cakes with reduced volumes and darker crumb appearance. However, staling rate is similar to non-organic confectionery products.

RECOMMENDATIONS TO INDUSTRY

- Millers can confidently use organic white flours and should be able to produce blends of comparable quality to non-organic blends.
- Bakers should be familiarised with the mixing characteristics (*e.g.* DDT) of the flours in order to optimise the mixing regime and facilitate adequate dough development.
- If needed, the mixing and gas-holding abilities of organic wholemeal flours can be improved by milling the bran to a smaller particle size and by mixing to an optimum regime (shorter mixing time).
- Although organic additives such as gluten, non-GM lecithin and cider vinegar improve crumb texture, this was not perceived in sensory panels. Therefore, the extra expense of addition and the difficulties in handling within a bakery processing environment may minimise their benefit.
- The composition and baking potential of organic confectionery flours and ingredients is comparable to non-organic ingredients.

ACKNOWLEDGEMENTS

We thank Aidan Morrissey, Stephen Flynn, Karen Hussey and Thomas Walshe for their valuable technical inputs to this project.

SELECTED PUBLICATIONS FROM THIS PROJECT

Keehan, D., Butler, F. and Gallagher, E. 2005. Flour quality and bread-baking characteristics of commercially-available organic white flours. *European Food Research and Technology* (submitted).

Stojceska, V., Butler, F., Gallagher, E. and Keehan, D. 2005. A comparison of the ability of several small and large deformation rheological measurements of wheat dough to predict baking behavior. *Journal of Food Engineering* (submitted).

Gonzales-Barron, U. and Butler, F. 2004. Comparison of seven thresholding techniques with the k-means clustering algorithm for measurement of bread crumb textures by digital image analysis. *Journal of Food Engineering* (in press).

Keehan, D., Gallagher, E. and Gormley, T.R. 2004. Evaluating the baking potential of organic flours. *Milling Technology*, February, 151-153.

Keehan, D. 2004. Evaluating the baking characteristics of commercially available organic flours and ingredients. M.Eng.Sc. Thesis (University College, Dublin).

Gonzales-Barron, U. 2005. Quantitative assessment of bread crumb quality using digital image analysis. Ph.D. Thesis (University College, Dublin).

Stojceska, V. 2005. The use of small and large strain rheological measurements to predict baking performance of bread and cake goods. Ph.D. Thesis (submitted)

REFERENCES

Bord Bia Report. 2000. Regulatory Framework for organic agriculture, pp 10–29.

Callejo, M.J., Gil, M.J., Rodriguez, G. and Ruiz, M.V. 1999. Effect of gluten addition and storage time on white bread pan quality: Instrumental evaluation. *Food Research and Technology*, **208**: 27 – 32.

Cauvain, S. and Young, L. 2001. Flour. In: *Baking problems solved* (Cauvain, S. and Young, L., eds.). Woodhead Publishing Limited, Cambridge, England pp. 19 – 37.

Galliard, T. 1986. Wholemeal flour and baked products. In: *Chemistry and Physics of Baking*, (Blanshard, J.M.V, Frazier, P.J. and Galliard, T., eds). The Royal Society of Chemistry, Burlington House, London, WIV OBN, pp 199 – 215.

Gooding, M.J., Davies, W.P., Thompson, A.J. and Smith, S.P. 1993. The challenge of achieving breadmaking quality in organic and low input wheat in the U.K – A Review. *Aspects of Applied Biology*, **36**: 189 – 198.

Krishnan, P.G., Faubion, J.M. and Hoseney, R.C. 1987. Effect of commercial oat bran on the characteristics and composition of bread. *Cereal Chemistry*, **64**: 55 – 58.

Mailhot, W.C. and Patton, J.C. 1988. Criteria of flour quality. In: *Wheat: Chemistry and Technology, Volume II* (Pomeranz, Y., ed). American Association of Cereal Chemists, St. Paul, Minnesota, pp. 69 – 90.

Starling, W. and Richards, M.C. 1993. Quality of commercial samples of organically-grown wheat. *Aspects of Applied Biology*, **36**: 205 – 209.

Stauffer, C.E. 2000. Going totally organic. *Baking and Snack* (April), pp 50 – 58.

Zghal, M.C., Scanlon, M.G. and Sapirstein, H.D. 2001. Effects of flour strength, baking absorption and processing conditions on the structure and mechanical properties of bread crumb. *Cereal Chemistry*, **78**: 1 – 7.

The National Food Centre

RESEARCH & TRAINING FOR THE FOOD INDUSTRY

Ashtown, Dublin 15, Ireland.

Telephone: (+353 1) 805 9500

Fax: (+353 1) 805 9550