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Wheat Flour Properties and End-Product Quality

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Contents

WHEAT FLOUR PROPERTIES AND END-PRODUCT QUALITY

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SUMMARY

- For pizza production, the flour quality values identified for the wheat cultivars, Promessa, Quintus (spring), and Soissons (winter) should be used as guidelines in selecting new cultivars and in the development of flour specifications.
- Similarly for biscuit production, compositional and rheological data for the cultivars, Riband, Woodstock (soft-milling) and Brigadier (hard-milling) should be used for identifying biscuit flours.
- The rheological properties of dough (as measured by the alveograph, extensograph and farinograph) did not relate to the baking quality for some wheat cultivars. However the rheological properties of the gel protein prepared from these flours explained their baking quality. The very high elastic moduli of these gels explained the basis of shrinkage of pizza bases produced from Baldus and Lavett flours and biscuits produced from Ritmo flour.
- Gluten index values >80 indicate a strong gluten and 50 - 60 medium quality. Gluten index is a rapid test to segregate flours into those suitable for pizza bases (strong gluten) or biscuits (medium quality). However the differentiation of gluten quality within each category was not good enough in some instances, to identify the flours that produced baked products of inferior quality.
- Gluten quality was too strong and protein content too high for a German flour used on its own for pizza bases. Its baking properties were dramatically improved when blended with an English flour.
- In sauce production, the use of chemically modified cooked starches affected apparent viscosity, flavour profile and textural characteristics of sauces in chilled or frozen convenience foods.
- A small number of commercial flour samples had particularly low native stickiness while others had relatively higher values. Some difference was detected in the range of stickiness values ex-mixer on addition of fungal alpha-amylase. This increase was magnified when doughs were allowed proof for 45 minutes, flours with lowest native stickiness increasing to a greater extent than those with higher native stickiness.

- In batter production it was evident that wheat cultivar had a major influence on the coating characteristics of the fish batters produced. Of the cultivars tested, the hard milling winter wheat cultivar Rialto performed best under the cooking test.
- There was a linear relationship between the weight of coating on the raw fish and the viscosity of the batter mixture. Peak paste viscosity of the batters and alpha-amylase activity did not affect coating properties. There was only a weak relationship between protein content and coating properties. The level of starch damage in the flours did not influence the viscosity of the batters.

INTRODUCTION

Many prepared consumer foods incorporate flour as an ingredient. Existing flours do not always satisfy the requirements of industry, as high speed processing lines used in modern production have a low tolerance for behavioural variations in flour doughs. For example, in industrial production it has been observed that pizza bases and biscuits often differ in quality from day to day. This can be attributed to (i) batch to batch variation in flour, (ii) alterations to pizza/biscuit recipe or (iii) changes in pizza/biscuit processing. The ultimate explanation remains unclear.

The quality of the protein in a flour is one of the main criteria in determining its end-use. After dough formation, the water insoluble fraction of flour protein is referred to as gluten. The manner in which a piece of gluten stretches or shrinks has a profound effect on the end-product. Flour for industrial production of pizza bases requires a "strong extensible gluten" so that after the dough pieces are pressed out they retain their shape. This is essential for pizzas that are to be boxed. Flour with too strong or too weak a gluten, would result in the dough pieces not being the required diameter. Flour for biscuit production on the other hand should contain a "weak extensible gluten" so that the dough will stretch easily and retain its shape after sheeting.

Many factors other than cultivar affect gluten quality. These include:

- growing conditions of the wheat crop, including season and the presence of disease
- handling of grain post harvest, i.e. drying at too high a temperature or delay in drying high-moisture grain
- presence of incorrect quantities of minor ingredients that may act as gluten modifiers in the dough
- changes in production method without adequate care in rebalancing the recipes.

The objective of this project was to identify the quality aspects of a flour to be used for pizza bases, biscuits, sauces and batters. This was achieved by assessing the compositional, rheological, and baking / cooking properties of a range of flours produced from home-grown and imported wheats. Investigations included :

(i) flour quality for pizza base and biscuit production (The National Food Centre);

(ii) sauce rheology, and evaluation of commercial wheat flours milled to the same specification (University College Cork)[1];

(iii) rheology and adhesion of fish batter coatings produced with flour from home- grown wheat cultivars (University College Dublin)[2].

The relevant research results are referred to in the summary of this report, technical details are given for the work performed at The National Food Centre.

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MATERIALS AND METHODS

Materials

Flour samples for investigation were prepared, using a Buhler mill from wheat (home-grown and imported) supplied by the Department of Agriculture and Food and a commercial mill. Commercial pizza and biscuit flours were sourced from a local mill.

Flour was produced for pizza bases from hard-milling wheat cultivars (six spring and three winter) and for biscuits from winter wheat cultivars (four hard and two soft- milling). The wheat samples were from the Department of Agriculture and Food field trials (1994-1996 harvests) at ten locations. The samples were pre-selected prior to milling, to comply with the millers' purchasing standards for protein content and Falling Number.

▲ Glutomatic system for estimating gluten index to give an indication of gluten quality.

Methods

The methods used to investigate flour quality were compositional, rheological and baking tests. By combining data from these three groups of tests, the suitability of flours used in pizza bases or biscuits could be predicted.

Compositional tests

The compositional tests refer to protein content, total gluten content, gluten index and gel protein weight. Gluten index is a rapid method for measuring wet gluten characteristics and gives an indication of gluten quality. The total gluten content and gluten index were estimated using a Glutomatic system. An indication of amylase activity was obtained from the Falling Number test.

Rheological tests

Rheological quality refers to the machining properties of dough. These include elasticity, resistance, extensibility, development time, stability, degree of softening and water absorption. Rheological properties were measured using the Chopin alveograph, Brabender extensograph and farinograph.

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

Of particular significance is the elasticity modulus, termed G prime (G'), which is measured using a Bohlin dynamic rheometer. The Bohlin measures the viscoelastic properties of the protein and separates the measurement into elastic and viscous components. Gluten, the main protein of wheat flour, consists of two main fractions known as glutenin and gliadin. It is believed that differences in breadmaking quality of wheat, that can be attributed to protein, reside mainly in the glutenin fraction (gel protein). This fraction was extracted, weighed and the gel protein subjected to dynamic rheometry in a Bohlin rheometer. The G', which relates to the elasticity of the dough, was calculated.

▲ Measuring the elasticity modulus of glutenin using a Bohlin VOR rheometer

BAKING TESTS

Pizza bases were produced from mechanically developed yeast dough. Dough pieces (120g) were reduced in height and sheeted to give a pizza base of 17.8cm (7”) diameter. Pizza base baking tests involved measurement of the area of the base before and after proofing, height after proofing, area and height after baking, oven spring, volume, crust and crumb colour. Colour was measured with a Hunter colour meter. The baked pizza bases were evaluated for texture profile using an Instron universal testing machine. Parameters measured were hardness, springiness, adhesiveness, cohesiveness, gumminess and chewiness.

Biscuits were produced from a short dough. The dough was sheeted to 3mm thickness and biscuits cut out using a 7cm diameter biscuit cutter. Biscuit baking tests included measurements of the volume, shrinkage, eccentricity (a measure of the distortion of the shrinkage) and texture of the biscuits. Texture was measured as the force required in Newtons to fracture the biscuit using a Kramer shear press.

RESULTS AND DISCUSSION

Flour for pizza bases from home-grown wheat

COMPOSITION

Protein content, Falling Number, total gluten content, gluten index and gel protein weight were investigated for their ability to aid in the prediction of flour quality for a range of wheat cultivars. These cultivars included Alexandria, Baldus, Devon, Lavett, Promessa, Quintus (spring) Genesis, Rialto and Soissons (winter).

Flour protein content ranged from 9.3% - 10.9% (at 14% moisture) and Falling Number from 245 - 347 sec. Total gluten content for all cultivars was slightly lower than for the commercial flour used as a control. These flours had protein content lower than the control flour (11.5%) and this would have influenced the total gluten result. Gluten index values for the majority of the cultivars were similar or higher than the control flour. Of the winter cultivars, Soissons had a gluten index value higher and Genesis and Rialto lower than the control flour (Table 1).

Table 1: Flour quality: mean values for pizza base flour from home grown spring & winter wheat (1994 - 96)

Cultivar	Gluten index %	Gel weight[1]	Volume (ml)	Oven spring (cm)
Spring				
Alexandria	90	9.89	572	0.78
Baldus	97	10.74	633	0.72
Devon	96	10.23	610	0.69
Lavett	99	11.40	565	0.61
Promessa	96	9.96	582	0.63
Quintus	90	10.56	527	0.47
Significance	***	NS	***	***
SED	2.73	0.91	60.99	0.09
Winter				
Genesis	89	8.81	523	0.52
Rialto	86	6.11	562	0.70
Soissons	98	8.35	596	0.64
Significance	**	***	**	NS
SED	3.54	0.56	20.23	0.37
Control[2]	95	9.58	610	0.56

[1] g/5g defatted flour

[2] Commercial pizza flour

NS = not significant; SED = standard error of difference

Gel protein weight (glutenin fraction of gluten extracted from flour) displayed no significant differences between spring cultivars. However, there were significant differences between winter cultivars, with Rialto having an exceptionally low gel protein content. The spring cultivars, Baldus and Lavett on the other hand had the highest gel protein content each year. Overall, the gel protein weight of the spring cultivars was slightly higher than the control flour (Table 1).

Considering the compositional measurements overall, the spring cultivars in each instance had higher values than their winter counterparts. The one exception was the winter cultivar, Soissons, which had a gluten index as good and better in many instances than the spring cultivars.

Rheological properties

The resistance of a dough to stretch and its extensibility are measured by the alveograph P and L values and by the extensograph max R and E values. Significant differences existed between the cultivars for these alveograph and extensograph measurements as well as alveograph deformation energy (W) and elasticity index (Ie) (Table 2). Overall, spring cultivars were not consistent in their ranking for these parameters. Winter cultivars were more consistent due to the wider variation in their overall flour quality.

▲ Chopin alveograph

When compared to the control flour, the spring and winter cultivars behaved differently for each of the alveograph and extensograph parameters. Some cultivars had values lower and others higher than the control (Table 2). Ie values on the other hand were an exception. They were all similar to the control with the exception of Baldus and

Lavett (spring) which were higher and Genesis and Rialto (winter) lower.

Significant differences between spring cultivars were observed for farinograph flour water absorption, dough stability and degree of softening but not for development time. The spring cultivars were not consistent in their ranking for these measurements. Winter cultivars on the other hand were more consistent, due to the wider variation in their overall flour quality. Some cultivars had values for farinograph measurements lower and others higher than the control. Alexandria (spring), Genesis and Rialto (winter) had much higher degree of softening and lower stability than the control, indicating their inferior gluten quality and unsuitability for pizza flour.

The investigation for protein quality by subjecting gel protein to dynamic rheometry using a Bohlin rheometer was a new venture for Irish flours. There was a significant difference in the elastic modulus of the gel protein at each of the frequencies investigated (0.1 - 10Hz) for both the spring and winter cultivars but not between years. Baldus and Lavett (spring) had the highest and Genesis and Rialto (winter) the lowest elastic modulus at each frequency. Elastic moduli for the former cultivers were much higher and for the latter, much lower than the control flour. Promessa, Devon (spring) and Soissons (winter) had values that were the most similar to the control (Fig 1).

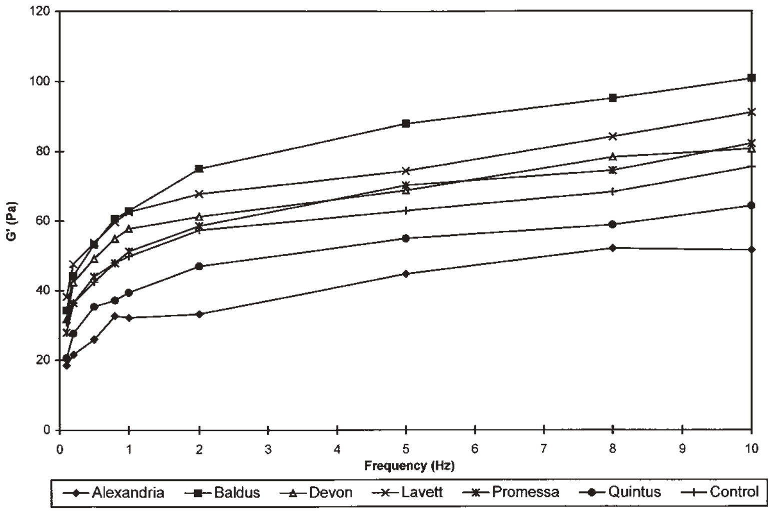


Figure1: Mean elastic modulus (G') of spring wheat (1994 - 96) and commercial pizza flour

Collectively, the above tests showed that some instruments were better than others in segregating pizza flours on a quality basis. For example, a Bohlin rheometer "elasticity modulus" and a alveograph "elasticity index" identified the cultivars Baldus and Lavett as possessing very elastic glutens, and Genesis and Rialto very weak glutens. Subsequent baking tests confirmed these findings.

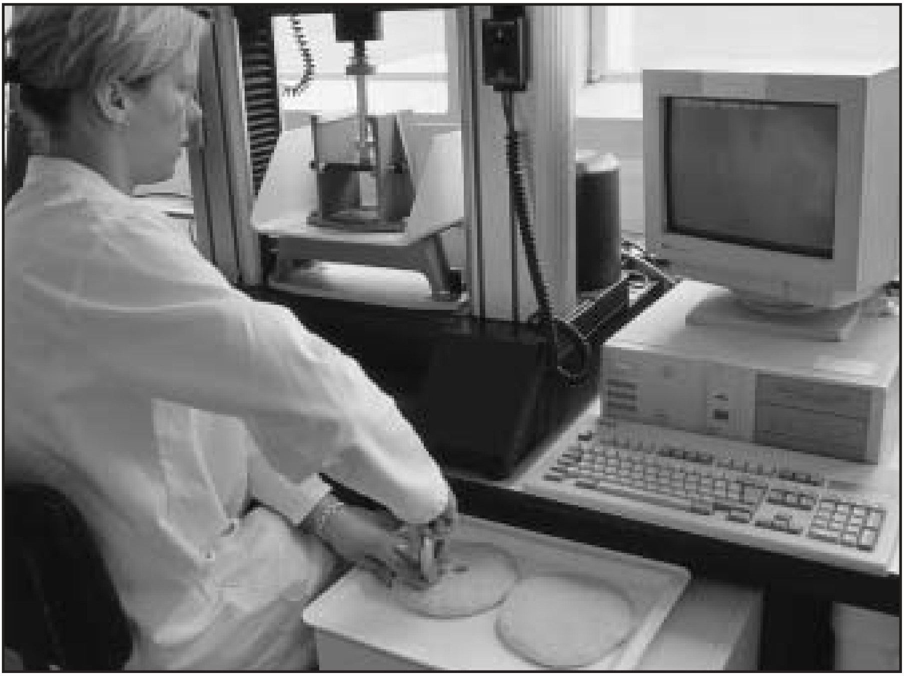
Table 2: Flour quality: mean rheological properties for pizza base flour from home-grown spring & winter wheat (1994 - 96)

Cultivar	Alveograph				Extensograph		
	P (mmH_2O)	L (mm)	W (J)	Ie (%)	Max R (EU)	E (cm)	R/E (EU)
Spring							
Alexandria	103.5	69.5	247.4	52.6	778	16.0	49.2
Baldus	65.5	106.5	223.6	59.9	741	17.9	42.0
Devon	96.0	90.5	276.9	52.7	782	18.1	44.0
Lavett	90.6	104.5	312.9	59.0	837	17.8	47.4
Promessa	62.5	128.7	223.1	52.5	912	16.7	55.3
Quintus	67.1	127.1	238.2	52.0	823	19.6	44.8
Significance	***	***	***	***	**	NS	NS
SED	3.17	11.67	16.56	1.60	85.00	1.89	6.64
Winter							
Genesis	82.9	63.0	175.0	44.6	828	13.1	56.1
Rialto	84.1	53.6	155.1	39.3	732	13.0	58.6
Soissons	77.7	92.5	236.6	56.8	899	14.9	60.3
Significance	NS	***	***	*	**	*	NS
SED	3.87	7.38	13.72	6.59	37.67	0.76	3.87
Control[1]	86.5	88.4	242.7	51.9	848	16.7	51.0

[1]Commercial pizza flour

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

NS= not significant; SED= standard error of the difference



▲ Measuring pizza bases for texture profile using an Instron universal testing machine

BAKING TESTS

There was a significant difference between the cultivars for the baking parameters investigated. These included, volume, height of the pizza bases after proofing and baking, oven spring (the difference between the previous heights), and the areas of the bases at the different stages of production. The base area before and after proofing and after baking was smallest for Baldus and Lavett and largest for Genesis and Rialto. In all seasons, Baldus and Lavett had very high elastic moduli compared with the other cultivars. This was reflected in the shrinkage of the pizza bases before and after baking with resulting increase in their height. Genesis and Rialto on the other hand, had very low elastic moduli compared with the other cultivars and the control. In this case there was a flowing of the dough pieces with a subsequent decrease in height of the pizza bases. Such pizza bases would be unacceptable on a production line where a uniform product is required.

Texture profile analysis of the pizza bases indicated significant differences between the spring cultivars in springiness with Devon being the most springy. Baldus and Lavett had the hardest, most chewy and most gummy bases and Quintus and Promessa the least. Of the winter cultivars, Soissons had the least chewy, cohesive and gummy base and Genesis the most. Pizza bases should not be too hard, chewy and gummy nor too soft.

Overall the cultivars, Promessa, Quintus (spring) and Soissons (winter) produced the most acceptable pizza bases and most similar to the control. Baldus, Lavett (spring), Genesis and Rialto (winter) were the least acceptable.

Flour for biscuits from home-grown wheat

Composition

Composition was investigated for flour from hard (Brigadier, Hussar, Reaper and Ritmo) and soft-milling (Riband and Woodstock) winter wheat cultivars.

Flour protein content ranged from 8.4 - 8.8% and the Falling Number from 210 - 279 sec. An indication of gluten quality and quantity was obtained from the Glutomatic test, with flours from soft and hard-milling winter wheats giving gluten index values lower than those obtained from the spring and bread-type winter cultivars used for pizza flour. The lower values are in line with the different type of gluten quality required for biscuit flour, i.e. a softer, more extensible gluten. Of the cultivars tested, Ritmo had a high gluten index value and much higher than the control biscuit flour. Other cultivars were only slightly higher than the control (Table 3). The total gluten content of all cultivars was similar to that of the control flour.

Gel protein weight differed significantly between cultivars. Ritmo had the highest gel weight each year and was much higher than the control flour; Hussar on the other hand, had the lowest.

Overall, the compositional measurements suggest that all cultivers with the exception of Ritmo might have possibilities as sources of biscuit flour.

Table 3: Flour quality: mean values for biscuit flour from home-grow winter wheat (1994 - 96)

Cultivar	Gluten index %	Gel weight[1]	Volume (ml)	Shrinkage (%)	Eccentricity (%)	Force (N)
Brigadier	59	5.15	19.7	19.9	6.0	2.29
Hussar	59	3.42	19.4	20.4	6.5	1.69
Reaper	59	6.08	20.9	23.4	8.1	2.16
Riband	61	5.86	22.4	19.1	6.6	2.01
Ritmo	76	7.89	20.2	25.8	7.8	1.88
Woodstock	54	6.12	21.5	21.4	6.3	2.14
Significance	NS	***	*	***	*	NS
SED	6.79	0.58	1.00	0.77	0.72	0.21
Control[2]	51	6.13	22.2	20.5	6.7	2.13

[1] g/5g defatted flour
[2] Commercial biscuit flour
NS = not significant; SED = standard error of the difference

Rheological properties

Alveograph and extensograph measurements showed differences between cultivars. Alveograph values for the soft-milling wheat cultivars Riband and Woodstock were similar and in line with the control flour data. Ritmo, on the other hand, was the least similar, exhibiting a much stronger gluten than the control flour. Extensograph parameters also indicated that Ritmo had a much stronger, and Woodstock a similar gluten to the control (Table 4).

Flour water absorption (measured by the farinograph) of the soft-milling cultivars Riband and Woodstock were similar to the control flour (52.3%) compared with the hard-milling cultivars which were higher (58-60%). However, as biscuits are a low moisture product, flour with a low water absorption is preferred. Dough development time and stability for all cultivars (with the exception of Ritmo) were slightly lower than the control. The differences however, were of no real significance.

Measurement of protein quality using a Bohlin rheometer showed there was a difference between cultivers in the elasticity modulus of the gel protein for the biscuit flour cultivars. Hussar and Ritmo had values for elastic modulus that were were much higher than the control at each frequency investigated (Fig 2).

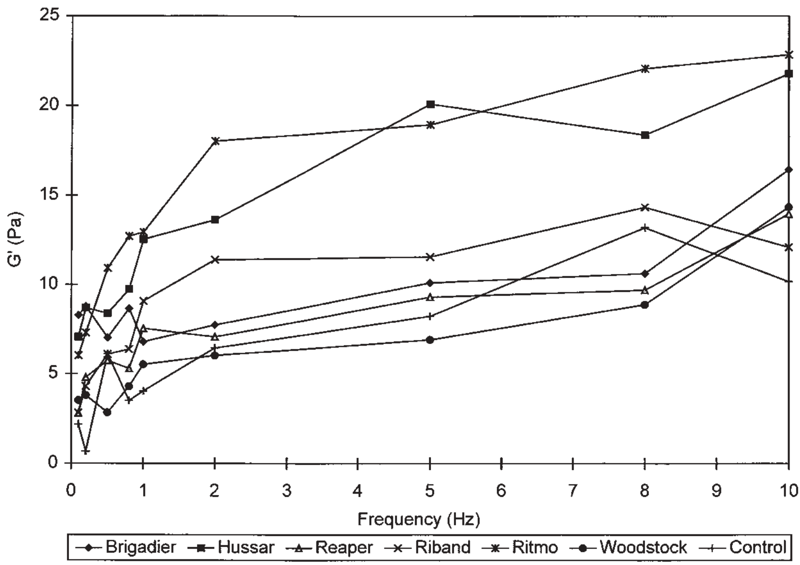


Figure 2: Mean elastic modulus (G′) of winter wheat (1994 - 96) and commercial biscuit flour

The rheological tests on the previous page indicate that some instruments were better than others in segregating biscuit flours on a quality basis. For example, a Bohlin rheometer "elasticity modulus" identified the cultivars Ritmo and Hussar as possessing glutens that were much more elastic than the control. Subsequent baking tests confirmed these findings.

Table 4: Flour quality: mean rheological properties for biscuit flour from home-grown winter wheat (1994 - 96)

Cultivar	Alveograph				Extensograph		
	P (mmH_2O)	L (mm)	W (J)	Ie (%)	Max R (EU)	E (cm)	R/E (EU)
Brigadier	56.7	33.4	68.1	0.0	432	11.6	37.7
Hussar	62.5	30.5	72.3	2.0	364	11.8	31.5
Reaper	59.6	57.2	98.9	30.8	448	15.5	30.0
Riband	33.5	72.1	59.0	29.8	461	14.7	32.1
Ritmo	68.4	65.0	133.3	37.6	656	14.9	46.4
Woodstock	33.8	77.7	62.6	30.7	553	14.8	39.3
Significance	***	***	***	***	***	***	**
SED	2.62	5.39	7.21	2.39	39.29	0.90	4.45
Control[1]	29.0	82.0	60.0	34.6	608	15.0	40.5

[1] Commercial biscuit flour
P = resistance to deformation; L=measured abscissa to rupture or extensibility;
W =deformation energy; Ie= elasticity index; R= resistance; E= extensibility
SED = standard error of the difference

Baking tests

Tests for baking quality indicated a difference between cultivars. The most important aspects of biscuit quality are texture of the finished product and absence of shrinkage and eccentricity (a measure of the distortion of the shrinkage). Biscuits with the least shrinkage and eccentricity were produced from the cultivars Brigadier and Riband followed by Woodstock and Hussar. Ritmo had much higher shrinkage and eccentricity than the control indicating its unsuitability for biscuit production. Riband had values for volume similar to the control, followed by Woodstock ; Hussar had the lowest volume. There was very little difference in colour between the cultivars and the control.

Texture was measured as the force (in Newtons) required to fracture a biscuit using a Kramer shear press. Results varied between cultivars. However, Woodstock, Reaper, Brigadier, and the control were similar and Riband slightly less firm. Hussar and Ritmo on the other hand produced softer biscuits (Table 3).

Relationships between the test variables for flour quality

There were a number of statistically significant correlations present for all flour-types investigated. Correlations higher than 0.6 were considered to be of practical value to bakers, and these are given in Table 5. In flour for pizza bases alveograph dough extensibility was strongly correlated with the farinograph dough stability. This indicated a relationship between the strength of the gluten and a flour's tolerance to mixing i.e. the stronger the gluten, the greater the stability. The alveograph elasticity index correlated with the rheometer elasticity modulus. This confirms the elasticity modulus as an indicator of gluten quality. Volume was highly correlated with the area of the dough pieces at the different stages of production and also oven spring. These data show that changes in pizza base shape and height influenced the final volume and appearance of the product. Various aspects of pizza base texture were also highly correlated with volume. These included hardness, springiness, cohesiveness, gumminess and chewiness as indicated from an Instron texture profile analysis. Increases in springiness and decreases in hardness, gumminess and chewiness were associated with higher pizza base volume.

Biscuit flour exhibited some inverse as well as positive correlations. Degree of dough softening was correlated to maximum resistance, and to a lesser extent to deformation energy and elasticity index. These data show that the degree of softening was influenced by the strength of the gluten present in the flour. Biscuit flour should have a weak extensible gluten. The presence of a strong elastic gluten in a biscuit flour would have serious consequences resulting in shrinkage and eccentricity of the biscuits. The relationships of degree of softening with maximum resistance, deformation energy, elasticity index were all inverse i.e. low values for the latter gave a high degree of softening and vice versa. All the following correlations were positive. The gel

Table 5: Relationships between the test variables for flour quality that may be of practical value to bakers

Variable	Correlation coefficient (r)
Pizza base flour	
Extensibility (L)[1] x dough stability[2]	0.66***
Volume x area before proofing	0.91***
Volume x area after proofing	0.94***
Volume x area after baking	0.94***
Volume x oven spring	0.85***
Volume x base hardness[3]	0.73***
Volume x base springiness[3]	0.92***
Volume x base cohesiveness[3]	0.93***
Volume x gumminess[3]	0.75***
Volume x chewiness[3]	0.75***
Elasticity index (Ie)[1] x elasticity modulus(G′)[5]	0.66***
Biscuit flour	
Gel protein weight x extensibility (L)[1]	0.62***
Gel protein weight x elasticity index (Ie)[1]	0.62***
Lx Ie[1]	0.81***
Deformation energy (W)[1] x maximum resistance[4]	0.62***
Deformation energy (W)[1] x development time[2]	0.62***
Deformation energy (W)[1] x dough stability[2]	0.71***
Deformation energy (W)[1] x biscuit shrinkage	0.74***
Deformation energy (W)[1] x degree of softening[2]	-0.61***
Elasticity index (Ie)[1] x degree of softening[2]	-0.62***
Maximum resistance[4] x degree of softening[2]	-0.73***

[1] Alveograph
[2] Farinograph
[3] Instron texture profile analysis of pizza bases
[4] Extensograph
[5] Bohlin rheometer

protein weight correlated with the alveograph extensibility and elasticity index. High gel protein weight is associated with dough exhibiting strong elasticity, which if present in biscuit flours will result in excessive shrinkage in the final product. Deformation energy was correlated with a range of other measurements investigated. These included extensograph maximum resistance of dough to stretching, farinograph dough development time, stability, and also shrinkage of the biscuits (Table 5).

The deformation energy is considered to be closely related to flour strength, and many users of the alveograph rely on this value in predicting the processing behaviour of the flour being evaluated. However, even though many of the correlations were significant ($p<0.001$), the actual correlation values obtained would indicate that using one quality test in isolation would not give a complete indication of gluten quality.

Effect of additives on flour from home-grown and imported wheats

The effect of additives on flours from home-grown and imported wheats was investigated on a limited basis. The individual flours of a commercial pizza flour blend (Irish, English, French and German), were assessed at two protein levels; as-is and with the addition of dry gluten to give a uniform protein concentration of 11%. Each was investigated with and without the addition of improvers i.e. pre-blend (containing minor bakery ingredients), L-cysteine hydrochloride and alpha-amylase. Differences were found in compositional and rheological properties between the flours from different countries, between the different protein levels of the same flour and between the flours with and without the improvers. The German and French flours produced the lowest volume and bake height. The French flour produced the hardest, least springy and most gummy base. The German flour had high protein content and an exceptionally strong gluten which resulted in its unsuitability for the baking procedure used. However, when this flour was blended with English flour, the resulting pizza bases had the best volume and product quality. These results suggest that the German and French flours would not be suitable for pizza base production without the addition of Irish and/or English flours, thereby emphasizing the advantages of blending flours with different properties for specific end-use applications.

CONCLUSIONS

- The rheological properties of dough as measured by the alveograph, extensograph and farinograph revealed that these tests are good indicators of gluten quality. However, with certain flours when these tests were used on their own to identify flour quality, misleading results were obtained.
- These problem flours were identified by the Bohlin rheometer. Such flours had very high elastic moduli.
- An indication of gluten quantity and quality was obtained from the gluten index test. Flour from spring and bread-type winter wheats gave higher values than those obtained from the soft and hard-milling winter wheats. Gluten index values >80 indicate a strong gluten suitable for pizza base flour while values in the range 50 - 60 show medium quality for biscuit flour. However differentiation using the gluten index within each category was not good enough in some instances to identify the flours that produced baked products of inferior quality.
- Despite variation in compositional, rheological and baking properties between seasons, certain cultivars were more suitable than others for either pizza bases or biscuits. Promessa, Quintus (spring) and Soissons (winter) were the most suitable for pizza base flour, and Riband (soft-milling) followed by Brigadier (hard-milling) and Woodstock (soft-milling) the most suitable for biscuit flour.
- Flour from hard-milling biscuit wheat had a higher water absorption (58.0 to 60.0%) than flour from the soft-milling wheats and the control biscuit flour (52.5%). As biscuits are a low moisture product, flour with a low water absorption should be used.
- Investigation of a commercial pizza flour blend showed the advantages of blending flours with different properties. Gluten quality was too strong and protein content too high for the German flour used on its own. Its baking properties were improved when blended with the English flour.
- The newer methodologies investigated for measuring gluten quality and the data generated were of particular interest to the milling and baking

industries. These included the elasticity modulus of the gel protein as measured by a Bohlin rheometer, the alveograph elasticity index and the gluten index. As the elasticity modulus of the gel protein had potential for identifying flours that produced baked products of inferior quality, trials with commercial flour samples were carried out successfully in collaboration with flour millers.

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LIST OF PUBLICATIONS FROM THIS PROJECT

Dwyer, E. and. O'Halloran, G.R. Rheological, compositional and functional properties of Irish biscuit flours from different harvests. (In preparation)

O'Halloran, G.R. and Dwyer, E. 1996. Compositional and rheological properties of flours in relation to end product quality (Abstract). Irish *Journal of Agricultural and Food Research*, **35**, (2): 197-198.

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