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LIPID QUALITY FACTORS IN BREEDING NEW ZEALAND WHEATS

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ABSTRACT

Possible relationships between lipid carbohydrate and baking quality were investigated in wheat samples representative of the 1984 New Zealand harvest. A series of 21 flours derived from 163 randomly selected samples were each baked in replicate using mechanical dough development (MDD) and bulk fermentation (BF) procedures. Flours were also analysed for their petroleum ether (40-60 °C)-extractable lipids, and lipid carbohydrate was determined as galactose equivalents using an anthrone-sulphuric acid colourimetric procedure. Statistical analysis of the results showed that there was no correlation between the MDD loaf volume scores and lipid carbohydrate. In contrast, the correlation coefficient, r, for the relationship between BF loaf volume scores and lipid carbohydrate was -0.62 (DF = 17). This relationship is significantly different from zero at a level of greater than 0.01. The relationships examined were not good enough to predict BF loaf volume scores from lipid galactose analyses. Moreover, the relationships are opposite in direction to those reported for North American flours.

KEYWORDS

Lipid galactose, loaf volume prediction, anthrone-sulphuric acid, colourimetric.

INTRODUCTION

Studies on the polar lipids of wheat flours, particularly the mono and di-galactosyldiglyceride glycolipid components of the polar lipids, indicated that galactolipids improve bread quality (Morrison, 1978). Studies on Kansas Hard Red Winter (Chung, 1982) and Canadian Spring Wheat (Bekes, 1983) cultivars found strong positive correlations between loaf volume and quantities of lipid carbohydrate, and between loaf volume and glycolipids respectively. (Glycolipid carbohydrate is mainly galactose (Morrison, 1978).) Bushuk *et al.* (Bekes, 1983) claimed the development of a quick screening test to predict loaf volume from their lipid data. In another study, their volume equations successfully predicted loaf volumes to within 5% of the experimentally measured values (Zawistowska, 1984). The longheld goal of using lipid data for screening samples in plant breeding programmes (Chung, 1982) may be close to being realised, in North America at least. In England however, the results of similar work on UK wheats have been less encouraging (FMBRA, 1984) and work has subsequently been discontinued (FMBRA, 1985).

One of the potential advantages of using lipid data is that analyses using HPLC techniques only require very small quantities of sample, allowing very early screening of breeding lines. Such a screening test could be used to complement electrophoretic and sodium dodecyl sulphate (SDS) analyses.

To examine relationships between baking quality as measured by loaf volume, and glycolipids in New Zealand wheats, a simple colourimetric analysis for lipid carbohydrate using an anthrone reagent was developed. Flours derived from a random selection of samples from the 1984 New Zealand harvest have been analysed to examine the relationships between lipid carbohydrate and loaf volumes to determine whether there is potential in New Zealand for a screening test based on lipid data.

MATERIALS AND METHODS

One hundred and sixty three randomly selected samples, representing lines of wheat harvested in New Zealand during 1984 were used in this study. Originally 200 lines were chosen, but 37 were eliminated either because of sprout damage or because there was no sample left after harvest testing. The weight of each sample was recorded and the samples were then mixed according to their harvest bakescores to give 21 bulked samples. After cleaning, each bulk was thoroughly divided to ensure homogeneity and milled on one of four Brabender Junior Quadrumat mills. Milling order and mill choice were randomised to minimise effects of extraction rate on flour lipid concentrations.

Five replicates of each flour were baked on the Wheat Research Institute's 50 g mechanical dough development (MDD) (1.5% fat) and two replicates of each flour were baked on the 125 g bulk fermentation (BF) (no fat) test baking systems using the following recipes:-

	50 g MDD	125 g BF
Flour	50 g	125 g
Salt	2%	2%
Ammonium Chloride	—	0.05%
Sugar	0.75%	0.75%
Bromate	50 ppm	30 ppm
Ascorbic Acid	100 ppm	—
Yeast	3%	2%
Fat	1.5%	—

The test baking was carried out using block designs with the inclusion of standards so that any possible systematic variations in the results could be eliminated.

The volume scores of the loaves were determined by height measurement and rape seed displacement for the 50 g MDD and 125 g BF loaves, respectively.

The flours were analysed for petroleum ether-extractable total lipid. Lipid carbohydrate in these lipids was determined as galactose (Chung, 1982) based on the premise that glycolipid carbohydrate is mainly galactose (Morrison, 1978).

The free total lipids were removed from duplicate 10 g samples of flour by one hour Soxhlet extraction with redistilled 40-60°C petroleum ether and weighed after drying in vacuo to constant weight (3-5 hours). The lipids extracted from each 10 g sample of flour were then dissolved in chloroform and the solutions made up to 100 ml in volumetric flasks. The lipids in each of three 1.0 ml aliquots of each chloroform solution were then analysed for lipid carbohydrate using the anthrone-sulphuric acid procedure of Yamamoto and Rouser (Yamamoto, 1970). Hence for each flour, six replicate lipid carbohydrate analyses were performed.

The standard absorbance v. galactose concentration curves were set up using 0, 30, 50, 100, 150 and 200 microgram per ml standard galactose solutions preserved with 2 mg/100 ml phenyl mercuric acetate. The equation for the standard curve was:-

$$\text{Absorbance} = 0.0389 + 0.00589\ [\text{Galactose}]$$

for which $r = 0.99$ for 67 degrees of freedom.

All baking and analytical replicate data were examined for normality of distribution and outliers. Suspected outliers were tested by application of the procedures of Grubbs and Beck (Grubbs, 1972) and eliminated from the data if confirmed. The replicate data were then combined and the means determined. The means of the analyses of each of the 21 flour samples were also checked for normality of distribution before carrying out regression

Table 1. Milling, baking and lipid analyses.

Flour	Extraction (%)	50 g MDD loaf vol. score	125 g BF loaf vol. score	Total lipid (mg)	Lipid carbohydrate[1]
1	52.5	-0.4	17.5	78.4	5.6
2	45.8	0.6	18.0	73.5	4.3
3	44.6	4.6	—	80.9	6.7
4	52.2	3.6	23.5	75.0	5.2
5	51.2	3.0	21.0	76.1	6.0
6	52.7	6.4	20.0	73.8	5.7
7	48.3	7.2	17.0	69.9	6.3
8	52.2	7.8	—	71.5	5.0
9	48.8	4.8	16[2]	69.8	6.6
10	50.8	8.6	21.5	80.8	5.8
11	48.5	10.6	24.5	84.6	5.0
12	40.1	9.0	21[2]	76.6	6.0
13	49.8	5.8	20.5	77.2	3.9
14	52.2	8.6	20.5	67.3	6.5
15	44.2	9.8	22.5	71.0	4.5
16	55.0	10.8	25.0	70.8	4.2
17	44.8	9.2	21.5	81.3	5.0
18	56.6	7.6	22.5	78.0	4.4
19	54.2	8.8	20.5	76.1	4.7
20	54.0	11.6	26.0	83.0	4.5
21	48.0	12.0	27[2]	75.0	4.3

[1] mg galactose equivalents per 10 g flour.
[2] Single analysis only.
MDD Mechanical dough development
BF Bulk fermentation
Total Lipid = mg per 10 g flour, soxhlet extraction, petroleum ether
50 g MDD loaf volume (cc) = 5.7 (LV score) + 238.9 (Baruch, 1984)
125 g BF loaf volume (cc) = 18.3 (BF score) + 300 (Baruch, 1984)

analyses. Regressions were calculated by the Model I method for Berkson's case (Berkson, 1950) (absorbance v. galactose concentration standard curve) and by the Model II method for bivariate normal distributions (loaf volume v. lipid galactose).

RESULTS

Table 1 shows the means of replicate extractions, loaf volumes and lipid analyses for the flours milled for this study.

Figure 1 shows the plot of loaf volume score v. lipid galactose for the 125 g BF test bake results.

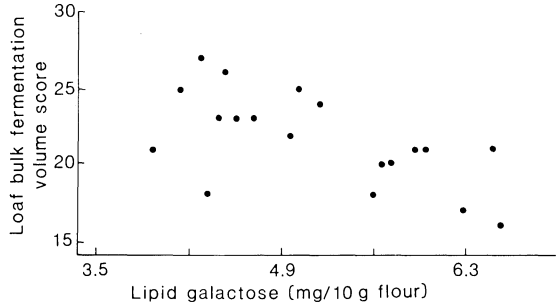

Figure 1. 125 g bulk fermentation loaf volume score v. lipid galactose.

The correlation coefficient r = −0.62 (DF = 17) for this relationship is significantly different from zero at a level greater than 0.01 (Rohlf, 1981). In contrast, the correlation coefficient r = −0.28 (DF = 19) for the plot of 50 g MDD loaf volume score v. lipid galactose was not statistically significantly different from zero.

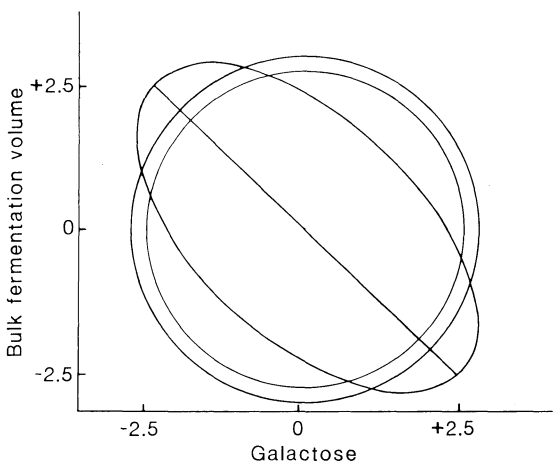

Figure 2. Equal frequency ellipse for standardised normal scores (95% confidence level).

Figure 2 shows the 95% homothetic ellipse about the normalised BF volume and lipid galactose scores. If there was no correlation, the ellipse would be the outer circle shown on the diagram. The ellipse encloses an area the size of the inner circle, about 78% of the outer circle area. The eccentricity of the ellipse represents visually the correlation. The 22% lost area represented the loss in the number of concomittant points on which predictability is inversely dependent. Within the 95% confidence limits, the mean lipid galactose value of 5.17 mg per 10 g flour predicts a volume value between 14.7 and 28.2, not a very useful prediction.

DISCUSSION

In a random selection of New Zealand wheats from the 1984 harvest, there was a negative relationship between BF loaf volumes and the levels of lipid carbohydrate (determined as galactose) in the flours. No correlation was observed for the MDD loaf volumes. The negative correlation for bulk fermentation is in complete contrast to the findings of Chung *et al.* (Chung, 1982) and Bekes *et al.* (Bekes, 1983) where the relationship was strongly positive for Kansas Hard Red Winter and Canadian Spring Wheats, respectively. It should be noted that the colourimetric analyses carried out by Chung *et al.* (Chung, 1982) and in this work, were based on the assumption that the sugar in cereal glycolipids is mainly galactose (Morrison, 1978). In fact the analyses actually represent lipid carbohydrate. On the other hand, the glycolipid values in the work of Bekes *et al.* were determined by silicic acid column chromatography.

The reasons for this negative relationship for the 1984 New Zealand wheats are not clear. However, the overall quality of the 1984 harvest was exceptionally poor. Work is underway to determine the loaf volume — lipid galactose relationships for a random selection of higher quality 1985 wheats. This should show whether there are any seasonal variations in the lipid data for New Zealand wheats and whether the results for the 1984 wheats were affected by seasonal influences.

The test of any relationship between a measure of quality such as loaf volume and an indicator of quality such as glycolipids, is in being able to accurately predict the measure of quality by an analysis of the indicator. For example, SDS volumes can be used in breeding programmes to screen out wheats of poor bread-baking quality (Griffin,

Table 2. 95% C.I. for BF loaf volumes, given a galactose analysis.

mg lipid galactose/10 g flour	95% C.I. for loaf volume scores
6.9	24.3 - 10.5
6.0	26.2 - 12.7
5.2	28.2 - 14.7
4.3	30.3 - 16.7
3.5	32.5 - 18.6

1983). Further analysis of the data for the New Zealand wheats during 1984, shows that the relationship between BF baking quality and lipid galactose for these wheats cannot be used for prediction purposes. This is clarified in Table 2, which shows the 95% confidence intervals for a prediction of the BF loaf volumes given an analysis for galactose equivalents in the petroleum ether-extractable flour lipids.

It is clear from this study that the positive relationship between loaf volumes and glycolipid or lipid carbohydrate in some North American wheats does not extend to New Zealand wheats during the 1984 season. Furthermore, the data obtained were not good enough to use as a screening method in plant breeding programmes.

A recent study has suggested a genetic influence on the levels of free galactolipids in hexaploid wheat flours (Morrison, 1984). It is therefore intended in future work to also thoroughly examine varietal differences among New Zealand wheat cultivars. A preliminary examination (Cressey, 1985) of the lipids from eight Rongotea and six Oroua flours suggested that varietal differences do exist.

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