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THE FLOUR QUALITY OF EARLY MATURING WHEAT VARIETIES

By W. P. CULLINANE, B.Sc. (Agric.), Adviser, and J. REEVES, B.Sc. (Agric.), Plant Geneticist

The present abundance of wheat on exporting markets has made importers very selective in choosing wheats to fulfil their requirements. Where these wheats are required for breadmaking and the wheats are otherwise sound, flour quality, i.e., protein content and strength becomes the main criterion, both as to price and even the desire to purchase. Many of the importing countries are able to produce varying amounts of wheat, but the protein content and baking strength are low, so that to raise their flour grists to a satisfactory level they require wheats which are high in these qualities.

At the end of each season, grain samples from the wheat variety trials on research stations are forwarded to the Cereal Research Laboratory, Perth, for grain and flour quality tests to determine their relative merits under the particular growing conditions at the various stations.

For the 1954/55 season in order to subject these tests to statistical analysis, samples were collected from each of the replicated plots in the early maturing variety trials at the Avondale, Chapman and Merredin Research Stations. By analysing each of the tests it is possible to obtain the differences necessary for significance and in this manner determine whether any particular variety is significantly higher in quality than any other variety under the conditions of that particular trial.

Yield and certain other characteristics of these early maturing varieties were discussed in a previous article in this Journal (1). The yields are included again in Table 1 as they are used in the calculations of pounds protein per acre.

Of the varieties under test, five are named varieties and four are cross-breds produced at the Merredin Research Station.

The varieties are:

- Bungulla
- Insignia 49
- Gabo
- Saga
- Wongoondy
- M.115—Eureka 2 X M60 (Sword X Kenya C.6041)
- M.116—Charter X (Bungulla) 2
- M.117—Charter X (Bungulla) 2
- M.118—Charter X (Bungulla) 2

Short descriptions of the cross-breds have been published previously (1), (2).

DESCRIPTIONS OF TESTS CARRIED OUT

When information is required concerning the desirability of a wheat for inclusion in a grist for the production of flour for breadmaking, almost the first consideration is its protein content. Protein is a complex substance containing nitrogen and in the case of non-leguminous plants, such as the cereals, the amount of protein produced by the plant will be limited by the amount of nitrogen available from the soil.

The amount of nitrogen in protein from a particular source varies only slightly and this feature is the basis of protein determination. The estimation of the amount of nitrogen in cereals can be made with
considerable accuracy and this figure multiplied by an accepted factor (5.7 in the case of wheat) is the recognised protein content of the grain.

The protein in flour is extremely important in breadmaking. When wheat flour is mixed with water it is the protein in it which produces that characteristic substance gluten. This gluten is the basis of that viscid network in the dough which retains the gases during pannary fermentation and thus enables the production in the bakehouse of large, light loaves of nutritious bread.

High quality bread does not wholly depend on the amount of protein in the flour. The quality of the gluten produced from this protein when it is made into dough is extremely important; in fact when the protein percentage rises above 9-10 per cent. (equal to 10-11 per cent. in the grain) it becomes the more important factor. The tests enumerated in this article for the determination of gluten quality are the farinograph and Pelshenke tests.

The farinograph test is perhaps the most widely used test for flour quality the world over. Flour and water are mixed in the bowl of the instrument and the behaviour of this mixture under the grueling abuse of the paddle in the bowl is recorded in the form of a graph or a farinogram. From this farinogram many characteristics of the flour may be noted. The most important perhaps being:

(a) Water absorption or the percentage of water necessary for a flour to become a true dough—this may range from 50 per cent. for a weak flour with a low protein content to 70 per cent. for a strong flour with a high protein content.

(b) Dough development time or the length of time mixing is necessary for the development of a true dough—a flour with a medium development approaches the ideal and is a function of protein content and variety.

(c) Stability or the ability of the flour and water mixture to maintain consistency with vigorous working. This is a measure of the tolerance of a flour to withstand fermentation and thus enable good bread to be baked over a longer period of maturity or dough ripeness.

The two latter characteristics are largely combined to give the strength figure—a figure which represents the inherent baking strength of a flour and figures have been recorded in our laboratory of from under 2 minutes to over 50.

The Pelshenke or whole-meal fermentation test is based on the ability of a doughball, made from the ground grain and a yeasted solution, when placed in distilled water to withstand disintegration. The longer the time (quoted in minutes) the higher the quality of the flour that may be milled from the grain.

Thus we have two types of test:

(a) the protein test on the grain, which is an index of the quantity of gluten which will be present in the dough;

(b) the farinograph and Pelshenke tests which though influenced by the quantity of the gluten are measures of gluten strength or quality. As these latter tests are influenced by the amount of gluten produced in the dough as well as its quality they become measures of actual baking strength.

There is a fairly close relationship between Pelshenke time and farinograph strength figure, the two measures of baking strength. However there are exceptions; at Merredin the Pelshenke time for Gabo is less, and for Wongoodly at Avondale it is more than could be expected from the respective strength figures. The farinograph figures are normally more reliable than the Pelshenke times.

The results of the tests are shown in Table 1.

VARIATION IN PROTEIN CONTENT

The range in the protein content of the samples is from 8.40 per cent. to 15.40 per cent., a difference of 7 per cent. When the differences are examined it is seen that at the low protein level of the wheats grown at Avondale there is only a difference of 0.57 per cent. between the protein content of the individual varieties, but at the higher
Table 1.

ESTS ON GRAIN AND FLOUR FROM LATE PLANTED WHEAT VARIETY TRIALS—1954-55.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Avondale</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Farinograph.</td>
<td>Pel-</td>
<td>Protein</td>
<td>Yield</td>
<td>Protein</td>
<td>Farinograph.</td>
<td>Pel-</td>
<td>Protein</td>
</tr>
<tr>
<td></td>
<td>Strength</td>
<td>shenke</td>
<td>Content.</td>
<td>(bush.</td>
<td>per</td>
<td>Strength</td>
<td>shenke</td>
<td>Content.</td>
</tr>
<tr>
<td>Figure</td>
<td>W.A.</td>
<td>Time</td>
<td></td>
<td>acre).</td>
<td></td>
<td>Figure</td>
<td>Time</td>
<td></td>
</tr>
<tr>
<td>Bungulla ...</td>
<td>Min.  4-7</td>
<td>% 56-9</td>
<td>Min. 8-56</td>
<td>22-47</td>
<td>Lb. 115-2</td>
<td>Min. 7-1</td>
<td>% 61-4</td>
<td>Min. 7-1</td>
</tr>
<tr>
<td>Insignia 49 ...</td>
<td>5-7</td>
<td>56-9</td>
<td>63-5</td>
<td>8-56</td>
<td>22-33</td>
<td>114-8</td>
<td>8-7</td>
<td>63-6</td>
</tr>
<tr>
<td>Wongoondy ...</td>
<td>3-8</td>
<td>63-7</td>
<td>65-2</td>
<td>8-40</td>
<td>22-67</td>
<td>114-4</td>
<td>17-6</td>
<td>67-9</td>
</tr>
<tr>
<td>Gabo ...</td>
<td>9-0</td>
<td>65-4</td>
<td>97-6</td>
<td>8-86</td>
<td>22-07</td>
<td>117-4</td>
<td>15-9</td>
<td>70-7</td>
</tr>
<tr>
<td>Saga ...</td>
<td>Min.</td>
<td>106-3</td>
<td>8-97</td>
<td>20-07</td>
<td>108-1</td>
<td>Min.</td>
<td>16-9</td>
<td>64-2</td>
</tr>
<tr>
<td>M. 115 ...</td>
<td>10-6</td>
<td>55-6</td>
<td>106-3</td>
<td>8-97</td>
<td>20-07</td>
<td>108-1</td>
<td>Min.</td>
<td>16-9</td>
</tr>
<tr>
<td>M. 116 ...</td>
<td>10-6</td>
<td>55-6</td>
<td>106-3</td>
<td>8-97</td>
<td>20-07</td>
<td>108-1</td>
<td>Min.</td>
<td>16-9</td>
</tr>
<tr>
<td>M. 117 ...</td>
<td>10-6</td>
<td>55-6</td>
<td>106-3</td>
<td>8-97</td>
<td>20-07</td>
<td>108-1</td>
<td>Min.</td>
<td>16-9</td>
</tr>
<tr>
<td>M. 118 ...</td>
<td>10-6</td>
<td>55-6</td>
<td>106-3</td>
<td>8-97</td>
<td>20-07</td>
<td>108-1</td>
<td>Min.</td>
<td>16-9</td>
</tr>
<tr>
<td>Difference for Significance</td>
<td>0-6</td>
<td>1-2</td>
<td>7-8</td>
<td>0-27</td>
<td>1-61</td>
<td>N.S.</td>
<td>1-6</td>
<td>1-7</td>
</tr>
<tr>
<td>5% Level ...</td>
<td>0-6</td>
<td>1-2</td>
<td>7-8</td>
<td>0-27</td>
<td>1-61</td>
<td>N.S.</td>
<td>1-6</td>
<td>1-7</td>
</tr>
<tr>
<td>1% Level ...</td>
<td>0-8</td>
<td>1-6</td>
<td>10-8</td>
<td>0-37</td>
<td>...</td>
<td>...</td>
<td>2-1</td>
<td>2-3</td>
</tr>
<tr>
<td>0-1% Level ...</td>
<td>0-8</td>
<td>1-6</td>
<td>10-8</td>
<td>0-37</td>
<td>...</td>
<td>...</td>
<td>2-1</td>
<td>2-3</td>
</tr>
</tbody>
</table>
| W.A. is water absorption on a 13.5% moisture basis. N.S.—Not Significant.
levels at Chapman and Merredin the differences are 1.18 per cent. and 1.40 per cent. respectively. However the difference between the average protein at Avondale, and at Chapman and Merredin respectively was 5.87 per cent. and 3.83 per cent. This confirms previous tests which show that, under our conditions, climate and soil fertility have more effect on protein content than variety.

CHAPMAN RESEARCH STATION
SEASON 1954-55
LATE PLANTED, WHEAT VARIETY TRIAL.
VARIETY - BUNGULLA; REPLICATION 4.
STRENGTH FIGURE - 7.3 Mins.
DOUGH DEVELOPMENT TIME - 2.8 Mins.
WATER ABSORPTION - 61.8%.

Fig. 1.—The strength figure of 7.3 minutes for Bungulla indicates that this variety has produced a flour of only moderate baking strength, even though the protein content is high

PROTEIN PER ACRE

Of the five varieties planted at all three stations, M.115 had the highest protein, though this was not significantly higher than Gabo at Avondale or Merredin. It however gave significantly lower yield per acre than the other four varieties at both Avondale and Merredin. At Chapman, Gabo and Wongoondy significantly out-yielded it and in only one instance, was its yield higher than another variety and then not significantly so. The other variety was Insignia 49 at Chapman.

It is possible to produce wheats whose protein content is higher than that of the ordinary varieties, but these are often low yielding; the cross-bred M.115 may be taken as an example of this. But yield is also important to the farmer as it is largely the factor on which financial returns depend, and thus not so much as a compromise but as a measure of greatest returns, the concept of protein per acre is being increasingly studied. Yield has always been important, while protein content has long been recognised as one of the necessary corollaries for a good bread wheat, so that this concept, unconsciously perhaps, has long been in evidence.

Millington (4) has discussed this matter and suggested that there is a tendency for a variety which produces grain with a higher protein content to be lower yielding. He also showed that when seasonal influences favour high protein content the yields tend to be lower. At Chapman in 1954 Gabo significantly outyielded Insignia 49, but the protein content of Insignia 49 was higher than Gabo; these results were a reversal of those of the season 1953.

The average protein per acre of the five varieties grown at the three research stations were:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Protein per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gabo</td>
<td>134.9</td>
</tr>
<tr>
<td>Wongoondy</td>
<td>130.6</td>
</tr>
<tr>
<td>Bungulla</td>
<td>128.1</td>
</tr>
<tr>
<td>Insignia 49</td>
<td>126.0</td>
</tr>
<tr>
<td>M.115</td>
<td>122.0</td>
</tr>
</tbody>
</table>

Gabo has thus returned the highest average yield of protein per acre, but it was out-yielded at Chapman by Wongoondy (though not significantly) and only Insignia 49 was significantly lower at this station. At Merredin it had the highest protein per acre yield of the nine varieties, and was significantly higher at the 5 per cent. level than the four varieties, Bungulla, Wongoondy, M.117 and M.118. The results at Avondale showed only slight differences and these were not significant. Thus, though it appears probable that Gabo on the average will yield more protein per acre than the three varieties, Bungulla, Insignia 49 and M.115, the results of this series of tests are inconclusive. It is hoped to carry out further
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The crossbred M.115 gave the highest grain protein of the five varieties on all three research stations and of the other four varieties planted at Merredin, only Saga was superior. Under nearly all circumstances therefore, the grain from this crossbred may be expected to be comparatively high in protein.

The mean of the other four varieties planted at all three stations was:

<table>
<thead>
<tr>
<th>Variety</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gabo</td>
<td>12.10</td>
</tr>
<tr>
<td>Insignia 49</td>
<td>11.98</td>
</tr>
<tr>
<td>Wongoondy</td>
<td>11.78</td>
</tr>
<tr>
<td>Bungulla</td>
<td>11.54</td>
</tr>
</tbody>
</table>

Gabo also registered the highest figures for these four varieties at each station, except at Chapman where both Insignia 49 and Wongoondy were superior, though not significantly so. However in all trials it was superior to Bungulla (though not significantly at Chapman).
As the data is only for a single season some caution must be expressed in reaching a conclusion, but it appears that the average protein content of Gabo is probably higher than that of the other three varieties and is higher than Bungulla.

**PROTEIN QUALITY AND BAKING STRENGTH**

As mentioned previously there is a fairly close relationship between Pelshenke time and farinograph strength figure. As the farinograph strength figure is normally the more reliable index of protein quality and baking strength, it is this measure which is considered in this discussion.

Accepting the Merredin tests as a standard and a strength figure of 10 minutes as the division between weak and medium strength varieties, the wheats may be divided into two groups, as follows:—

- **Weak varieties**—Bungulla, Insignia 49, M.117 and M. 118.
- **Medium-strong varieties**—Gabo, Saga, Wongoondy and M.115.

In addition M.116 is almost of medium strength and could be rated as belonging to the lower ranges of the medium-strong group.

Reference to Table 1 will show that as the protein content increases so does the strength figure, though all varieties do not react in the same way, and the increment for each unit of protein increase is not the same for each variety. The rate of increase for Gabo and M.115 is greater than for Insignia 49 and Bungulla, while the rate of increase for Wongoondy is much greater still, as Wongoondy has the lowest strength figure under the low protein range at Avondale and the highest figure of the series under the high range at Chapman. Thus no advantage will be gained by sowing Wongoondy in preference to the low strength varieties Bungulla and Insignia 49, when the protein content of the crop may be expected to be low. However where a moderate to high protein may be expected i.e. on medium to high fertility soils Wongoondy will produce grain of good strength.

This rate of increase is low in the case of Insignia 49 and Bungulla and no matter how high the protein, they will never produce really strong grain, though Insignia 49 at the same protein level, will be stronger than Bungulla.

Gabo and M.115 show a high increase of strength with increasing protein content, with the advantage that even at low protein levels they have a reasonable strength. However to produce a good loaf of bread a flour should have at least 9 per cent. of protein (equivalent to a grain protein of 10 per cent.). Wheats with comparatively high strength and low protein content will be more useful in blending with low strength wheats of high protein content than by using directly for breadmaking.

**WATER ABSORPTION**

Water absorption is often included in strength definitions by leading authorities. The amount of water a flour will absorb is a factor of considerable importance to the baker, enabling him to manufacture more loaves from the same quantity of flour.

Water absorption is a function of variety and protein content. The wheats under review fall into two groups, those with a high absorption, Gabo, Saga and Wongoondy, and the remainder with a low to medium absorption. As the protein increases the water absorption also increases. Millington (4) has calculated this increase for Gabo and Insignia 49, two varieties that may be taken as representative of the above groups, at approximately 1 per cent. for each 1 per cent. increase of dry gluten* for Gabo and $ per cent. for each 1 per cent. increase for Insignia 49. He also calculated that at the 10 per cent. dry gluten level the water absorption of Gabo would be almost 6 per cent. higher than of Insignia 49. Owing to the generally higher water absorption of the higher baking quality varieties and the tendency for them to have higher protein contents, more loaves of more nutritious bread can be made from a ton of Gabo flour than from a ton of Insignia 49 flour. As Millington (4) has pointed out, this in certain instances would enable a premium of tenpence a bushel to be paid with no increase or even a decrease in the flour costs for each loaf of bread.

*Approximately a 1% increase in wheat protein will give 1% increase in dry gluten.
CONCLUSION

Wheat varieties are classified according to their flour quality into three groups, weak, medium-strong and strong. Bungulla and Insignia 49 can be placed in the weak group—the above tests have shown that Insignia 49 is slightly stronger than Bungulla. Gabo and Wongoondy are of the medium-strong type, being lower in strength than such strong varieties as Pusa 4, Comeback and Festival.

These tests have shown that under adverse conditions, as during the 1954-55 season at Avondale, the stronger varieties produce flour which is not much higher in strength than that from the weaker varieties Bungulla and Insignia 49. However with better conditions and more fertile soils, the stronger varieties have the inherent capacity to produce flour which is far superior in quality for breadmaking than that from the weaker varieties grown under the same conditions.

Many of our soils even in the virgin state are of low fertility, and to maintain and raise this fertility and thus improve wheat yields and flour strength (3), increase the yields of other cereals, provide nutritious pastures for our flocks and preserve a cover of herbage for the conservation of the surface soil, it is vital that suitable rotations be practised and as far as possible leguminous pastures should be the basis of these rotations.

These tests have shown that climate and soil conditions have far more effect than variety on the protein content of the grain. They have also shown that the weaker varieties cannot produce strong grain even when grown under the most favourable conditions.

To produce stronger grain it is necessary to sow such better quality varieties as Gabo, Wongoondy (late planting) and Kondut, Javelin 48, Eureka (early planting) on soils raised in fertility to as high a level as possible.

ACKNOWLEDGMENT

The assistance received from the staff of the Government Chemical Laboratories for the protein determinations; from the Agricultural Research stations for the carrying out of the trials and the recording of yields; and from the Plant Research Division for the statistical analyses, is gratefully acknowledged.


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