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Flour milling and baking

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Do changes in proteins during mixing explain the baking quality of flour blends?

This Research Bulletin explains our recent research on how the baking quality of flour blends relates to their protein composition. Much research has been done over the last 20 years on the protein content of pure wheat varieties. However, flour is normally milled from a grist of several varieties. You might expect that you could predict the behaviour of the flour milled from a grist by averaging the properties of its component wheats in proportion. Our recent research suggests that this assumption may not be true. A research finding that is particularly significant for both flour millers and bakers is that blending a strong flour with a weaker one can produce blends requiring less work input, but with high baking quality (Sutton, 1998).

The largest protein molecules known probably occur in bread (Sutton and Wrigley, 1996). The largest gluten proteins of wheat flour have molecular weights of many millions, and baking increases their size further. The large size of gluten proteins makes them insoluble in water. This property makes them useful protein stores for the young wheat plant and also confers the unique bread-making properties of wheat flour. Gluten proteins determine many important characteristics of wheat flours, as explained in several previous Research Bulletins (Understanding protein cross-linking, #2, Autumn 1998, J. Gerrard and S. Fayle; Dough Development - beyond 2000, #27, November 1996, N. Larsen; and Research on wheat proteins, #26 July 1996, K Sutton).

Many of the important processing properties of wheat flours can be explained in terms of their chemical composition and properties. Gliadin proteins confer the viscous, flowing properties to wheat flour doughs, act as lubricants and allow the gluten structure to 'slip'. Glutenin proteins, which exist as polymers of many sub-units, provide the elastic properties of wheat flour doughs. Parts of glutenin protein molecules have a structure somewhat like that of a coil spring and these regions also act like springs by resisting an extension force and springing back after it is removed.

Glutenin polymer size appears to have an important influence on the functional properties of gluten proteins (Sutton and Wrigley, 1996). We have recently found that MDD optimum work input of a flour increases with the size of its glutenin protein aggregates, i.e. stronger flours contain larger protein aggregates than weaker ones (Sutton, 1998). This is reasonable if glutenin polymers cause the differences in dough strength between different wheat varieties. It is a general rule that as polymers increase in size their mechanical strength increases. In addition to the effect of polymer size, there are also quantitative effects. Although the aggregates in a strong variety may be similar in size to those in a medium strength variety, the stronger wheat will contain a greater proportion of protein in the large aggregates than medium strength.

Australian researchers in the early 1990s found that the proportion of large glutenin aggregates present in a wheat flour correlated well with the mixograph maximum resistance, R_{max} (Gupta et al., 1993). Later studies showed that the proportion of small glutenin aggregates in flour correlated with mixograph extensibility (Bangur et al., 1997). Our studies have examined how mixing affects the molecular weight distribution of glutenin proteins. Our recent study of the protein size profiles of 4 New Zealand wheats with a wide range of MDD work inputs found that the proportion of 'very large' glutenin aggregates was strongly related to the MDD optimum work input of the flour (Figure 1) (Simmons and Sutton, 1997; Sutton, 1998).

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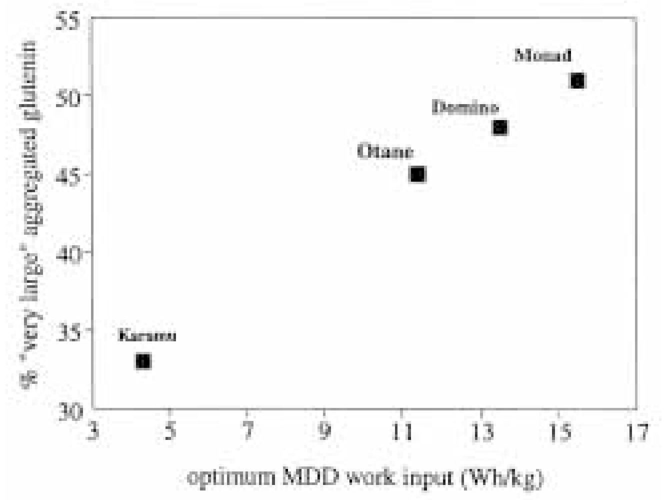

Figure 1.

The same study examined the effect of MDD mixing on the glutenin proteins in blends of a strong flour, milled from the variety Monad, and a weak flour, Karamu, to see if the trends observed for single varieties also occurred in blends. For flours milled from single wheat varieties we found that the same fixed work input changed the protein composition of a strong flour less than that of a weak flour. This explains the higher tolerance to overmixing of some strong varieties. This effect appears to result from a combination of the molecular size and quantity of glutenin proteins.

However, commercial flours are normally milled from grists containing several varieties of wheat. We thought that the proteins in flour milled from mixed grists might behave quite differently from those milled from pure varieties. If flours behave in a 'linear' or 'additive' manner then we could predict the properties of a blend, such as its water absorption, optimum work input, or test bake loaf volume, from those of the constituent flours and their proportion in the blend. On the other hand, if the components in the blend interact then these variables could be either significantly bigger or smaller than predicted from the component flours. Feedback from industry and from our test baking staff suggested that the performance of flour blends often cannot be accurately predicted from that of the constituent flours. This suggested that flour blends commonly perform in a non-linear manner, which signalled that investigating this topic could benefit the industry.

Figure 2 illustrates that the work input required to mix a dough to optimum increased in proportion to blend composition.

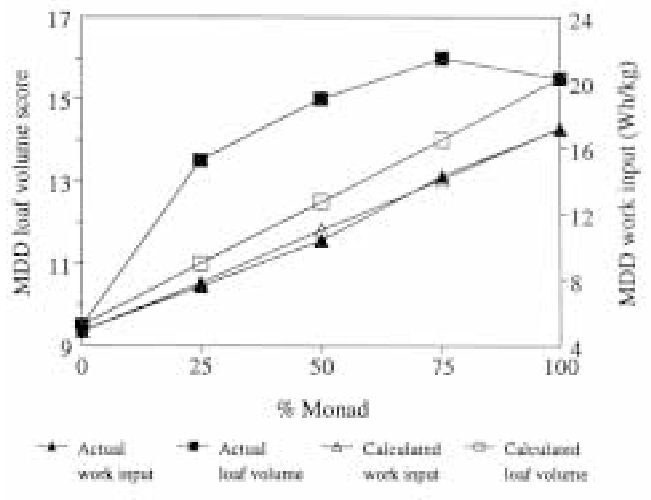

Figure 2.

This observation indicates that dough work input requirements of flour blends may be predicted from the composition of the grist by summing the protein composition of the components. However, Figure 2 also illustrates that the MDD loaf volume was not proportional to blend composition. This indicates that the baking quality of the flour blends cannot be predicted from flour protein composition in a similar way.

Further research investigated the basis of these non-linear baking effects. Test bake loaves made from a blend of 50% Monad and 50% Karamu had loaf volumes similar to that of 100% Monad flour, but required significantly less work input. This may be very significant to the flour milling and baking industry. Therefore, we mixed a 50:50 blend of Karamu and Monad at varying work inputs with a constant water absorption and measured the volumes of the resulting loaves (Figure 3).

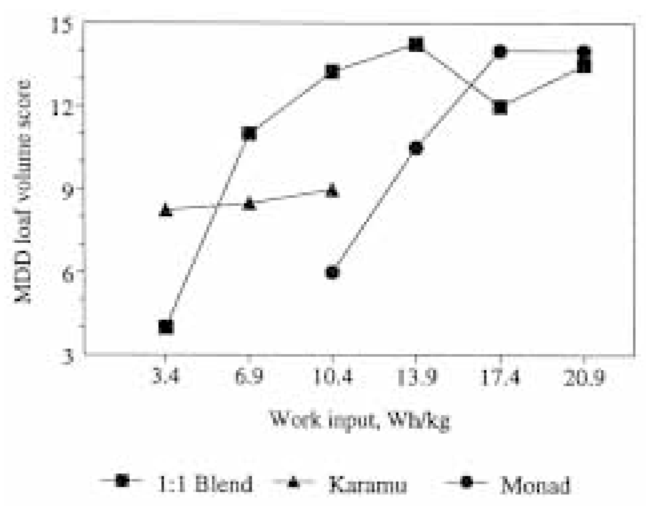

Figure 3.

Figure 3 shows that the loaf volumes of loaves baked from the blend had a baking performance quite unlike that of an average of the two component varieties. Instead, the flour blend behaved like an entirely different flour and the baking quality could not be predicted from that of the two component flours. It is particularly significant that the baking performance of the 50:50 blend was much more like that of the stronger Monad component than an average of the two. Figure 4 illustrates the changes in the distribution of the very large glutenin proteins for the 50:50 blend and for its individual component varieties. Figure 4 shows that the protein distribution in the 50:50 blend changed less than in the individual component flours. Again, proteins in the blend behaved quite differently from proteins in either of the component varieties or an 'average' of the two. Figure 4 also shows that the profile of the very large glutenin proteins in the blend was more like that of the Monad flour than the Karamu flour. This observation may explain the baking performance curves in Figures 2 and 3 where the Karamu/Monad blend behaved more like the Monad component than an average of the two components. These differences in behaviour between the blend and the component flours are not yet understood, but would be explained by some sort of protein exchange in the flour blend during mixing.

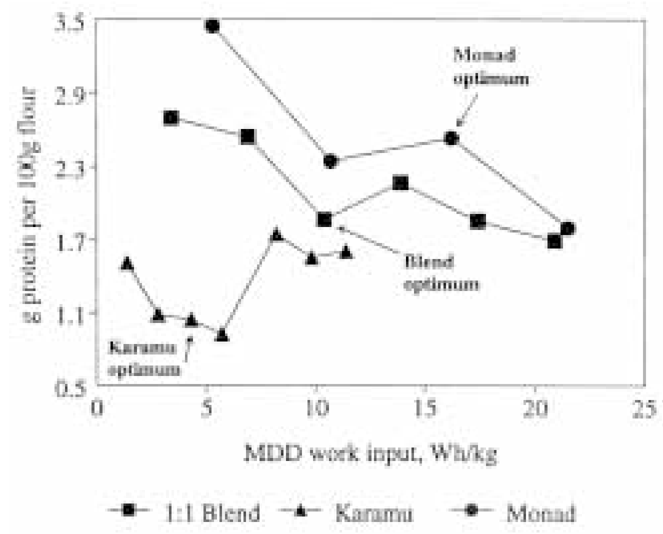

Figure 4.

Future work

These results suggested two avenues for future research into flour blends which could be of great commercial significance to the flour milling and baking industry.

- Firstly, it is important to extend the research into flour blends to discover whether the non-linear behaviour of baking quality and protein occurs in other blends of flours more similar than Monad and Karamu.
- Secondly, it should be of great significance to the industry to extend the investigation of flour blending to flour streams. 'Straight-run' commercial flours are generally made by combining several flour streams. If these flour streams show the same non-linear blending behaviour as flours, then research on flour streams will be important commercially. It would enable the industry to maximize its production of high quality, value-added products by providing a more predictable, scientific basis for blending selected combinations of flour streams.

These two research aims have been built into Crop & Food Research's new programme of research funded by the Foundation for Research, Science and Technology. This programme has long term funding to undertake fundamental studies of protein distribution in mill streams and various flour blends with strong emphasis on practical outcomes for the New Zealand flour milling and baking industry.