# VALUE ADDED WHEAT CRC
# PROJECT REPORT

# Arnott's Blending Project

## Project 2.1.1

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## Summary

This study examines the interactions between 2 commercial flours (WA Soft and WA Noodle) and 2 varieties (Rosella and Snipe). The protein and rheological characteristics of the flours and blends of the flours were investigated using standard laboratory procedures, and a number of non-linear relationships were found. These are probably due to differing glutenin alleles in the various varieties. However, there were considerably less non-linear interactions than were found in the previous study of Hard wheats blended with Soft wheats.

The most important findings of this study were:

1. Rosella had a significantly higher protein level and higher dough strength (as reflected by dough development time, energy input and maximum dough resistance) than the other three flours.
2. Rosella has a tendency for non-linear rheological behaviour when blended with other flours, probably due to a combination of *Glu-A3* and *Glu-B3* alleles interaction.


## Introduction

The various characteristics of different varieties of wheat render each variety suitable for a distinct category of end-use. Varieties with high protein and hard endosperm are used for bread wheats, while those with low protein and soft flours are used for biscuits and cakes. There is also a niche market for higher protein, soft flours in the noodle industry. Recently, Arnott's has been experimenting with blending these higher protein Soft (Noodle) wheats with ordinary Soft varieties to produce crackers, which are normally made from a blend of Hard and Soft wheats.

There are a number of problems experienced with blending Hard wheats with Soft wheats, since many of the varieties used contain different types of glutenin alleles. These different alleles interact in processing to cause non-linear effects which are difficult to accurately predict (Bekes and Wrigley, 1999). A previous project by Hartono *et al* (2003) showed that there were some non-linear interactions occurring with the flours used by Arnott's that could be causing the problems encountered by the company.

This project investigated the effects of blending Soft and Noodle wheat varieties and commercial flours on the dough rheology, to see if non-linear effects were still an issue.

## Aims

Arnott's have commissioned a study into the relationships between noodle and soft types of flours.

The aims of this study are:

1. To investigate the dough quality of soft and noodle type flours.
2. To investigate interactions between quality parameters of wheat flour blends, particularly noodle and soft wheat flours.
3. To suggest where non-linear interactions may cause problems in end product quality.

## Methods

Four different flour types (Table 1), 2 commercial flours (WA Soft and WA Noodle) and 2 varieties (Rosella and Snipe) were milled at Allied Mills, Toowoomba, Qld., and blended in proportions of 25%/75%, 50%/50% and 75%/25% at Summer Hill, NSW. These blended samples were sent to Allied Mills, Queensland, for Farinograph and Extensograph testing.

**Table 1: Variety flour blends**

| | WA Soft | WA Noodle | Snipe | Rosella |
|---|---|---|---|---|
| **WA Soft** | WA Soft | | | |
| **WA Noodle** | 25/75<br>50/50<br>75/25 | WA Noodle | | |
| **Snipe** | 25/75<br>50/50<br>75/25 | 25/75<br>50/50<br>75/25 | Snipe | |
| **Rosella** | 25/75<br>50/50<br>75/25 | 25/75<br>50/50<br>75/25 | 25/75<br>50/50<br>75/25 | Rosella |

The protein content of each flour was determined using NIR techniques at SARDI Grain Quality Laboratory, SA.

Each flour was tested on both the Farinograph and Extensograph using the standard methods of the American Association of Cereal Chemists by Allied Mills, Toowoomba, Qld. In addition, work input was measured on the farinograph using a Work Input Meter. Unfortunately each flour was only tested once. For the extensographs, each dough was mixed for only 5 minutes, and the trace was centred on the 500 BU line at the 5 minute mark.

The allele types present in each flour were obtained from a database of alleles and varieties (Table 2).

**Table 2: Allele types present in flours used.**

| | HMW | | | LMW | | |
|---|---|---|---|---|---|---|
| **COMMERCIAL FLOUR** | ***Glu-A1*** | ***Glu-B1*** | ***Glu-D1*** | ***Glu-A3*** | ***Glu-B3*** | ***Glu-D3*** |
| **WA Soft** | | | | | | |
| Datatine (~50%) | 2* | 7*+8 | 2+12 | f | b | a |
| Tincurrin (~30%) | 2* | 7*+8 | 2+12 | f | d | a |
| Harrismith (~20%) | 2* | 7*+8 | 2+12 | f | g | a |
| **WA Noodle** | | | | | | |
| Calingiri | 2* | 13+16 | 2+12 | d | d | a |

| | HMW | | | LMW | | |
|---|---|---|---|---|---|---|
| **VARIETY** | ***Glu-A1*** | ***Glu-B1*** | ***Glu-D1*** | ***Glu-A3*** | ***Glu-B3*** | ***Glu-D3*** |
| Rosella | 2* | 7*+8 | 2+12 | b | b | b |
| Snipe | N | 7*+8 | 2+12 | c | b | b |

# Results

## *Protein*

The results for the protein tests are shown in Figure 1. Rosella had the highest amount of protein, 10.9%, followed by WA Noodle (9.7), Snipe (8.5) and WA Soft (8.1).

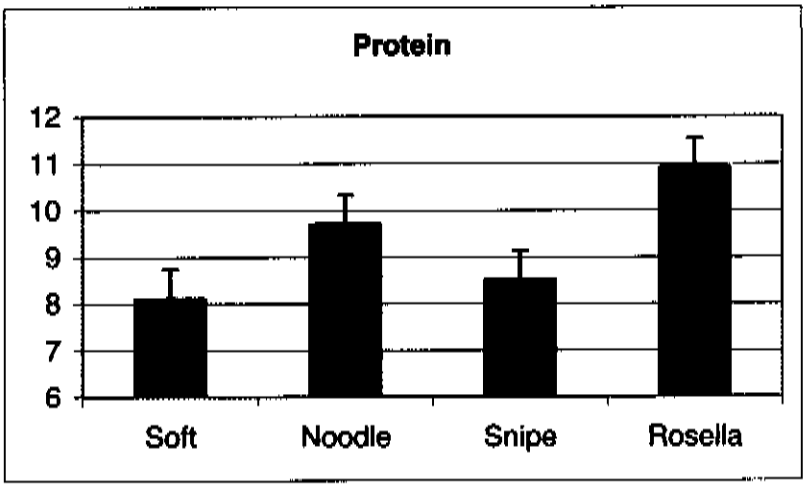


**Figure 1: NIR protein results for pure flours.**

Since the previous experiment (Hard-Soft Wheat Flour Blending) had shown that there were no interactions with flour protein, the blended flours were not individually measured. Protein content for the blends was calculated from the proportions of different flours in the blends.

## *Farinograph*

### Water absorption

The WA Noodle wheat showed the highest water absorption of the pure flours, but this was not very different to Snipe or Rosella (Figure 2). The WA Soft flour had much lower water absorption than the other 3 flours.

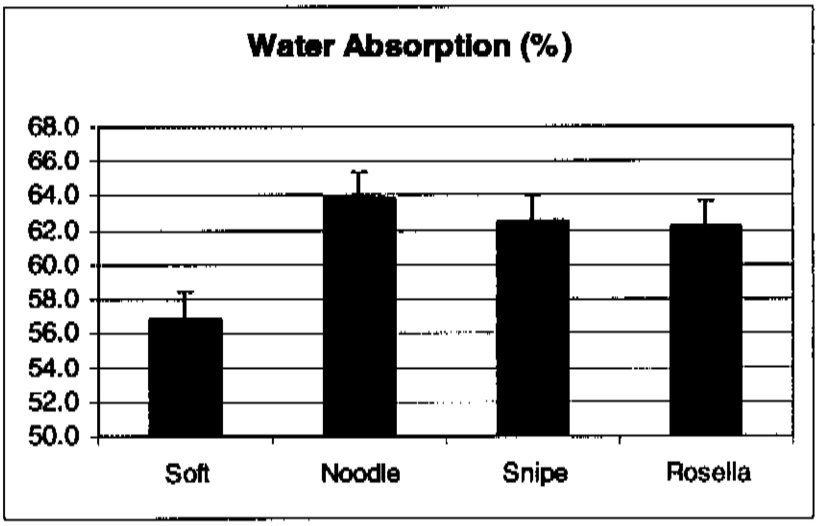


**Figure 2: Water absorption of Pure Flours. (I = s.e.)**

The blends showed a few non-linear effects (Figure 3). An unusually large water absorption was recorded for the 75/25 blend of WA Soft and Snipe, but this is probably an outlier. The WA Soft/WA Noodle blend showed a tendency to have lower than expected water absorption as more WA Soft was added to the blend. The Rosella/Snipe blend also had slightly lower than expected water absorption at between 50 and 75 % Rosella in the blend. The WA Soft/Rosella, Snipe/WA Noodle and Rosella/WA Noodle blends were linear.

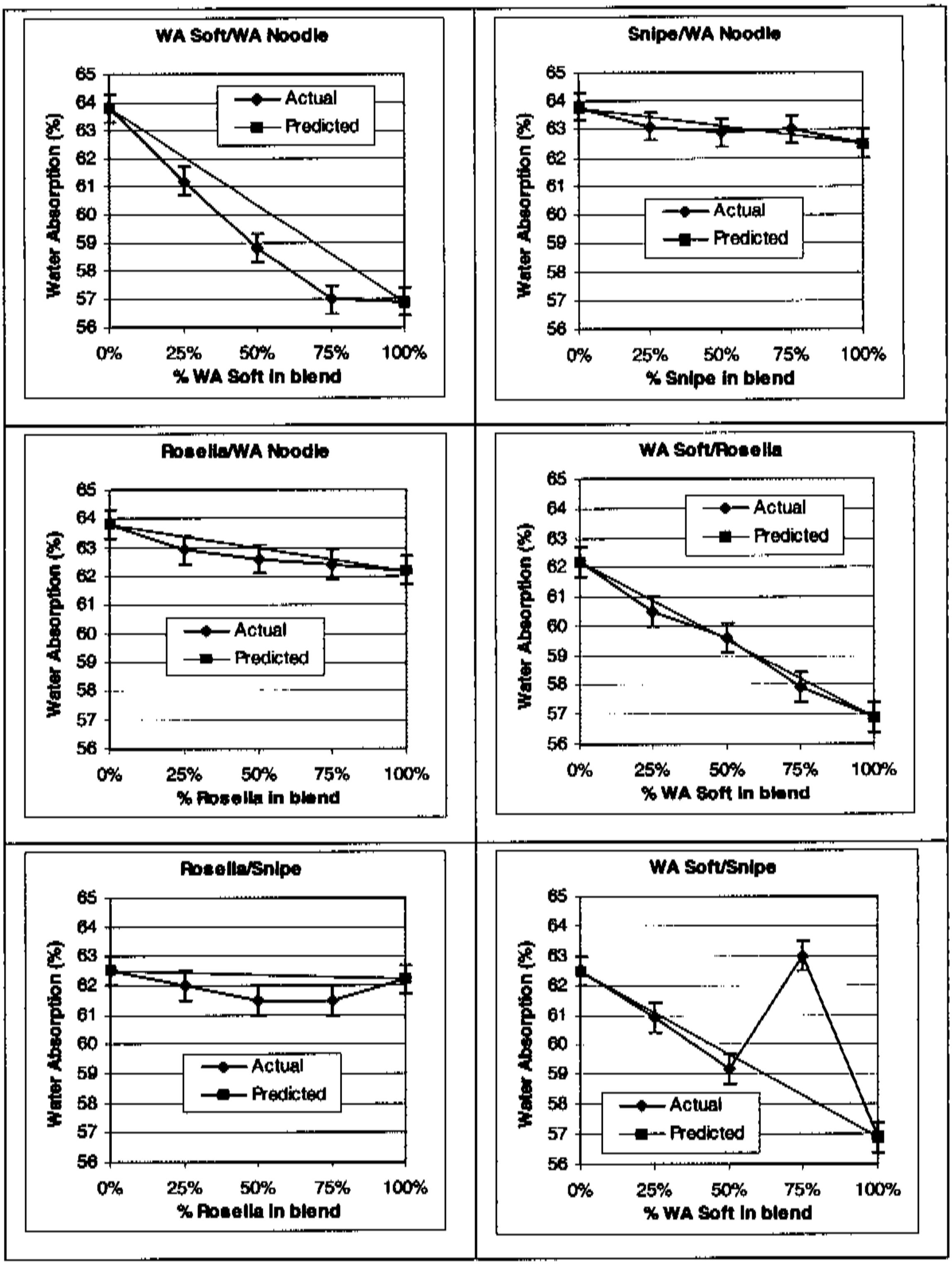


**Figure 3: Water Absorption of different blends. (I = 0.5%)**

## Dough Development Time

Rosella had a clearly longer dough development time (DDT) than the other 3 pure flours.

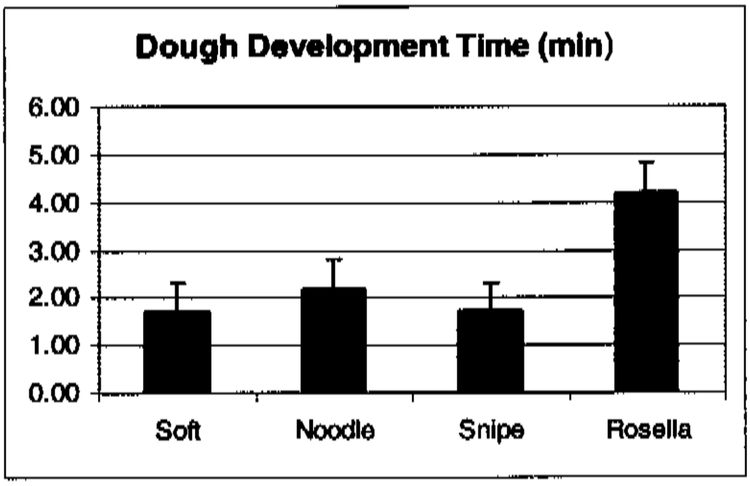


**Figure 4: Dough Development Time of Pure Flours. (I = s.e.)**

The blended flours showed some non-linear effects in the Rosella/WA Noodle blends and the WA Soft/Rosella blends. The WA Soft/WA Noodle blends had lower DDT than expected when mixed in a 50/50 blend by about 0.8 minutes. The Rosella/WA Noodle blends and the WA Soft/Rosella blends had higher than predicted DDT when there was more Rosella in the mix. The Rosella/WA Noodle blends showed some variation, but no significant non-linearity except at 25% Rosella, which had a higher DDT than expected. All other blends had dough development times within 1 minute of that predicted by a straight line equation.

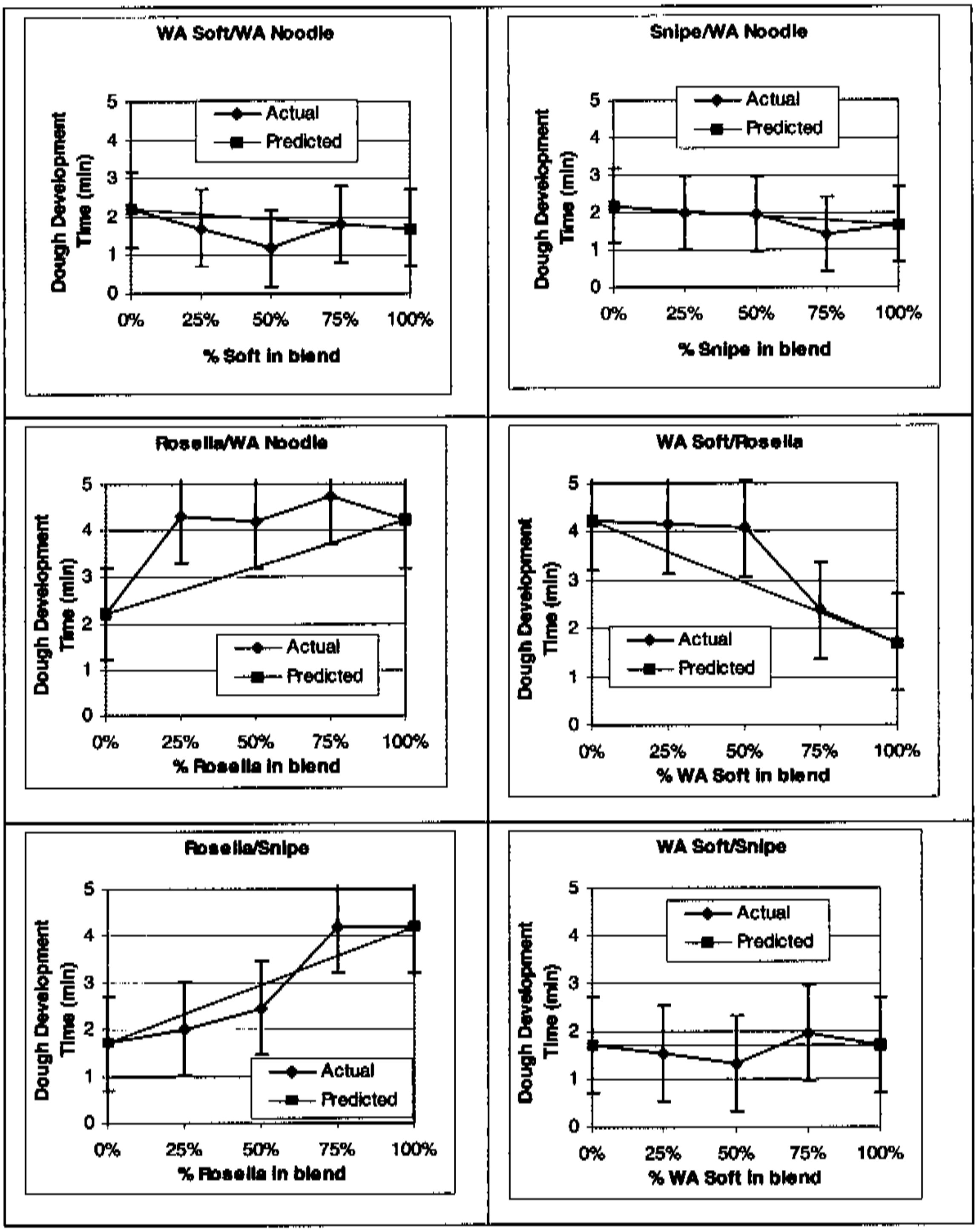


**Figure 5: Dough Development Time of different blends. (I = 1 min)**

## Stability

WA Noodle flour had the highest stability (6.85 min), and WA Soft and Snipe the lowest (3.0 and 3.52 min respectively). Rosella had an intermediate stability of 4.21 minutes.

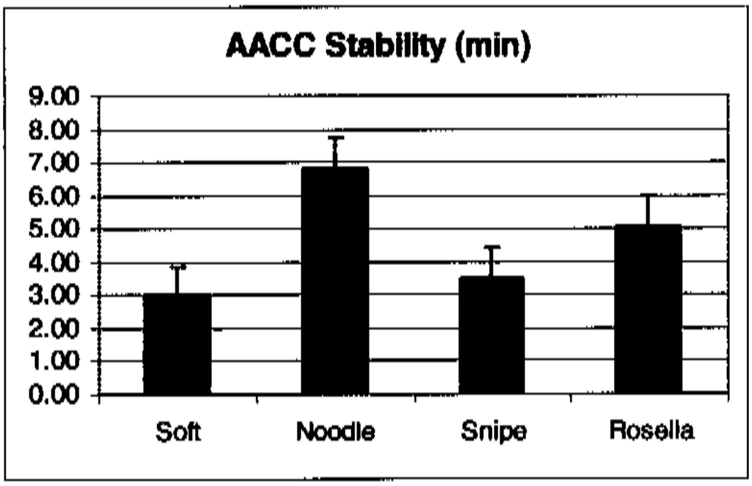


**Figure 6: Stability of Pure Flours. (I = s.e.)**

The results showed that all blends had a tendency towards non-linearity (Figure 7), with increased stability over that predicted by a straight line between the parent flours. Only the Snipe/WA Noodle blend did not differ in stability by more than 1 minute. Rosella seemed to have the strongest non-linear effect, causing interactions with all flours. WA Noodle and Snipe did not interact strongly, although there was a tendency for increased stability to occur. The WA Soft flour appeared to interact strongly with Snipe, and less strongly with Rosella and WA Noodle.

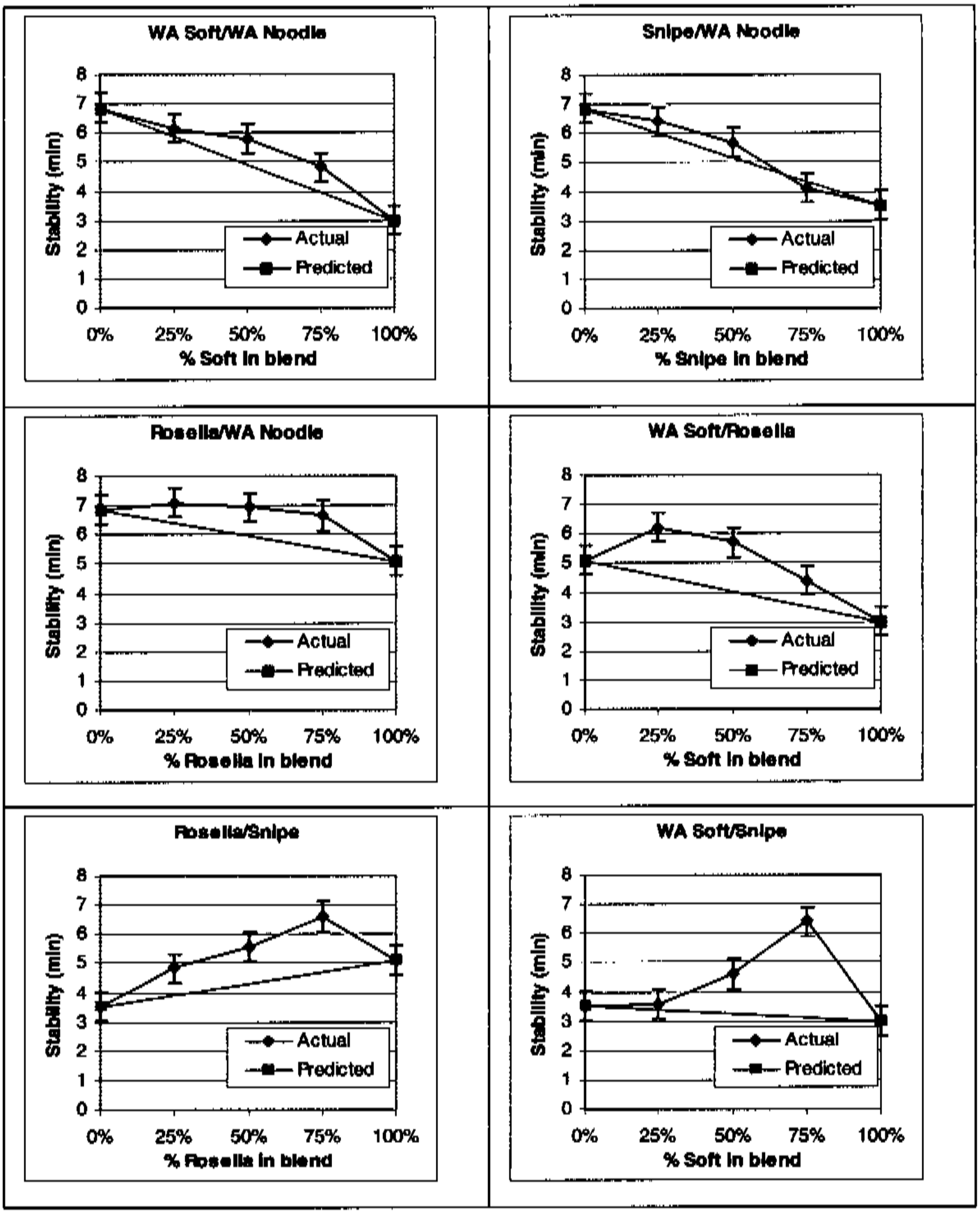


**Figure 7: Stability of different blends. (I = 1 min)**

## Mixing Tolerance Index

Mixing Tolerance Index (MTI) is very similar to "5-min Breakdown". It is the difference in Buhler Units (BU) between the top of the curve at peak dough development and the top of the curve 5 minutes after peak. A higher MTI value indicated less tolerance to mixing (greater breakdown).

The WA Soft flour showed the highest MTI score of 75 BU (see Figure 8), with the other 3 flours all between 47 and 56 BU.

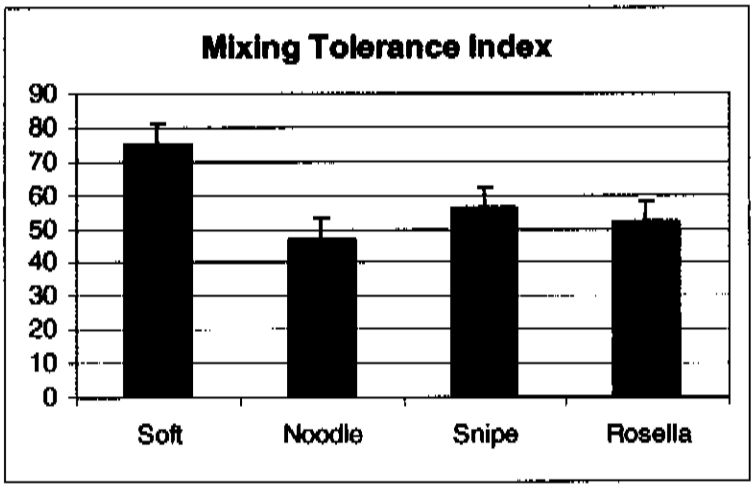


**Figure 8: Mixing Tolerance of Pure Flours. (I = s.e.)**

The blended flours all showed decreased MTI (better resistance to breakdown) when blended. Some of these were close enough to the predicted line to be non-significant (see Figure 9), others differed widely from the prediction. The WA Soft flour had high non-linearity when combined with Snipe and WA Noodle, and WA Noodle showed non-linear effects when combined with all other flours. However it was not easy to predict the extent of the non-linearity, as it did not follow a consistent pattern.

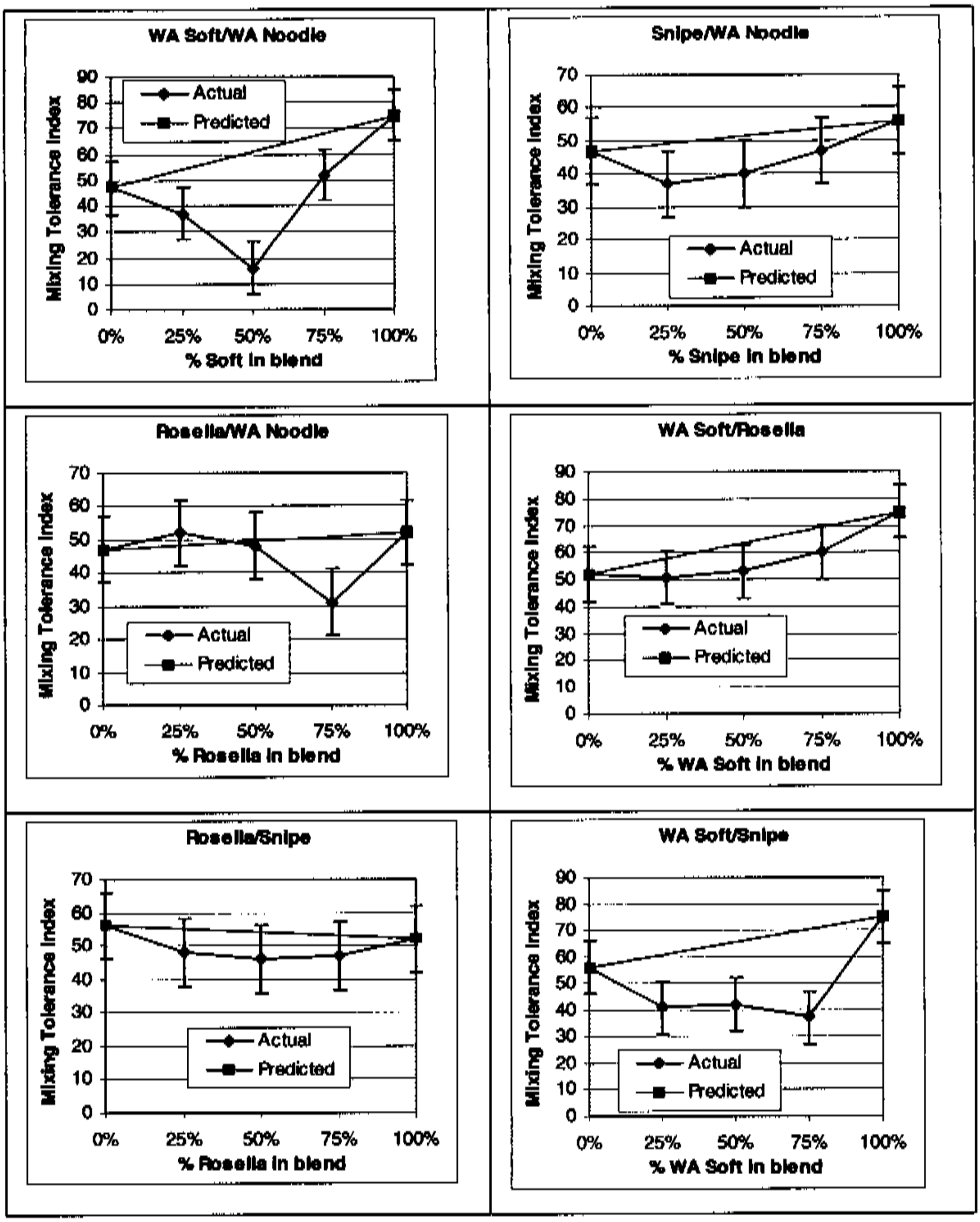


**Figure 9: Mixing Tolerance of blends. (I = 10 BU)**

## Work Input Units

The Work Input Units (WIU) are a measure of the amount of energy needed to be used to develop the dough. As can be seen in Figure 10, Rosella needs almost twice as much energy to develop the dough as any of the other 3 flours.

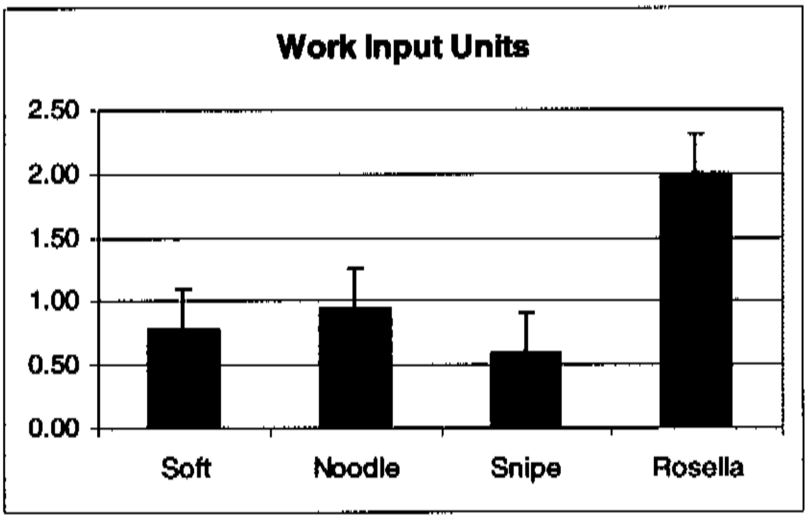


**Figure 10: Work Input Units for Pure Flours. (I = s.e.)**

The blends showed strong non-linear effects in only one of the combinations – Rosella and WA Noodle. Most non-linearity occurred at a 25% Rosella, 75% WA Noodle mix. All other blends were close to the predicted line (Figure 11).

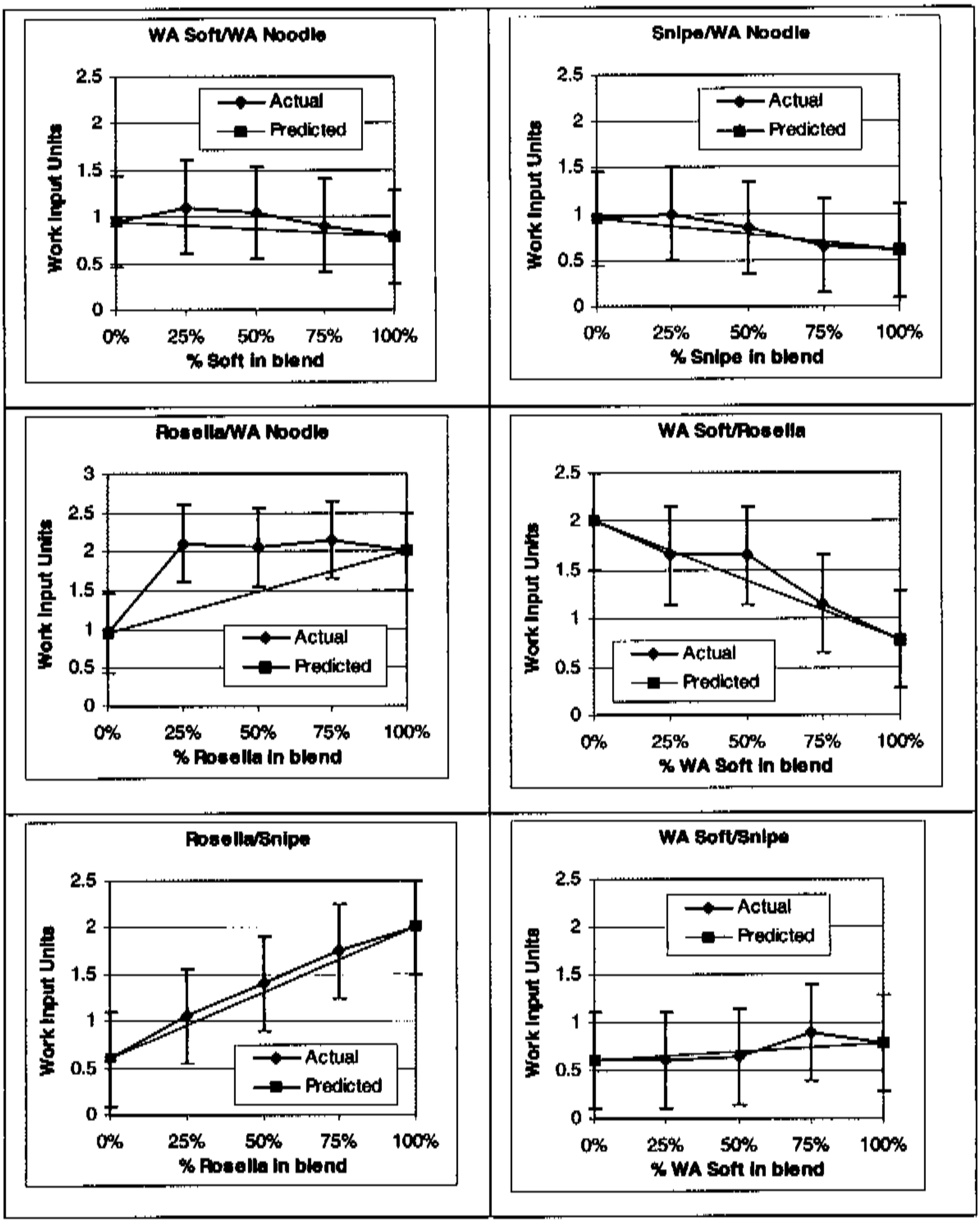


**Figure 11: Work Input Units for blends. (I = 0.5)**

## *Extensograph*

### Dough Strength (Rmax)

Rosella had the strongest dough (395 BU), WA Noodle had intermediate strength (300 BU) and WA Soft and Snipe had weak doughs (230 and 240 BU respectively).

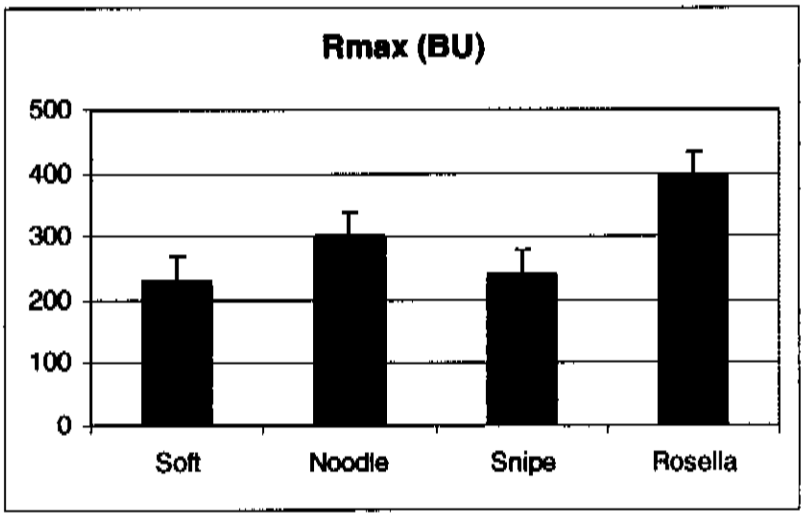


**Figure 12 Dough strength of Pure Flours. (I = s.e.)**

The blended flours only showed significant non-linearity with the WA Soft/Snipe blend (at 75% WA Soft). Other WA Soft blends tended to be slightly stronger than predicted. All other blends varied about the predicted line.

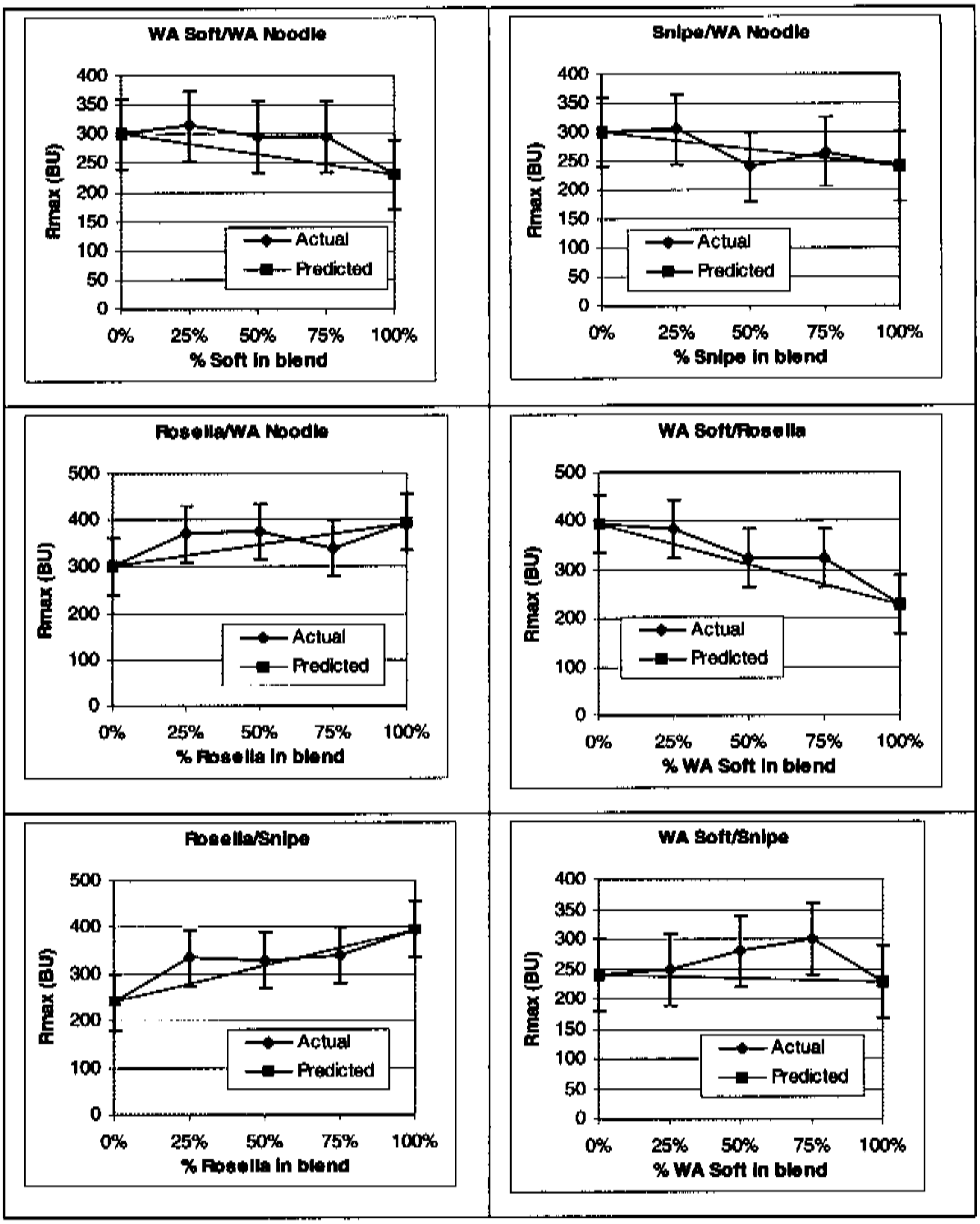


**Figure 13 Dough strength of blends. (I = 60 BU)**

## Extensibility

Rosella was the most extensible of the 4 pure flours, and WA Soft the least. WA Noodle and Snipe were very similar (Figure 14).

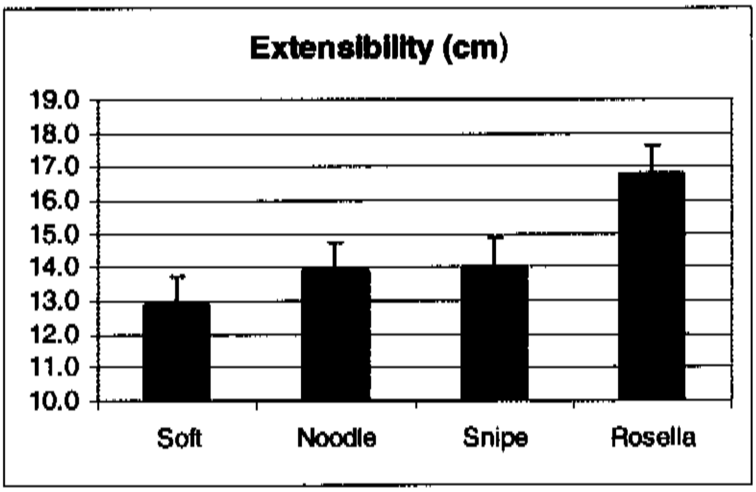


**Figure 14: Extensibility of Pure Flours. (I = s.e.)**

The blends showed no significant differences in extensibility (Figure 15) except perhaps in the WA Soft/Rosella blend, where extensibility was maintained at the Rosella level until 50% WA Soft was added, when it began to decline to the WA Soft level.

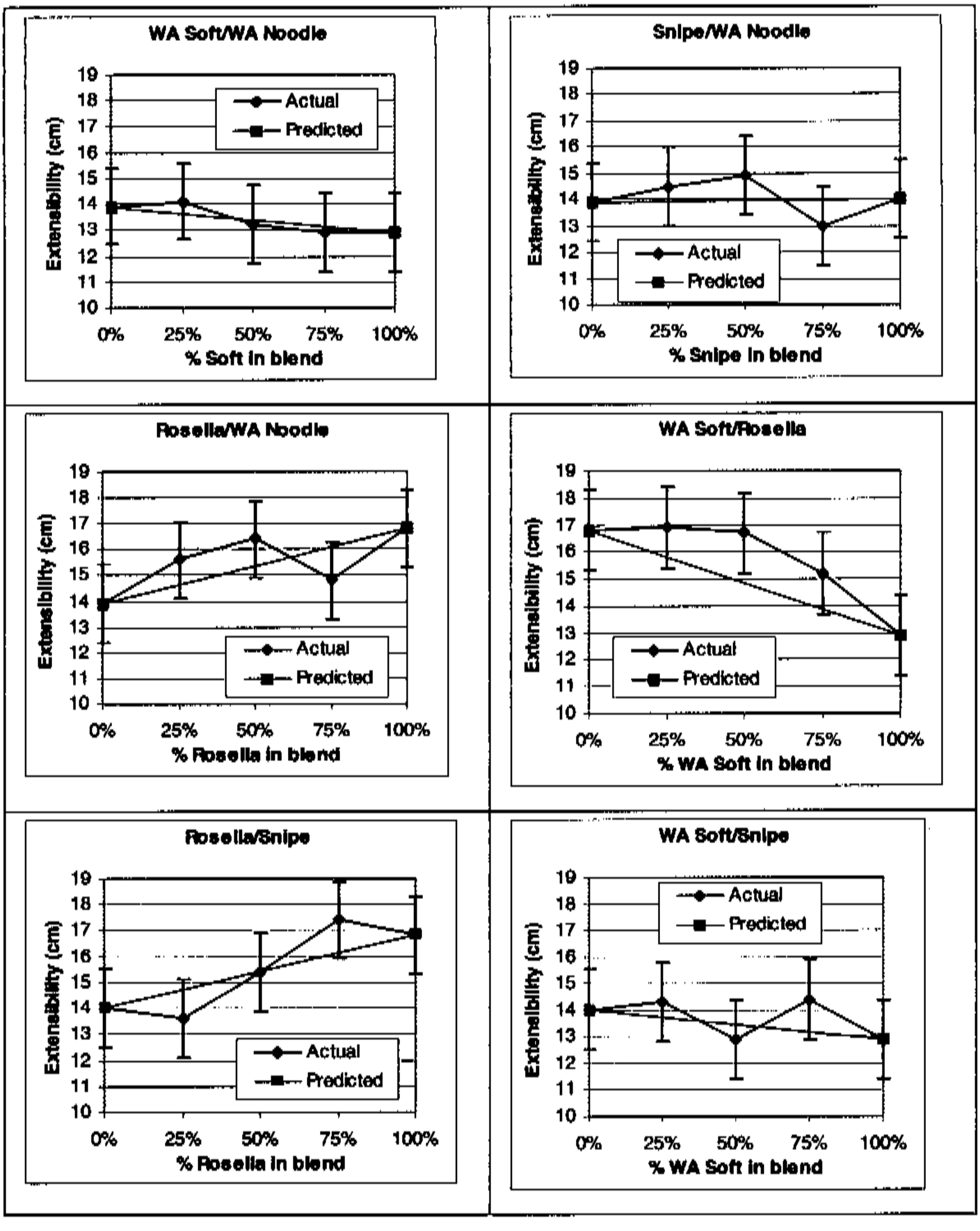


**Figure 15: Extensibility of blends. (I = 1.5 cm)**

## Extensibility per unit Protein

Extensibility per unit protein (E/P) gives an idea of how extensible the dough is when the effect of protein content is normalised. For example, although Rosella flour made the most extensible dough, once the higher protein content is taken out it is much more comparable to the other flours (Figure 16) and has less extensibility per unit protein than WA Soft and Snipe. The WA Noodle flour retains low extensibility even when protein is accounted for.

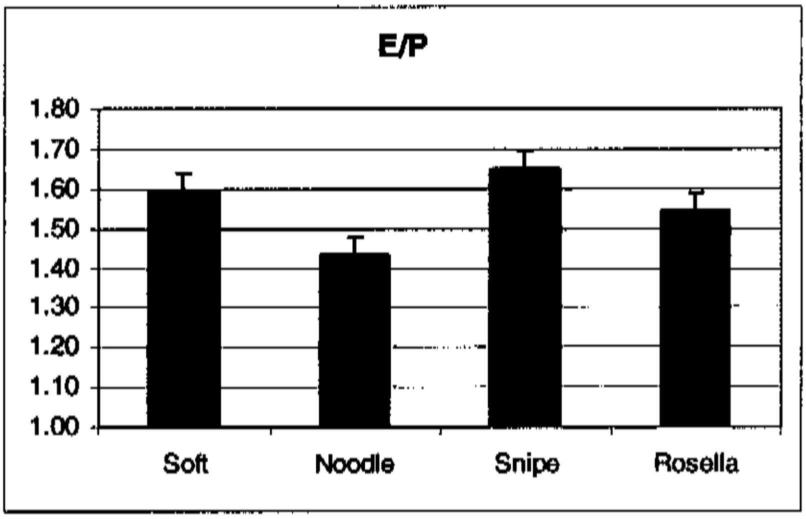


**Figure 16: E/P of Pure Flours. (I = s.e.)**

There were a number of non-linear effects apparent in the E/P results (Figure 17). It is difficult to separate genuine non-linearity from sample variation. The WA Soft/Rosella blend showed strong interaction, with the greatest deviation from the predicted line at between 25 and 50% Rosella in the mix. This also occurred, but to a lesser extent, in the Rosella/WA Noodle blend. In the Rosella/Snipe blends, 25% Rosella resulted in a reduction of E/P, but 75% Rosella increased E/P – this may be an example of sample variation.

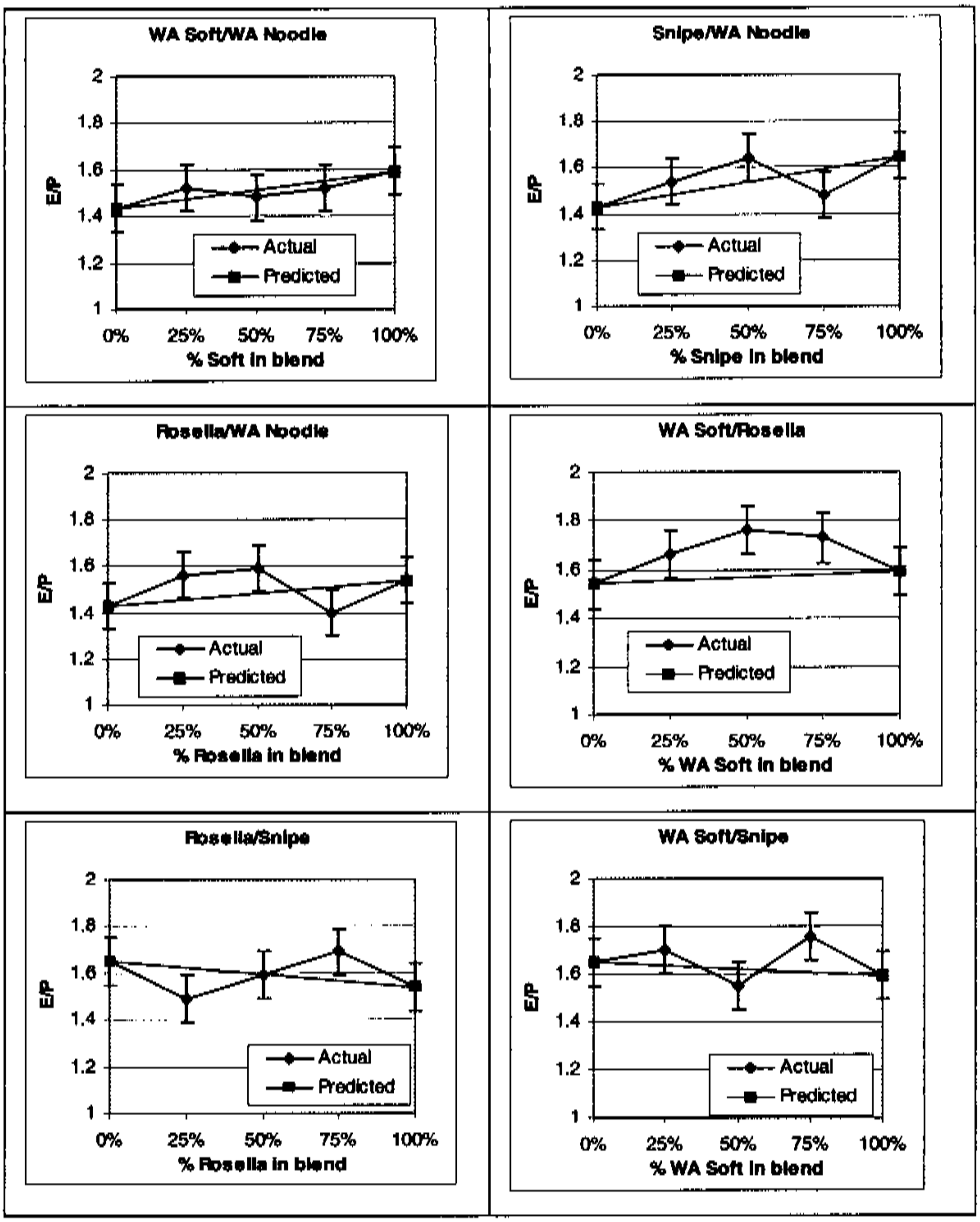


**Figure 17: E/P of blends. (I = 0.1)**

## Discussion

The 4 different flours each have differences in their glutenin allele composition, and this is seen in the way in which almost all the flour combinations have some degree of non-linear interaction in most of the characteristics measured.

Water absorption is most strongly non-linear in the WA Soft/WA Noodle blend. The WA Soft/Snipe blend also shows one sample with an unexpected result, but since only one sample was tested in each blend, this result is highly likely to be an outlier and should not be relied on. This sample also had odd results in the Stability test, and it is probable that there is a common reason.

Dough Development Time was only significantly non-linear in the Rosella/WA Noodle blend. These flours differ at the *Glu-B1, A3, B3* and *D3* loci. However, WA Noodle did not show non-linearity with any other flour type. Rosella showed more of a tendency towards non-linearity, but has alleles more similar to the other flours. It is possible that the high protein content of Rosella and differing *Glu-B1* alleles combined to produce the non-linear effect seen in the Rosella/WA Noodle blend, while the effect was diminished when Rosella was blended with the other flours with the same *Glu-B1* allele type.

All flours showed mild degrees of improved stability when blended. Again Rosella seemed to have a good effect. Rosella contains both *Glu-A3b* and *Glu-B3b,* which are alleles known for a positive effect on dough strength and stability. Snipe also has the *Glu-B3b* allele, but it has a null allele at *Glu-A1*, which reduces dough strength and stability.

Mixing Tolerance Index shows the breakdown of the dough within 5 minutes. Most blends had reduced breakdown, which accords well with their increased stability. Interestingly, only the Rosella/WA Noodle blend showed a non-linear effect with Work Input Units. The particular combination of alleles here may be the answer. Alternatively, the result may be due to an outlier.

Rmax results showed that there did not appear to be any significant non-linear effects in the blended flours, except possibly in the WA Soft/Snipe blend.. This may be because dough strength is strongly determined by the *Glu-D1* alleles, which in this set of flours are all the same.

The extensibility results only showed significant non-linearity with the WA Soft/Rosella blend. This may be an effect of the different *Glu-A3* and *Glu-B3* alleles interacting. This effect was also seen in the E/P results. It appears that the particular combination of alleles in the WA Soft and Rosella blends has a non-linear effect on extensibility, increasing it over the predicted linear line. The ability to increase the extensibility per unit protein of a flour by blending is an important finding which should be further investigated.

In summary, it appears that the addition of Rosella to WA Soft, WA Noodle and Snipe flours can either have no effect, or cause a slight improvement in stability, reduced breakdown (MTI) and improved extensibility. This may be accompanied by a small reduction in Water Absorption. The good combination of *Glu-A3* and *Glu-B3* alleles present in Rosella is a possible cause of this. However, care should be taken to allow for the much higher protein content of Rosella in interpreting these results. A low-protein Rosella flour may have a smaller effect.

The different *Glu-B1* allele in the WA Noodle flour did not appear to cause significant non-linear effects when blended.

## Recommendations:

When taking these recommendations into account, it must be remembered that the data used here was only gathered in one laboratory, using standard equipment and methods. The equipment and methods may be very different to the conditions found in a commercial operation. For example, the addition of salt, baking powder, yeast, and palm oil to a dough formula (as found in Salada™) will alter the dough properties. These conclusions from the laboratory data need to be confirmed with blends from a commercial scale mill and under factory conditions.

As far as can be seen from this data, there should be no large problems arising from non-linear effects with blended flour. What non-linear effects did occur were mostly to improve dough stability and extensibility. Caution should be used in mixing dough from WA Noodle/Rosella blends however as it may have a longer than expected development time. Whether these higher protein noodle soft flours blends will perform adequately in the manufacture of cracker biscuits though is so far unknown. Actual bake testing is the only way to investigate this.

## References:

Approved Methods of the American Association of Cereal Chemists, 1987, vol.2.

Bekes, F. and Wrigley, C.W. 1999. Prediction of the dough properties of blended flours based on variety mix. *Quality Wheat CRC Report No. 35.*

Hartono, D.S., Tonkin, R.E., Cornish, G.B., Miskelly, D., Dines, J. and Kennett, A. 2003. Non-Linear interactions in soft wheat flour blending. *Value Added Wheat CRC Project Report (unpublished).*