



QUALITY WHEAT CRC PROJECT REPORT

**Project 4.4.1: Defining starch quality for enhanced
performance of baked products**

Effect of Starch Properties on Bread

Baking Part 1: A to B Starch Granule Ratio

Ken Quail and Hon Yun

BRI Australia, Quality Wheat CRC Ltd

Date: December 1999

**QWCRC Report No: 38
Copy No: 1**

**CONFIDENTIAL
(Not to be copied)**

Quality Wheat CRC has taken all reasonable care in preparing this publication. Quality Wheat CRC expressly disclaims all and any liability to any person for any damage, loss or injury (including economic loss) arising from their use of, or reliance on, the contents of this publication.

QUALITY WHEAT CRC REPORT

Effect of Starch Properties on Bread

Baking Part 1:

A to B Starch Granule Ratio

Project Title : Defining starch quality for enhanced performance of baked products

Project Number : 4.1.1

Project Leader : Dr Hon Yun
BRI Australia Ltd.,
PO Box 7, North Ryde, N S W, 2113
(Ph) 98889600 (Fax) 98885821

Program Manager : Dr Ken Quail
(Ph) 98889600 (Fax) 98885821

Date : December 1999

Prepared for the Co-operative Research Centre for Quality Wheat Products and
Processes

Project Aims

1. To develop systems for the manipulation of the starch components of flour, suitable for baking assessment.
2. To investigate chemical and structural change of starch granule and starch components during bread making procedures (dough preparation, baking process and storage) and to define the role of starch and its components for bread quality.
3. To define the optimum A to B starch granule ratio for bread quality.

Executive Summary

Ten flour samples representing a range of starch properties were selected for the study. This included Null4A and normal types. Flour swelling power results ranged from 11.76 to 16.24 and RVA peak viscosity from 203 to 417. Amongst these samples there was some indication that higher loaf volume was associated with samples with lower peak viscosity. These results indicated value in pursuing the impact of starch properties on breadmaking.

The flour samples were separated into gluten, starch and water soluble components. The starch was separated into prime and tailing components. The prime starch was further separated into A and B granule components using a sedimentation procedure. Particle size analysis and microscopy indicated excellent purity of the A and B granule fractions. Microscopy indicated that the starch granules were intact.

The A granules had a higher RVA peak viscosity than the B granules for the two varieties tested. There was a highly significant linear relationship between peak viscosity and A granule content. There is no obvious explanation for this behaviour. In contrast, A granules had lower swelling power. Again there was a highly linear relationship between A granule content and swelling power. This appears to be due to the effect of the higher surface area to volume ratio of the "many small" B granules compared to the "few larger" A granules.

A small scale test baking method using 40g of flour for high top and square sandwich loaves was developed to assess baking quality and staling. Measuring the effects of added fat, which reproduced the results obtained at full scale baking, showed the effectiveness of this test.

The first reconstitutions compared the prime starch of the selected flour samples in a common background of gluten, tailing starch and water solubles. The water absorptions associated with the starches varied as did the mixing requirements which is to some extent dependent on the water absorption

which influences dough viscosity. However the magnitude of these differences was greater than expected and requires further investigation. There were apparent relationships between staling measures and starch properties, which would require more extensive testing to confirm. These results may have been influenced by the water addition. Starch source had only a small effect on specific loaf volume.

The A and B granules were baked with the prime starch at 100%A, 50%A and 50%B and 100%B. A common background of gluten, tailing starch and water solubles was used. Increasing B granules increased bakery water absorption, produced loaves with higher specific loaf volume and softer bread crumb. Higher proportions of B granules clearly improved the baking quality of both the high top and square loaves.

The prime starch samples were also assessed for their gel making properties. The RVA set back was clearly related to gel strength, which confirms earlier published studies for noodles. Increasing A granule content in the prime starch increased gel firmness; this is consistent with the influence of A granules on crumb firmness and is independent of water addition as the same starch concentration was used for each of the gels.

Starch properties clearly influence bread baking. A higher B granule content appears to increase water absorption, increase bread volume and reduce crumb firmness. These results suggest that increasing B granule content could be a valuable breeding objective, especially as many new Australian wheat varieties struggle to have adequate water absorption. Further work to study the effect of B granules on baking should be encouraged to support any breeding commitments.

Detailed Discussion of Results

1. Flour sample properties

Ten Australian wheat varieties were selected to represent a range of starch properties. Samples consisted of a reference Batavia and the same 4 wheat varieties from two different regions, Gilgandra and Myall Vale, and a soft variety, Cadoux for comparison study. Flours represent broad range of baking quality (Figure 1) and physicochemical properties including pasting viscosity, swelling power, Farinograph properties (Table 1).

Figure 1 Baking quality of flour samples (volume)

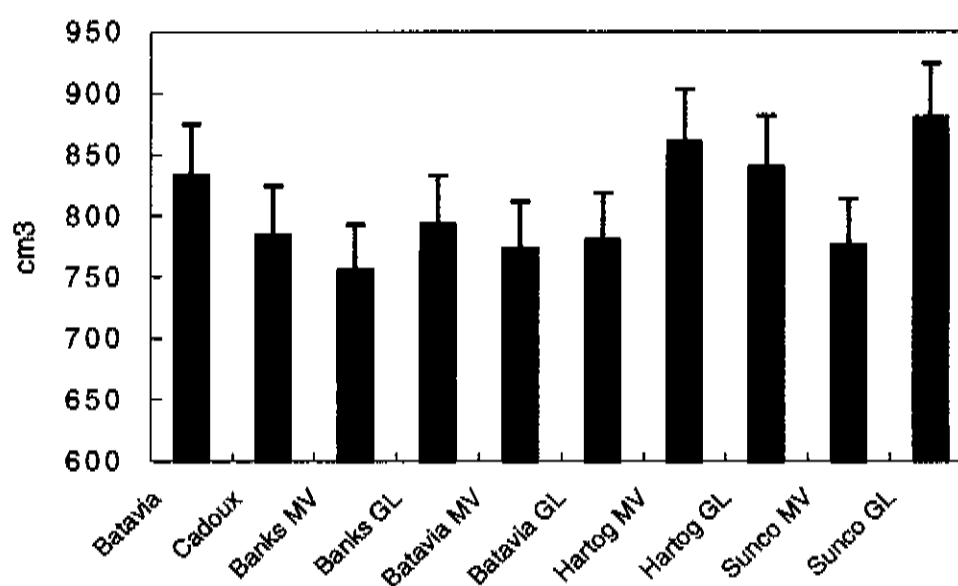


Table 1 Physical and chemical properties of flour

	Protein content (%)	Starch damage (%)	Water absorption (%)	Peak viscosity (RVU)	Swelling power
Batavia	13.3	7	63.2	417	13.941
Cadoux	9.0	5.2	54.3	389	16.241
Banks GL	10.3	6.4	60	218	12.002
Banks MV	10.1	7.3	57.8	309	11.755
Batavia GL	10.2	6.4	59.8	291	15.155
Batavia MV	10.5	8.3	59	386	14.638
Hartog GL	11.1	7	60.1	203	13.586
Hartog MV	10.1	9	59.5	369	14.852
Sunco GL	10.6	5.6	58.6	245	12.688
Sunco MV	10.7	8.3	58.8	331	12.522

(SR: Straight Run, MV: Myall Vale, GL: Gilgandra)

It was found that when flour peak viscosity increased volume of high top loaf bread decreased (Figure 2). The result indicated the potential significance of starch properties for bread quality. Amylose content tended to be associated with lower bread firming, which was measured by the ratio of firmness of 48h to 24hr (Figure 3). Higher amylose content showed a slower firming process which tends to go against the findings of our waxy wheat work.

Figure 2 Bread volume change on RVA peak viscosity

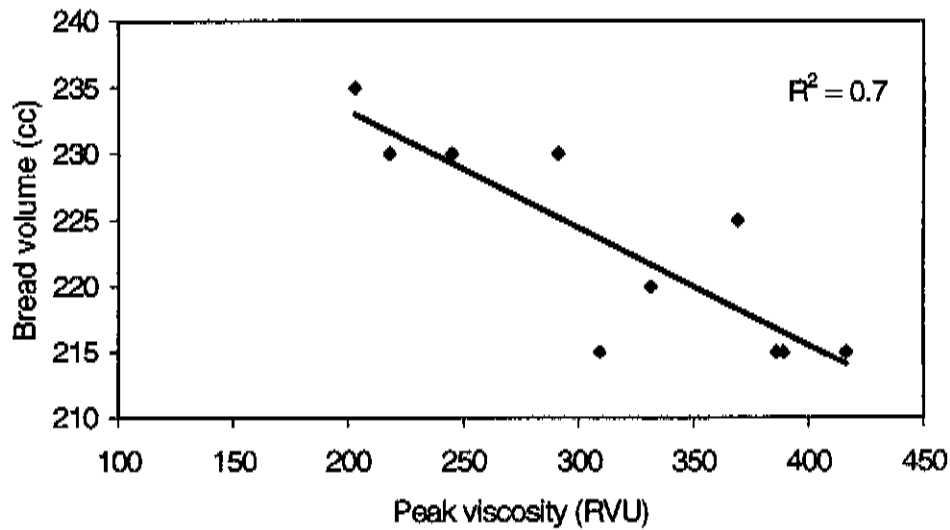
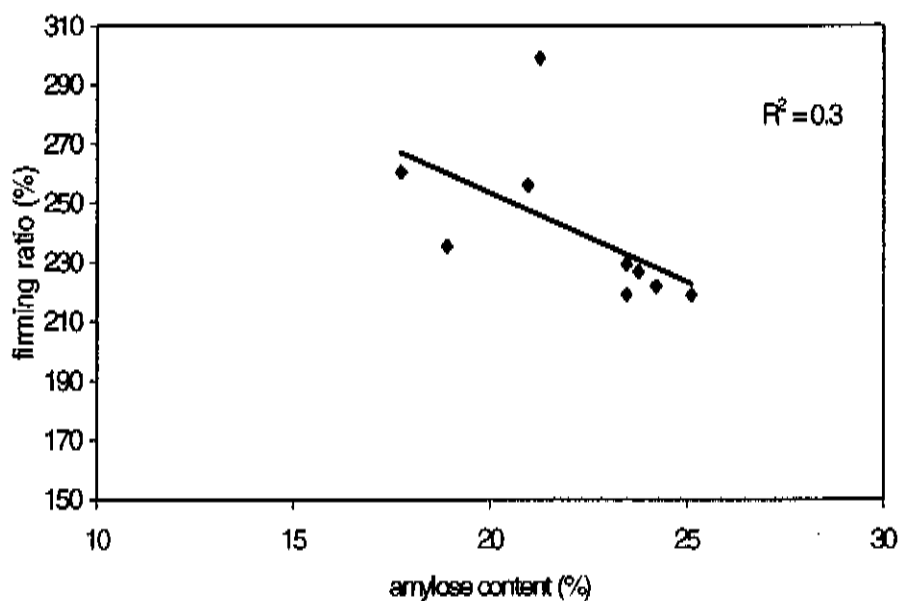


Figure 3 Change of bread firming ratio on amylose content



2. Starch preparation

2.1. Flour separation

Flour samples were separated into gluten, starch and water-solubles using a hand washing procedure with good recovery (> 96%) (MacRitichie, 1985). The starch fraction was carefully further separated into prime and tailing starch by centrifugation. The prime starch component represented from 66% to 72% of the total starch. Physical and chemical properties of the prime starch samples prepared are shown in Table 2. A relatively narrow range of peak viscosity was observed among prime starch samples when compared with corresponding parent flour samples. Starch B granule content ranged from 18.8% to 30.5% which showed appropriate selection of wheat varieties for the study of starch granule effect on baking quality.

Table 2 Physical and chemical properties of prime starch samples

	Starch damage (%)	Protein content (%)	B granule content (vol %)	Average granule size (μ)	Peak viscosity (RVU)	Swelling power
Batavia	0.9	0.24	24.8	16.4	254	14.594
Cadoux	0.3	0.22	20.8	17.8	286	16.387
Banks GL	0.9	0.24	25.5	16.5	136	11.084
Banks MV	1.2	0.22	23.6	16.9	144	11.058
Batavia GL	0.5	0.22	30.5	15.3	212	14.223
Batavia MV	0.7	0.21	26.7	16.5	305	15.617
Hartog GL	0.9	0.39	18.8	18.3	217	13.320
Hartog MV	1.4	0.26	21.8	18.3	238	13.459
Sunco GL	1.3	0.30	22.8	17.3	191	11.928
Sunco MV	0.9	0.31	24.9	17.0	209	11.869

2.2. Starch granule separation

A and B starch granules were separated from intact pure prime starch using a sedimentation method modified from Geddes et al (1965). The optimum condition of the sedimentation procedure was established by analysing starch granule distribution using a Malvern Particle Sizer. The A granule fraction was obtained after 2hrs of sedimentation and the B granule fraction was collected from supernatant after 2 1/4hrs representing the critical sedimentation period. The graph shows clear separation of starch granules in size by the procedure developed (Figure 2). Observation under light microscopy showed that granules were intact. Detailed separation procedure is described in Figure 3. Both physical and chemical analysis data of A and B granule groups are shown in Table 3. Compared with A granule group, B starch granules had higher swelling power property and lower RVA peak viscosity which appeared to be an important physicochemical characteristic of

B starch granule groups. The amylose content of the A granules was slightly higher than B granules.

Figure 2 Starch granule separation showing the whole prime starch and the two starch granule fractions

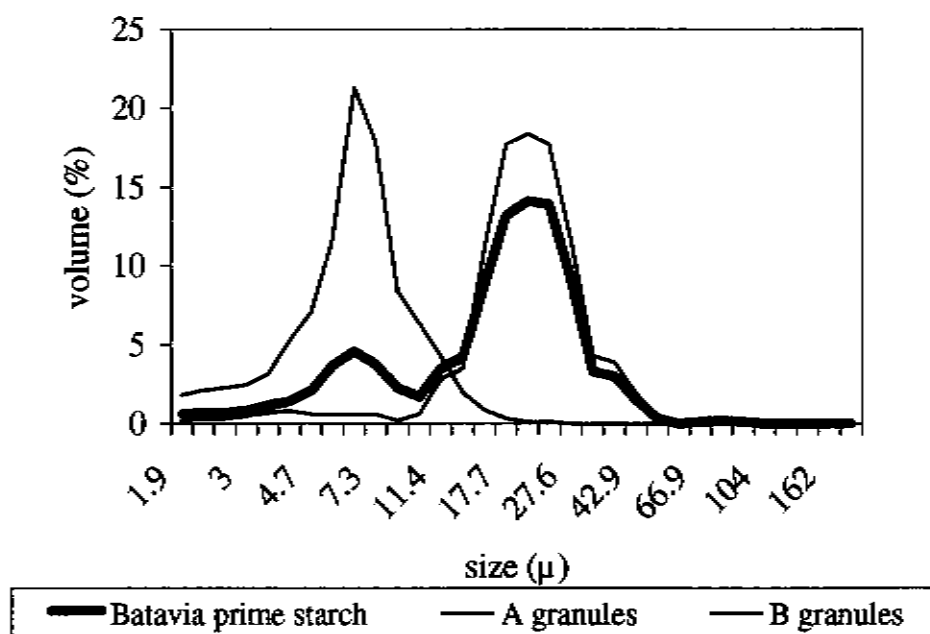


Table 3 Physical and chemical properties of Batavia A and B starch granule groups

	A granules	B granules
Protein content (%)	0.16	0.15
Lipid content (%)	0.26	0.12
Amylose content (%)	26.6	24.2
Average granule size (μ)	28.2	5.3
Peak viscosity (RVU)	255	172
Swelling power	14.624	22.859

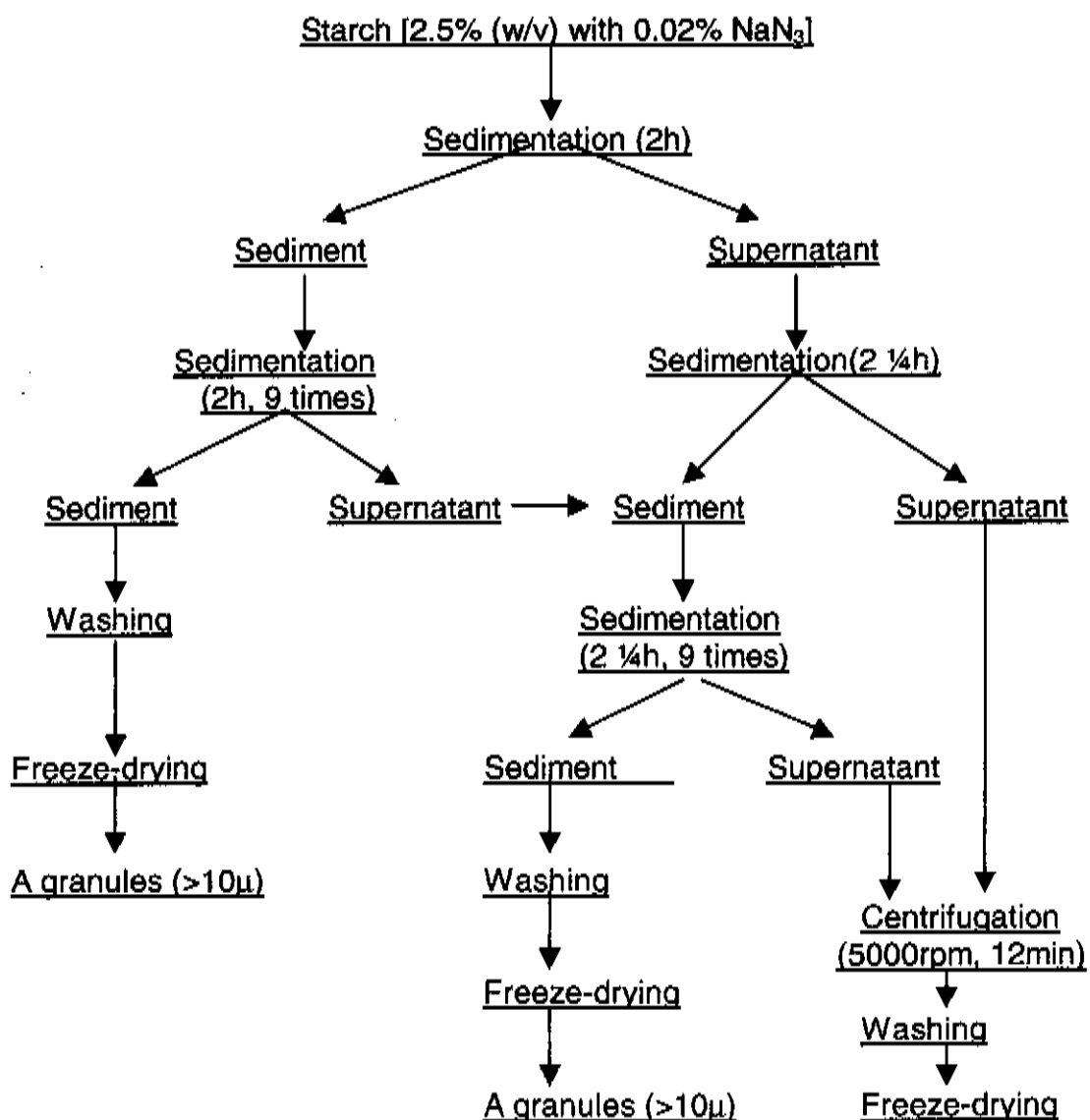
3. Effect of A to B starch granule ratio on RVA and swelling power property

A and B starch granule groups from the reference variety Batavia and the negative reference Cadoux were proportionally recombined. Reproducibility of three measurements was good for two varieties. Correlation between A granule content and RVA peak viscosity is depicted in Figure 4. As A starch granule content increased RVA peak viscosity increased. The same increasing trend was observed for Cadoux. However, the change in rate of viscosity between the two varieties was different indicating some difference in

granule properties between varieties tested. The observation was confirmed from the result that with Batavia peak viscosity increased by 10% for 100% A granules whereas with Cadoux 14.7% increase in peak viscosity was observed for 100% A granules. With 100% B granules peak viscosity decreased by 25.8% for Batavia while 21% decrease was observed for Cadoux. The viscosity of the prime starch samples fell on the derived lines which indicated sound fractionation and reconstitution techniques.

A significant negative correlation was observed between A granule content and swelling power value (Figure 5). It is considered that this was due to the larger surface area and number of B starch granules. For 100% B granules of Batavia, which originally contained 81.4% (w/w) of A granules, swelling power increased by 27%. For Cadoux swelling power of 100% B granules increased by 26.5% (Cadoux prime starch contained 85% (w/w) of A granules).

Figure 3 Starch granule separation procedure into large A and small B granules



↓
B granules (<10μ)

Figure 4 RVA peak viscosity vs A granule content

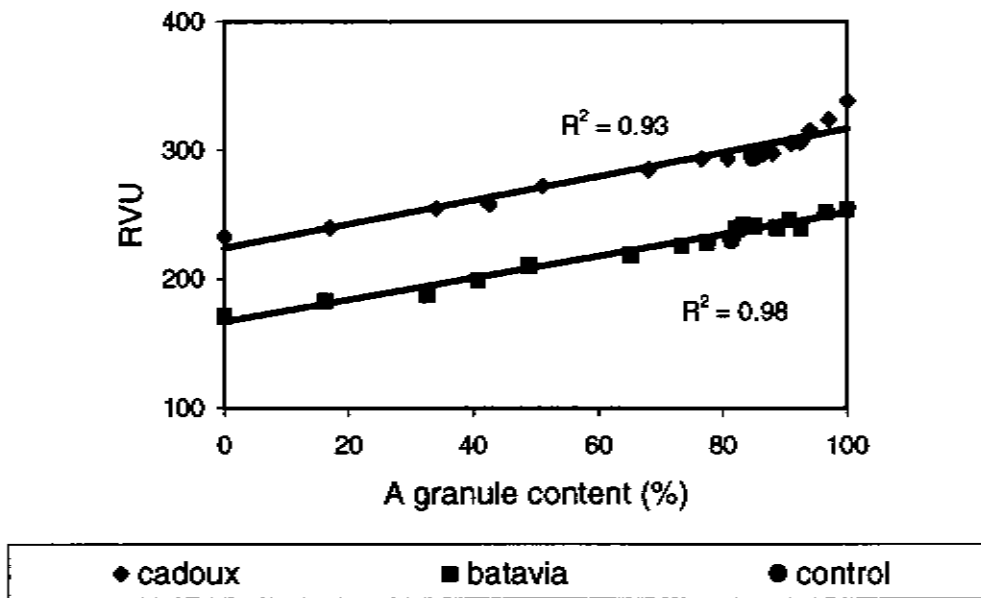
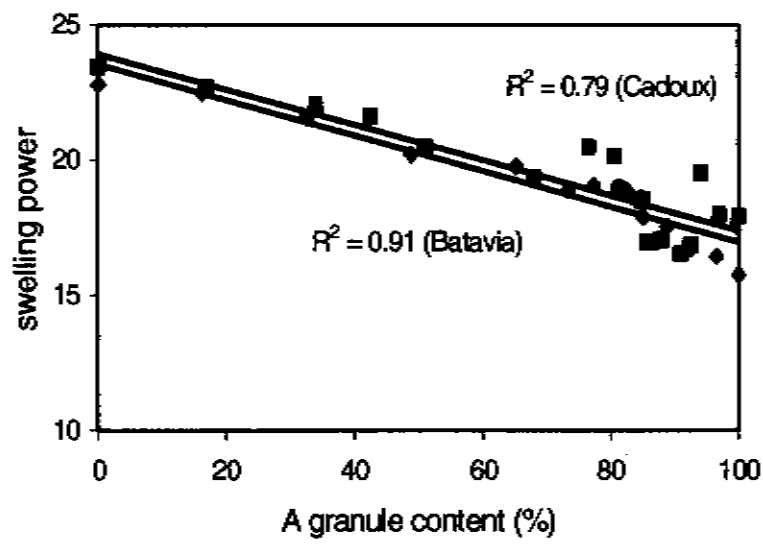


Figure 5 Correlation between A granule content and swelling power

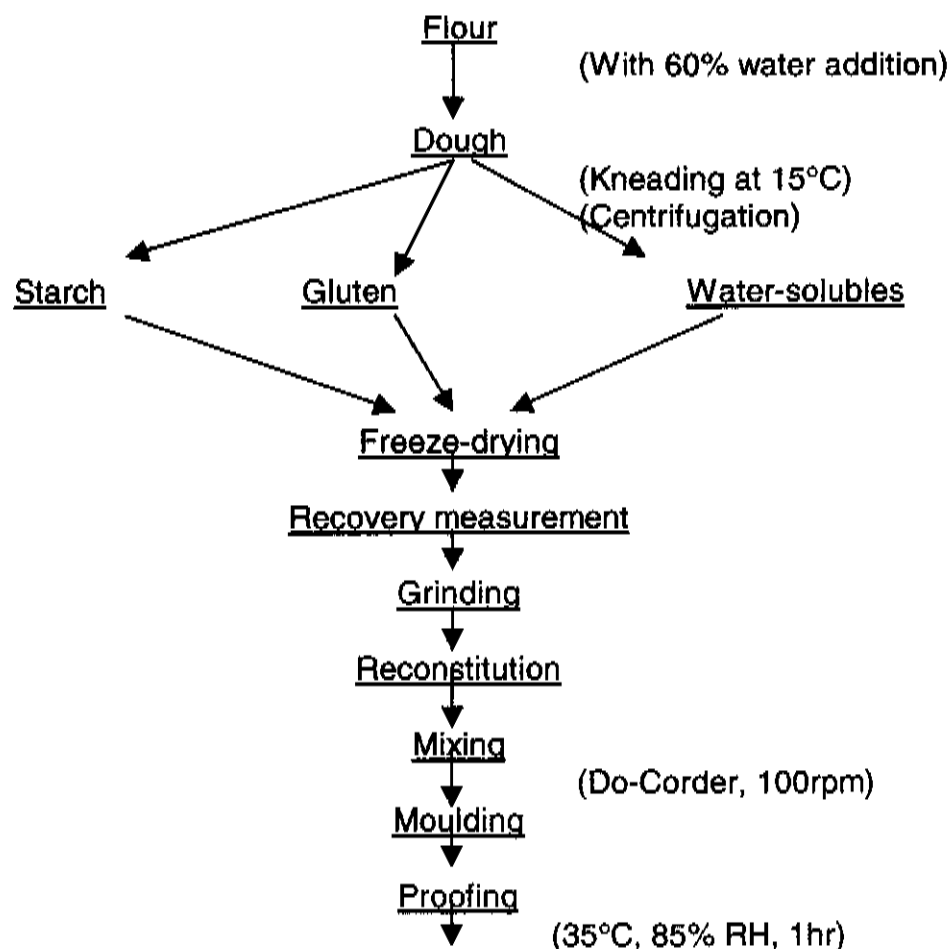


4. Development of test baking methodology

4.1. Establishment of reconstititional test baking procedure

A similar method to MacRitchie (1985) was used for small scale test baking and reconstitution with a number of exceptions including the inclusion of the water soluble component. Dried Batavia gluten, water-solubles and tailing starch were combined in the same composition as the reference flour and used as a base flour. The other prime starch fractions were mixed with the base flour for the test baking. Small scale baking (40g) procedure for high top and square loaf was developed. Detailed baking procedure is shown in Figure 6. The humidification effect of reconstituted flour on baking quality was tested. Consistant firmer crumb texture was measured with bread made from non-humidified flour. Negligible change in loaf volume was observed. Effect of fat on baking quality was also tested. The result showed firmer texture with fat-free bread and the difference between treatments was consistant on all varieties. The baking procedure, therefore, was simplified by excluding humidification step and removing fat.

Figure 6 Reconstititional bread making procedure



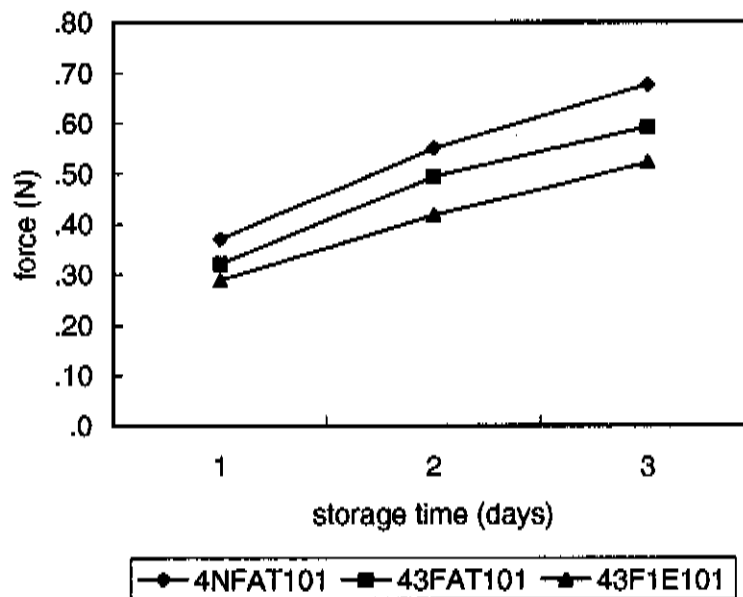
Test baking

(240°C, 12min)

4.2. Development of bread crumb firmness test procedure

A small block of bread was cut from the middle slice of a sample loaf. Dynamic compression test was experimented varying compression depth and frequency. Continuous double 10% compression showed sensitive change of crumb firmness over time without damaging the surface structure of the sample block. From Texture Analyser force-distance profile, crumb firmness was defined by dividing the first peak area by 10% of sample thickness and elasticity was defined by calculating the ratio of the first peak area over the first thickness to the second peak area over the second thickness. Change of crumb firming ratio was determined by the ratio of firmness (48h) to firmness (24h). A sample of crumb firmness measurement by 10% compression on time is shown in Figure 7. These results showed a predicted response for the addition of fat to the baking formulation and were consistent with a similar trial on full scale samples using the AACC method.

Figure 7 Compression test for bread baked with three levels of fat addition



5. Baking trial

5.1. Prime starch reconstituted bread test baking trial

Reconstituted flour samples were prepared by blending each starch fraction with identical Batavia gluten and water-solubles. Physical and chemical properties of reconstituted flour samples were measured. RVA pasting viscosity, swelling power and Mixograph properties of reconstituted flour are shown in Table 4. It was found that pasting viscosity and swelling power

properties of reconstituted flour were similar to corresponding prime starch samples, which confirms the major role of starch in viscosity and swelling power properties. However mixing property measured by 2g Mixograph showed interesting results. Even though samples contained the same gluten mixing time and peak resistance varied significantly. This indicates that starch property affected rheological behaviour of dough resulting in different baking quality. This would largely be due to the effect of starch damage on water absorption. However, other starch factors may account for a component of this given that the correlation between starch damage and mixing time was significant but not strong.

Table 4 Physicochemical properties of prime starch reconstituted flour

	Peak viscosity (RVU)	Swelling power	Mixing time* (sec)	Peak resistance*
Batavia	257	15.692	250	204
Cadoux	273	16.5671	225	209
Banks GL	161	12.560	187	197
Banks MV	177	13.075	221	191
Batavia GL	220	15.697	288	191
Batavia MV	286	15.827	233	196
Hartog GL	209	14.974	326	261
Hartog MV	228	14.716	250	207
Sunco GL	188	12.832	345	193
Sunco MV	205	13.317	278	195

*By 2g Mixograph

Small scale high top loaf samples are shown in Figure 8. Dough was made using Do-Corder set to a speed of . Water addition of each sample was adjusted by the same dough consistency as the reference, Batavia reconstituted sample. Texture analysis of crumb showed that elasticity of high top loaf increased as the starch damage value increased (Figure 9). It was observed that for the 10 starch samples bread volume increased with the increase of B granule content. This seemed to be due to the effect of water absorption. There was a positive trend between peak viscosity and crumb firming ratio of high top loaf. Swelling power of starch appeared to have positive correlation with firmness of square loaf, which was not observed in high top loaves (Figure 11). More samples would be required to confirm these trends.

Figure 8 High top loafs of bread made from reconstituted flour

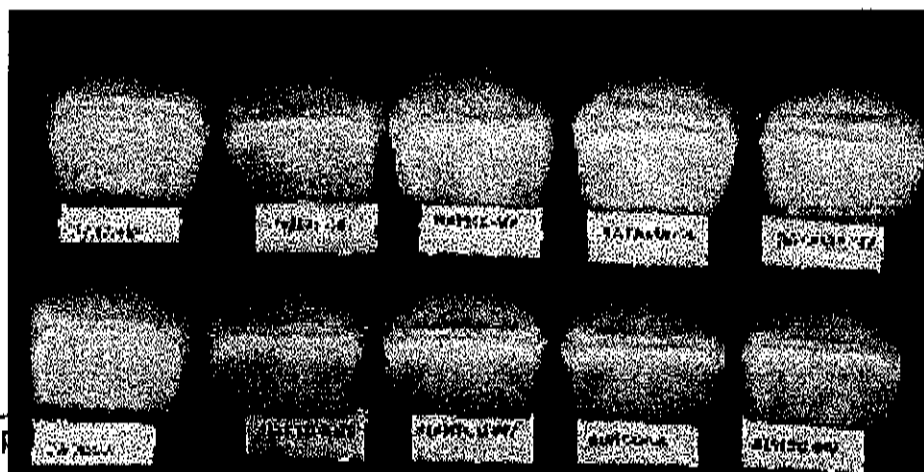


Figure 9 Change of bread crumb elasticity on starch damage

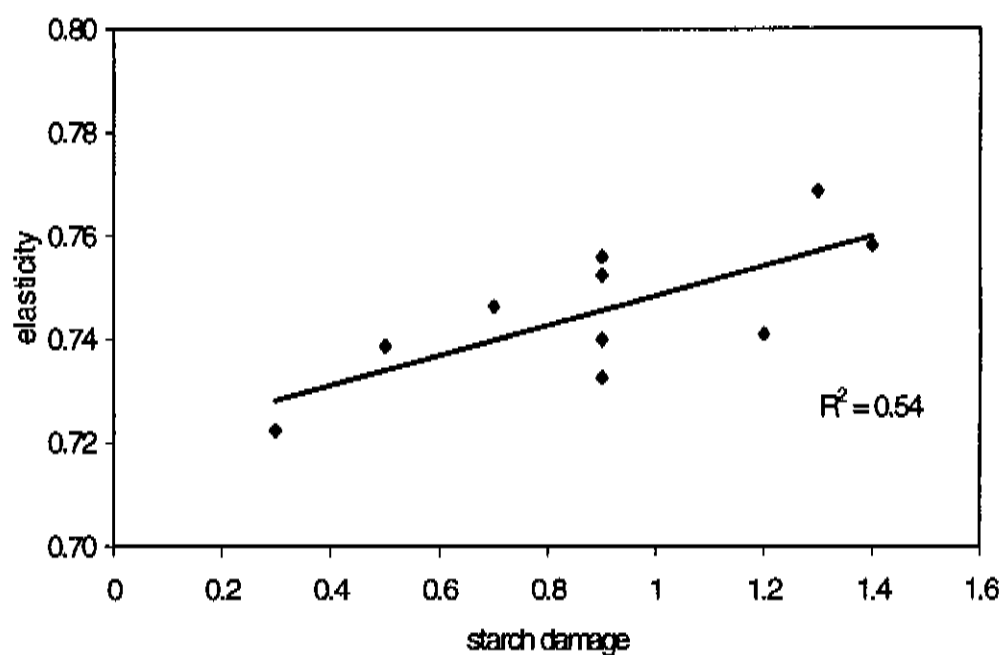


Figure 10 Change of bread volume on B starch granule content

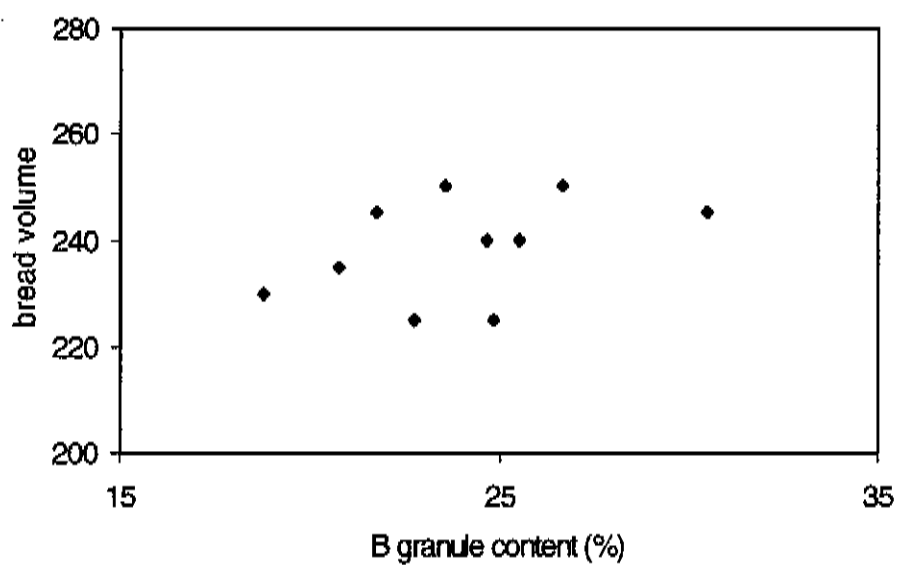


Figure 11 Change of firming ratio on peak viscosity

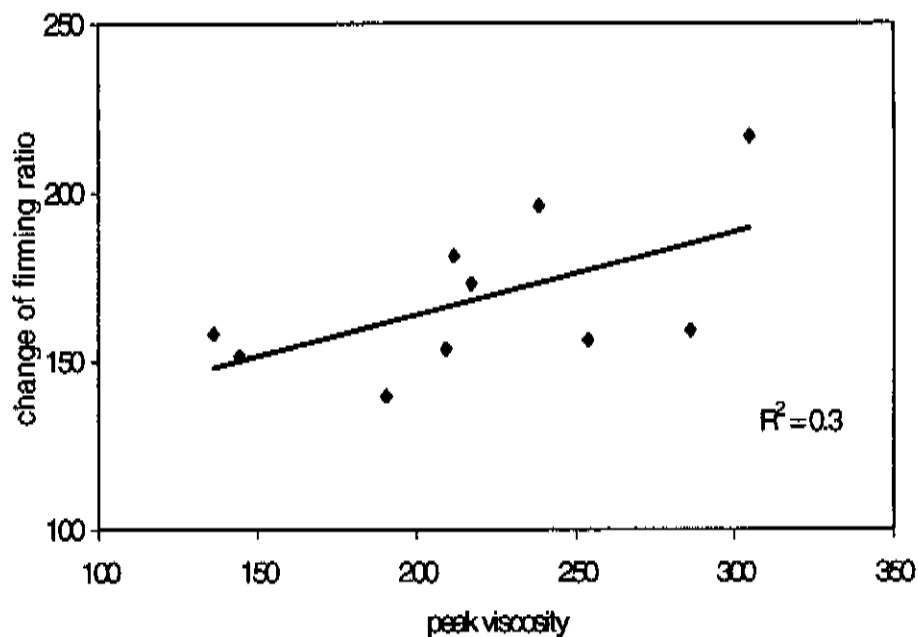
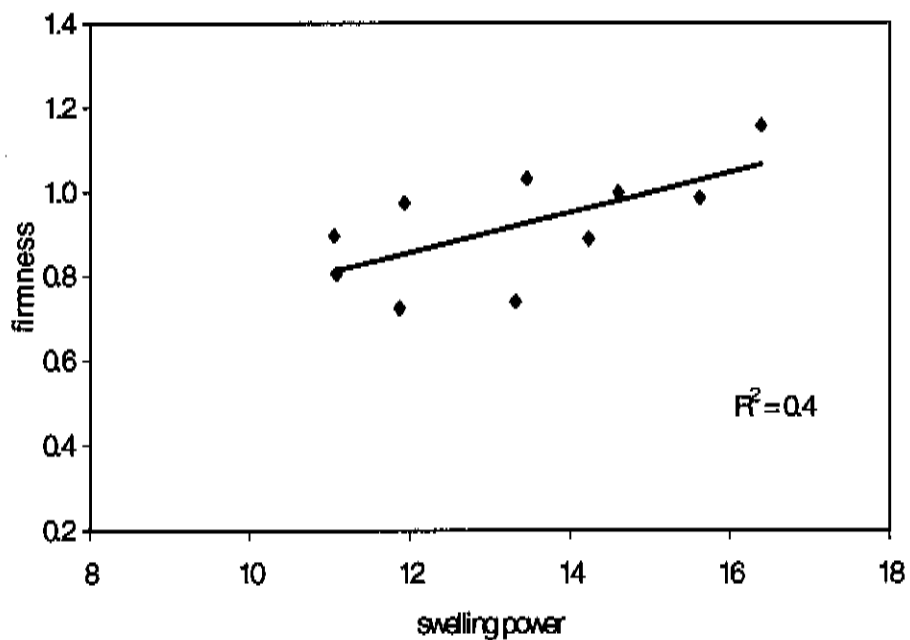


Figure 12 Firmness of square loaf against swelling power



5.2. A and B starch granule reconstituted bread test baking trial

A and B starch granules were proportionally mixed with Batavia gluten tailing starch and water-solubles. On the basis of Do-Corder mixing property water addition of each reconstituted flour was adjusted for dough consistency. However at 100% B granules the consistency used was tighter than for the other doughs as full water addition would have overloaded the dough with water – this is based on the experience of working with dietary fibre sources. Figure 11 shows test baking results of small scale high top loaves made from reconstituted flour with different A to B granule ratio. As B granule content increased, volume of high top loaves increased. This may be due to the higher water absorption ability of B granules and structural characteristics of B granules (Figure 12). Crumb texture became softer as B granule content increased. Figure 13 shows the crumb firmness change of high top loaves. The bread maintained better crumb elasticity when the B granule content was high (Figure 14). Test baking results of square loaves showed that softer crumb texture with more B granules was not simply due to higher water absorption of B granules resulting in larger volume of high top loaves, but due to structural characteristic of B granules in bread crumb (Figure 15).

Figure 11 High top loaves of bread made from A and B starch granule reconstituted flour

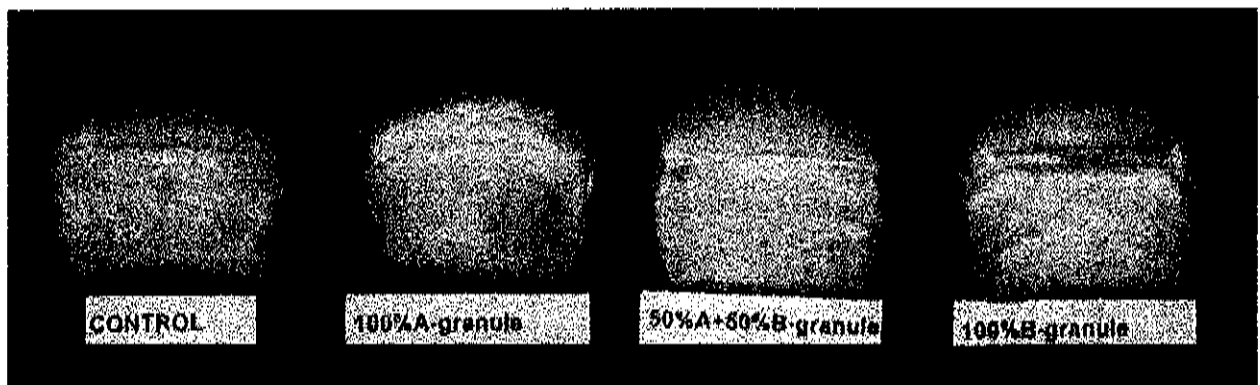


Figure 12 Bakery water addition for A & B granule reconstitutions

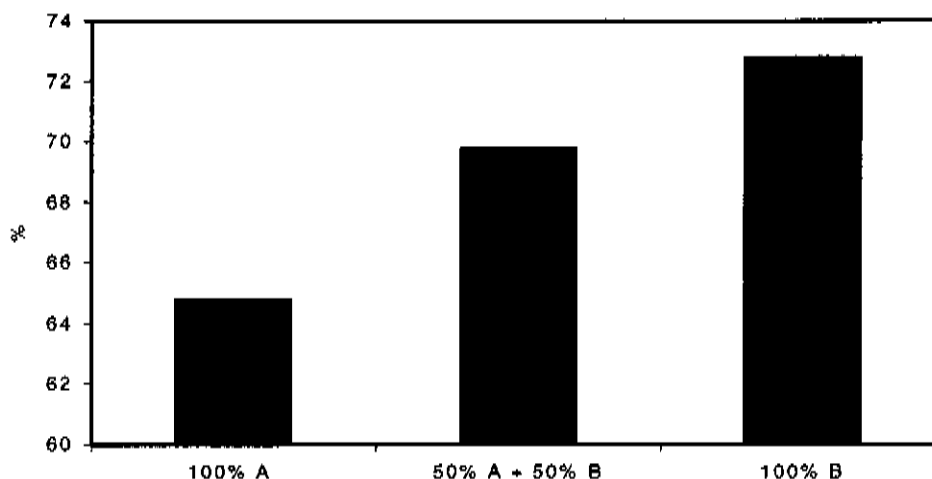


Figure 13 Crumb firmness of high top loaves for A & B granule reconstitutions

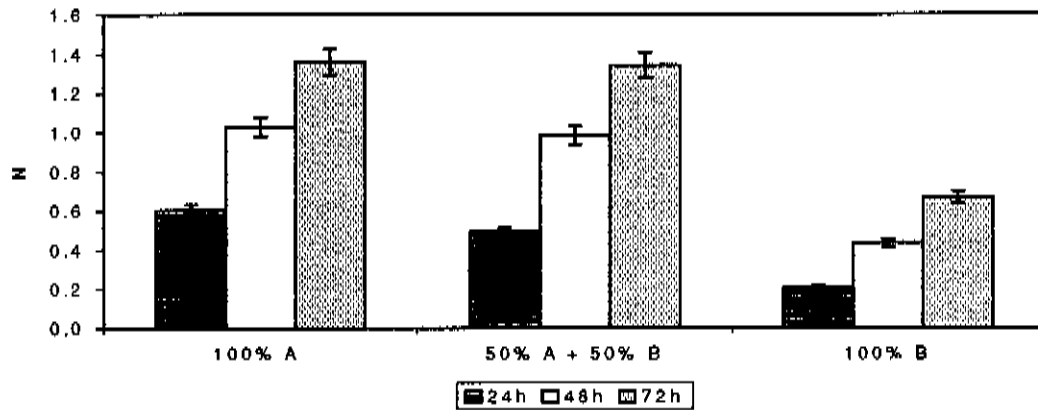


Figure 14 Crumb elasticity of high top loaves

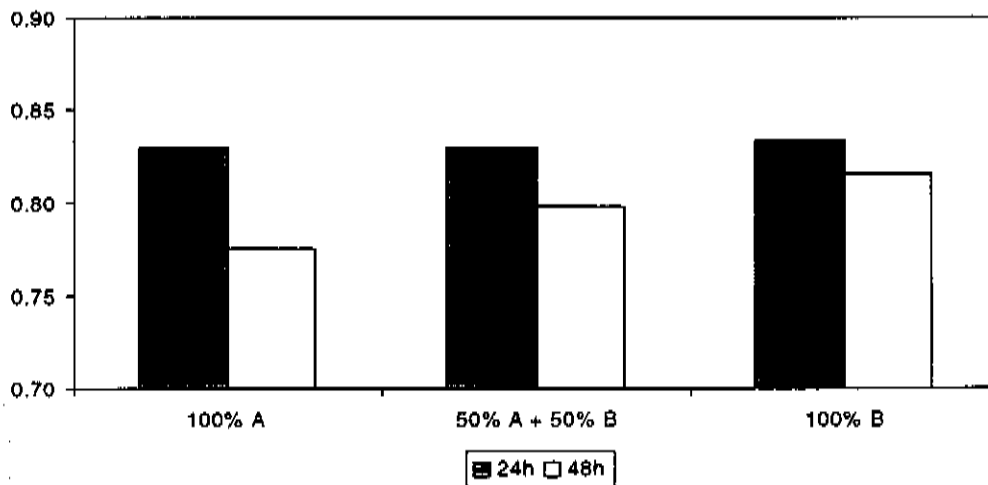
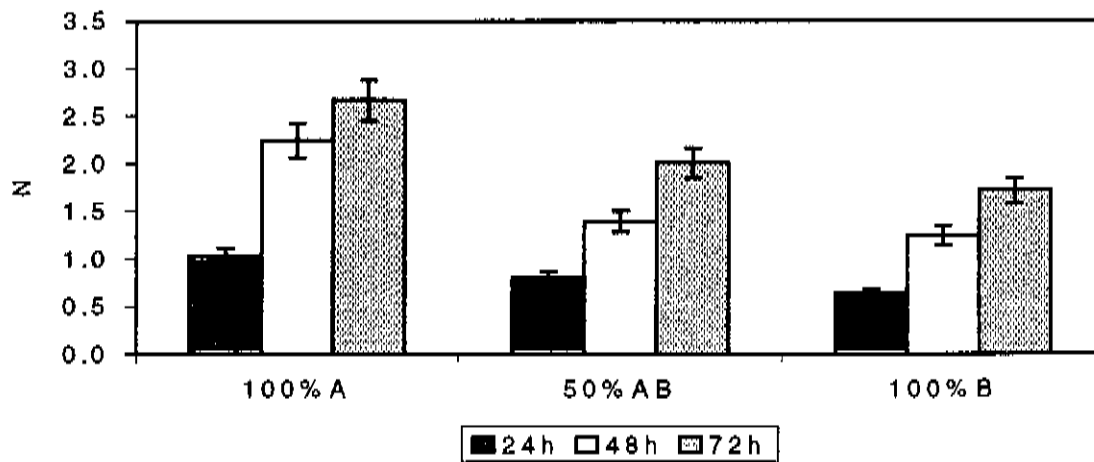


Figure 15 Crumb firmness of square loaves



6. Starch gel test

Starch gels were made with 3g of prime starch (14% mb) in 25ml deionised water. Gel strength was measured after 24hr. Setback viscosity showed significant positive correlation with gel firmness (Figure 16).

Starch gel made by proportional reconstitution with A and B starch granules at constant water addition showed obvious decrease in firmness with increase in B granule content (Figure 17). This indicates that bread crumb firmness is not simply affected by the higher water absorption of B granules.

Figure 16 RVA setback viscosity against firmness of starch gel

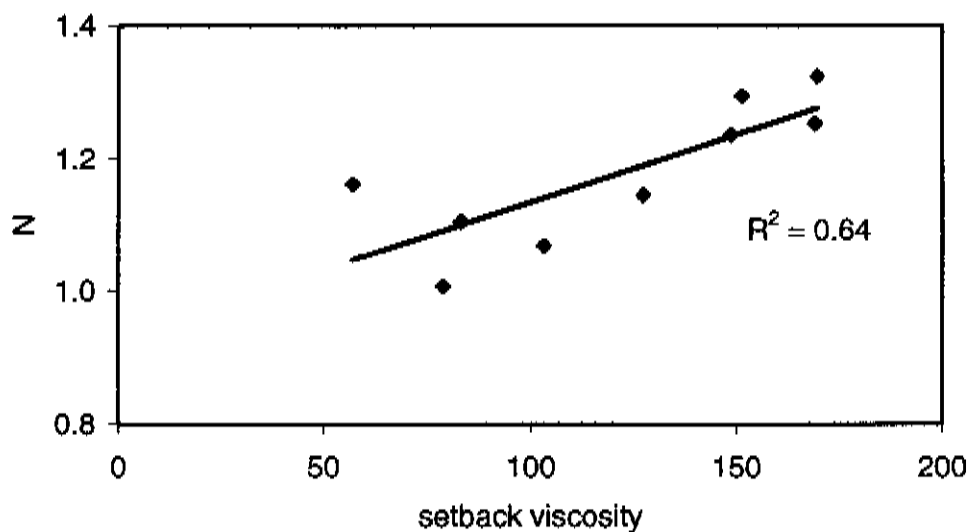
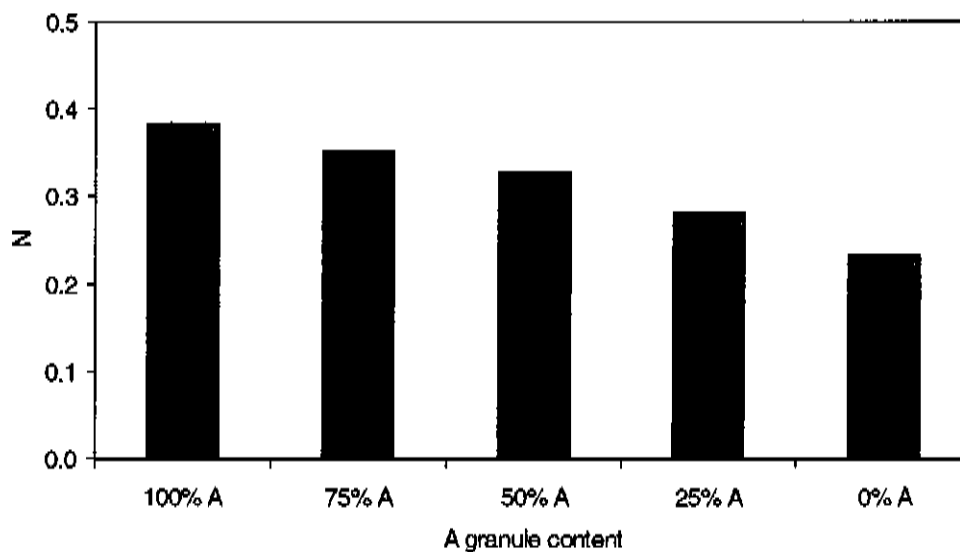


Figure 17 Firmness of starch gel on different A granule content



Reference

Macritchie, F.: J. of Cereal Sci. 3 (1985), 221

Geddes, R., C. T. Greenwood and S. L. MacKenzie: Carbohydrate Res. 1 (1965), 71.