Optimization of Rapid-Visco Analyser Test Conditions for Predicting Asian Noodle Quality

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ABSTRACT

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A variety of Rapid-Visco Analyser (RVA) operating conditions have been tested with starch, flour, and wholemeal for predicting the quality of wheats for the manufacture of Japanese white-salted noodles. Using starch as the substrate, an initial temperature of 60°C has been found to be optimum, and the best heating time from this initial temperature to the peak temperature of 95°C was ≈6 min. Significant correlations were found between peak viscosity of starch pastes and noodle quality under these operating conditions. For flour and wholemeal samples, the correlations were not as high as for isolated starch. The correlations with wholemeal or flour and noodle quality could be improved by the addition of α-amylase inhibitors. Measuring RVA viscosity of flour or wholemeal in the presence of silver nitrate gave viscosities which showed highly significant correlations with noodle quality. These correlations were similar to those obtained with isolated starch. It appears that the improvement is due to inhibition of the α-amylase present in grain and flour. Correlations were also observed between flour paste viscosity and alkaline noodle quality. These could be increased either by inhibiting α-amylase with silver nitrate or by pH adjustment with sodium carbonate but the change was not significant. The improvement of the correlations by α-amylase inhibitors in this sample set was not as great as observed with Japanese white noodles.

Various types of Asian noodles form a major end use of Australian wheat and ≈25–30% of the Australian wheat crop is exported for this purpose. The starch properties of the wheat play a major part in determining the quality of the noodles made from it (Nagao et al 1977, Moss 1980, Oda et al 1980). Starch swelling power has been a good predictor of wheat quality for Japanese white-salted noodles (WSN) (Crosbie 1991, McCormick et al 1991) and has been developed as a method for rapid screening of varieties for this purpose (Crosbie et al 1992). The absence of the granule-bound starch synthase (GBSS) allele on the 4A chromosome has also been proposed as a means of selecting lines for noodle-making purposes in Australian wheat breeding programs (Zhao and Sharp 1996).

High pasting viscosity, measured by either the amylograph or Rapid-Visco Analyser (RVA), has also been characteristic of starch from wheats with good Japanese noodle-making potential (Oda et al 1980, Crosbie 1991). The relationship between starch paste viscosity and noodle-making quality has been well described (Konik et al 1992, 1993). Some correlations between aspects of yellow alkaline noodle (YAN) quality (particularly smoothness and firmness) and starch paste viscosity have also been reported (Konik et al 1994). The viscosity of isolated starch is highly correlated with WSN quality (Konik et al 1992), but viscosity of flour and wholemeal has poorer correlations with noodle quality (Panozzo and McCormick 1993).

The RVA was initially developed as a tool for the rapid evaluation of sprout damage at grain receival points (Ross et al 1987). Extension of this technology by incorporating controlled heating and cooling, enabled development of an instrument capable of measuring the viscosity of flour or starch pastes during gelatinization in a manner similar to the amylograph (Walker et al 1988). The advantage of using the RVA for this purpose was its relatively small sample size (3–4 g) and the speed at which the test could be conducted (10–20 min). The capability of easily programming the heating-cooling cycle gave a flexibility that permitted optimization of conditions to suit a particular purpose.

It has been reported, however, that varying the heating and cooling conditions in the RVA can lead to large changes in the measured viscosities (Batey and Curtin 1996). In particular, changing the initial temperature or the heating rate usually resulted in significant variation in the peak and final viscosities. The size of this effect varied in a study of a group of samples, and there was not a good correlation between the values obtained at the different initial temperatures. It was therefore considered probable that the choice of operating conditions could be important in using the RVA for predicting noodle-quality potential of wheats.

Although the pasting properties of starch are better correlated with noodle quality than corresponding measurements on flour and wholemeal (Panozzo and McCormick 1993), it would be impracticable to isolate starch from each sample before testing. Thus, any viscosity test must be applied to flour or, preferably, wholemeal samples. One ubiquitous component in wheat is α-amylase, which is found in small quantities even in sound grain and is likely to have an effect on the paste viscosity of flour and wholemeal, particularly the latter. Inhibition of α-amylase activity before and during viscosity measurements has been reported for acid (Meredith and Pomeranz 1982), chelating agents such as ethylenediamine tetraacetic acid (EDTA) (Kickhaefer and Walker 1995), and heavy metal salts such as mercuric chloride (De Haas et al 1978) and silver nitrate (Hutchinson 1966). Silver nitrate has also been used to inhibit amylolytic activity during flour swelling volume tests of breeding lines to overcome the effects of sprout damage (Crosbie and Lambe 1993), and in RVA measurements on landraces of wheat (Bhattacharya and Corke 1996). It was considered likely that use of similar inhibitors for RVA prediction of noodle quality might also be of value.

In the work described here, a range of RVA conditions has been studied to determine their effect on predicting potential noodle quality. The use of α-amylase inhibitors and alkaline salts was also examined. The aim was to optimize the use of the RVA in the prediction of noodle quality.

MATERIALS AND METHODS

All flours and wheats were provided by the Bread Research Institute of Australia and were from the Australian Interstate Wheat Variety Trials (IWVT). Samples comprised a set of advanced breeding lines grown at several locations, with a different set being grown each season. The sets contained mostly hard lines with a wide range of dough properties. The varieties Cook, Eagle, Egret, Halberd, and Oxley were grown in all the trials

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alongside the breeders' lines, and flour from these varieties was included in the study. All of the wheats were sound, and flour Falling Number values ranged from 280 to 440. The flour had been prepared by milling the wheat to 60% extraction with a Buhler experimental mill. Whole meal was obtained by grinding in a Falling Number model 3300 grinder. The samples for WSN were from the 1988-89, 1989-90, and 1990-91 seasons, and those for YAN were from the 1991-92 season. All wheats were milled within 12 months of harvest, and the flours were stored at <10°C before analysis. Analyses were made within six months of milling.

Noodle-quality data was also provided by the Bread Research Institute and comprised results of sensory testing by trained taste panels. Data had been obtained using the standard Japanese procedure for WSN (Anon 1985) and the procedures described by Miskelly and Moss (1985) for YAN. Total noodle quality was a composite value obtained by summing the scores for three individual texture analyses. For WSN, only the total score (out of 50) was available for the samples examined, and these ranged from 28 to 38.5 (mean 33.3, standard deviation 2.55). In the case of the alkaline noodle data, the individual scores were available for firmness, smoothness, and elasticity. These were summed to give a total noodle score out of 30. The range of total scores was 18–21.5 (mean 20.12, standard deviation 0.59). The individual component scores were: smoothness 6.0–7.8 (mean 7.17, standard deviation 0.36), firmness 4.8–6.7 (mean 5.80, standard deviation 0.47), and elasticity 6.6–7.6 (mean 7.14, standard deviation 0.28). Values for noodle quality were distributed fairly evenly over the whole stated range for both types of noodles.

Purified water (Milli-Q grade) was used in all procedures. Statistical analysis was performed using the Minitab software package (Minitab Inc., State College, PA). Methods for comparing correlations were as described by Snedecor and Cochran (1989).

Starch Preparation

Wheat starch was washed from flour with a twin-bowl gluten washer (Glutomatic model 2220, Falling Number AB, Stockholm, Sweden) using two 10-g samples of flour simultaneously with 0.2% (w/v) sodium chloride as the wash solvent. Starch from 2× 10 g of flour was combined, and was subjected to repeated water-washing, centrifugation (5,000 × g), and separation by decantation. Three washing cycles were applied, using 200 mL of water for each wash. After each cycle, the protein and tailing starch layer was carefully removed by scraping it off the sedimented starch, and the tailings layer was mixed with water and recentrifuged to isolate any starch inadvertently removed. This starch pellet was pooled with the main starch product before the final wash. The final starch product was freeze-dried. In large-scale preparations, 300 g of flour was mixed with 180 mL of water in a Hobart mixer, and the resulting dough was kneaded by hand under water (2L). The gluten ball and large particulate material were removed by passing the mixture through a fine-mesh screen (120 µm), and the kneading step was repeated three times. The combined filtrates were centrifuged and washed with water as for the small-scale preparation, using 1L of water for each wash.

TABLE I
Effect of Different Rapid-Visco Analyser (RVA) Temperature Profiles on the Correlation Coefficient of RVA Peak Viscosity of Starch with Japanese Noodle-Eating Quality

Initial Temperature	Heating Time (min)	Heating Rate (°C/min)	r (n = 10)
50°C	1[a]	45	0.56
	3	15	0.66*[b]
	6	7.5	0.79**
	6.75	6	0.77**
	7.71	5.8	0.69*
	9	5	0.67*
55°C	1[a]	40	0.55
	3	13.3	0.59
	6	6.7	0.74*
	5.33	7.5	0.68*
	6.86	5.8	0.66*
	8	5	0.60
60°C	1[a]	35	0.69*
	3	11.7	0.71*
	6	5.8	0.87***
	4.67	7.5	0.76**
	5.25	6.7	0.84**
	7	5	0.79**
65°C	1[a]	30	0.64*
	3	10	0.68*
	6	5	0.70*
	4	7.5	0.72*
	4.5	6.7	0.72*
	5.14	5.8	0.69*

[a] Maximum practicable heating rate was ≈20°C/minute, depending on ambient conditions. A 1-min heating time was employed as a means of heating to 95°C as fast as possible.

[b] *, **, *** = Significance levels at $P < 0.05$, $P < 0.01$, $P < 0.001$, respectively.

RVA Conditions

RVA measurements were made using 3.0 g of starch or 4.0 g of flour or wholemeal suspended in 25.0 mL of water. The mixture was stirred at 960 rpm for 10 sec, and then at 160 rpm for the remainder of the test. The standard temperature profile comprised the following steps: hold at 60°C for 2 min, heat to 95°C at 5.83°/min over 6 min, hold at 95°C for 4 min, cool to 50°C at 11.25°/min over 4 min, and hold at 50°C for 4 min. In some experiments, the initial temperature and heating rate were varied as shown in Table I. In these experiments, the times and temperatures for each stage after 95°C was reached were the same as in the standard profile. The RVA parameters measured were peak viscosity (the maximum hot paste viscosity), holding strength (the trough at the minimum hot paste viscosity), and final viscosity (the viscosity at the end of the test after cooling to 50°C and holding at this temperature). From these values were calculated the breakdown (peak viscosity minus holding strength) and setback (final viscosity minus holding strength). All values were expressed in RVA units (RVU).

To determine the effect of α-amylase inhibitors and alkali on the RVA viscosity, the water was replaced with the same volume of a solution of ≈12 m*M* silver nitrate, sodium carbonate (10 m*M*), EDTA (10 m*M*), or ethylene glycol-bis(β-aminoethyl ether) tetraacetic acid (EGTA) (10 m*M*). For silver nitrate, this was achieved by reducing the water volume by 0.5 mL and adding 0.5 mL of 10% (w/v) silver nitrate solution; the other solutions were made up directly at the concentrations used. All were used with the standard temperature profile.

RESULTS

Effect of Different Temperature Profiles

A sufficient quantity of starch was available from 10 flours to enable a study using different temperature profiles with initial temperatures of 50, 55, 60, and 65°C. The aim was to keep the total length of the test as short as possible while retaining the ability to discriminate on noodle-quality potential. Accordingly, the heating times to 95°C were 1, 3, and 6 min from all initial temperatures. In practice, a 1-min heating time was nominal—the maximum practicable heating rate was 20–23°C/min, and 1 min was used in the profile as a means of ensuring that the peak temperature was achieved as soon as possible. The 3-min heating time was considered to be optimal in allowing for a rapid but achievable heating rate from all temperatures, while restricting the total time to as short as possible; and 6 min was considered longer than desirable. Of these times, a 6-min heating time gave the best correlations with all initial temperatures (Table I). However, changing the initial temperature, while leaving the heating time unchanged, necessarily causes the heating rate to vary also. Therefore, in addition to the three heating times listed above, for each initial temperature there were heating times corresponding to heating rates of 7.5, 6.7, 5.83, and 5°C/min. They were chosen to imitate the heating rates for reaching 95°C from 50, 55, 60, and 65°C, respectively, in the empirically determined optimum time of 6 min. This was to test whether the variations between values obtained for different initial temperatures were caused by the heating rate rather than by the temperature.

Varying either the initial temperature or the heating rate affected the values obtained for the various RVA characteristics, and also the correlation coefficients of peak viscosity with Japanese noodle quality (Table I). Changing the initial temperature appeared to have a greater effect on the correlation coefficient than changing the heating rate, except at a starting temperature of 65°C. It was observed that the best correlations were obtained with an initial temperature of 60°C and a heating time of 5–6 min. Correlations of quality with RVA peak viscosity obtained using this initial temperature were better than those using different temperatures.

The differences in the correlation coefficients were tested for significance by the methods described by Snedecor and Cochran (1989). Tested as a group, the values were significantly different ($P < 0.001$) and did not represent the same value. The highest value (0.87) obtained for the procedure using an initial temperature of 60°C and a heating time of 6 min, was significantly different ($P < 0.05$) from all others, except the value of 0.84 obtained for a heating time of 5.25 min at the same initial temperature. For all initial temperatures, except 65°C, there were some significant differences between the values obtained for the different heating times at the same initial temperature. For 65°C, the lack of significant differences between any of the values reflects the limited effect that changing the heating rate had on the peak viscosity.

For simplicity, a standard profile was constructed utilizing an integral number of minutes for each step. For the sample set studied, the optimum time to heat from 60 to 95°C was between 5.25 and 7 min. The standard time for heating was thus set at 6 min. The initial holding time (2 min) was selected because shorter initial times diminished the repeatability (Batey and Curtin 1996). The holding time at 95°C, the cooling time, and final holding time at 50°C were all set at 4 min, giving a total test time of 20 min. The times for these stages are less important than the heating time (Batey and Curtin 1996).

Relationship of Japanese Noodle Quality with the RVA Viscosity of Isolated Starch, Flour and Wholemeal

All starch, flour, and wholemeal samples were tested using the standard profile described above. A comparison of the correlation coefficients between the RVA parameters and the eating quality of Japanese WSN is given in Table II. The data for starch and flour for the 14 wheat samples available as wholemeal was analyzed and has been presented separately, as well as being included in the analysis of the 97 starch and flour samples.

For the samples measured as wholemeal, no RVA parameter was significantly correlated with noodle quality, but the breakdown showed the highest value ($r = 0.52$, $n = 14$). For the flour and starch from the same wheats, the relationship with breakdown was greater than for wholemeal ($r = 0.71$ and 0.82, $P < 0.01$ and $P < 0.001$, $n = 14$, for flour and starch, respectively), and the relationship with peak viscosity was also significant. Setback was also significant for starch ($r = –0.55$, $P < 0.05$). For the full set of 97 flours and starches, breakdown was the most significant for both flour and starch ($r = 0.66$ and 0.54, respectively; $P < 0.001$ for both). With starch the correlation of setback with quality was greater than for peak viscosity, although both were highly significant. In flour, peak viscosity had a slightly higher correlation and a greater significance than setback.

The viscosity of a number of wholemeal flours was examined using the RVA in the presence of silver nitrate, and the peak and final viscosities were increased by varying amounts for each sample. Typical increases are as shown in Fig. 1, similar to those reported by other workers (Klassen and Hill 1971, Meredith 1971, Holm et al 1988). The effect of metal-complexing agents, such as EDTA and EGTA, both of which also act as amylase inhibitors, was also examined. These also increased the viscosity of wholemeal pastes but not to the same extent as silver nitrate. The effect of these α-amylase inhibitors on the correlations between viscosity and noodle quality is shown in Table III. All three inhibitors caused an increase in the values for the correlation coefficients, but neither EDTA nor EGTA was as effective as silver nitrate.

The pasting viscosities of all the flour samples were measured in the presence of silver nitrate. All viscosity parameters measured with silver ions showed correlations with noodle quality more

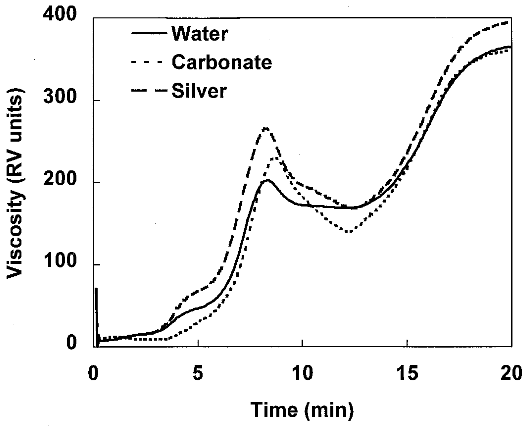

Fig. 1. Pasting curves from Rapid-Visco Analyser analysis of flour in water and with added silver nitrate or sodium carbonate.

TABLE II
Comparison of Correlation Coefficients Between Japanese Noodle-Eating Quality and Rapid-Visco Analyser Pasting Values of Wheat Starch, Flour, and Wholemeal

	Starch		Flour		Wholemeal
	$n = 14$	$n = 97$	$n = 14$	$n = 97$	$n = 14$
Peak viscosity	0.69**[a]	0.38***	0.64*	0.29**	0.24
Holding strength	–0.14	–0.09	0.05	–0.11	0.12
Final viscosity	–0.48	–0.35***	–0.23	–0.19	–0.16
Breakdown	0.82***	0.66***	0.71**	0.54***	0.52
Setback	–0.55*	–0.46***	–0.38	–0.27**	–0.33

[a] *, **, *** = Significance levels at $P < 0.05$, $P < 0.01$, $P < 0.001$, respectively.

TABLE III
Effect of α-Amylase Inhibitors on Correlation Coefficients of Eating Quality of Japanese Noodles with Some Selected Rapid-Visco Analyser Pasting Characteristics of 14 Wholemeal Samples

Viscosity Parameter	Inhibitor[a]		
	EDTA	EGTA	$AgNO_3$
Peak	0.46	0.56*[b]	0.74**
Breakdown	0.55*	0.61*	0.80***
Setback	–0.29	–0.41	–0.63*

[a] EDTA = ethylenediamine tetraacetic acid; EDTA = ethylene glycol-bis(β-aminoethyl ether) tetraacetic acid; $AgNO_3$ = silver nitrate.

[b] *, **, *** = Significance levels at $P < 0.05$, $P < 0.01$, $P < 0.001$, respectively.

TABLE IV
Correlation Coefficients of Eating Quality of Japanese Noodles with Rapid-Visco Analyser Pasting Characteristics of Wheat Flour and Wholemeal, Measured Using $AgNO_3$

Viscosity Parameter	Flour ($n = 97$)	Wholemeal ($n = 14$)
Peak viscosity	0.47***[a]	0.74**
Holding strength	–0.33***	0.19
Final viscosity	–0.57***	–0.21
Breakdown	0.54***	0.80***
Setback	–0.62***	–0.63*
Difference (peak – final viscosity)	–0.62***	–0.85***

[a] *, **, *** = Significance levels at $P < 0.05$, $P < 0.01$, $P < 0.001$, respectively.

significant than those measured without silver (Table IV). Breakdown still showed a larger correlation than peak viscosity. However, the difference between final and peak viscosities gave the most significant correlation with noodle quality for both flour ($r = –0.62$, $P < 0.001$, $n = 97$) and wholemeal ($r = –0.85$, $P < 0.001$, $n = 14$).

Relationship of RVA Flour Viscosity with Alkaline Noodle Quality

Although protein is expected to make a greater contribution to the quality of alkaline noodles, some relationships between aspects of noodle quality and starch properties have been reported (Konik et al 1994). The same flours studied by those workers were used in our study to test whether the standard RVA procedure we have developed for WSN was also applicable to alkaline noodles. The correlation coefficients between the paste viscosities of the flours and smoothness, firmness, elasticity, and total quality are presented in Table V. These correlations are significantly better than those reported previously.

Sodium carbonate (or sometimes a 9:1 mixture of sodium and potassium carbonates) is added to flour in the preparation of doughs for YAN (Miskelly and Moss 1985). It seemed appropriate to measure the viscosity in the presence of alkaline salts to see whether any effect on the properties of the dough could be related to the viscosity. The amount of sodium carbonate used was based on flour weight and was the same as normally incorporated into the doughs for noodle preparation. Its effect on the viscosity of some flour samples are shown in Table VI. In general, when measured in sodium carbonate, there was a trend for a minor increase in the peak viscosity over the values measured in water but a decrease in the final viscosity and holding strength. The size of the change varied with flour from different cultivars. A typical RVA pasting curve measured in the presence of sodium carbonate is shown in Fig. 1.

RVA measurements of these flours were also taken in the presence of silver nitrate. Its effect was invariably to increase the viscosity, often by a very large amount (Table VI). However, although using either sodium carbonate or silver nitrate gave slight improvements in the correlations between viscosity and noodle quality (Table V), the alteration was not significant in either case.

DISCUSSION

It is clear that the operating conditions of the RVA can have an effect on both the actual value measured for the pasting viscosity and the ability to use those values for predicting noodle quality. Interestingly, the highest initial temperature (65°C) usually gave the highest peak viscosity, yet the lowest viscosity was frequently observed with the second highest temperature (60°C). With an initial temperature of 65°C, there was little variation in the peak viscosity observed, although longer heating times usually gave a slightly reduced final viscosity. This lack of variation in the peak viscosity was reflected in the relatively small variation in correlation coefficients for noodle quality with viscosity. Use of a rapid heating rate (as fast as possible) gave the poorest correlation with all initial temperatures. The usual method for cooking noodles is to drop them into boiling water, and a rapid heating step might have been expected to give the highest correlations. Instead, long heating times tended to give paste viscosities with the highest correlations with Japanese noodle quality. This is probably more of an effect of hydration than actual heating times. Although the temperature of a noodle in boiling water would rapidly rise, the movement of water into the noodle would be relatively slow. As gelatinization needs to be preceded by hydration, the time for this occurrence is more closely represented by the heating time in the RVA.

TABLE V
Correlation Coefficients[a] of Alkaline Noodle Quality of Flours (n = 23) with Rapid-Visco Analyser (RVA) Peak Viscosity, Breakdown, and Peak Minus Final Viscosity of Flour Measured Using Water, Sodium Carbonate, and Silver Nitrate Solutions

Quality Parameter	RVA Solution	Peak	Breakdown	Peak Minus Final
Smoothness	Water	0.84***[a]	0.84***	–0.80***
	Na_2CO_3	0.86***	0.88***	–0.87***
	$AgNO_3$	0.88***	0.89***	0.88***
Firmness	Water	–0.60**	–0.62**	–0.61**
	Na^2CO_3	–0.57**	–0.56**	–0.51*
	$AgNO_3$	–0.58**	–0.60**	–0.58**
Elasticity	Water	–0.31	–0.29	–0.27
	Na_2CO_3	–0.31	–0.30	–0.19
	$AgNO_3$	–0.27	–0.27	–0.23
Total quality	Water	–0.24	–0.22	–0.21
	Na_2CO_3	–0.21	–0.20	–0.12
	$AgNO_3$	–0.19	–0.20	–0.18

[a] *, **, *** = Significance levels at $P < 0.05$, $P < 0.01$, $P < 0.001$, respectively.

In utilizing any test for predicting the quality of a product to be made from wheat, it is desirable to minimize the processing required before performing the test. When using starch paste viscosity to predict noodle quality, there is a conflict between minimizing the processing of the sample and the potential reliability of the test. Wholemeal, which requires minimal processing, gave the poorest correlations with Japanese noodle quality, while isolated starch gave better correlations but required the wheat to be milled to flour from which the starch was then isolated. This was also observed by Panozzo and McCormick (1993). As well as requiring additional steps, the starch washing was both time consuming and labor intensive. It was also necessary to dry the starch before performing the RVA test. As a test for screening large numbers of samples, it is obviously unsatisfactory. The additional components present in flour and whole grain must have an effect on the measured viscosity and thus on the correlations obtained. Konik et al (1992) reported that including the protein content and hardness (as particle-size index) into a multiple regression with starch viscosity gave improved correlations with Japanese noodle quality but there was still much of the variance to be accounted for.

α-Amylase is usually present at low levels in wheat flour and grain. Its presence in large amounts, as a result of either sprouting or the production of late maturity α-amylase in the developing grain (Mares and Mrva 1993), would cause the wheat or flour to be rejected for noodle production and for many other purposes, but the small amounts normally present in sound grain presumably do not have any significant effect on noodle quality. They do, however, have a significant effect on the viscosity of flour or wholemeal pastes. Measurement of the viscosity in the presence of α-amylase inhibitors should allow the inherent viscosity of the starch to be measured without the reduction caused by α-amylase. For this purpose, silver nitrate was more effective than either EDTA or EGTA. It is assumed that the silver binds strongly at or near the active site of the enzyme, while EDTA and EGTA compete for the calcium ion which is a requirement for the enzyme's activity. EGTA, with a larger binding constant for calcium, was slightly more effective at increasing the viscosity than EDTA. Higher concentrations of EDTA or EGTA may have been more effective due to better competition for the calcium, but increased concentrations of salts have also been observed to cause reductions in the viscosity (I. Batey, *unpublished data*). These opposing effects may have diminished or annulled any benefit from using higher concentrations.

TABLE VI
Effect of Sodium Carbonate and Silver Nitrate on the Rapid-Visco Analyser (RVA) Pasting Viscosities of 23 Wheat Flour Samples Used for Yellow Alkaline Noodle Preparation

		Increase		
	RVA Parameter	Mean	Maximum	Minimum
Na_2CO_3	Peak viscosity	8	58	–25
	Final viscosity	–28	3	–70
	Holding strength	–28	–8	–51
$AgNO_3$	Peak viscosity	87	131	47
	Final viscosity	17	48	–16
	Holding strength	7	24	–9

The presence of α-amylase in wheat and flour can explain both the reason for the viscosity of wholemeal being a poorer predictor of noodle quality than flour, in its turn being worse than starch, and the reason for the improvement of correlations in the presence of α-amylase inhibitors. Inclusion of other factors, such as protein content, should also improve the correlations, as shown by other workers (Konik et al 1992). This may be because a higher protein content tends to mean a reduced starch content, and hence a decreased viscosity because of lower starch concentration in the gel. Interactions between the starch and protein may also influence the viscosity, which would also account for the reported improvements in correlations (Konik et al 1992, 1993, 1994) when the protein content is included. Hardness may affect the viscosity by increasing the amount of damaged starch. There is usually a shoulder, or sometimes an actual small peak ahead of the main viscosity peak in the RVA trace, particularly when the initial temperature is 60 or 65°C (Batey and Curtin 1996). This premature gelatinization appears to be related to damaged starch; it may also reduce the peak viscosity by varying amounts in approximate proportion to the damaged starch content.

The failure of sodium carbonate to improve significantly the correlation of viscosity with YAN quality may have been because the correlations with viscosity measured in water were already very high. It should also be noted that silver nitrate did not significantly improve the correlation between viscosity and YAN quality, a direct contrast with the results for WSN. It is apparent that the action of sodium carbonate is quite different to that of silver nitrate. While silver invariably increased the peak viscosity, usually by a large amount, and rarely decreased either the final viscosity or holding strength, sodium carbonate caused a reduction in peak viscosity for about one third of the samples studied, in the final viscosity for most samples, and in the holding strength for all samples. The effect is obviously from the carbonate ion, as neutral salts, such as sodium chloride or sodium nitrate, have had little effect on the values for pasting viscosity at the same concentration (Batey and Curtin 1996). This suggests that it is the alkalinity of the carbonate rather than its size or charge having the effect on viscosity.

CONCLUSION

The conditions used for measuring the pasting viscosity of starch in the RVA can have a major effect on the prediction of noodle quality for both WSN and YAN. The inclusion of an α-amylase inhibitor in the slurry during the measurement of viscosity increases the viscosity and improves the correlation of viscosity with WSN quality, with silver ions being the most effective inhibitor tested. The addition of silver nitrate or sodium carbonate to the mixture does not have much effect on the correlations of viscosity with YAN quality.

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