Shortened Temperature Program for Application with a Rapid Visco Analyser in Prediction of Noodle Quality in Wheat

G. B. Crosbie,[1,2] P. C. Chiu,[1] and A. S. Ross[3]

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ABSTRACT

The use of the Rapid Visco Analyser (RVA) for application in the screening of wheat breeding lines for starch quality and potential noodle quality has been limited by relatively low sample throughput. Current methods generally enable only 20–30 samples to be tested each day. This study sought to develop a more rapid time-temperature profile that could be applied to whole meal samples. A profile that involved a total analysis time of 7.5 min/sample gave measurements of peak viscosity (PV) and breakdown (BD) on whole meal that were highly correlated with corresponding measurements obtained using a more conventional profile that had been applied to low-extraction flours. BD and PV were also highly correlated with the total texture score of ramen (Chinese-style alkaline noodles as manufactured in Japan), but only when 1 m*M* $AgNO_3$ was used to eliminate the effects of α-amylase.

Studies in the late 1970s on noodle quality in wheat pointed to the importance of amylograph pasting properties of the isolated starch (Shirao and Moss 1978; Moss 1980; Oda et al 1980). However, both the starch isolation procedure and the amylograph test were time-consuming, and a faster method was needed for application in wheat breeding (Crosbie 1989).

One development was the swelling power test, first used to characterize starch quality differences among wheat cultivars by Toyokawa et al (1989) and Crosbie (1989). The swelling power test was further developed into the more rapid flour swelling volume (FSV) test by Crosbie (1989, 1991); Crosbie and Lambe (1990, 1993), and Crosbie et al (1992) for application on flour and whole meal samples. The FSV test has been applied in the development of improved noodle wheat cultivars in Western Australia (Crosbie 1997a) and in noodle quality research elsewhere (Battacharya and Corke 1996; Battacharya et al 1997; Wang and Seib 1996; Kovacs et al 1997; Fu et al 1998; Morris 1998). The test requires 0.5 g or less of sample, is highly heritable (Morris et al 1997), is insensitive to low levels of α-amylase (Crosbie et al 1993), and has a throughput of up to three batches of 48 samples/day (Morris 1998).

Another development was the temperature-programed Rapid Visco Analyser (RVA), which led to a substantial increase in sample throughput compared with the earlier amylograph methods. Among the many studies in which the RVA has been applied to wheat starch, flour, or whole meal, a range of time-temperature profiles has been used. These include the profiles of Konik and Moss (1992) at total time 18 min (also used by Konik et al 1994; Ross et al 1997; Crosbie et al 1999); Panozzo and McCormick (1993) at 20 min; Bhattachatya and Corke (1996) at 22 min; Yun et al (1996) at 14.5 min; and Batey et al (1997) at 20 min. Although adequate for research studies, the times are still too long for the methods to be applied at early stages in wheat breeding. Morris (1998) reported the application of a shortened profile in which the sample was rapidly heated and the test terminated as soon as the paste peak viscosity (PV) was clearly defined. This was developed specifically for the screening of early generation wheat breeding lines. However, Batey et al (1997) found that correlations between paste viscosity measurements and noodle texture were lowered if a rapid heating rate was used.

If the main aim in RVA testing of flour or whole meal is to measure the inherent starch pasting properties of the sample, it is necessary to eliminate the effects of α-amylase (Bhattacharya and Corke 1996; Bhattacharya et al 1997; Batey et al 1997; Crosbie 1997b), even the low levels of α-amylase found in flour milled from sound grain (Crosbie et al 1999). In a recent study, Crosbie et al (1999) pointed to substantial effects of low levels of amylase on pasting properties due to the ideal conditions for amylolysis provided by the RVA when using the 18-min profile. The effect was more pronounced on PV than breakdown (BD). After treatment with 1 m*M* $AgNO_3$, both PV and BD were highly correlated (inversely) with the texture score of boiled ramen.

An alternative approach to chemical inactivation of α-amylase is heat inactivation, which is the means by which the FSV test is considered to achieve its insensitivity to low levels of the enzyme (Crosbie et al 1993, 1999) The main factor appears to be the low residual time that FSV tubes are maintained in the critical temperature range (55–80°C) for α-amylase activity (Perten 1964; Meredith 1970; Crosbie et al 1993). Maximizing the rate of heating through this temperature range may also reduce the sensitivity of the RVA test to the effects of α-amylase. The shortened profile used by Morris (1998), which was aimed at reducing analysis time, may be affected less by α-amylase activity, despite the poorer results obtained with rapid heating by Batey et al (1997).

The main aim of this study was to determine if a faster profile could be employed than that used in a previous study (Crosbie 1999) without compromising the utility of the test to predict noodle quality. The study involved two experiments. The first experiment involved a comparison of the profile used previously (Crosbie et al 1999) with a standard RVA profile (Standard 1) using 40% extraction flour. Total analysis time for these profiles was 18 and 13 min, respectively. Time in the temperature range 55–80°C was 3.0 and 2.1 min, respectively. The second experiment involved a comparison of the preferred profile from experiment 1 with a rapid profile similar to that described by Morris (1998) and applied to whole meal samples. In the rapid profile, total analysis time was 7.5 min and the time in the temperature range 55–80°C was 1.7 min.

MATERIALS AND METHODS

Grain and Flour Samples

The samples used in this study included 20 flours that were milled to 40% extraction on a Buhler MLU-202 laboratory mill (Crosbie et al 1999). In addition, whole meal samples were prepared by grinding subsamples (20 g) of the same 20 wheat samples in a Tecator laboratory grinder fitted with a 0.5-mm sieve. A commercial sample of flour used in the manufacture of ramen in Japan was also tested. Further details of these samples were reported previously (Crosbie et al 1999).

The 21 flours and 20 whole meal samples were analyzed for FSV and RVA pasting parameters using three different time-temperature profiles. FSV tests were conducted with water and 0.5 m*M* $AgNO_3$. RVA tests were conducted with water and 1 m*M* $AgNO_3$.

[1] Agriculture Western Australia, Locked Bag No. 4, Bentley Delivery Center, WA 6983, Australia.

[2] Corresponding author. E-mail: gcrosbie@agric.wa.gov.au.

[3] Dept. of Crop and Soil Science, Oregon State University, Corvallis OR 97331.

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TABLE I
Means, Ranges of Values, and Coefficients of Variation (CV) for Rapid Visco Analyser (RVA) Parameters[a] Assessed in Water and 1 m*M* $AgNO_3$

Sample	Test Parameter	Water			1 m*M* $AgNO_3$		
		Mean (RVU)	Range (RVU)	CV (%)[b]	Mean (RVU)	Range (RVU)	CV (%)
Flour							
RVA, K-M 18-min profile	PV	197	138–231	11	271	237–312	7
	BD	110	90–134	14	155	116–198	15
RVA, Std 1, 13-min profile	PV	223	173–266	12	270	221–305	11
	BD	92	62–132	22	113	69–154	26
Whole meal							
RVA, Std 1, 13-min profile	PV	179	108–218	15	249	205–297	11
	BD	80	57–106	20	107	69–146	24
RVA, rapid, 7.5-min profile	PV	212	158–255	12	258	227–300	8
	BD	88	64–116	20	109	76–149	20

[a] PV = peak viscosity; BD = breakdown. Parameters measured in Rapid Visco Analyser units (RVU).
[b] CV = coefficient of variation (%)

TABLE II
Correlation Coefficients Between Flour Paste Viscosity Parameters and Ramen Total Texture Score[a,b]

	K-M 18-min Profile		RVA Standard 1 Profile	
	Water	1 m*M* $AgNO_3$	Water	1 m*M* $AgNO_3$
PV	–0.14	–0.71**	–0.54*	–0.84**
BD	–0.56**	–0.78**	–0.72**	–0.78**

[a] PV = peak viscosity; BD = breakdown.
[b] *, ** = $P \leq 0.05$ and 0.01, respectively.

TABLE III
Correlation Coefficients Between RVA Parameters Assessed on Whole Meal and Flour[a]

RVA Profile and Sample Type	Water		1 m*M* $AgNO_3$	
	PV	BD	PV	BD
Standard 1 whole meal vs. Standard 1 flour	0.78**	0.92**	0.96**	0.98**
Rapid whole meal vs. Standard 1 flour	0.73**	0.93**	0.93**	0.97**

[a] PV = peak viscosity; BD = breakdown. ** = $P \leq 0.01$.

TABLE IV
Correlation Coefficients Between Swelling Volume and Paste Viscosity Parameters[a] of Whole Meal and Total Texture Score of Ramen Prepared from Corresponding Flours

Profile	Water	$AgNO_3$ Solution[b]
RVA Standard 1		
PV	–0.31	–0.82**[c]
BD	–0.61**	–0.77**
Rapid profile		
PV	–0.19	–0.75**
BD	–0.59**	–0.72**
Flour swelling volume (FSV)	–0.81**	–0.80**

[a] PV = peak viscosity; BD = breakdown.
[b] 1 m*M* $AgNO_3$ used for RVA tests: 0.5 m*M* $AgNO_3$ used for FSV tests.
[c] *, ** = $P \leq 0.05$ and 0.01, respectively.

Canisters coated on the inside with polytetraflouroethylene were used in RVA tests with 1 m*M* $AgNO_3$ solution.

RVA Test Time-Temperature Profiles

K-M 18-min profile. Profile of Konik and Moss (1992) as used by Ross et al (1997) and Crosbie et al (1999). Tests were conducted on flour (3.5 g on a 14% moisture basis) with sufficient distilled water or 1 m*M* $AgNO_3$ solution to make a total suspension weight of 28.5 g. The RVA was set at 65°C for 2 min, then increased at 15°C/min to 95°C, held at 95°C for 6 min, decreased at 15°C/min to 50°C, and held there for 5 min; total time was 18 min.

RVA Standard 1. Tests were conducted on flour (3.5 g on a 14% moisture basis) and whole meal (4 g on a 14% moisture basis) with sufficient distilled water or 1 m*M* $AgNO_3$ solution to make a total suspension weight of 28.5 g (tests with flour) or 29.0 g (tests with whole meal). The temperature of the RVA was set at 50°C for 1 min, then increased at 12°C/min to 95°C, held at 95°C for 2.5 min, reduced at 12°C/min to 50°C, and held there for 2 min; total time was 13 min. Sample weights, suspension weights, and the temperature program were in accordance with Standard 162 (ICC 1996).

Rapid method. Tests were conducted on whole meal (4 g on a 14% moisture basis), with sufficient distilled water or 1 m*M* $AgNO_3$ solution to make a total suspension weight of 29.0 g. The RVA temperature was set at 50°C for 0.5 min, then increased at 15°C/min to 95°C (the maximum heating rate achievable on the model 3D+ RVA in our laboratory was 16.4°C/min) held at 95°C for 2.5 min, reduced to 50°C in 1.5 min; total time was 7.5 min. The tests were continued long enough to enable the holding strength and BD to be assessed. To measure only peak viscosity, total analysis time could be reduced to 6.5 min by reducing the time at 95°C from 2.5 min to 1.5 min.

RVA parameters measured were peak viscosity (PV), highest viscosity during 95°C heating stage; holding strength (HS), lowest viscosity during 95°C heating stage; and breakdown (BD), difference between PV and HS.

FSV Tests

Tests were conducted on flour (0.40 g, db) and whole meal (0.45 g, db) in water and 0.5 m*M* $AgNO_3$ as described by Crosbie et al (1992) and modified by Crosbie and Lambe (1993).

Noodle Tests

Ramen was prepared and the total texture score assessed as described previously (Crosbie et al 1999).

RESULTS AND DISCUSSION

Results of RVA Tests on Flour and Whole Meal

The results of RVA tests on flour and whole meal samples are presented in Table I. The results of tests on flour samples using the K-M 18-min profile are the same as previously reported (Crosbie et al 1999) but have been reproduced here to facilitate comparisons with the other test results. Other analytical data on the wheat and flour samples have been previously reported, including the Falling Number values of the whole meal samples which ranged from 408-706 sec (Crosbie et al 1999).

Comparison of K-M 18-min and RVA Standard 1 Profiles

Correlations between RVA parameters PV and BD assessed on low-extraction flour and the total texture score (TTS) of ramen

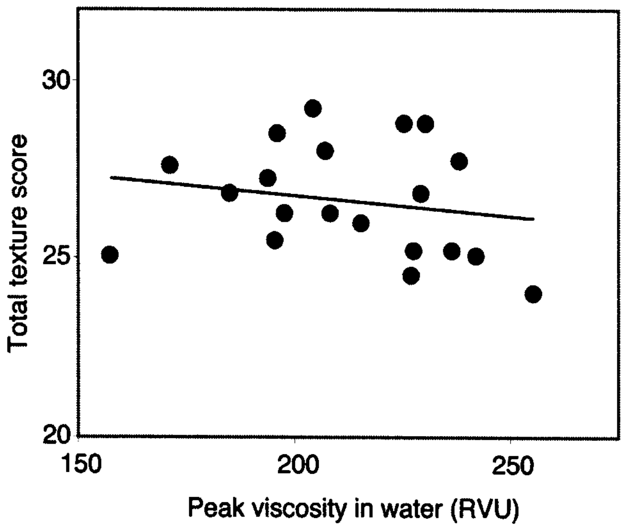

Fig. 1. Relationship between peak viscosity of whole meal assessed in water (rapid profile) and total texture score of ramen from corresponding samples of low-extraction flour ($r = -0.19$, not significant).

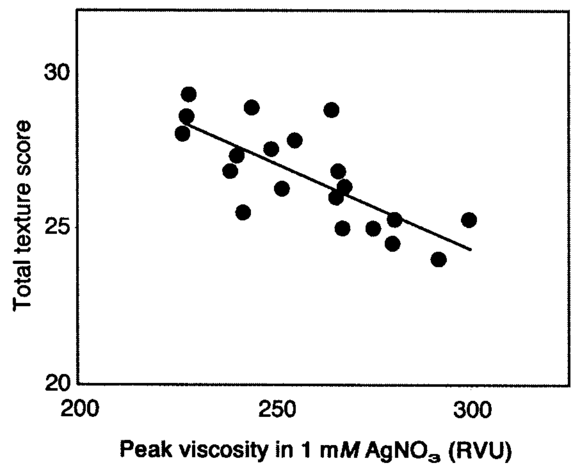

Fig. 2. Relationship between peak viscosity of whole meal assessed in 1 m*M* $AgNO_3$ (rapid profile) and total texture score of ramen from corresponding samples of low-extraction flour ($r = -0.75$, $P \leq 0.01$).

prepared from the same flour are shown in Table II. These include results from a previous study with the K-M 18-min profile (Crosbie et al 1999). In the previous study, correlations between RVA parameters PV, BD, and TTS were improved by the use of 1 m*M* $AgNO_3$ instead of distilled water. An improvement was also observed in the present study using the RVA Standard 1 profile, although the correlations involving PV and BD assessed in water were higher than those achieved with the K-M 18-min profile. The improved correlations could be considered consistent with a slightly greater degree of heat inactivation of α-amylase that may have resulted from faster heating through the critical temperature range of 55–80°C for amylase activity (2.1 min for RVA Standard 1 compared with 3.0 min for the K-M 18-min profile). Since the correlations associated with the 13-min RVA Standard 1 profile were at least comparable with those obtained with the K-M 18-min profile, the 13-min RVA Standard 1 profile is preferred. However, even with the RVA Standard 1 profile, it is clear that inactivation with 1 m*M* $AgNO_3$ is still needed for complete inactivation of α-amylase.

Comparison of RVA Standard 1 and Rapid 7.5-min Profiles

RVA parameters measured on whole meal samples using both the RVA Standard 1 and the rapid 7.5-min profiles were highly correlated with corresponding data measured on flour using the RVA Standard 1 profile (Table III). Again, correlations involving PV were improved when the tests were conducted using 1 m*M* $AgNO_3$ instead of water.

RVA parameters PV and BD, assessed on whole meal using both the RVA Standard 1 and rapid 7.5-min profiles, were highly correlated with noodle TTS when the RVA tests were conducted with 1 m*M* $AgNO_3$ (Table IV). However when the RVA tests were conducted in water the correlation coefficients between PV and TTS were nonsignificant and those between BD and TTS were significant but of lower magnitude. Using the rapid 7.5-min profile, the time in the critical temperature range for α-amylase activity was substantially reduced. However, there was still sufficient opportunity, in terms of both the presence of α-amylase enzymes not yet heat-inactivated and the onset of starch susceptibility to amylase attack during gelatinization, for a substantial amylolytic effect to be expressed.

The relationship between peak viscosity of whole meal assessed in water and 1 m*M* $AgNO_3$ using the rapid profile and the total texture score of ramen is shown in more detail in Figs. 1 and 2, respectively

FSV assessed on whole meal samples was significantly correlated with total texture score when the tests were conducted in both water and 0.5 m*M* $AgNO_3$, reflecting the lower sensitivity of the FSV test to α-amylase (Crosbie et al 1993, 1999).

CONCLUSIONS

The study confirmed that RVA tests for PV and BD conducted on whole meal samples using both Standard 1 and rapid profiles, correlated highly with corresponding data from low-extraction flour (using the Standard 1 profile) and the texture of noodles prepared from these flours. There was one exception, PV assessed in water, which in this study was not correlated with total noodle texture score. Even with the rapid 7.5-min profile, correlations were greatly enhanced by the use of 1 m*M* $AgNO_3$ and this was especially evident for PV. When 1 m*M* $AgNO_3$ was used, PV was at least as highly correlated as BD with TTS. Without the need to measure BD, the rapid profile may be completed in 6.5 min.

The results from this study provide confirmation of the approach suggested by Morris (1998), with the proviso that 1 m*M* $AgNO_3$ or a suitable alternative α-amylase inhibitor is used in the RVA test. As a tool for the screening of breeding lines for inherent starch and potential noodle quality, the rapid profile should enable those laboratories with access to a RVA, to increase throughput substantially to ≈60 samples per day, without compromising the utility of the results. Nevertheless, the test is still slower than the FSV test which may be preferred in some laboratories.

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