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THE TECHNICAL JOURNAL OF NEWPORT SCIENTIFIC®
JULY 2006
ISSN 1449-1311

ANALYSIS OF STARCH-LIPID COMPLEXES BY RVA™

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This paper was first published in Cereals 2004, the Proceedings of 54th Australia Cereal Chemistry Conference and 11th Wheat Breeders Assembly, 21–24 September, 2004, Canberra, ACT. *The proceedings information is on the web at* http://www.raci.org.au/division/cereal/Cereals_2004_TOC.pdf.

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INTRODUCTION

Amylose is an essentially unbranched a(1→4) glucan that forms helices with hydrophobic interiors. These helices can form inclusion complexes with linear hydrophobic molecules, which can influence the properties of starch in food products with high starch content. Starch-lipid complexes can improve the shelf life of foods, and are considered to contribute to resistant starch, since they are hydrolysed more slowly by enzymes than starch alone. Starch-lipid complexes have been prepared and analysed in many different ways, but there are still relatively few methods that link complex formation directly to changes in functionality.

In this study, we have used the Rapid Visco Analyser (RVA) in a rapid method to form and analyse starch-lipid complexes. We describe the effect of monopalmitin (MP), which is used as an emulsifier in the food industry, on the viscoelastic properties of wheat starch pastes.

MATERIALS AND METHODS

Wheat starch (Wheaten cornflour) was from Penford Pty Ltd and was used as supplied. According to the supplier's specifications, it contained 9.9% moisture, 0.25–0.30% fat, and 25.5% amylose. MP was from Sigma-Aldrich.

The pasting properties of wheat starch mixed with MP were examined using a Newport Scientific RVA–4. MP was weighed accurately into a test canister and 25 ± 0.01ml of distilled water was added, followed by 2.5 ± 0.01 g of starch. The mixture was agitated by raising and lowering the plastic paddle through the canister 10 times. Newport Scientific standard method 1 (STD1) was used for the tests. Starch-only reference pasting curves were recorded in each set of tests.

Iodine binding was measured by the method of Gilbert and Spragg (1964) with modifications as follows. Starch paste (5.0 g) was removed from the RVA canister at the conclusion of the run and mixed with 25 ml of distilled water at 40–50°C in a 50-ml capped tube. The tube was vortexed for 2 min., and 100 µl of the resulting dispersion was mixed with 15 ml of distilled water and then was added to 2 ml of iodine solution (2.0% of KI and 1.3% of I_2 in distilled water). The absorbance was measured at 690 nm. The starch-only paste was used as a reference. To avoid starch retrogradation the tests were performed within 60 min. Complexing index was calculated as follows:

$$CI = [(Abs_{reference} - Abs_{starch\text{-}lipid})/Abs_{reference}] \times 100.$$

RESULTS AND DISCUSSION

The RVA trace of wheat starch was significantly affected by adding MP in the concentration range of 13.6 to 82 µmol per test (Figure 1). Holding viscosity was decreased, whereas final viscosity (FV) and setback (SB),

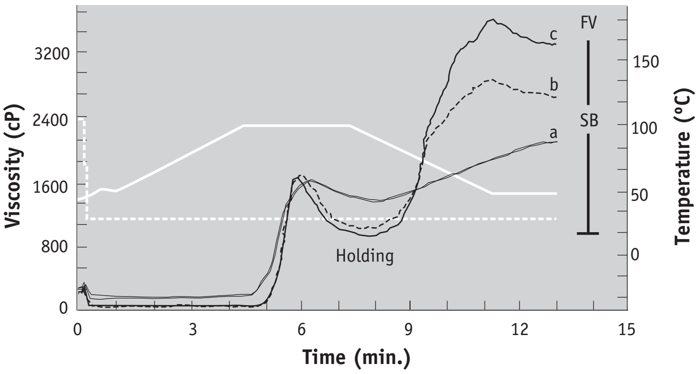

Figure 1
RVA traces of starch and starch mixed with MP. Starch only (a), starch mixed with 41 µmol MP (b), and starch mixed with 68 µmol MP (c) traces are shown.

which is the difference between final and holding viscosities, were significantly increased. There was relatively little effect on the peak viscosity and peak time (Figure 1).

The formation of amylose-lipid complexes reduces the water binding capacity of amylose and as a result decreases the viscosity of starch pastes (Karkalas and Raphaelides, 1986; Kaur and Singh, 2000; Ozcan and Jackson, 2002). In the present study, a significant decrease was noted in holding strength when MP was added to the starch, consistent with the formation of complexes as the starch granules were disrupted and the starch molecules dispersed under the effect of heat and stirring in the RVA. Significant increases in final viscosity and setback were observed in starch-MP samples compared to the starch-only reference during the cooling phase (Table 1), as was also reported by Liang et al. (2002). The formation of amylose-lipids complexes tends to reduce amylose recrystallisation during the cooling phase, and with more amylose remaining dispersed the final viscosity increases.

Amylose helices occupied by lipid have reduced binding capacity for iodine, which results in decreased absorbance at 690 nm as indicated by an increasing complexing index as the concentration of lipid increases. An inverse relationship was observed between the effect of MP on CI and holding strength, whereas strong positive correlations were obtained between CI and final viscosity, and between CI and setback, as the concentration of MP was increased (Table 1).

Table 1
Effect of MP concentration on RVA parameters and I_2 complexing of wheat starch.

MP CONCN*	FINAL VIS.	SETBACK	HOLDING	CI
0	2100	812	1288	0
13.6	2417	1090	1327	9.8
40.9	2929	1868	1061	15.4
68.2	3299	2360	939	34.0
75.0	3330	2381	966	37.9
81.8	3319	2353	949	40.0

*µmol added to 2.5 g starch and 25 ml H_2O

CONCLUSION

The RVA can be used as a rapid method to determine the formation of starch-lipid complexes, with the final viscosity and setback parameters giving a quantitative measure of the complexes as indicated by the good correlation with the iodine binding test.

Acknowledgement This project is supported by funds from the Value Added Wheat CRC.

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Assessing solvent retention capacities of flours using the Rapid Visco Analyser™

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The solvent retention capacity (SRC) test (AACC Method 56-11) involves suspending wheat flour in four solvents (water, lactic acid, sodium carbonate, sucrose). The SRC is the weight of the solvent held by flour after centrifugation, expressed as per cent of flour weight on a 14% moisture basis. The four SRC values obtained from the tests are used to assess flour quality and functionality, and are useful for predicting baking performance:

- water indicates absorption of water during mixing
- 5% lactic acid partially hydrates the gluten (low pH)
- 5% sodium carbonate hydrates damaged starch (high pH)
- 50% sucrose solubilises pentosans and gliadins.

The conventional method is tedious and time consuming, requiring at least 45 min. for results. The RVA method involves holding a concentrated suspension of flour (15.00 g at 12% moisture) and solvent (25.0 g) at 25°C, followed by heating and holding at 50°C (Table 1). Each test is completed within 10 min., with the four solvents giving results within 40 min. During the test the viscosity reaches a plateau, then when heated to 50°C the viscosity decreases (Figure 1). The viscosities at 3 min. and 10 min. are useful indicators of product quality.

The RVA can be used as a simple means to assess the SRC of wheat flour, with results that are well correlated with those obtained from the conventional SRC method (Figure 2). The main advantages of the method are that tedious sample preparation steps are eliminated and results from individual solvents can be obtained more quickly.

TIME	TYPE	VALUE
00:00:00	Temp.	25°C
00:00:00	Speed	1000 rpm
00:01:00	Speed	160 rpm
00:05:00	Temp.	25°C
00:07:00	Temp.	50°C
00:10:00	End of test	–

Table 1
RVA SRC profile.

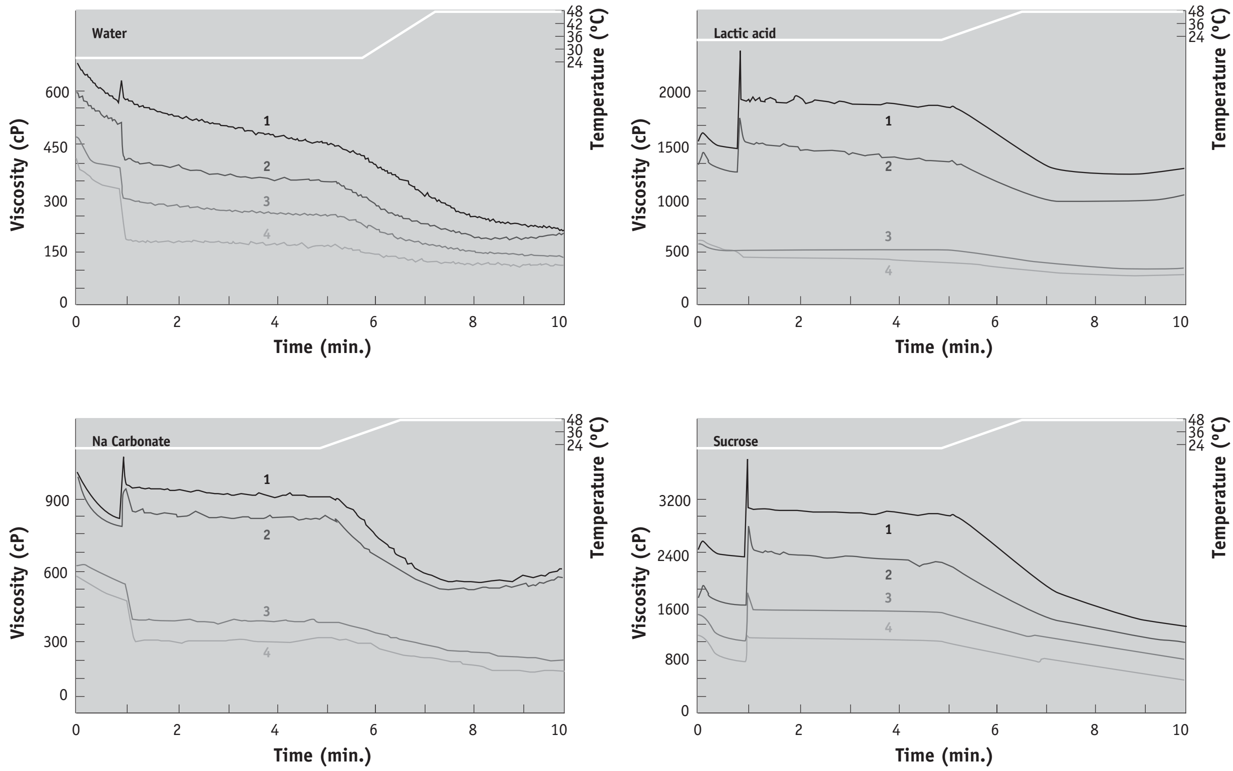

Figure 1
RVA profiles of flour samples (numbered 1 to 4) tested with water, 5% lactic acid, 5% sodium carbonate, and 50% sucrose using the RVA SRC Method. The graphs show varying effects of the four solvents on each of the flours.

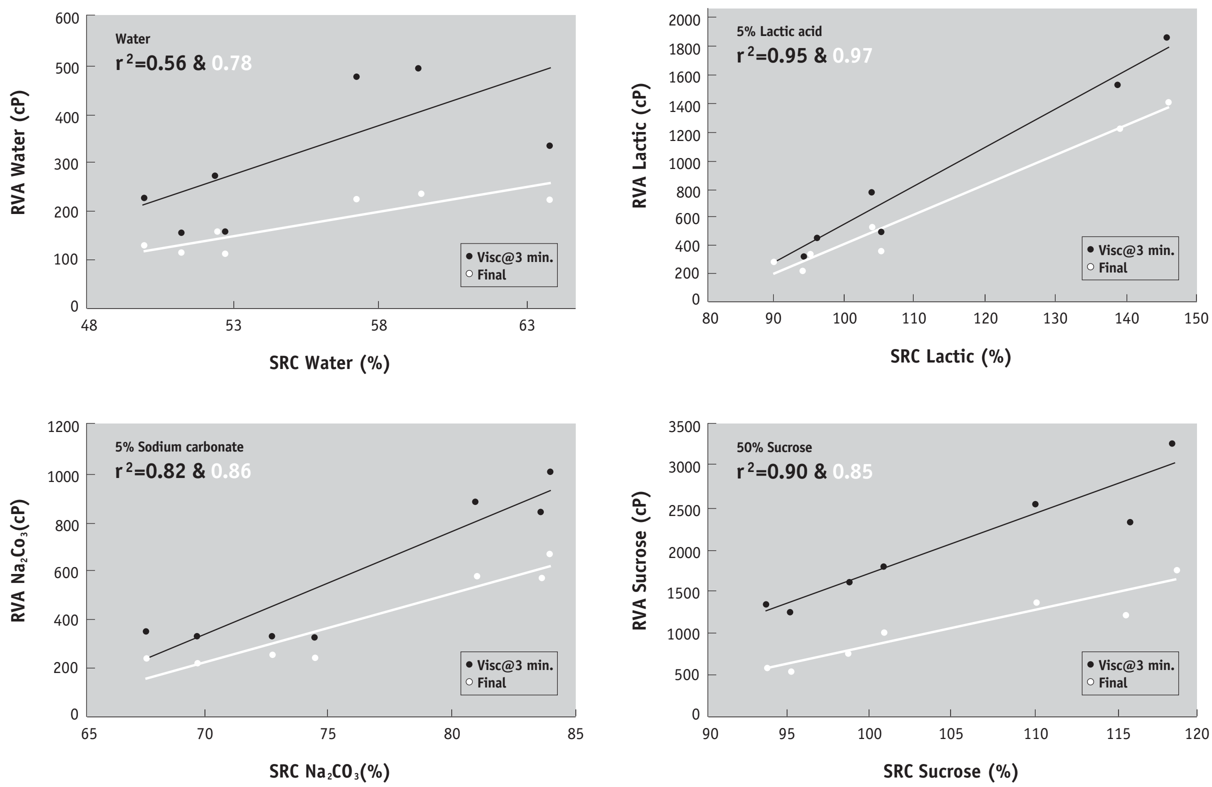

Figure 2
Correlation between conventional SRC values and RVA viscosities at 3 (black) and 10 minutes (white) for flour tested in water, lactic acid, sodium carbonate and sucrose.

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