

RVA



T H E N E W S T A N D A R D

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S p e c i a l I s s u e

The RVA - 4

Released World Wide

Last October, in Nashville Tennessee at the occasion of the 79th Annual Convention, the AACC held a special symposium on the Rapid Visco Analyser. As a contribution to the Symposium, Newport Scientific presented the latest model of the Rapid Visco Analyser, the RVA-4. This instrument represents the distillation of nearly ten years experience with accelerated starch pasting, and takes the technology available to starch chemists another significant step.

The design specification for the RVA-4 was really provided by our customers. Ever since the first RVA-3, we have maintained close contact with RVA users. Assisting with method development, supplying special enhancements and constantly pushing the instrument's capacity, we have learnt a lot about the abilities and limitations of the RVA. When the time came to release a new model of the instrument, we had a very good idea of what was needed.

Possibly the most significant advance that has come with the RVA-4

is viscosity measurement at varying shear rates. This is achieved through variable speed of the stirring motor. As starch is a very non-Newtonian fluid, this feature brings another dimension to characterising starch.

At the same time we have increased the maximum torque available from the motor, measuring viscosities nearly ten times greater than that available from the Series 3 RVAS. The new motor and power-supply also has more capability at the low end of the viscosity range, allowing measurements on materials around ten times thinner than before.

To enhance the new hardware capabilities of the RVA-4 we completely re-wrote the Thermocline and Thermoview software programs. The new RVA software, shipped as standard with the RVA-4 and called Thermocline for Windows, brings all the benefits of Windows operation. Examples are running multiple RVAs on one computer, data collection concurrent with data analysis background operation of the software, and standard Windows interactions.

The functions of the two DOS programs (TC and TV) have now been merged into a single program. Some of the important features include 128 step

test profiles, complex mathematical analysis of data files, enhanced output (printing) and extremely flexible display capabilities. Service costs have been addressed with software calibration functions. To complement the extended viscosity range and variable shear facilities, Thermocline for Windows also presents data in the fundamental units of centipoise (mPa.s).

From the [photograph](#) of the RVA-4 you will also notice that we have added direct user interaction capability. A 16 key keypad and four line, twenty character LCD display allows stand alone (no computer needed) operation. Test and analysis parameters can be loaded into battery backed RAM, for use where hostile environment or other reasons preclude a permanently connected computer.

We are very proud of our new product, and we are sure that you will like the power and versatility we have built into it. With the RVA-4 we believe we have consolidated Newport Scientific's leadership in the characterisation of starch viscosities. Please take a look at the illustrative examples in this special edition of RVA World. If you would like to know more, contact either Newport Scientific at support@newport.com.au or your local [distributor](#).

If you're serious about starch ... there is only the Rapid Visco Analyser



Applications of the RVA - 4

The RVA-4 and ThermoLine for Windows software provide several enhancements over the existing RVA models and DOS software. These include variable speed control, measurement at higher viscosities, better measurement at lower viscosities, viscosity measurement in fundamental units, complex multistep testing profiles, concurrent testing and analysis and enhanced analysis and reporting functions.

These new facilities substantially extend the range of possible applications available using the RVA. Examples of these new applications are given below.

Variable Shear

The ability to vary shear in the RVA makes it possible to select conditions which imitate many industrial processing conditions, or conditions of end-use. Thus the suitability of various starches for such applications could be tested in the RVA before commercial use. Modification of testing profiles also affords information on the wider rheological properties of starches, indicating for example how processing could be altered to improve final product quality.

Starch pastes and gels display complex and variable rheological characteristics that depend on the heating profile, shear history, starch type, starch concentration, modifications, other materials present and so forth.

Starch viscosity is typically non-Newtonian where a reduction in viscosity with both increased shear stress (pseudoplastic flow, or shear thinning) and increased time (thixotropy) is usually observed. The degree of non-Newtonian behaviour varies considerably

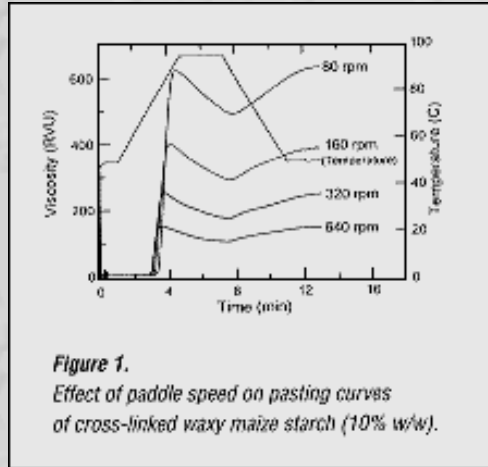


Figure 1.
Effect of paddle speed on pasting curves of cross-linked waxy maize starch (10% w/w).

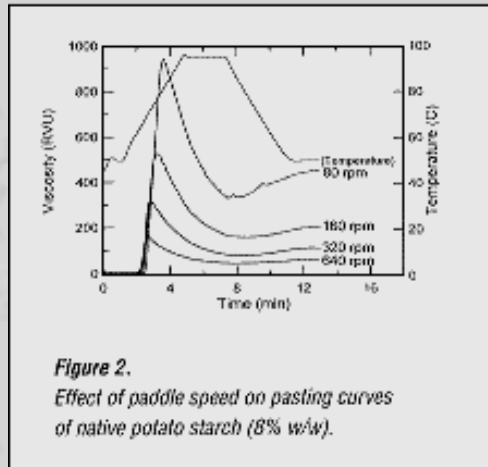


Figure 2.
Effect of paddle speed on pasting curves of native potato starch (8% w/w).

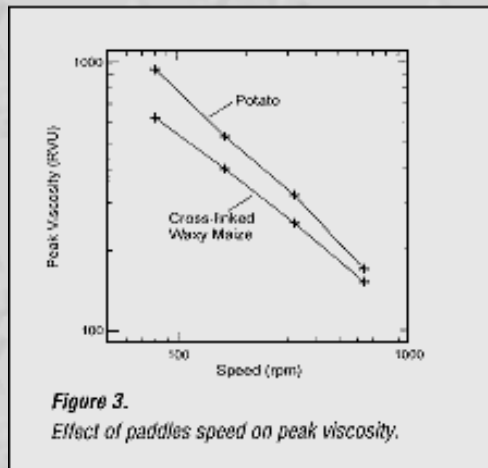


Figure 3.
Effect of paddle speed on peak viscosity.

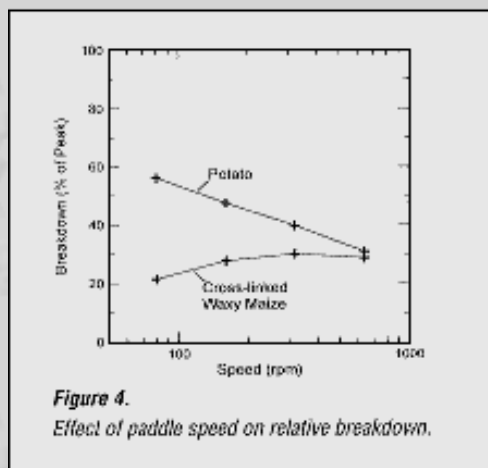


Figure 4.
Effect of paddle speed on relative breakdown.

between certain starches, or even for the same starch under different cooking conditions.

For the experiments shown below, an unmodified potato starch and a cross-linked waxy maize starch were tested. Potato starches are shear susceptible, typically forming a high peak viscosity which rapidly breaks down under shear. Conversely, the cross-linked waxy maize starch also forms a relatively high peak viscosity but is modified to resist breakdown under shear.

Figs. 1 and 2 show such modified maize and native potato starches respectively, tested using the STD1 profile but varying the paddle speed. The potato starch shows higher peak but lower final viscosity than the maize starch in all cases. Both starches show similar log-log reductions in apparent viscosity with increasing shear (Fig. 3). However, breakdown as a percent of peak viscosity for the two starches is quite different (Fig. 4). The relative breakdown of the potato starch decreases linearly with the log of speed, whereas that of the modified maize increases to a plateau, the two curves converging at the higher shear rates.

Note that a minimum speed of 80 - 160 rpm is usually required to keep starch granules in homogenous suspension prior to gelatinisation. Failure to do so results in stratification within the gel and misleading results. A variable height paddle is available and can be used where low speeds are required.

Shear-dependent rheological behaviour can be assessed using a shear hysteresis loop such as shown in Fig. 5. In this case, glucose syrup (a Newtonian material) and 6% potato starch previously cooked using the STD1 profile, were subjected to a shear profile of 80, 160, 320, 640, 320, 160 and 80 rpm, each for 1 min. The glucose syrup shows a flat viscosity line indicating Newtonian behaviour.

The potato starch, by comparison, decreases in viscosity with increasing shear, and does not recover to the original viscosity, indicating both shear thinning and thixotropy.

A typical pasting test (STD1 profile) can be combined with a shear hysteresis loop in one RVA test (Fig 6), to provide a large amount of information on a sample. To investigate the effect of degree of cook on final product rheology, such a combined profile was used, varying the maximum temperature in the profile to 68, 70, 85 and 95°C for maize starch and to 60, 70, 85 and 95°C for potato starch. 68°C was used for the maize starch as it failed to appreciably swell below this temperature.

the variable shear facility thus provides considerable scope for improved characterisation of starches when used in combination with the preexisting flexible temperature ramping control. Over 100 steps can be entered in any one profile, providing considerable flexibility in tailoring tests to meet even the most complex shear and temperature protocols.

Extended Viscosity Range

The extended viscosity range of the RVA 4 allows for characterisation of materials up to 50,000 centipoise at 80 rpm, approximately an order of magnitude higher than possible with previous models. This facility is of particular use for the characterisation of thick pastes and syrups. Glucose and corn syrups are obvious candidates, where not only overall viscosity, but also degree of Newtonian behaviour, can be assessed.

Other high viscosity materials that can be tested include oils, such as the silicone oil shown in Fig. 11. Another application is improved measurement of final viscosity in starches that show a high peak viscosity but a low final viscosity, such as occurs with some oxidised starches.

The RVA 4 also offers improved measurement at low viscosities, below 500 cP. Relatively low viscosity foods such as batters, salad dressings, mayonnaise and so forth are candidates for such analysis. Low concentrations of starches are used in many processes, eg. paper making, and low viscosities result from starch hydrolysis, eg. in thin-boiling starches, so the applications are numerous here.

Of particular interest is the analysis of pre-cooked foods in the RVA. Fig. 12 shows a comparison of two corn flake

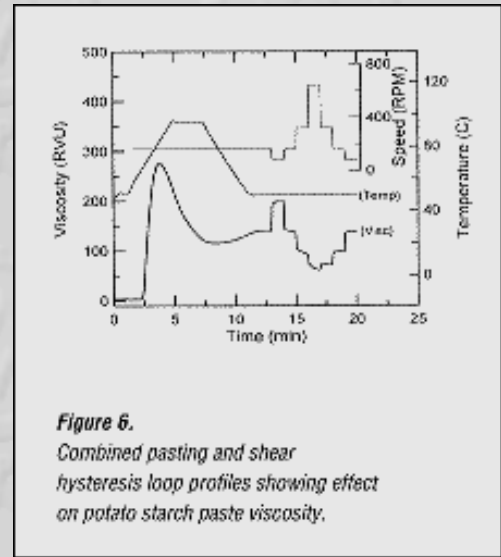


Figure 6. Combined pasting and shear hysteresis loop profiles showing effect on potato starch paste viscosity.

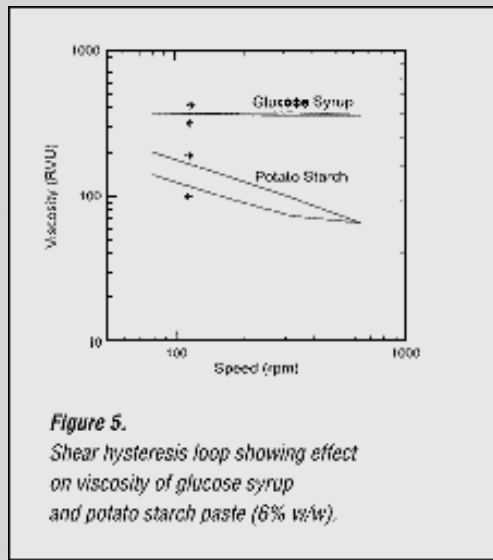


Figure 5. Shear hysteresis loop showing effect on viscosity of glucose syrup and potato starch paste (6% w/w).

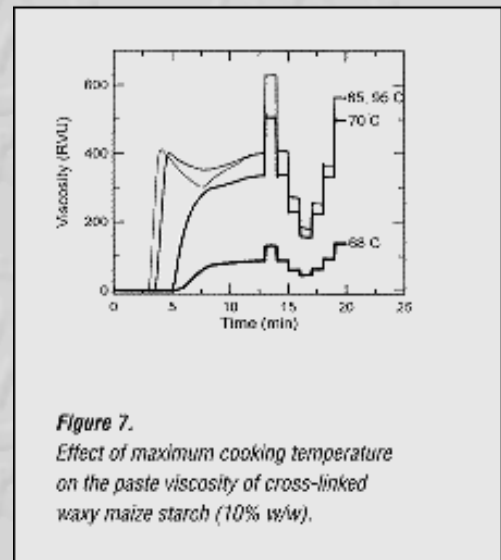


Figure 7. Effect of maximum cooking temperature on the paste viscosity of cross-linked waxy maize starch (10% w/w).

Onset of swelling was delayed by use of lower cooking temperatures, and the degree of viscosity development was retarded in the maize starch at 68 and 70°C (Fig. 7) and at 60°C for potato starch (Fig. 8). The final viscosity was highest for the most cooked maize starches, but was highest for the least cooked potato starches. Further, the maize-starch showed minimal thixotropy (Fig. 9), whereas this was quite marked for potato (Fig. 10), except at the lowest cooking temperature.

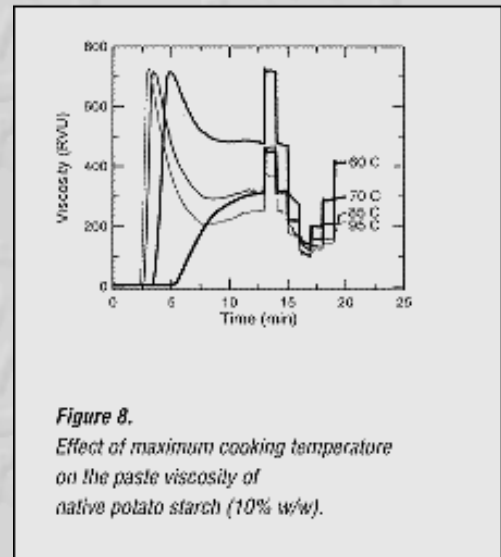


Figure 8. Effect of maximum cooking temperature on the paste viscosity of native potato starch (10% w/w).

products, one the original and the other a generic brand. A typical heat-hold-cool profile was used for the tests. The high initial viscosity of the generic brand shows the presence of considerable cold-swelling material, indicative of more severe processing typical in extruded foods. On the other hand, the original product is more representative of a low shear batch cooking process.

Fundamental viscosity units

Although the RVA's paddle is not a mathematically defined shape, it is nonetheless possible to measure viscosity in fundamental units, if not shear rate, by calibrating the instrument to a standard. Measurement in centipoise (or millipascal.sec) is available, providing a universally accepted reference for comparison of material viscosity.

It should be remembered that any non-Newtonian material, and especially starch, shows an apparent viscosity that varies with shear and/or time. Consequently, conditions of measurement affect viscosity readings, so standardised techniques are required to achieve comparable results. There are a number of internationally approved standard methods available for use with the RVA, details of which can be obtained from [Newport Scientific](#) and its [agents](#).

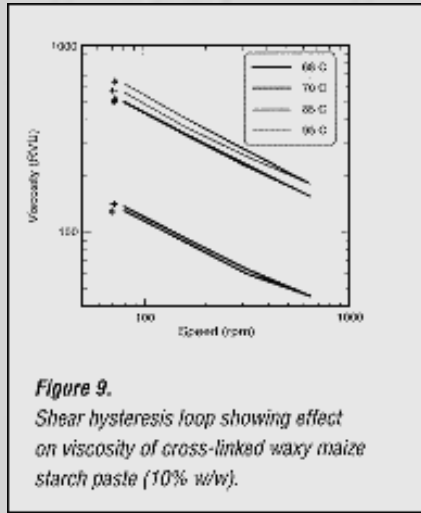


Figure 9. Shear hysteresis loop showing effect on viscosity of cross-linked waxy maize starch paste (10% w/w).

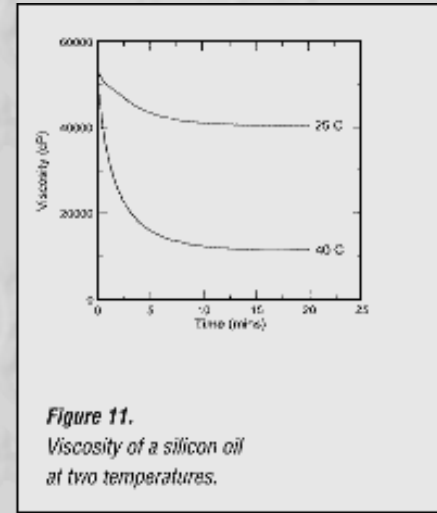


Figure 11. Viscosity of a silicon oil at two temperatures.

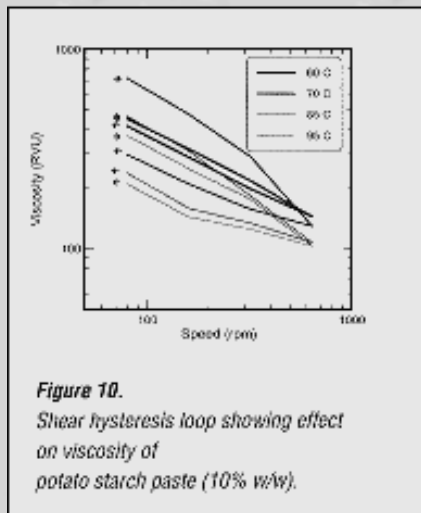


Figure 10. Shear hysteresis loop showing effect on viscosity of potato starch paste (10% w/w).

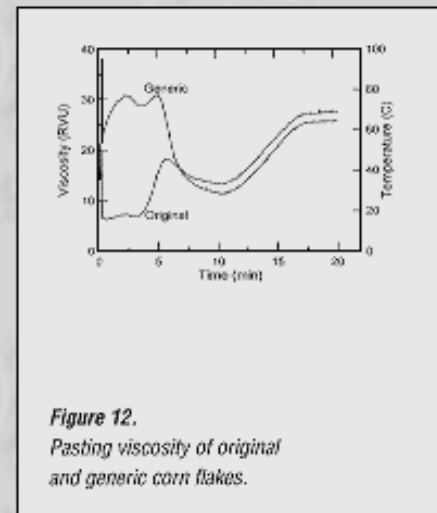


Figure 12. Pasting viscosity of original and generic corn flakes.

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