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Use of RVA™ to assess the quality of soybean protein

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INTRODUCTION

Soybean seeds have a protein content of 35–40% on a dry weight basis, which makes them a relatively inexpensive source of protein for human consumption. Published results reveal that soybean storage proteins, whose contents vary among different varieties, have a significant role in determining the yield and quality of tofu.

When heated, soy proteins are transformed from the 'soluble' state to a cross-linked 'gel-like' state in protein gelation. The stability and the firmness of a protein gel are affected by a variety of factors, such as the nature and concentration of the protein and the way the gelation of protein was induced.

The RVA can be used to examine the effects of thermal processing on the functional properties of protein such as soybean meal that in a simplified way could be considered a mixture of protein, oil and water.

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MATERIALS AND METHODS

Materials

Twenty soybean cultivars grown in Canada, NSW or Queensland. A portion of each sample was ground in an 8" laboratory mill and sieved through a 600 microns sieve.

Rapid Visco Analyser

Soybean meal was mixed with 25.0 g deionized water at room temperature and run on an RVA–4 using two different sample weights:

1. constant 8.0 g of soybean flour
2. sample weights calculated to give 3.0 g protein in each sample, to determine effects of protein quality independent of protein quantity.

The profile is that first used by Turner et al. (1996).

Seed protein content

The percentage of nitrogen in each sample was determined by thermal combustion. Protein content was calculated on a dry weight basis.

Variable	Minimum	Maximum	Mean
Protein content [%]	32.89	37.84	35.73
11S/7S	1.71	4.57	2.70
RVA visc. [RVU]	184	457	306
RVA peak time [s]	468	835	630
RVA slope start [s]	267	302	282
3-g RVA visc. [RVU]	212	445	347
3-g RVA peak time [s]	495	745	625
WAC [g/g]	1.857	2.763	2.201

Table 1
Observed properties of the flours averaged over 20 soybean samples.

Protein subunit composition

Agilent 2100 Bioanalyzer automated microfluidic electrophoresis platform was used to analyse protein extracts from different seedlines. Protein 200 LabChip Kit was used to evaluate the relative expression of β-conglycinin (7S) and glycinin (11S) in different samples. The ratio of 7S/11S proteins was then calculated.

Water absorption capacity of the flour

Water absorption capacity (WAC) of soybean flours was measured by the centrifugation method of Sosulski (1962) and expressed as grams of water bound per gram of sample on a dry basis.

RESULTS

The RVA pasting curve of one of the soybean flours is shown in Figure 1. Significant differences were observed in protein content, pasting characteristics, 11S/7S ratio and WAC of flours from different soybean cultivars (Table 1).

The results of SDS electrophoresis (Shunhu method) of soy protein extracts indicated a great diversity in protein subunit composition. The 11S relative content varied between 63.1 and 81.3%, 7S relative content varied between 17.8 and 36.8% and 11S/7S ratio varied between 1.71 and 4.57 with an average of 2.70. A positive

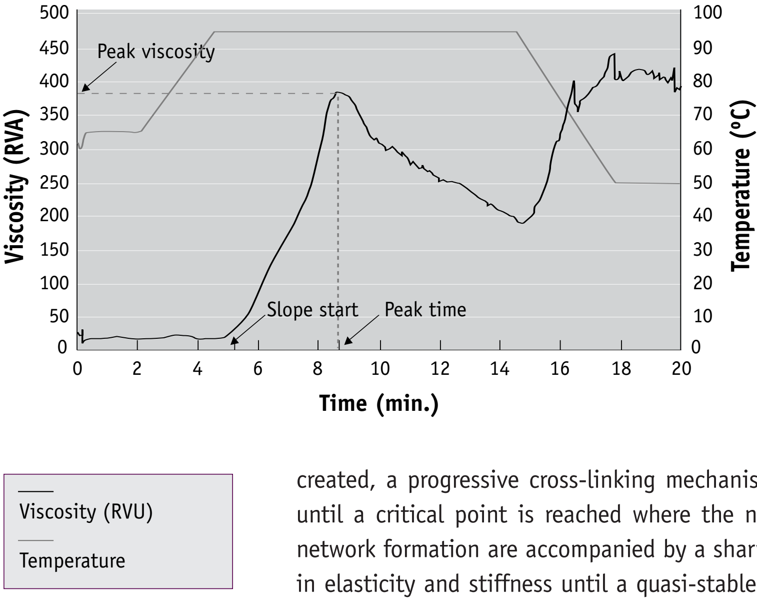

Figure 1
The RVA pasting curve of one of the soybean flours.

correlation was observed between 11S/7S ratio and the 3 g RVA viscosity ($r = 0.485$, $P < 0.05$).

When a constant amount of soybean meal (8.0 g) is used, it's likely that the quality differences in protein are suppressed by the differences in protein content. This is supported by the positive correlation between the RVA viscosity and the soybean protein content ($r = 0.732$, $P < 0.005$). A positive correlation was also found between the WAC and RVA viscosity ($r = 0.536$; $P < 0.01$) and between WAC and RVA slope start ($r = 0.521$; $P < 0.05$).

DISCUSSION

When environmental conditions favourable to gelling are created, a progressive cross-linking mechanism takes place. Increasing clusters of associated chains develop until a critical point is reached where the network spans the whole sample volume. The gel point and the network formation are accompanied by a sharp increase in viscosity. The network continues to further increase in elasticity and stiffness until a quasi-stable state is reached, providing there are no interfering effects such as syneresis.

Tests with sample weights adjusted to contain a constant 3.0 g protein level showed substantial differences between RVA viscosity curves. This indicates that the viscosity results were affected by factors additional to simple protein content. 7S and 11S were shown to have different gel-forming properties and their ratios have a significant role in determining the yield and quality of tofu, which are important factors influencing acceptability of tofu by producers and consumers (Tay and Perera, 2004; Tay et al., 2005; Mujoo et al., 2003). Results show that the RVA is able to detect the differences in 7S/11S ratios among soybean varieties while tests with constant sample weights are useful for predicting the water absorbing properties of soybean flours.

CONCLUSION

The details of thermal gelation differ with the origin of protein used, and reflect the unique primary structure of the particular protein and the types of bonds that contribute to the secondary and tertiary structure of the proteins. The RVA is useful for simulating the effects of thermal processing and changes in environmental conditions on the rheological properties of food proteins. The RVA curve is able to reveal supplementary information in addition to a simple protein content that is currently used by soy food processors.

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Optimised methods for detecting the effect of flour additives in the doughLAB III — Effect of improvers: hydrocolloids and emulsifiers

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A summary of the paper presented at ICC Jubilee Conference, 4–7 July 2005, Vienna.

The effects of hydrocolloids (namely coarse and fine soybean flour) and emulsifiers on dough quality were examined on the doughLAB, a z-arm dough mixer that tests the quality and characteristics of doughs. Using AACC Method 54-21 (30°C, 63 rpm), untreated flour was tested on the doughLAB to determine the optimum water absorption (WA). This WA was used for subsequent tests with the additive for that flour.

Optimum WA for the untreated flour was determined to be 63.8%. To observe the effect of the soybean flour on curve shape and features, this WA was used for testing flour treated with both soybean flours at concentrations of 5 and 10% w/w (Figure 1). The treated flours had higher hydration capacities due to the presence of water absorbing soy fibre, resulting in the rise in torque. The higher the concentration of soybean flour, the larger the increase in torque.

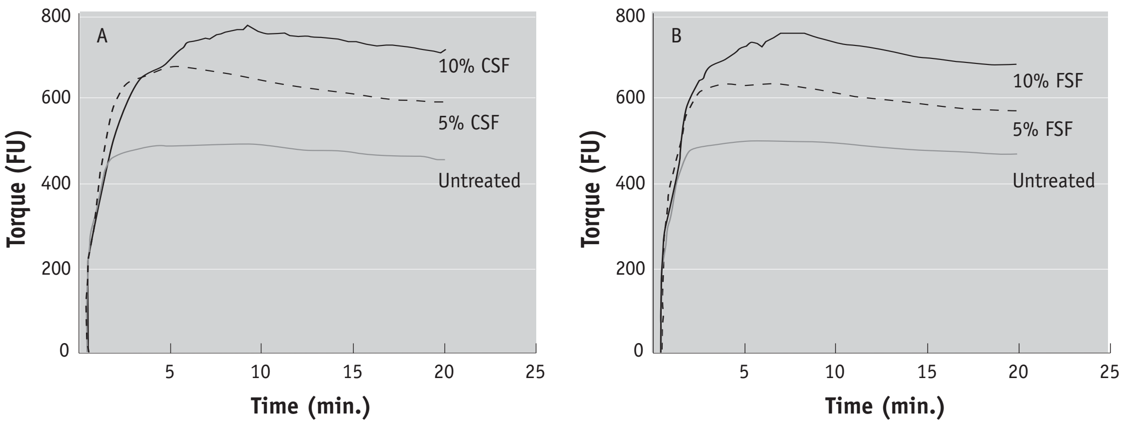


Figure 1
doughLAB curves of wheat flour with and without coarse (CSF) (A) and fine (FSF) (B) soybean flour at concentrations of 5 and 10% w/w flour.

In order to observe the effect of soy addition on the WA and other flour quality parameters, new WA values (to centre the torque on 500 FU) were determined for the treated flour at both concentrations (Figure 2, Table 1).

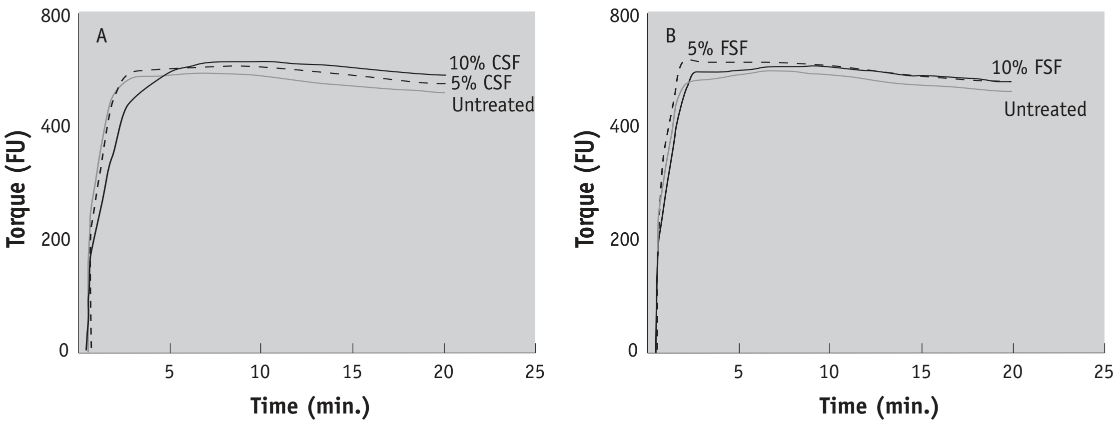


Figure 2
doughLAB curves of wheat flour with and without coarse (CSF) (A) and fine (FSF) (B) soybean flour at concentrations of 5 and 10% w/w flour. Samples were tested at optimum WA to centre each curve on 500 FU.

The addition of soybean flour increased the WA of the wheat flour (Table 1) due to the increased hydration capacity. Soybean flour addition also resulted in stronger doughs, as observed with longer dough development times (DDTs) and stabilities (Table 1), and whiter doughs (fine soybean flour only). These effects are probably due to the presence of lipoxygenase in the soybean flour, which oxidises unsaturated fatty acids, as well as

Optimised methods for detecting the effect of flour additives in the doughLAB

CONTINUED

Table 1 *Dough quality parameters of wheat flour with and without soybean flour as measured on the doughLAB. The peak of each sample was centred on 500 FU for comparison purposes.*

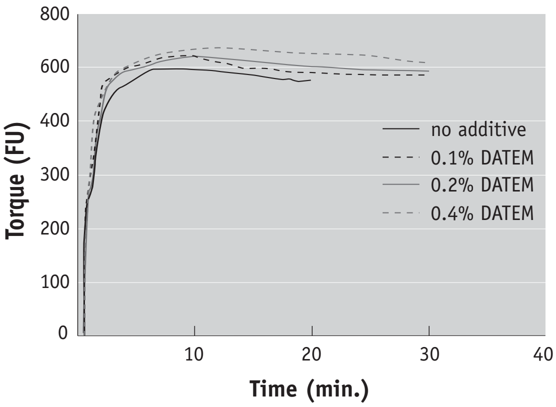
Sample	Conc. (%)	Peak (FU)	WA (%)	DDT (min.)	Stability (FU)	Dough colour
Untreated	0	493	63.6	6.77	14.47	Off white
Course soy flour	5	505	69.5	7.57	14.98	Off white with dark specks
	10	511	75.2	8.42	14.98	
Fine soy flour	5	508	67.9	6.40	15.42	Whiter than untreated
	10	505	73.1	8.17	14.92	

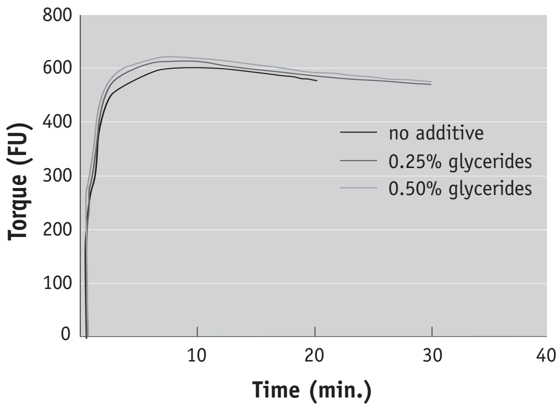
the yellow carotene pigments of flour (bleaching effect) (Sluimer, 2005). The coarse soybean flour did not show any bleaching effect, as the coarse particles were visible in the resulting mixed dough.

Emulsifiers are used as dough strengtheners. They also increase loaf volume and exhibit antistaling effects. The effects of two types of emulsifiers (DATEM, and mono- and diglycerides) on dough quality were tested on the doughLAB. DATEM, a surfactant consisting of diacetyl tartaric acid esters of mono- and diglycerides, exhibits effective dough conditioning functions, yielding doughs that have improved tolerance, are drier and easier to process, exhibit better gas retention, and produce loaves with greater volume and finer texture (bakingbusiness.com). Addition of DATEM to hard flour resulted in later DDTs and longer stabilities (Figure 3). The higher the concentration of DATEM, the larger the effect on dough quality.

Figure 3 *(right) doughLAB curves showing the effect of DATEM on dough quality of hard flour.*

Figure 4 *(far right) doughLAB curves showing the effect of glycerides on dough quality of hard flour.*





A monoglyceride is a fat molecule in which only one of the three hydroxyl groups of glycerol is esterified to a fatty acid. By being partially water-soluble and more fully fat-soluble, it acts as a surfactant and finds important applications as an emulsifier and antistaling agent. A diglyceride has two of the hydroxyl groups esterified to fatty acids, and also acts as an emulsifier and antistaling agent. Addition of glycerides caused an increase in torque (and hence WA) and dough stability (Figure 4).

Similar experiments have been trialled and results achieved for other additives, such as sugar, salts, lipids, oxidising and reducing agents, hydrocolloids, and enzymes. Work is continuing on optimising the sensitivity and speed of these tests by altering mixing speed and temperature regimes, to suit both the product/process in question and the properties of the additive.

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