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Research Article

Relationships between rheological properties of rice flour and quality of vermicelli

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Abstract: The objectives of this research were to study the relationships between the rheological properties (peak viscosity, final viscosity, breakdown and set back) of rice flour measured using a Rapid Visco Analyser (RVA) and a Brabender, and to study the relationships between rheological properties of rice flour and qualities of dried vermicelli (breaking strength) and reconstituted vermicelli (tensile strength, firmness and surface stickiness). In this research, twenty nine samples of rice flour containing amylose content of 22.68 - 27.40% were used. The results showed that peak viscosity, final viscosity and set back measured from RVA had linear relationships with the values measured from Brabender with R^2 of 0.7377-0.7014. The final viscosity of rice flour measured by RVA had linear relationships with the breaking strength of dried vermicelli and tensile strength of reconstituted vermicelli with R^2 of 0.6956 and 0.7400, respectively. However, the breakdown of rice flour and the firmness of reconstituted vermicelli had inverse linear relationship with R^2 of 0.7156.

Keywords: rheology, cereals, noodles, Brabender, Rapid visco analyzer, Thailand

Introduction

Vermicelli is one of the most popular varieties of rice noodles widely consumed in Thailand. Normally, vermicelli is produced from broken rice. Since no single rice cultivar has been shown to be more appropriate for the production of rice noodles, many cultivars are usually selected and mixed together in order to obtain the best quality vermicelli. The production of vermicelli starts with milling of broken rice into rice flour. The pasting properties of rice flour are key determinants of quality which significantly impact the final product texture. Rapid Visco Analyser (RVA) and Brabender can be used for measuring

the pasting properties of rice flours. Both of these analysers operate on a similar principle [1, 2]. However, the testing procedure of Brabender is time-consuming and requires a

large amount of sample. This leads to the use of RVA in many industries. Nonetheless, slight differences can be found in pasting profile and viscosity because both instruments are different in their construction, operation and temperature-time profile.

Attempts to relate the pasting behaviours of rice flour with cooked rice texture have met with variable success. Limpisut and Jindal [3] reported that pasting temperature, peak and setback viscosities were the most significant variables in the development of predictive models for evaluating the hardness and adhesiveness of cooked rice. This finding was similar to that reported by Juliano and Pascual [4] who found that the peak viscosity correlated with hardness and stickiness of cooked rice. However, limited data are available in the literature on the relationship between pasting profile of rice flour and texture of vermicelli. Thus the objectives of this study were to determine the correlation between pasting properties of rice flour from RVA and Brabender and to compare the pasting properties of rice flour based on RVA measurement with the texture qualities of dried and cooked vermicelli. This information is expected to relate RVA data with Brabender data and to be used as a guideline to maintain desired product texture through the process.

Materials and Methodology

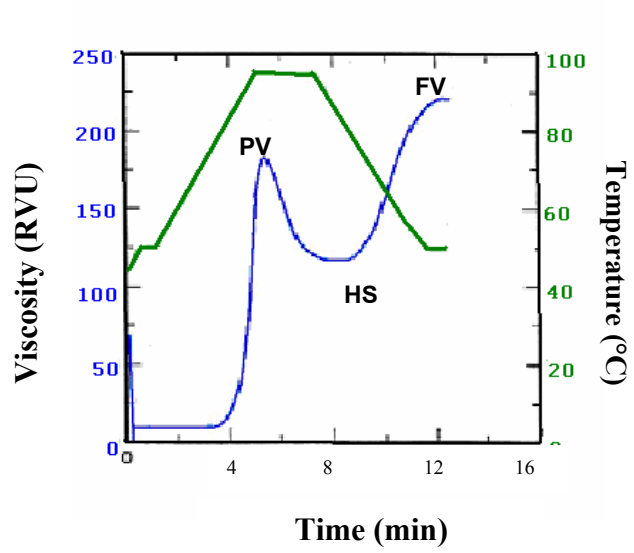
Materials

Twenty nine rice flour samples prepared by mixing 4 Thai rice varieties, i.e., Chainat, Leuang Pratew 123, RD1 and RD9 in various ratios were obtained from a local noodle factory. The mixed rice was dry-milled and subsequently sieved through a 120 mesh screen to produce flour samples (amylose content of 22.68 - 27.40%) for determining the pasting properties. All samples were stored in a refrigerator at $4\pm2^{o}C$ until required for use.

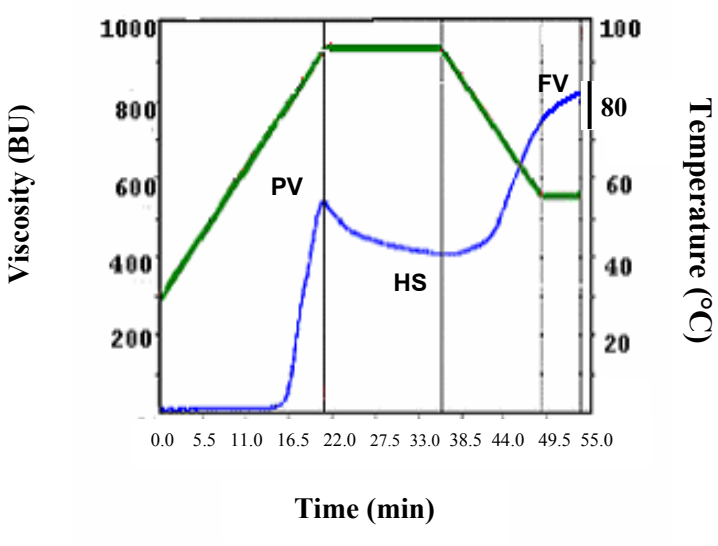
Dried vermicelli was prepared from the aforementioned rice flour by the means used by the local noodle factory. Rice flour slurry was prepared with the concentration of 30-33% and allowed to stand for 3 h before transferring to a continuous conveyer. The slurry was steamed then cooled. The gelatinized rice sheet was cut into strips.

Pasting properties

The pasting properties of rice flour samples suspended in distilled water were determined by RVA (RVA-4, Newport Scientific, Australia) and Brabender (Model PT100, Germany). In RVA, the sample (2.5 g, 12 g/100 g moisture basis) was weighed directly in the RVA canister and distilled water was added to obtain a sample weight of 25.0 g. The sample was held at $50^{o}C$ for 1 min. and then heated to $95^{o}C$ at a rate of $11.84^{o}C$/min. After holding at $95^{o}C$ for 25 min., the sample was cooled to $50^{o}C$ at a rate of $-11.84^{o}C$/min and held for 4.4 min. The rotation speed was maintained at 160 rpm during the process. In Brabender, 40 g of sample was suspended in distilled water to obtain a sample weight of 450 g. The slurry was heated to $95^{o}C$ at a rate of $1.5^{o}C$/min and then held at $95^{o}C$ for 20 min. Afterwards it was cooled to $50^{o}C$ at a rate of $-1.5^{o}C$/min. The rotation speed was maintained at 75 rpm. All samples were tested in triplicate. The pasting properties, including peak viscosity (PV), holding strength (HS), breakdown viscosity (BD=PV-HS), final viscosity (FV) and setback viscosity (SB=FV-PV) from both instruments were obtained from typical characteristics plots as shown in Figure 1.



(a)



(b)

Figure 1. Typical pasting profiles of rice flour obtained from (a) Rapid Visco Analyzer, RVA and (b) Brabender showing peak viscosity (PV), holding strength (HS) and final viscosity (FV).

The texture of dried vermicelli and cooked vermicelli

The texture of dried vermicelli cut into 5.0 cm lengths was determined by using Texture Analyser (Model TA-XT2i, England) equipped with three point bending rig (HDP/3PB). The maximum force or breaking strength (BS) was measured during compression of the sample at a test speed of 5 mm/s.

Cooked vermicelli was prepared by soaking dried vermicelli at room temperature for 3 min and then boiling in excess water until completely cooked (1 min). Cooked samples were cooled with distilled water and drained for 2 min. A texture analyser equipped with a tensile rig, blade set with knife (HDP/BSK) and cylindrical probe (P36R) was used to determine tensile strength (TS), firmness (FN) and surface stickiness (SS) of cooked

vermicelli. The test speeds used were 3 mm/s, 0.5 mm/s and 2 mm/s for TS, FN and SS, respectively.

All tests were replicated three times using a fresh sample each time.

Results and Discussion

Relationships between the pasting properties determined by RVA and Brabender

A direct comparison of pasting properties (PV, FV, BD and SB) obtained from RVA and Brabender is presented in Figure 2. Among the viscosity parameters, PV, FV and SB from RVA were correlated with those from Brabender with r^2 of 0.7014-0.7377. However, BD values from RVA were not correlated with those from Brabender. This finding is in agreement with the results of Limpisut and Jindal [3], who studied the pasting properties of rice flour stored at 30°C for 6 months and found that PV, FV and SB determined by the two instruments showed high positive correlation with the r^2 of 0.847, 0.819 and 0.746, respectively.

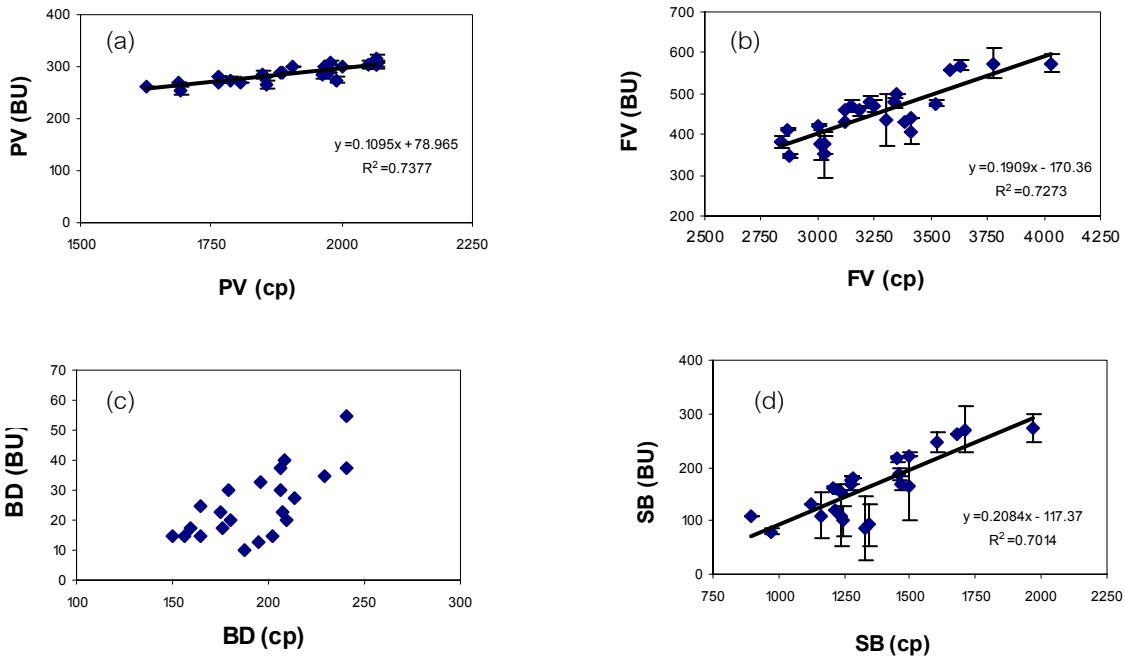


Figure 2. Correlations between pasting properties determined by RVA and Brabender of rice flour, representing (a) peak viscosity, PV; (b) final viscosity, FV; (c) breakdown viscosity, BD; and (d) setback viscosity, SB.

Relationships between breaking strength of dried vermicelli and pasting properties of rice flour

Linear correlation coefficients between BS measured by the texture analyser and pasting properties determined by RVA are presented in Figure 3. The results showed that only FV was correlated with BS (r^2=0.6956). Since BS is an indication of the sample resistance to impact force during handling, the sample which had higher FV should be more stable during transportation. In addition, the developed model in Figure 3 might be used to predict the stability of dried vermicelli during transportation.

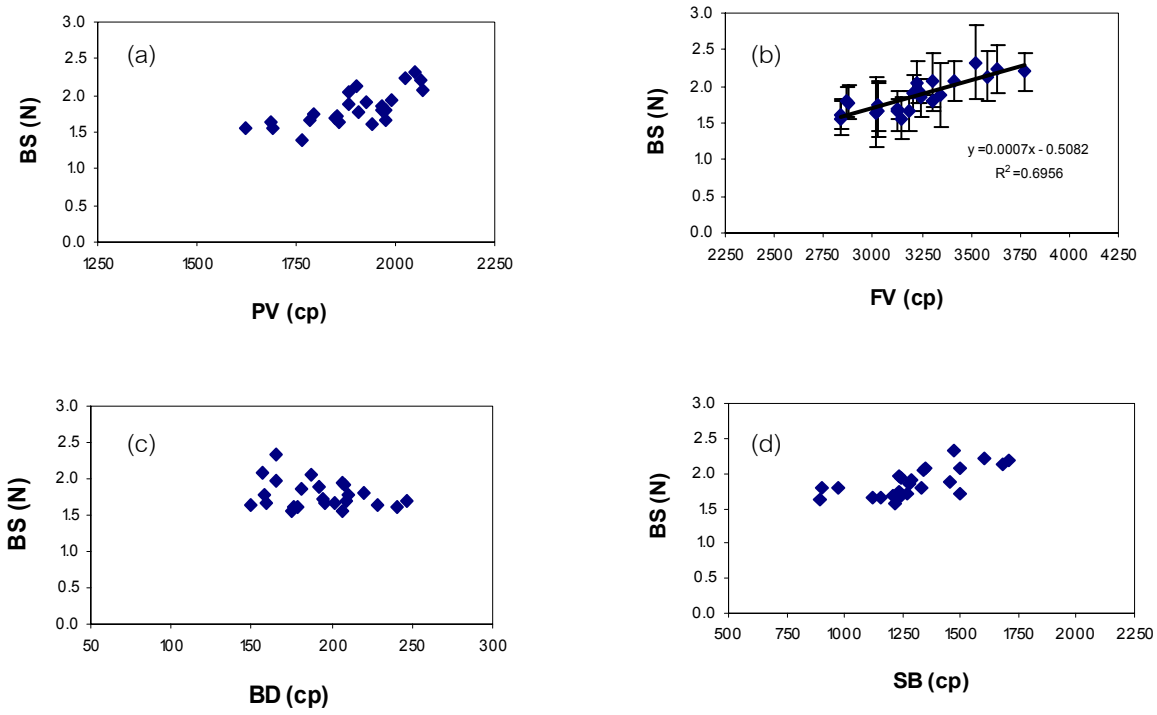


Figure 3. Correlations between breaking strength (BS) of dried vermicelli measured by Texture Analyser and (a) peak viscosity, PV; (b) final viscosity, FV; (c) breakdown viscosity, BD; and (d) setback viscosity, SB of rice flour determined by RVA.

Relationships between tensile strength of cooked vermicelli and pasting properties of rice flour

Correlation analysis between tensile strength (TS), the tensile force required to breakdown the cooked vermicelli and pasting properties of rice flour were examined. Figure 4 demonstrates no relationships between TS and pasting viscosity except FV. In this study, it was noticed that FV alone could be used for estimating TS of cooked vermicelli due to its positive correlation with TS (r^2=0.7400).

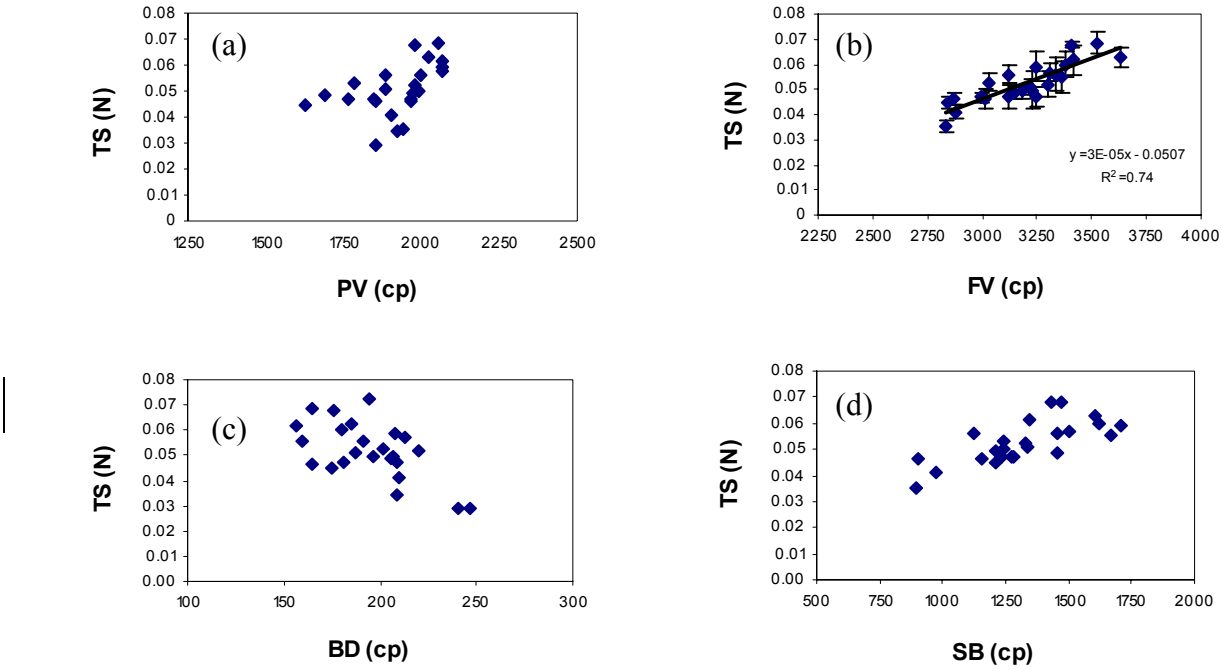


Figure 4. Correlations between tensile strength (TS) of cooked vermicelli measured by Texture analyzer and (a) peak viscosity, PV; (b) final viscosity, FV; (c) breakdown viscosity, BD; and (d) setback viscosity, SB of rice flour determined by RVA.

Relationships between firmness of cooked vermicelli and pasting properties of rice flour

Figure 5 shows that PV, FV and SB demonstrated no correlation with firmness (FN). However, a reasonable coefficient was obtained from the relationship between BD and FN (r^2=0.7156). This indicated that a predictive model could be developed for estimating the cooked vermicelli firmness from breakdown value. The present results are in agreement with other researchers. Sandhu and Singh [5], reported that firmness of corn starch gel was negatively correlated to break down viscosity of corn starch. Limpisut and Jindal [3], reported that firmness of cooked rice showed a reverse trend with breakdown viscosity of rice starch.

Relationships between stickiness of cooked vermicelli and pasting properties of rice flour

There were no significant correlations between noodle stickiness and RVA paste viscosities (Figure 6). Similar results have been reported by Ross, Quail and Crosbie [6], who reasoned that the starch granule of cooked vermicelli was different from that of RVA paste. This was because the integrity of the starch granule of RVA was substantially disrupted under high shear conditions during determination, whereas the structure of retrograded granule in cooked vermicelli remained intact.

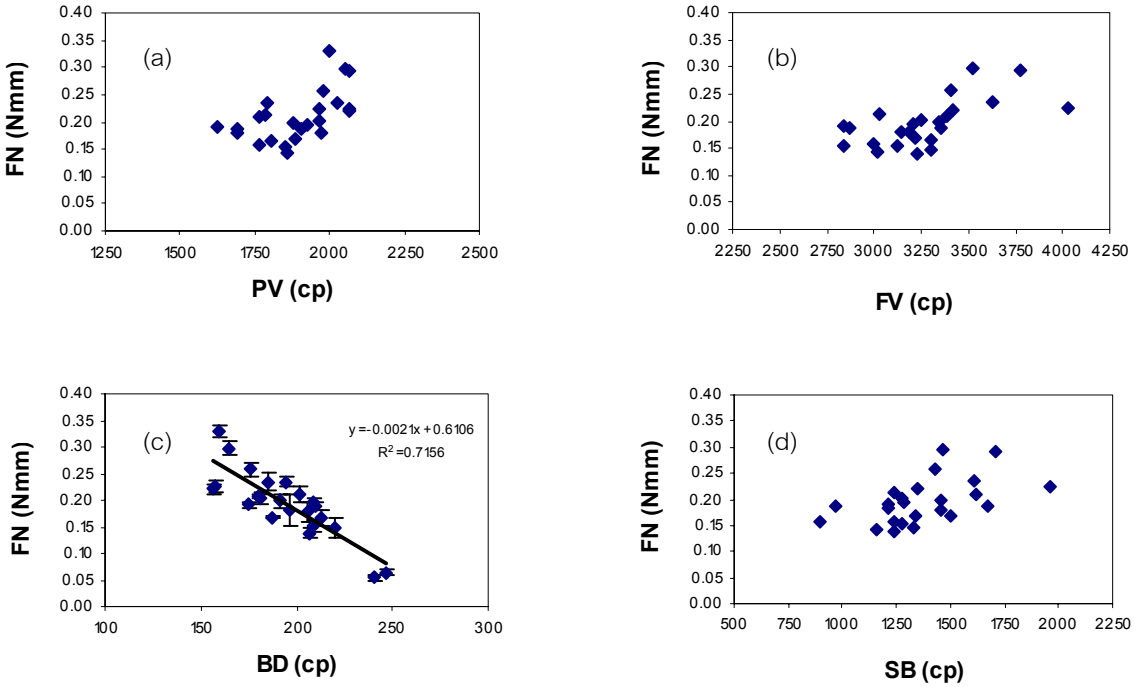


Figure 5. Correlations between firmness (FN) of cooked vermicelli measured by Texture analyzer and (a) peak viscosity, PV; (b) final viscosity, FV; (c) breakdown viscosity, BD; and (d) setback viscosity, SB of rice flour determined by RVA.

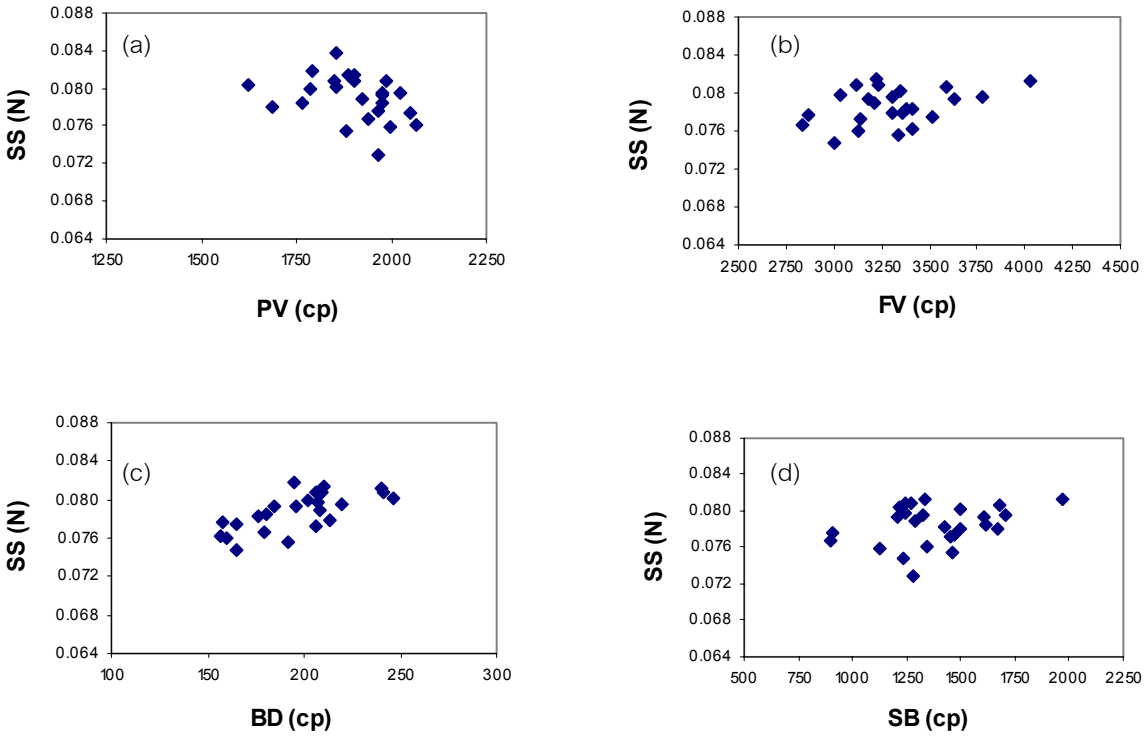


Figure 6. Correlations between surface stickiness (SS) of cooked vermicelli measured by Texture analyzer and (a) peak viscosity, PV; (b) final viscosity, FV; (c) breakdown viscosity, BD; and (d) setback viscosity, SB of rice flour determined by RVA.

It was noticed that RVA could be used for estimating the breaking strength (BS) of dried vermicelli and tensile strength (TS) and firmness (FN) of cooked vermicelli with reasonable accuracy (R^2>0.7). However the stickiness (SS) of cooked vermicelli could not be estimated from the pasting properties of rice flours determined with RVA.

Conclusions

SB and FV determined by RVA and Brabender showed significant correlations. The results also showed that FV could be used for predicting BS and TS of dried vermicelli and cooked vermicelli, respectively. In addition, BD showed some promise for evaluating FN of cooked vermicelli.

Acknowledgments

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