Rheological Properties of Purple Sweet Potato Flour and Its Application to Noodle Product

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Abstract: Purple sweet potato is a nutritious and abundantly available food crop in Asia, that it has received much attention because of its nutritional and the accumulation of anthocyanins. The functional properties and anthocyanin content of purple sweet potato flour (PSPF) were investigated. The pasting profiles of PSPF measured by Rapid Visco Analyzer (RVA) with respect to temperature, viscosity and time attributes were investigated. The pasting curve and viscosity parameters were demonstrated that final viscosity and setback were 1677.33, 817.33 mPa.s, respectively. However, it did not show peak viscosity. The flour paste of PSPF showed a shear thinning behavior of pseudo-plastic materials, the apparent viscosity decreased with increasing shear rate. The parameter values, consistency coefficient (k) and flow behavior index (n) were 0.45 Pa.s^n and 0.55, respectively. In addition, the PSPF contained anthocyanin content of 2.36 mg/g dry sample. The quality characteristics and anthocyanin content of noodle substituted with different levels at 10%, 20%, 30%, and 40% were investigated. While the substitution of PSPF increased, the anthocyanin content of noodles increased from 0.48 to 1.02 mg/g dry sample. However, the PSPF had affected the lightness and texture properties of noodle products. The tensile strength and the elasticity decreased as the levels of PSPF increased from 20.54 to 16.61 g and 16.07 to 7.79 mm, respectively.

1 INTRODUCTION

Sweet potato is an abundant and inexpensive crop in Asia. Purple sweet potato has received the most attention compared to white, yellow and orange sweet potato because of nutritional value. It contains a high content of anthocyanin which possess biological functions such as free radicals scavenging, antimutagenicity, hepato-protective, antihypertensive and antihyperglycemic activities (Suda *et al.*, 2003; Shan *et al.*, 2013). Purple sweet potato is normally processed to the flour and used as an ingredient for food products. Flour processing was able to preserve of anthocyanin (Shan *et al.*, 2013; Kim *et al.*, 2012; Xu *et al.*, 2015).

Noodle products are a traditional food in Asia. Therefore, traditional noodles are prepared mainly from basic ingredients (wheat flour, water, and salt) thus lack of essential nutritional components, such as dietary fiber, vitamins, and minerals (Choo and Aziz, 2010). Noodle in which substitution with purple sweet potato flour (PSPF) is the one promising option for healthy products. However, there is a lack of data about the functional properties of PSPF and nutritional information of noodle products substituted with PSPF. This study aims to investigate the rheological properties of PSPF and the influence of PSPF on the texture, color, and anthocyanin content of noodle products.

2 MATERIALS AND METHODS

2.1 Materials

Purple sweet potatoes (Okinawa varieties) are harvested about 90 days were purchased from Rajamangala University of Technology Srivijaya, Nakhon Si Thammarat province, Thailand. Wheat flour and salt (NaCl) were purchased from the local supermarket. All chemicals and reagents used in this study were of analytical grade.

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2.2 Methods

2.2.1 The Preparation of Purple Sweet Potato Flour

Purple sweet potato flour (PSPF) was prepared using a modified method of Chainarong *et al.* (2014). PSPF was packed in silver aluminum foil bags and stored at 4 ˚C for further analysis.

2.2.2 Pasting Characteristics

Pasting characteristics of PSPF was determined using a Rapid Visco Analyzer (RVA). The suspension of PSPF (12% w/w, db) was started at 25 °C and then heated to 95 °C at a rate 1.5 °C/min, held at this temperature for 3 min and then the sample was cooled to 25 °C at a rate 1.5 °C/min and held for 5 min. The parameters pasting temperature (Tp), peak viscosity (PV), breakdown (BD), setback (SB) and final viscosity (FV) were recorded.

2.2.3 Flow Behaviour

Flow behavior of PSPF was determined using a modified method Noosuk *et al*. (2003). PSPF 8% (db, w/w) was heated at 95 °C for 15 min and was transferred to a rheometer equipped with coaxial cylinder geometry (Z41). The sample was measured the viscosity and shear stress with shear rates range 10-1000 s^{-1} at 60 ˚C. The consistency coefficient and the flow behavior index were calculated.

2.2.4 Determination of Anthocyanin Content

Purple sweet potato flour was extracted and determined for anthocyanin content using a modified method of Yang and Gadi (2008).

2.2.5 Noodle Preparation

Noodles were prepared using a modified method Zhou *et al.* (2015). In this study, wheat flour was substituted by PSPF at levels of 10%, 20%, 30%, and 40%. The noodle dough was through a noodle machine to form a noodle dough sheet and was slit into 2.5 mm thickness. The noodle strands were pre-cooked in boiling water 30 sec and cooled for further analysis.

2.2.6 Color Measurement

The color of noodles was measured using a colorimeter by Hunter Lab Colorflex.

2.2.7 Textural Properties of Noodle

The textural properties of noodles were determined as described by Shan *et al.* (2013) using a texture analyzer (TA-XT2i). The maximum tension force and the maximum distance was measured.

2.2.8 Statistical Analysis

The data were expressed as mean ± standard deviation (SD) of triplicate, in a completely randomised design. The data were analyzed using analysis of variance (ANOVA), followed by Ducan's multiple range test to determine the significant differences among the means at the 95% confidence level.

3 RESULTS AND DISCUSSION

3.1 Rheological Properties of Purple Sweet Potato Flour

The pasting profiles of PSPF measured by RVA are shown in Figure 1, with respect, viscosity and time during the heating and cooling cycle. According to the classification of Schoch and Maywald (1968) are shown PSPF exhibited restricted-swelling (c-type) and curve did not show pasting peak, but rather a very high viscosity during decreasing of temperature. In addition, viscosity parameters are shown in Table 1. BD, SB and FV of PSPF were 12.33, 817.33, 1677.33 mPa.s, respectively. Pasting properties are influenced by the size and shape of starch granules, amylose content, branched chain-length distribution of amylopectin.

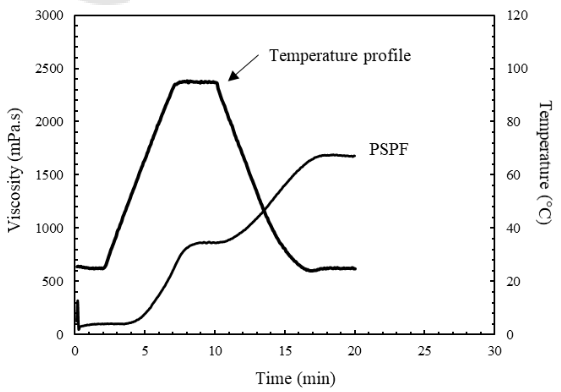

Figure 1: Pasting profiles of purple sweet potato flour.

The flow behavior at 60˚C over the shear rate range of 10-1000 s^{-1} of PSPF followed the power law equation (R^2= 0.99, $p<0.05$). The relationship of apparent viscosity and shear rate of PSPF are shown in Figure 2, the apparent viscosity decreased with increasing shear rate. In addition, flow behavior (n) of PSPF was less than 1 (Table 1), indicating that PSPF exhibited shear-thinning behavior of pseudo-plastic materials (Evans and Haisman, 1980; Doublier, 1981; Ellis *et al.*, 1989). Figure 2 showed PSPF occurred hysteresis loops, indicating that it was time-dependent non-newtonian flow behavior of thixotropy.

Table 1: Viscosity parameters from Rapid Visco Analyzer (RVA) and consistency coefficient and flow behavior index of purple sweet potato flour.

Pasting parameters	Value
Tp (°C)	-
PV (mPa.s)	-
BD (mPa.s)	12.33±1.53
SB (mPa.s)	817.33±7.02
FV (mPa.s)	1677.33±6.66
Flow behavior	
k ($Pa.s^n$)	0.45±0.06
n	0.55±0.01
area	940.78±62.33

Note: Each value is mean of triplicate ± SD. PSPF, purple sweet potato flour; Tp, pasting temperature; PV, peak viscosity; BD, breakdown; SB, setback; FV, final viscosity; k, consistency coefficient; n, flow behavior index.

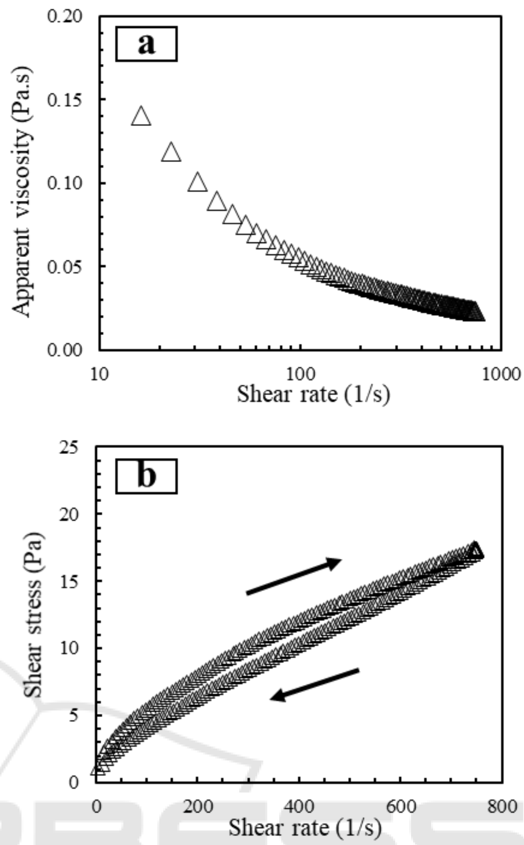

Figure 2: Relationship of apparent viscosity and shear rate of purple sweet potato flour at 60 ˚C over the shear rate range of 10-1000 s^{-1} (a) and relationship of shear stress and shear rate of purple sweet potato flour (b).

3.2 Application of Purple Sweet Potato Flour to Noodle Product

3.2.1 Anthocyanin Content of Noodle Substituted with Purple Sweet Potato Flour

The anthocyanin content of PSPF and noodles substituted with PSPF are shown in Table 2. The anthocyanin content of PSPF and noodles substituted with PSPF were significantly different ($p<0.05$). PSPF had high anthocyanin content of 2.36 mg/g dry sample. The anthocyanin content increased as the levels of PSPF substitution increased significantly ($p<0.05$) from 0.48 to 1.02 mg/g dry sample.

Table 2: Anthocyanin content of purple sweet potato flour and noodles substituted with purple sweet potato flour.

Samples	Anthocyanin content (mg/g dry sample)
PSPF	2.36±0.02^a
PSPF substitution (%)	
0	0.27±0.03^f
10	0.48±0.01^e
20	0.72±0.01^d
30	0.83±0.01^c
40	1.02±0.01^b

Note: Each value is mean of triplicate ± SD. $^{a-f}$ Means with different small letter superscripts in the same column are significantly different at 95% confidence level. PSPF, purple sweet potato flour.

3.2.2 Color of Noodle Substituted with Purple Sweet Potato Flour

The color of PSPF and noodles substituted with PSPF are shown in Table 3. Noodles substituted with PSPF at different levels were significantly different from the color in terms of L*, a*, and b* ($p<0.05$). Increasing levels of PSPF decreased the lightness (L* value) significantly ($p<0.05$) from 44.96 to 30.59 with increasing levels of PSPF from 10% to 40%. In similarly, b* value decreased from 4.42 to -0.13. However, the substitution of PSPF increased, a* value significantly increased ($p<0.05$).

Table 3: Color of purple sweet potato flour and noodles substituted with purple sweet potato flour.

Samples	L*	a*	b*
PSPF	57.77±0.70[b]	17.97±0.33[a]	-3.09±0.09[f]
PSPF substitution (%)			
0	70.46±0.28[a]	2.19±0.07[f]	19.72±0.23[a]
10	44.96±0.62[c]	12.25±0.09[e]	4.42±0.09[b]
20	38.01±0.18[d]	14.76±0.09[d]	1.46±0.07[c]
30	33.59±0.02[e]	15.19±0.11[c]	0.57±0.07[d]
40	30.59±0.58[f]	15.64±0.21[b]	-0.13±0.05[e]

Note: Each value is mean of triplicate ± SD. [a-f] Means with different small letter superscripts in the same column are significantly different at 95% confidence level. PSPF, purple sweet potato flour.

3.2.3 Texture Properties of Noodle Substituted with Purple Sweet Potato Flour

The textural properties of noodles substituted with PSPF are shown in Table 4. Increasing levels of PSPF decreased the tensile strength and the elasticity significantly ($p<0.05$) from 20.54 to 16.78 g_f and 16.07 to 7.79 mm, respectively. It might be due to flour has a low protein content and the relative amounts of gluten protein fractions are also important on the texture properties of noodles will be soft (Kovacs *et al.*, 2004; Fu, 2008). The tensile strength of noodle substituted with 10% PSPF was not significantly different ($p<0.05$) comparing with wheat noodle (0%PSPF).

Table 4: Textural analysis of noodles substituted with purple sweet potato flour.

Samples	Tensile Strength (g_f)	Elasticity (mm)
0% PSPF	20.83±1.48[a]	63.95±3.78[a]
10% PSPF	20.54±1.51[a]	16.07±1.92[b]
20% PSPF	18.85±0.58[b]	14.17±1.92[b]
30% PSPF	16.18±0.78[c]	9.76±1.10[c]
40% PSPF	16.61±0.94[c]	7.79±1.74[c]

Note: Each value is mean of triplicate ± SD. [a-c] Means with different small letter superscripts in the same column are significantly different at 95% confidence level. PSPF, purple sweet potato flour.

4 CONCLUSIONS

The pasting profiles of PSPF measured by RVA did not show peak viscosity. The flour paste of PSPF exhibited a shear thinning behavior of pseudo-plastic materials. The substitution of PSPF increased the anthocyanin of noodles increased. Moreover, the PSPF had affected the lightness and texture properties of noodle products. The tensile strength and the elasticity decreased as the levels of PSPF increased. The utilization of PSPF as an ingredient in noodles might be beneficial that provides nutritional value and is a healthy food choice for consumers.

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