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Effect of Soybean Flour on Physico-chemical, Functional, and Rheological Properties of Composite Flour from Rice, Sweet Potato, and Potato

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Abstract: Three composite flours were prepared by combining rice flour, potato starch, sweet potato flour, soybean flour, and xanthan gum in the ratio of 30: 15: 50: 4.5: 0.5; 30: 15: 45: 9.5: 0.5; and 30: 15: 40: 14.5: 0.5, were analysed for selected physical, chemical, functional, and rheological properties. Fat, protein, ash, and crude fibre content were found to increase with increase in the ratio of soybean flour and decrease in the ratio of sweet potato flour in the mixture. The composite flours were not significantly different in water and oil absorption capacity, swelling power, and baking expansion. There was a tendency for the relative viscosities of the composite flours to increase significantly with increasing proportion of the soybean flour and decreasing proportion of sweet potato flour in the mixture. Pasting viscosity measurements of the composite flours gave maximum (peak) viscosity values ranging from 582.00–668.67 cP. The pasting analysis results indicated increased level of setback and final viscosity, pasting temperature, setback and stability ratio while peak viscosity decreased with increasing proportion of soybean flour and decreasing proportion of sweet potato flour in the mixture.

Keywords: Composite Flour, Rheological Properties, Sweet Potato, Xanthan Gum

INTRODUCTION

In recent years, breads and other bakery products have been produced using gluten free composite flours. These flours are advantageous in developing countries such as Indonesia by reducing the importation of wheat flour and encourages the use of locally grown crops as flour. Gluten-free composite flours can be made by blending various flour with completely free of any gluten, obtained from other cereals, legumes, tubers, and root crops in appropriate mixture (Olaoye *et al.* 2006). Xanthan gum is added to naturally gluten-free flours to mimic the viscoelastic properties of gluten (Lazaridou *et al*. 2007), while

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soybean flour is used to improve the protein quality (Okoye *et al*. 2008). The aim of this study was to design a composite flour comprising rice and sweet potato flour, potato starch, soybean flour, and xanthan gum. The physicochemical, functional, and rheological properties of the resulting composite flours were determined.

MATERIALS AND METHODS

Yellow-fleshed cultivar of sweet potato and anjasmoro variety of soybeans were processed into flour, and potato tubers were processed into starch using the technique described by Singh *et al.* (2008), Okoye *et al.* (2008) and Park *et al.* (2009), respectively. Commercial rice flour and whole-wheat flour were procured from local market. Xanthan gum was procured by SIGMA-Aldrich.

A completely randomised design was employed. The ratio of the composite flours were the main treatments, and wheat flour (WF) was used as control. Composite flours were prepared by blending rice flour, potato starch, sweet potato flour, soybean flour, and xanthan gum in the ratio of 30: 15: 50: 4.5: 0.5 (T_1); 30: 15: 45: 9.5: 0.5 (T_2); 30: 15: 40: 14.5: 0.5 (T_3); and 100% wheat flour as control (T_4). Samples were weighed based on 100 g standard. The samples then were analysed for moisture, ash, crude fibre, protein (N *6.25), crude fat and carbohydrate (AOAC 1995). The colour of composite flours were determined by using a chromameter (Minolta Type CR-300, Japan) and considered the parameters L*, a*, and b*. The L* scale ranges from 0 black to 100 white; the a* scale extends from a negative value (green hue) to a positive value (red hue); and the b* scale ranges from negative blue to positive yellow.

Water absorption index (WAI) and oil absorption index (OAI) were determined according to the methods of Niba *et al.* (2001), and swelling power was determined based on a modified method of Leach *et al.* (1959). Rheological or pasting properties of composite flour were evaluated with Rapid Visco Analyser (RVA, Model Tecmaster Newport Scientific, Australia). The following data were recorded: pasting temperature (P_{temp}); peak viscosity (PV); trough viscosity (TV); breakdown (BD) = PV–TV; final viscosity (FV); setback viscosity (SB) = FV–TV, stability ratio (SR) = TV/PV, and setback ratio (SBR) = FV/TV (AACC 2000).

Three replicates of all the experiments were carried out. Differences between the range of the properties were determined using the method of Least Significant Difference (LSD) tests at 95% confidence level ($p<0.05$).

RESULTS AND DISCUSSION

Table 1 showed the physicochemical, functional, and rheological properties of composite flour (T_1, T_2, and T_3) and wheat flour (T_4). There were significant differences in the colour of composite flour (T_1, T_2, and T_3) and wheat flour (T_4) in terms of lightness (L*), yellowness (b*), and greenness (a*). The composite flour had the lower lightness and greenness value but had the higher yellowness value than that in wheat flour.

There were significant differences in the moisture, protein, ash, carbohydrate, and fibre content of various composite flours. The moisture and protein content of composite flour (T_1, T_2, and T_3) were significantly lower than that of the wheat flour (T_4), while ash, fat, carbohydrate, and fibre content were significantly higher than that of the wheat flour. The protein, fat, ash, and fibre content of composite flours increased while the carbohydrate and moisture content decreased with increasing level of soybean flour. This could obviously due to the higher content of protein, fat, and ash (minerals) in soybean seed (Abioye *et al.* 2011).

There were no significant differences in water and oil absorption index among the composite flours (T_1, T_2, and T_3) and wheat flour (T_4), but the wheat flour samples recorded the least value. The oil absorption index of flour is important as it improves the mouth feel and retains the flavour (Igbabul *et al.* 2014). Swelling power increased significantly with increased of soybean flour, and wheat flour had the highest value. Swelling power is often related to their protein and starch content (Woolfe 1992).

The pasting temperature of composite flours ranged from 73.12°C to 74.22°C and increased with increasing level of soybean flour and wheat flour had the highest value. The results of rheological (pasting) properties show that increasing level of soybean flour reduced the peak and breakdown viscosity. This indicates that the flour may be suited for products requiring low gel strength and elasticity (Abioye *et al.* 2011). The set back and final viscosity increased with increase in soy flour level. The viscosity of composite flour was significantly lower than wheat flour. This might be due to the higher gluten content on wheat flour (Igbabul *et al.* 2014).

Table 1: Summary of physicochemical, functional, and rheological properties of composite flours.

Properties	Composite flours			
	T_1	T_2	T_3	T_4
Colour:				
L*	90.37±0.10^{c}	91.52±0.06^{b}	91.73±0.06^{b}	94.49±0.77^{a}
a*	4.36±0.6^{a}	0.62±0.04^{c}	0.12±0.01^{d}	1.16±0.34^{b}
b*	21.60±0.40^{b}	24.27±0.11^{ab}	25.67±0.08^{a}	13.23±5.51^{c}
Moisture (%)	10.97±0.36^{b}	9.69±0.11^{d}	10.52±0.11^{c}	13.35±0.41^{a}
Ash (%)	1.42±0.03^{b}	1.52±0.03^{b}	1.75±0.14^{a}	0.82±0.03^{c}
Protein (%)	5.65±0.76^{c}	5.62±0.46^{c}	6.60±0.17^{b}	11.37±0.48^{a}
Fat (%)	2.37±0.44^{c}	3.24±0.15^{b}	4.64±0.20^{a}	1.67±0.35^{d}
Carbohydrate (%)	80.69±0.90^{a}	80.78±0.42^{a}	77.49±0.13^{b}	73.36±0.72^{c}
Fiber (%)	0.99±0.03^{d}	1.63±0.12^{b}	1.91±0.12^{a}	1.37±0.15^{c}
WAI (g/g)	2.81±0.17	2.66±0.21	2.68±0.19	2.53±0.48
OAI (g/g)	2.08±0.07	2.02±0.17	2.09±0.17	1.95±0.14
Swelling Power (g/g)	9.76±0.75^{bc}	9.64±0.06^{c}	10.52±0.15^{b}	11.70±0.30^{a}
Baking Expansion (ml/g)	0.71±0.06^{b}	0.71±0.03^{b}	0.77±0.04^{b}	0.87±0.06^{a}
P_{temp} (°C)	73.12±0.23^{c}	73.38±0.23^{c}	74.22±0.58^{b}	83.97±0.23^{a}
PV (cP)	582.00±20.78^{c}	668.67±18.72^{b}	566.33±17.79^{d}	2.472.00±49.87^{a}
BD (cP)	333.33±21.96^{c}	372.33±13.80^{b}	264.33±4.16^{d}	1.161.00±18.52^{a}
SB (cP)	178.33±3.51^{c}	213.00±6.08^{b}	230.33±13.61^{b}	1.329.00±24.56^{a}
CPV (cP)	427.00±5.00^{c}	509.33±12.50^{bc}	532.33±35.22^{b}	2.640.00±56.24^{a}
SR	1.72±0.01	1.72±0.01	1.76±0.01	2.01±0.01
SBR	0.43±0.02^{b}	0.44±0.01^{b}	0.53±0.02^{a}	0.53±0.03^{a}

Notes: Values with similar superscripts in a column do not differ significantly ($p<0.05$, n=3, least significant difference tests). T_1, T_2, and T_3 = composite flour from rice flour, potato starch, sweet potato flour, soybean flour, and xanthan gum in the ratio 30:15:50:4.5:0.5;30:15:45:9.5:0.5; and 30:15:40:14.5:0.5, respectively, T_4 = wheat flour (control).

CONCLUSION

Composite flour from rice flour, potato starch, sweet potato and soy bean flour, and xanthan gum in different proportion of sweet potato and soybean flour had the difference physicochemical, functional and rheological properties. Composite flour in the ratio of rice flour: potato starch: sweet potato flour: soybean flour: xanthan gum 30: 15: 40: 14.5: 0.5 had the highest protein, fat, ash, and fibre content. Although the viscosity of composite flour was lower than that in wheat flour, but it can be used to replace wheat flour for products requiring low gel strength and elasticity like cookies and cakes.

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