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Evaluation of physico-chemical and functional properties of composite flour from cassava, rice, potato, soybean and xanthan gum as alternative of wheat flour

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Abstract

This work aims at examining the physical, chemical and functional properties of composite flour produced with cassava, rice, soybean flours, and potato starch and added with 0.5% xanthan gum. Nine blends of composite flours were prepared by homogenously mixing rice flour, cassava flour, soybean flour, and potato starch (RF:CF:SF:PS) in the proportions of 30:50:15:4.5, 30:45:20:4.5, 30:40:25:4.5, 30:45:15:9.5, 30:40:20:9.5, 30:35:25:9.5, 30:40:15:14.5, 30:35:20:14.5, 30:30:25:14.5. Composite flour produces were subjected to proximate, paste and functional properties analyses. The moisture content, fat, protein, ash and crude fiber of the composites were as follows: 9.37-12.07% db, 1.33-4.91%, 4.50-6.22%, 0.74-1.12% and 1.13-1.94% compared with wheat flour 13.32% db, 6.30%, 2.12%, 1.31% and 7.52%, respectively. There was no significant difference (P > 0.05) recorded for water absorption index and gelatinization temperature between nine blends of composite flours and wheat flour. Peak, set back, cooling capacity and breakdown viscocisity were: 2311.67-4423.00 cP, 1199.33-1556.33 cP, 2618.67-3415.00 cP and 992.00-2437.67 cP. The value of composite flour viscosities were higher than paste characteristics of wheat flour. The colour of composite flour showed by the L^* value of chromameter were 95.71-97.10 compared with wheat flour 95.02. Hence, it was concluded that the composite flours from rice, cassava, and soybean flour, potato starch using xanthan gum had the physicochemical and functional properties which can be considered similar to wheat flour for making wheatless products. The composite flour with the proportion of rice flour 30%, cassava flour 40%, potato starch 15%, soybean flour 14.5% and xanthan gum 0.5% had the physicochemical, functional and pasting properties that comparable to those of wheat flour.

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Introduction

In the past, wheat flour has been used for production of noodle and baked products such as breads, cakes, biscuits, and cookies. This is because of the nature and functional properties of the wheat flour proteins. But, local climatic condition in Indonesia as the tropical country is not suitable for profitable wheat production. Hence, Indonesia and other tropical countries have been dependent on imported wheat to fulfill their requirement for the manufacture of various food products based on wheat flours. On the other hand, some individuals are intolerant to glutens of wheat and the related cereals oats, rye, and barley. This intolerance, celiac disease, seriously impairs intestinal absorption and can lead to severe malnutrition (Ciclitira and Ellis, 1987; Davison and Bridges, 1987).

In bakery gluten forms, as glutenin molecules, cross-link to make a sub-microscopic network and associates with gliadin, which contributes with viscocity and extensibility to the mix. Gluten content was implicated as a stalling factor of bread, because it binds water by hydration. The development of gluten affects the texture of the baked goods (Alvarenga *et al.*, 2011). Nowadays, efforts were aimed on steps to identify those nonwheat sources that could be used in tropical countries to extend the usage of wheat flour in bread making, thus affect saving in foreign exchange by limiting wheat importation. Such nonwheat flours are obtained from other cereals, legumes, tubers, and root crops, for example maize, sorghum, rice, soybean, shorgum, cassava, sweet potato, potato, and plantain (Shahzadi, 2005; Olaoye *et al.*, 2006; Oladunmoye *et al.*, 2010; Alvarenga *et al.*, 2011; Idolo, 2011; Oluwamukomi *et al.*, 2011). Cassava, rice, potato and soybean are commercially cultivated in Indonesia. Cassava is a root crop, rich in starch and used as staple food in tropical countries. Cassava flour has been examined as a local alternative to wheat flour. Cassava flour may also be consumed by those with celliac disease, but they cause technological

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difficulties in breadmaking and impart unusual taste to bread (Alvarenga *et al.*, 2011). Rice is staple food in Indonesia. Rice flour is obtained by milling broken rice grains and used for baby food, breakfast foods and meat products, for separating powders for refrigerated, preformed, unbaked biscuits, dusting powders, breading mixes; and for formulation for pancakes and waffle (Luh and Liu, 1980). Rice flour can be used as a wheat flour replacement since it lacks gluten and contains low levels of sodium and a high amount of easily digested carbohydrates, making it desireable in celliac diets (Yimaki *et al*., 1991).

Potato is one of the major food item consumed throughout the world, because it is easy to prepare and can be eaten as staple food, as complementary vegetable or as a snack foods (Chadha, 1994; Chalom *et al*., 1995; Shirsat and Thomas, 1998). Potato is one of commercial starch sources for industrial application. Potato starch possesses unique characteristics that are suitable for food application. It has a larger granule size and higher degree of phosphorylation than other commercially available starches (Singh *et al*., 2003; Jobling, 2004). The existence of phosphate in potato starch is of immense importance, as this confers high viscosity (Noda *et al.*, 2004, 2004a, 2006, 2006a). In bread making, starch contributes to the formation of texture and quality of dough and bread (Sandstedt, 1961), acts as temperature triggered water-sink in baked products (Hoseney *et al*., 1978; Hoseney, 1984). Soybean is an excellent source of protein (35-40%), rich in calcium, iron, phosphorus and vitamins, and also the only source of all the essential amino acids (Ihekoronye and Ngoddy, 1985). Soybean proteins are rich in lysine but deficient in sulphur containing amino acids, whereas cereal proteins are deficient in lysine, but have adequate amounts of sulphur amino acids (Eggum and Bearne, 1983). Adition of soybean flour to cereal based products could be a good option to provide better overall essential amino acid balance, helping to overcome the world protein calorie malnutrition problem (Livingstone *et al.*, 1993). Soybean flour and soybean protein has been used as composite flour in the production of bread (Dhingra and Jood, 2002; Basman *et al.*, 2003; Ribotta *et al.*, 2004; Sanchez *et al.*, 2004; Olaoye *et al*., 2006), missi roti/chapatti (Kadam *et al*., 2012) and biscuit (Akubor and Ukwuru, 2005; Oluwamukomi *et al.*, 2011).

Composite flour technology refers to the process of mixing various flours from tubers with cereals or legumes with or without addition of wheat flour in proper proportions to make economic use of local cultivated crops to produce high quality food products. Some studies were reported on the use of cereal-tuber-legume combination for the production of various products (Akubor and Ukwuru, 2005; Oladunmoye *et al.*, 2010; Kadam *et al*., 2012). It can be deduced from these reports that the qualities of product depend on the proportional composition of the composites and flour properties (Oladunmoye *et al*., 2010).

Despite a recent advance in formulation of non-wheat flour from cereal-tuber-legume combination, the replacement of gluten in cereal-based products, such as bread, biscuit, cake and pasta, still represent a significant challenge of technology (Gallagher *et al.*, 2004). Gluten in wheat flour has a fundamental role in breadmaking, as it is an essential structure-building protein that provides viscoelasticity to the dough, good gas-holding ability and good crumb structure of the resulting baked product (Gallagher *et al*., 2004). Addition of hydrocolloids such as pectin, agar-agar, guar gum and xanthan gum is the most important approaches developed to mimic the properties of gluten in gluten-free bakery products (Moore *et al*., 2006; Lazaridou *et al.*, 2007; Arendt *et al*., 2008; Alvarenga *et al.*, 2011; Ho and Noor Aziah, 2013).

This study is one of the efforts to promote the use of composite flours in which flour from locally grown crops and soybean with high protein content was used to produce protein-enriched composite flour. Thus, the aim of this work was to develop and evaluate the optimum proportion of cassava flour, potato starch, and soybean flour for production of composite flour made from rice, cassava, and soybean flour and potato starch and applying the hydrocolloid xanthan gum compared with wheat flour (as reference sample). Published studies on physicochemical and functional properties of composite flour provides information about the behaviour of flours for reseachers on this area.

Materials and Methods

Commmercial rice flour and whole-wheat flour procured from PT.Budi Makmur Perkasa Indonesia and PT.Indofood Sukses Makmur Tbk. Indonesia, respectively. Gunting saga cassava tuber, desiree potato tuber and anjasmoro variety of soybeans were sourced from local market in Medan, North Sumatera. Xanthan gum (G1253, Sigma-Aldrich USA) was procured from PT.Elo Karsa Utama (Jakarta, Indonesia).

Cassava flour preparation

Cassava tubers were washed, peeled and cut into thin slices and soaked in 0.3% sodium metabisulphite

Table 1. Different treatment used to prepare composite flour

Treatment	Cassava Flour (%)	Potato Starch (%)	Soybean Flour (%)
T_1	50	15	4.5
T_2	45	20	4.5
T_3	40	25	4.5
T_4	45	15	9.5
T_5	40	20	9.5
T_6	35	25	9.5
T_7	40	15	14.5
T_8	35	20	14.5
T_9	30	25	14.5

solution for 5 minutes. The soaking solution was drained and the thin slices were sprayed in a tray and were oven drying at 60°C for 10 hours and after which it was milled into flour. The flours were screened through a 80 mesh sieve. The flours were stored in polyethylene bags before using.

Potato starch preparation

The fresh potato tubers were sorted, washed thoroughly, macerated using grate machine, diluted 1:3 w/v with tap water and filtered though cheesecloth. Starch in the filtrate was allowed to settle for 12 hours at room temperature (27-30°C). The supernatant was decanted and discarded while starch were resuspended in water for 3 hours and kept at room temperature for 3 hours to settle. The starch sediment was dried in a convection oven at 50°C for 12 hours, cooled to room temperature. The starch was then sieved through a 80 mesh sieve, packed and sealed in polyethylene bags before using.

Soybean flour preparation

Soybean grains were thoroughly cleaned to remove the dust and other foreign materials. The clean grains were soaked into water for 6 hours and then boiled in pressure cooker for 5 minutes. They were removed, dehulled and dried in the oven at 50°C for 24 hours after which they were ground into flour in an electric grinder. The flour were sieved through 80 mesh sieve. The flour samples were kept in airtight container before using.

Composite flour preparation

The constant percentage of rice flour at 30% due to it's ability to increase the viscosity elasticity and a solid dough of composite flour (Dautant *et al.*, 2007). The constant percentage of xanthan gum at 0.5% due to its function as a thickening agent and stabilizer to complete the characteristics of free gluten flour (Gambus *et al.*, 2007). The three different intervals of cassava flour, potato starch, and soybean flour used in composite flours due to focus on the effect of the different ratio of each of flour on the characteristics of composite flours. Cassava flour (CF) was blended with rice flour (RF) and soybean flour (SF), potato starch (PS) and xanthan gum (XG) in different combination (Table 1) by using a mixer. The composite flour samples were stored in polyethylene bags. Ingredient and composite flour samples the were analyzed for proximate, physical, functional and pasting properties. Wheat flour (WF) was used as control flour.

Physicochemical properties of flour

The chemical analysis of individual flours (WF, CF, RF, SF, PS) and each treatment of composite flour including moisture content by oven drying method, crude protein by Kjeldahl's method, crude fat by soxhlet method, ash by dry ashing, crude fiber by gravimetric methods (AOAC, 1995), and total carbohydrates obtained by difference. The chemical used in this study were analytical grade. The color of ingredient and 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.

Functional properties of flour

The functional properties of individual and composite flour such as water absorption index (WAI), oil absorption index (OAI) and swelling power were determined by standard methods. WAI and OAI were determined according to the methods of Valdez-Niebla *et al.* (1992), Ju and Mittal (1995) and Subrahmanyam and Hoseney (1995) as modified by Niba *et al.* (2001). Flour samples (1 g) were suspended in 5 ml of water (for WAI) or vegetable oil (for OAI) in a centrifugal tube. The slurry was shaken on a platform tube rocker for 1 minute at room temperature and centrifuged at 3000 rpm for 10 minutes. The supernatant was decanted and discarded. The adhering drops of water was removed and reweighed. WAI and OAI were are expresses as the weight of sediment/initial weight of flour sample (g/g).

The swelling power of flours were determined based on a modified method of Leach *et al.* (1959). Approximately 0.1 g of sample was transferred into a weighed graduated 50 ml centrifuge tube. Distilled water was added to give a total volume of 10 ml. The sample in the tube was stirred gently by hand for 30 s at room temperature, and then heated at 60°C for 30 min. After cooling to room temperature, the samples were centrifuged for 30 min at 3000 rpm. The weight of sediment was recorded.

Pasting properties of flours

Pasting properties of WF, RF, CF, PS and composite flour were evaluated with Rapid Visco

Analyzer (RVA, Model Tecmaster Newport Scientific, Australia). A suspension of 3 g (14% w.b.) of flour in 25 g of distilled water underwent a controlled heating-and-cooling cycle under constant shear where it was held at 50°C for 1 minute, heated from 50 to 95°C at 6°C/minutes, held at 95°C for 5 minutes. The following data were recorded: pasting parameters of time from onset of pasting to peak viscosity (P time); temperature at which peak viscosity was reached (P temp); peak viscosity (PV); viscosity at the end of holding time at 95°C or hot paste viscosity (HPV); breakdown (BD) = PV-HPV; viscosity at the end of the hold time at 50°C or cold paste viscosity (CPV); setback viscosity (SB) = CPV-HPV, stability ratio (SR) = HPV/PV, and setback ratio (SBR) = CPV/HPV.

Data analysis

Data using completely randomized design was analyzed using SAS Version 9.2 for windows. The data reported in all tables are an average of triplicate observations subjected to one-way anlysis of variance (ANOVA). 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

Physicochemical properties of Composite Flour

The chemical composition of individual and composite flours are given in Table 2 and Table 3, while color characteristics of composite flour are shown in Table 4. From Table 2 it was found that the moisture content of potato starch was higher than others, while ash, protein and fat were highest in soybean flour, and the highest fiber content was found in cassava flour. Chemical analysis of composite flour (Table 3) revealed that various treatments of composite flours significantly affected the moisture, ash, protein, fat and fiber contents. There were significant differences in the colours of composite flours (Table 4).

There were significant differences in the moisture contents of various composite flours, and were significantly lower than that of the control (wheat flour). The moisture content of composite flour samples in the present study ranged from 9.37% to 11.94% compared to reported values of 11 to 15% depending upon storage conditions and hygroscopic nature of flour (Shahzadi *et al*., 2005). The level of moisture content in the composite flours were within the recommended moisture levels 14% for safe storage. The moisture content should be below 14% to prevent microbial growth and chemical changes during storage (Shahzadi *et al*., 2005).

Table 2. Chemical composition of potato starch and rice, cassava, and soybean flours as raw materials for composite flours

Flour	Moisture (%)	Ash (% db)	Protein (% db)	Fat (% db)	Fiber (% db)
Potato Starch	15.98 ± 0.36	0.16 ± 0.05	4.54 ± 0.28	0.29 ± 0.10	0.47 ± 0.01
Rice Flour	12.85 ± 0.22	0.39 ± 0.05	5.14 ± 0.85	0.58 ± 0.10	0.74 ± 0.03
Cassava Flour	8.51 ± 0.22	1.06 ± 0.06	4.98 ± 0.21	0.65 ± 0.05	2.62 ± 0.29
Soybean Flour	6.63 ± 0.09	4.23 ± 0.09	13.70 ± 0 .70	27.15 ± 0.55	2.35 ± 0.09

The values are expressed as the mean of three replicate samples ± standard deviation

Table 3. Chemical composition and color characteristics of composite flour from rice, cassava and soybean flour, potato starch and xanthan gum

Flour	Moisture (%)	Ash (% db)	Protein (% db)	Fat (% db)	Fiber (% db)
T_1	11.62 ± 0.24^{b}	1.08 ± 0.04 ^{a}	5.36 ± 0.90 ^{bcd}	1.79 ± 0.13^{e}	1.94 ± 0.07^{a}
T_2	12.07 ± 0.11 ^{b}	0.87 ± 0.25 ^{c}	5.28 ± 0.16 ^{cd}	1.56 ± 0.04^{ef}	1.89 ± 0.03^{a}
T_3	11.94 ± 0.13 ^{b}	0.75 ± 0.09 ^{c}	4.50 ± 0.55^{d}	1.33 ± 0.06^{f}	1.13 ± 0.06^{c}
T_4	10.33 ± 0.47 ^{c}	1.05 ± 0.03 ^{ab}	5.39 ± 1.03 ^{bcd}	2.92 ± 0.15^{c}	1.93 ± 0.06^{a}
T_5	9.98 ± 0.39^{c}	0.89 ± 0.03 ^{bcd}	5.37 ± 0.29 ^{bcd}	2.23 ± 0.27^{d}	1.34 ± 0.01^{b}
T_6	10.16 ± 0.86^{c}	0.99 ± 0.01 ^{bc}	4.72 ± 0.50 ^{d}	2.64 ± 0.25^{c}	1.35 ± 0.06^{b}
T_7	9.37 ± 0.01^{d}	1.12 ± 0.04 ^{a}	6.22 ± 0.07 ^{b}	4.91 ± 0.16^{a}	1.40 ± 0.04^{b}
T_8	10.03 ± 0.12 ^{c}	1.08 ± 0 ^{a}	5.71 ± 0.28 ^{bc}	4.26 ± 0.28^{b}	1.32 ± 0.07^{b}
T_9	10.14 ± 0.20^{c}	1.05 ± 0.02 ^{ab}	5.37 ± 0.55^{bcd}	4.14 ± 0.05^{b}	1.31 ± 0.06^{b}
WF	13.32 ± 0.16^{a}	0.75 ± 0. ^{c}	11.49 ± 0.07 ^{a}	2.12 ± 0.04^{d}	1.31 ± 0.10^{b}

The values are expressed as the mean of three replicate sampels ± standard deviation. Values with similar superscripts in a column do not differ significantly ($P < 0.05$)

Table 4. Color characteristics of composite flour from rice, cassava and soybean flour, potato starch and xanthan gum

Flour	Color		
	L*	a*	b*
T_1	96.67±0.08 ^{b}	-0.73±0.06^{a}	5.83±0.08^{f}
T_2	96.74 ±0.20^{ab}	-0.79±0.04^{b}	5.66±0.05^{f}
T_3	97.10±0.59 ^{a}	-0.87±0.01^{c}	5.77±0.01^{f}
T_4	96.52±0.11 ^{bc}	-0.98±0.01^{d}	7.27±0.05^{d}
T_5	96.30±0.02 ^{c}	-1.03±0.03^{e}	7.11±0.09^{de}
T_6	96.29±0.23 ^{c}	-1.01±0.01^{de}	6.99±0.02^{e}
T_7	95.88±0.06 ^{d}	-1.05±0.01^{e}	7.92±0.31^{c}
T_8	95.78±0.05 ^{d}	-1.11±0.02^{f}	8.12±0.11^{bc}
T_9	95.71±0.07 ^{d}	-1.13±0.00^{f}	8.20±0.16^{b}
WF	95.02±0.01 ^{e}	-0.90±0.01^{c}	10.01±0.05^{a}

The values are expressed as the mean of three replicate sampels ± standard deviation. Values with similar superscripts in a column do not differ significantly ($P < 0.05$)

The ash contents of composite flours ranged from 0.75-1.12% and were significantly higher than that in wheat flour. Maximum ash content (1.12%) was observed in T_7 (40% CF, 15% PS, 14.5% SF) but statistically was not difference from other treatment, except that in T_3 (40%CF, 25%PS, 4.5%SF). The treatment of T_3 (40% CF, 25% PS, 4.5% SF) had the lowest ash content. The T_1 (50% CF, 15% PS, 4.5% SF) and T_2 (45% CF, 20% PS, 4.5% SF) treatment had the higher ash content than T_3 (40% CF, 25% PS, 4.5% SF) even though they had the same level to that of soybean flour. In the T_1 (50% CF, 15% PS, 4.5% SF) and T_2 (45% CF, 20% PS, 4.5% SF) treatment, the cassava flour levels were higher than that in T_3 (40% CF, 25% PS, 4.5% SF). It can be concluded that ash content will be increased as the level of soybean and cassava flour increased.

Table 3 shows that the protein content of composite flours in various treatment were significantly lower than the wheat flour samples. Among of composite flours the treatment of 40% CF, 15% PS, 14.5% SF (T_7) has the highest protein content. It was observed that, the protein content increased as the level of soybean and cassava flour increased. This may be due to the high protein content in soybean and cassava flour compared with potato starch as shown in Table 2. This similar observation was made in a research study by Akpapunam *et al.* (1997) and Olaoye *et al.* (2006).

Fat content of composite flours ranged from 1.33% to 4.91% being lowest for T_3 (40% CF, 25% PS, 4.5% SF) and highest for T_7 (40% CF, 15% PS, 14.5% SF). The highest fat content were recorded for the highest soybean and cassava flour level in composite flour. The initial fat content of the raw material affected the fat content of the respective composite flour. Soybean flour has the highest fat of 27.15% (Table 2).

The fibre content obtained in composite flours, as shown in Table 3 ranged from 1.31% to 1.94%. The highest fibre content was found in T_1 (50% CF, 15% PS, 4.5% SF) treatment and was not significantly difference than those in T_2 (45% CF, 20% PS, 4.5% SF) and T_4 (45% CF, 15% PS, 9.5% SF), while the lowest fibre content was found in T_3 (40% CF, 25% PS, 4.5% SF). Cassava and soybean flour had the higher fibre content than those in potato starch and rice flour. At the same level of soybean flour, the higher fibre content occurs in the higher cassava flour level. This is may due to the higher fibre content in the cassava flour than that in soybean flour.

The color of the composite flours was significantly whiter but less red than that of wheat flour (Table 4). All of the composite and wheat flours in this study were more green as shown in negative value of b^*. The highest and the lowest L^* value or white color were found in T_3 (40% CF, 25% PS, 4.5% SF) and T_9 (30% CF, 25% PS, 14.5% SF), respectively. It can be noted that the L^* value decreased as the level of soybean flour increased. The color of composite flour depends on the soybean flour level.

Functional properties of composite flours

There was no significant in water absorption index of composite flours and wheat flour (Tabel 5), but in oil absorption index and swelling power there were significant differences among composite flours and wheat flour. Water absorption index for composite flour ranged from 2.36 g/g for T_7 (40% CF, 15% PS, 14.5% SF) and 2.63 g/g for T_6 (35% CF, 25% PS, 9.5% SF), while in wheat flour 2.12 g/g. There was also minimal variability in water absorption index among the composite flours. Water absorption index is an important processing parameter and has implications for viscosity. It is also important in bulking and consistency of products, as well as in baking application (Niba *et al*., 2001).

Table 5. Functional properties of composite flours

Flour	Water Absorption Index (g/g)	Oil Absorption Index (g/g)	Swelling Power (g/g)
T_1	2.53 ± 0.22^a	2.08 ± 0.17^a	9.63 ± 0.07^c
T_2	2.53 ± 0.17^a	2.03 ± 0.07^{ab}	10.86 ± 0.16^b
T_3	2.62 ± 0.03^a	1.87 ± 0.01^c	12.21 ± 0.05^a
T_4	2.45 ± 0.14^a	1.92 ± 0.07^{bc}	8.15 ± 0.57^d
T_5	2.59 ± 0.43^a	1.93 ± 0.05^{bc}	9.16 ± 0.29^c
T_6	2.63 ± 0.04^a	1.88 ± 0.06^c	9.62 ± 0.30^c
T_7	2.36 ± 0.01^a	1.94 ± 0.00^{abc}	4.27 ± 0.32^f
T_8	2.44 ± 0.00^a	1.94 ± 0.02^{abc}	4.46 ± 0.20^f
T_9	2.53 ± 0.01^a	2.05 ± 0.06^{ab}	6.75 ± 1.11^e
WF	2.12 ± 0.02^a	2.02 ± 0.10^a	7.13 ± 0.89^e

The values are expressed as the mean of three replicate sampels ± standard deviation. Values with similar superscripts in a column do not differ significantly ($P < 0.05$)

Oil absorption index of composite flours ranged from 1.87 g/g for T_3 (40% CF, 25% PS, 4.5% SF) to 2.08 g/g for T_1 (50% CF, 15% PS, 4.5% SF). The highest oil absorption index for composite flour was found in T_1 (50% CF, 15% PS, 4.5% SF) and did not differ significantly with T_2 (45% CF, 20% PS, 4.5% SF), T_7 (40% CF, 15% PS, 14.5% SF), T_8 (35% CF, 20% PS, 14.5% SF), T_9 (30% CF, 25% PS, 14.5% SF) and wheat flour, while the lowest oil absorption index was found in T_3 (40% CF, 25% PS, 4.5% SF) and did not differ significantly with T_4 (45% CF, 15% PS, 9.5% SF), T_5 (40% CF, 20% PS, 9.5% SF), T_6 (35% CF, 25% PS, 9.5% SF), T_7 (40% CF, 15% PS, 14.5% SF) and T_8 (35% CF, 20% PS, 14.5% SF). These results showed that the oil absorption index of composite flour were affected by soybean and cassava flour level. In T_1 and T_2 although the soybean flour level were lower than T_4 (45% CF, 15% PS, 9.5% SF), T_5 (40% CF, 20% PS, 9.5% SF), and T_6 (35% CF, 25% PS, 9.5% SF) but the cassava flour levels in these treatment were higher than T_4 (45% CF, 15% PS, 9.5% SF), T_5 (40% CF, 20% PS, 9.5% SF) and T_6 (35% CF, 25% PS, 9.5% SF). In the treatment of T_7 (40% CF, 15% PS, 14.5% SF), T_8 (35% CF, 20% PS, 14.5% SF) and T_9 (30% CF, 25% PS, 14.5% SF) the soybean flour level were higher than other treatments. The oil absorption index is influenced by the lipophilic nature on the granula surface and interior which were influenced for functional properties of starches (Babu and Parimalavalli, 2012). The major chemical affecting oil absorption index is protein, which is composed of both hydrophilic and hydrophobic parts. Non-polar amino acid side chains can form hydrophobic interactions with hydrocarbon chains of lipid (Eltayeb *et al*., 2011) and has implication in functional properties of flours. Oil absorption index is importance since oil acts as flavor retainer and

Table 6. Pasting profile of composite fluors

Flour	P_{temp} (°C)	PV (Cp)	HPV (Cp)	BD (Cp)	SB (Cp)	CPV (Cp)	SR	SBR
T_1	72.02 ± 0.03^{a}	4266.67 ± 53.98^{b}	1864.00 ± 11.53^{b}	2402.67 ± 42.77^{ab}	1199.33 ± 29.74^{f}	3063.33 ± 19.86^{c}	0.44 ± 0.00^{e}	1.64 ± 0.02^{g}
T_2	71.78 ± 0.23^{a}	4423.00 ± 11.36^{a}	1985.33 ± 14.57^{a}	2437.67 ± 4.73^{a}	1320.00 ± 10.39^{e}	3300.00 ± 12.53^{c}	0.45 ± 0.00^{e}	1.66 ± 0.01^{g}
T_3	71.62 ± 0.03^{a}	4347.00 ± 52.09^{a}	1975.33 ± 18.01^{a}	2371.67 ± 34.27^{b}	1439.67 ± 11.02^{bc}	3415.00 ± 27.87^{a}	0.45 ± 0.00^{e}	1.73 ± 0.00^{f}
T_4	72.05 ± 0.00^{a}	3124.00 ± 90.27^{c}	1597.00 ± 34.00^{c}	1527.00 ± 56.43^{c}	1234.00 ± 32.74^{f}	2831.00 ± 66.36^{de}	0.51 ± 0.00^{d}	1.77 ± 0.01^{e}
T_5	71.88 ± 0.25^{a}	3019.00 ± 37.64^{d}	1506.00 ± 18.52^{d}	1513.00 ± 43.58^{c}	1363.67 ± 3.51^{d}	2869.67 ± 16.92^{d}	0.50 ±0.01d	1.91 ± 0.01^{d}
T_6	71.38 ± 0.28^{a}	3107.00 ± 97.78^{cd}	1575.00 ± 39.96^{c}	1532.00 ±58.21c	1556.33 ± 49.57^{a}	3131.33 ± 88.95^{c}	0.51 ± 0.00^{d}	1.99 ± 0.01^{c}
T_7	72.07 ± 0.03^{a}	2311.67 ± 23.80^{f}	1313.67 ± 24.09^{fg}	998.00 ± 11.41^{e}	1305.00 ± 17.00^{e}	2618.67 ± 14.36^{f}	0.57 ± 0.01^{b}	1.99 ± 0.03^{c}
T_8	72.05 ± 0.00^{a}	2358.00 ± 36.43^{ef}	1353.00 ± 28.62^{f}	1005.00 ± 8.54^{e}	1415.67 ± 11.93^{c}	2768.67 ± 37.61^{e}	0.57 ± 0.00^{b}	2.05 ± 0.02^{ab}
T_9	71.35 ± 0.22^{a}	2390.67 ± 8.02^{ef}	1398.67 ± 10.07^{e}	992.00 ± 18.08^{e}	1478.67 ± 10.69^{b}	2877.33 ± 11.06^{d}	0.59 ± 0.0^{a}	2.06 ± 0.01^{a}
WF	77.80 ± 10.58^{a}	2433.00 ± 46.29^{e}	1281.67 ± 20.50^{g}	1151.33 ± 28.38^{d}	1311.33 ± 18.50^{e}	2593.00 ± 39.00^{f}	0.53 ± 0.00^{c}	2.02 ± 0.00^{b}

P_{temp} = pasting temperature, PV = Peak viscosity, HPV= hot paste viscosity, BD= Breakdown viscosity, B=setback viscosity, CPV = cold paste viscosity, SR=Stability ratio, SBR=setback ratio.

The values are expressed as the mean of three replicate sampels ± standard deviation. Values with similar superscripts in a column do not differ significantly ($P < 0.05$)

increase the mouth feel of foods, improvement of palatability and extension of shelf life particularly in bakery or meat products where fat absorptions are desired (Aremu *et al*., 2007).

Swelling power in the composite flours ranged from 4.27 g/g for T_7 (40% CF, 15% PS, 14.5% SF) to 12.21 for T_3 (40% CF, 25% PS, 4.5% SF). There were significant differences in swelling power among formulation treatments of composite flour as well as wheat flour. Swelling power decreased as the level of soybean flour increased, but in the same level of soybean flour, the swelling power increased as the level of potato starch increased and cassava flour decreased. Swelling power is often related to their protein and starch content (Woolfe,1992). A higher protein content in flour may cause the starch granules to be embedded within a stiff protein matrix, which subsequently limits the access of the starch to water nd restricts the swelling power (Aprianita *et al*., 2009). The amylopectin is primarily responsible for granule swelling, the higher amylopectin content in composite flour with higher level of potato starch would increase the swelling power of composite flour (Tester and Morrison, 1990). Moorthy and Ramanujam (1986) reported that the swelling power of granules is an indication of the extent of associative forces within granule.

Pasting properties of composite flours

Table 6 shows the pasting profile of composite flours as well as wheat flour. The pasting temperature is an indication of the minimum temperature required to cook or gelatinize the flour (Kaur and Singh, 2005). There were no significant differences in pasting temperatures between various treatments of composite flours as well as wheat flour, but in general the pasting temperature in composite flours were lower than that of wheat flour. This may be due to the addition of xanthan gum in composite flours. These results are in accordance with those reported by Ho and Noor Aziah (2013) that the addition of xanthan gum to composite flour blends gives a lower pasting temperature.

The results of the pasting characteristics indicate that the higher level of soybean flour reduced the peak viscosity (PV), hot paste viscosity (HPV), break down viscosity (BD) and cold paste viscosity (CPV) of composite flour this due to the present of fat from soybean flour that decrease the viscosity (Dautant *et al*., 2007). In general the viscosity of composite flour was higher than wheat flour, but at the soybean level of 14.5% it was found that the viscosity of composite flour was quite similar with that of wheat flour. The addition of xanthan gum in composite flour may be attributed to the higher viscosity than wheat flour (Ho and Noor Aziah, 2013).

The PV of composite flours ranged from 2311.67 cP for T_7 (40% CF, 15% PS, 14.5% SF) to 4347.00 cP for T3 (40% CF, 25% PS, 4.5% SF). At the level of soybean flour 14.5%, the PV value was not difference significantly with that of wheat flour. The relatively low peak viscosity in the higher level of soybean in composite flour indicates that the flour may be suited for products requiring low gel strength and elasticity (Abioye *et al*., 2011).

The HPV is the minimum viscosity value measuring the ability of paste to withstand breakdown during cooling; it ranged between 1313.67 cP for T_7 to 1985.33 cP for T_2 for composite flours. The final viscocity indicated the re-association of starch granules especially amylose during cooling time after gelatinization and the formation of gel network (Chanapamokkhot and Thongngam, 2007). The lower breakdown (BD) and final viscosity (CPV) as increase in soybean flour indicates the ability of the flour to form a viscous paste or gel after cooking and cooling as well as the resistance of the paste to shear stress during stirring (Abioye *et al*., 2011; Phattanakulkaewmorie *et al*., 2011). The lower setback viscosity with increase in soybean flour level, indicating the more retrogradation level during cooling and the higher staling of products made from the flour. The increasing of soybean flour will increase the setback viscosity in composite flour, and in the treatment of T_7 (40% CF, 15% PS, 14.5% SF), the setback viscosity was not differences with wheat flour. Stability and setback ratio increased as the level of soybean flour increased.

Conclusion

The physical, chemical and functional properties of the composite flours from rice flour, cassava flour, soybean flour, potato starch and xanthan gum were determined by cassava and soybean flours and also potato starches because in this study the rice flour and xanthan gum were in constant levels. The higher level of soybean flour will increase the protein and fat content in composite flours. The fibre content of composite flours were determined by the level of cassava and soybean flour. The fibre content increased as the level of cassava and soybean flour increased. All of composite flour treatments were whiter than that of wheat flour and the color of composite flour depends on the soybean flour level. Water and oil absorption index and swelling power of composite flours although were significantly differences with wheat flour, but they are quite similar. These characteristics were the important process parameters and have implication for viscosity, consistency as well as in baking application. In term of pasting profile, no significant differences were found in the pasting temperatures of all of the composite flours. The addition of xanthan gum gives a lower pasting temperature. The higher level of soybean flour was significantly reduced the peak viscosity, hot paste viscosity, break down viscosity and cold paste viscosity of composite flour. The viscosity of composite flour was higher than wheat flour, but at the level of soybean 14.5% it was found that the viscosity of composite flours were quite similar with wheat flour. These results are important to be applied in the non wheat bakery products such as bread, cookies and cakes. The indicative optimal proportion of composite flour was rice flour 30%, cassava flour 40%, potato starch 15%, soybean flour 14.5% and xanthan gum 0.5%, and at this proportion the physicochemical, functional and pasting properties of composite flour was comparable to those of wheat flour.

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