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FULL PAPER

The nutritional and functional properties of noodles prepared from sorghum, mung bean and sago flours

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Abstract

Noodles are popular carbohydrate-rich food products generally made from wheat flour. This study developed a new type of noodle out of local resources namely sorghum flour, mung bean, and sago starch with the following formula variations: F1 (20:30:50), F2 (30:30:40), F3 (40:30: 30), F4 (50:30:20) and F5 (60:30:10). The nutritional and functional property of each formula then analysed. All formulas fulfilled the daily dietary intake recommendations, which contain approximately 9.64-11.83% protein, 0.17-0.33% fat, 86.76-88.74% carbohydrate, with total calories of 397-399 kcal/100 g. F1 has the highest dietary fibre content (13.16%), with 4.2% soluble dietary fibre (SDF) and 9.48% insoluble dietary fibre (IDF). The resistant starch content of all formulas was relatively high, between 16.35-21.57%. Based on the results of this study, sorghum flour, mung bean and sago starch flour-based noodles can be a good source of daily nutrition which also include functional compounds such as dietary fibre and resistant starch.

1. Introduction

Nowadays, consumers prefer food products that offer multiple benefits. Not only they have to be sensorially appealing, but they should also be a good source of nutrition to fulfil the daily requirement and have extra benefits for health. The opportunity to optimize the local food commodity is very high, in addition to its abundant resources, many local commodities have been reported to have functional compounds that are beneficial to our health. For instance, dietary fibre (DF) and resistant starch (RS) content can be developed as functional food (Khan *et al*., 2013). Sorghum contains 10.37% DF and 9.50 mg/100 g RS. Mung beans contain 16.35% DF and 9.63 mg/100 g RS, while sago starch contains 11.07% DF and 10.58 mg/100 g RS (Wahjuningsih *et al*., 2020). The high dietary fibre content in food products is an additional brand value. Previous studies have shown that dietary fibre is very beneficial for health. The consumption of DF can modulate the immune system, improve the health of the digestive tract by increasing probiotic activity and the formation of short-chain fatty acids (SCFA), also reducing the risk of Diabetes Mellitus and Cancer (Kaczmarczyk *et al*., 2012; Jha *et al*., 2017). RS is also known to improve gut health, increase the production of butyric acid which can suppress inflammatory factors and toxic biomarkers. A high resistant starch diet can also reduce the number of pathogenic bacterial colonies in the intestine (DeMartino and Cockburn, 2020; Giuberti and Gallo, 2020).

Product innovations are needed to improve consumer habits to consume healthier food products. The development of noodles is the solution to an alternative carbohydrate with good sensory quality and easy preparation, hence the consistently high demand in several countries. Usually, noodles are made from wheat as the raw material which produced a smooth, soft and elastic texture (Liu *et al*., 2020). To improve its functional properties, some studies have developed non-wheat noodle products using local commodities, such as breadfruit and pumpkin (Nanthachai *et al*., 2020; Purwandari *et al*., 2014), rice flour (Fernandes *et al*., 2013), Jabuticaba peel flour (Garcia *et al*., 2016), and chickpeas (Padalino *et al*., 2015). A preceding study had studied the physical and sensory characteristics of noodles made out of sorghum (*Sorghum bicolor L.*), mung bean *(Vigna radiata)*, and sago *(Metroxylon sagu)* starch (Wahjuningsih *et al*., 2020). This study aims to determine the nutritional content and functional properties of noodles in several formulas as a potential alternative food source of carbohydrates.

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2. Materials and methods

2.1 Materials

The materials used in this study were sorghum flour, mung bean and sago starch obtained from local farmers. A pro-analytic reagent used from Sigma-Aldrich, Co. (USA).

2.2 Noodles preparation

The noodles processing methods refer to Wahjuningsih *et al*. (2020). The five formulas with different proportions of sorghum flour and sago starch were prepared. The composition of each formula consisted of sorghum flour, mung bean and sago starch, with the proportion of 20:30:50 (F1), 30:30:40 (F2), 40:30:30 (F3), 50:30:20 (F4) and 60:30:10 (F5), respectively. Then, about 30% water was added. After that, the dough was steamed for 35 mins and then cooled. The moulded dough then dried at 50°C.

2.3 Nutritional analysis

The nutritional value was analysed through the proximate test refers to AOAC (1984) and carbohydrate content determined by difference with the following equation :

$$Carbohydrate\ (\%) = 100\% - [\text{Moisture}\ (\%) + \text{protein}\ (\%) + \text{fat}\ (\%) + \text{Ash}\ (\%)]$$

2.4 Starch content

The starch content analysis was done through Direct Acid Hydrolysis. Samples were dissolved in distilled water, stirred for about 1 hour and filtered. The residue was washed and stratified using distilled water, followed by ether and 10% alcohol. The 25 mL of 25% HCl was added to the residue, heated to boil for 2.5 hrs with a reserve cooler. The temperature was then adjusted to room temperature, neutralized with 45% NaOH and diluted with distilled water to 500 mL, filtered. The starch content was calculated by multiplying the glucose content of the filtrate by 0.9.

2.5 Dietary fibre content

The dietary fibre content was analysed according to Asp *et al*. (1983), using multiple enzyme procedures with α-amylase, pepsin and pancreatin. First incubation by α-amylase in phosphate buffer (pH 6.0) at 80°C for 15 mins. The second incubation using pepsin (pH 1.5) at 40°C, for 60 mins. The third incubation with pancreatin at 40°C for 60 mins (pH 6.8). The mixture was then filtered to determine the insoluble fibre and soluble fibre content.

2.6 Resistant starch content

The resistant starch (RS) content was determined according to Goñi *et al*. (1996) with slight modifications. Samples were incubated in a buffer containing pepsin at 40°C for 1 hr, placed in a shaker water bath. Then, a buffer containing α-amylase was added, incubated at 37°C for 16 hrs to hydrolyse the digestible starch. The hydrolysate was centrifuged, and the residue was incubated with glucoamylase at 60°C for 45 mins to hydrolyse the resistant starch (RS). The RS is calculated by multiplying the mg of glucose by 0.9.

2.7 Statistical analysis

The data are presented as an average of three data replications. Statistical analysis using SPSS 20.0 through the one-way analysis of variance (ANOVA) with a significance of 5% was performed. The difference was interpreted by Duncan's Multiple Range Test (DMRT).

3. Results and discussion

The production of non-wheat noodles is not easy because wheat has a specific protein content, namely gluten which plays a special role in the formation of an elastic noodle texture (Kovacs *et al*., 2004). Technological modification of protein content and starch can contribute to the texture of non-wheat products, such as the use of sorghum flour, cornflour, and other protein sources with hydrocolloids (Larrosa *et al*., 2016; Padalino *et al*., 2016). Mung bean has a protein content of 22.89%, higher than wheat, which is 19.07% (Wahjuningsih *et al*., 2020). The protein content plays a role in water binding and forming a dough (Baik, 2010). Starch, a natural hydrocolloid, can be used to improve the texture of noodles. With the addition of starch, the texture of the noodles is elastic and not easily broken. The addition of starch also affects the quality of the cooked noodles, with good water holding capacity, facilitating the gelatinization and retrogradation processes during cooking. This retrogradation process contributes to the formation of resistant starch which is facilitated by a higher amylose content (Figure 1).

A preceding study reported the quality after cooking, and also the sensory characteristics of noodles made from sorghum, mung bean, and sago starch (Wahjuningsih *et al*., 2020). This study showed the nutritional value of the noodles in five different formula (Table 1). Noodles based on sorghum flour mung bean and sago starch can be used as an alternative staple food to fulfil the nutritional requirements. The noodles have a protein content of 9.64-11.83%, fat 0.17-0.33%, and carbohydrates 86.76-88.74%. The 100 g of noodles can provide energy for about 397-399 kcal (Table 1). The starch content of the noodles was 63.16-67.72%, with 25.29-27.88% of amylose and 35.47-40.7% of

Table 1. Nutritional value of five non-wheat noodles formula

Composition	F1	F2	F3	F4	F5
Moisture (%)	3.83 ± 0.06^{a}	4.88 ± 0.08^{b}	5.61 ± 0.09^{d}	6.39 ± 0.05^{e}	5.41 ± 002^{c}
Ash (%)	1.41 ± 0.01^{e}	1.21 ± 0.01^{a}	1.27 ± 0.01^{c}	1.29 ± 0.01^{d}	1.24 ± 0.01^{b}
Protein (%)	9.64 ± 0.09^{a}	10.08 ± 0.14^{b}	10.71 ± 0.11^{c}	11.25 ± 0.05^{d}	11.83 ± 0.36^{e}
Fat (%)	0.21 ± 0.00^{b}	0.33 ± 0.01^{c}	0.19 ± 0.01^{a}	0.18 ± 0.00^{a}	0.17 ± 0.01^{a}
Carbohydrate (%)	88.74 ± 0.08^{e}	88.38 ± 0.14^{d}	87.83 ± 0.10^{c}	87.28 ± 0.06^{b}	86.76 ± 0.36^{a}
Calories (kcal/100 g)	397.11 ± 0.05^{a}	399.06 ± 0.08^{d}	398.57 ± 0.09^{b}	398.99 ± 0.03^{d}	398.79 ± 0.07^{c}
Calories from fat (kcal/100 g)	1.87 ± 0.00^{b}	2.93 ± 0.09^{c}	1.67 ± 0.05^{a}	1.63 ± 0.00^{a}	1.57 ± 0.05^{a}

Values are expressed as mean±standard deviation. Values with different superscript within the row are statistically significant different ($p<0.05$).

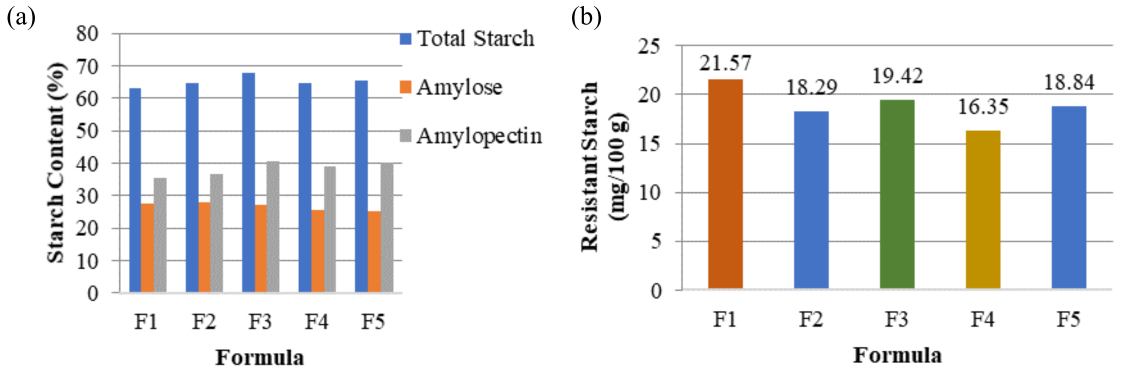

Figure 1. Starch content; total starch, amylose and amylopectin (a) and resistant starch (b) of sorghum, mung Bean and sago starch-based noodles

amylopectin (Figure 1a). This starch content can affect the cooking quality of the noodles, including gelatinization time of noodles and noodle retrogradation. The retrogradation process that occurs in the process of making noodles facilitates the formation of resistant starch, namely Resistant Starch Type III. Resistant starch is non-digestible starch, that cannot be absorbed in the small intestine (Marsono, 1998). This resistant starch occurs naturally in food ingredients or because of the cooking process. The presence of resistant starch is widely expected for its benefits for health, it can act as a prebiotic that improves colonic microflora, improves gut health and lower the risk of colon cancer (Marsono, 1998; Lockyer and Nugent, 2017). The content of resistant starch in F1-F5 was relatively high, around 16.35-21.57% (Figure 1b). F1 has the highest resistant starch content mirroring the highest proportion of sago starch. It proved that sago starch is easily retrograded in the noodle-making process, thus increasing the formation of Type III resistant starch which is resistant to digestive enzymes. Haliza *et al.* (2006) also investigated that the use of sago-based noodles to stimulate a higher resistant starch production, which was 9.45 mg/g, compared to wheat noodles with 2.44 mg/g. Wahjuningsih *et al.* (2016) utilizing sago starch in the production of analogue rice, showed that the higher proportion of sago starch used, the higher the resistant starch value. The higher composition of sago starch also produces a product with a lower glycaemic index and is a suitable alternative for people with diabetes mellitus type 2.

Sorghum flour, mung bean and sago starch utilization can increase the dietary fibre content of noodles, considering the dietary fibre content of the three flours is higher than wheat flour (Wahjuningsih *et al.*, 2020). The highest total dietary fibre (TDF) content was found in F1 with the highest proportion of sago starch, which was 13.16%, with 4.2% SDF and 9.48% IDF. The lowest content of dietary fibre was in F5 with the lowest proportion of sago starch (6.48%), with 0.19% SDF and 6.73% IDF (Figure 2). Uthumporn *et al.* (2014) reported that the dominating dietary fibre in sago starch is cellulose, hemicellulose, pectin and lignin. Dietary fibre is much desired in a commercial product because of its benefits for health (Jha *et al.*, 2017). Dietary fibre has been reported to be beneficial in weight reduction, slows gastric emptying, lowers post-prandial blood sugar, hypo -cholesterol and maintains colon health (Perry and Ying, 2016).

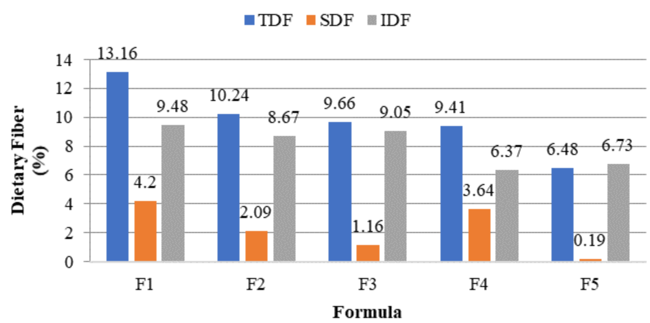

Figure 2. Dietary fibre content of five sorghum, mung bean and sago starch-based noodles formula

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4. Conclusion

The non-wheat noodles prepared in this study have good nutritional content and can be used as an alternative staple food. This non-wheat-based noodle also has the potential to be developed as a functional food product because it contains bioactive compounds of dietary fibre and resistant starch. Further research is needed to determine its specific role in health.

Conflict of interest

The authors declared no conflict of interest.

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