Nutritional and sensory characteristics of tiwul made from different fortified tuber flours

Indrie Ambarsari[1,*], *Retno* Endrasari[2], and *Selvia Dewi* Anomsari[2]

[1] Research Center for Food Technology and Processing, National Research and Innovation Agency Republic of Indonesia
[2] Assessment Institute of Agricultural Technology Central Java, Indonesian Agency for Agricultural Research and Development, Ministry of Agriculture

Abstract. Tiwul is a traditional Indonesian food with good functional properties regarding a low glycemic index. However, like other tuber-based products, tiwul also faced nutritional deficiency issues. Therefore, this study aims to optimize the quality of traditional tiwul by modifying the formulation using different tuber flours and adding soybean flour as a fortificant. Three kinds of tuber flour (cassava, sweet potato, and canna) were used as tiwul raw material. These materials were fortified with 10% soybean flour, respectively. Unfortified (native) tuber flours were used as a control treatment. The flours were processed into tiwul with the traditional processing method. The result showed that adding soybean flour as a fortificant of tuber flour significantly improved the nutritional value of tiwul as the end product. Among examined formulations, fortified sweet potato resulted in the highest ash (3.96%), highest protein (8.26%), and lowest carbohydrate (80.23%) of tiwul. The utilization of fortified canna resulted in the highest insoluble fiber (19.01%) of tiwul. Interestingly, the sensory analysis showed that unfortified cassava flour had the highest acceptance for color, taste, and texture of tiwul. This condition indicated that original products still ranked top for local customer preferences.

1 Introduction

Tiwul is a traditional Indonesian food made from cassava (*Manihot esculenta*) and commonly consumed by Javanese. Nowadays, the consumption of tiwul as an alternative carbohydrate source has become more popular and gained much attention due to its low glycemic index (GI) and gluten-free, which is beneficial for patients with specific health problems like celiac disease [1]. Besides cassava, other tuber crops such as sweet potato (*Ipomoea batatas*) and canna (*Canna edulis*) are also prospective to obtain a low glycemic index tiwul.

Unfortunately, some nutritional deficiency issues have often been associated with tuber-based products, particularly those deficient in protein [2,3]. This shortcoming provides an opportunity to improve the nutritional value of tiwul through fortification. Fortification could

* Corresponding author: indrie.amb@gmail.com

be described as adding certain ingredients or nutrients in a food formulation to enhance the end product's nutritional value [4,5].

Legumes are a suitable carrier in the fortification process because they represent an attractive source of protein, fibers, vitamins, minerals, and bioactive compounds. Legumes and tubers are nutritionally complementary [6]. Therefore, it could be used as a fortificant in the tiwul production. Earlier research reported that adding soybean as a fortificant is more effective than other legumes in improving the nutritional quality of tuber flour [6]. Enrichment food products with soybean flour have been recommended and often associated with their beneficial effects on human health since soybean is rich in high-quality protein and oil [7].

This study aimed to examine the effects of soybean fortification on the nutritional and sensory attributes of tiwul made from different tubers. In this work, cassava flours as a raw material of tiwul would be replaced with sweet potato and canna flours, as they have gained much attention in this recent years as the potential non-rice carbohydrate source in Indonesia. More information about fortified tuber flours would help extend its application to local traditional Indonesian food and improve the end-product quality.

2 Methods

2.1 Materials

Tubers (cassava, sweet potato, and canna) were purchased from a farmer in Gunung Pati, Semarang. Meanwhile, soybean was obtained from Grobogan.

2.2 Sample preparation

Tubers were processed by peeling, slicing, drying, milling, and sieving into flours. The tubers should keep immersed underwater during the slicing process to avoid discoloration due to enzymatic browning. Meanwhile, soybean used as fortificant was first soaked into distilled water (four times the total weight of soybean) for 8 hours to remove the husk, drained, dried, and milled into flour. The drying process of tuber chips and soybean grains was performed using a cabinet dryer (45±5° C) for 24 h, whereas the milling process used a food processor (Fomac FCT-Z200). The flours were sieved into 80 mesh particle sizes following the British Standard.

The fortification process was implemented by adding 10% soybean flour into the tuber flour. This fortification level was selected by reviewing the production cost and customer acceptance. Early studies reported that fortification using 10% legume was generally well accepted [8,9]. This present study compared the characteristics of native and fortified tiwul made from different tuber flour. Production of tiwul was adopted from the traditional processing method in rural Javanese. The flour was splattered with water and battered until forming a soft dough. Afterward, the doughs were steamed for 20 min and dried in a cabinet dryer (45±5° C) for 24 h. The dried products were packed in polyethylene (PE) bags and stored in an airtight container for further analysis.

2.3 Analysis

The nutritional properties of tiwul, including moisture, ash, protein, lipid, and carbohydrate, were determined based on the Approved Methods of Analysis [10], while dietary fiber was measured using the enzymatic method [11]. Each variable of nutritional attributes was represented on a dry basis.

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Sensory evaluation of cooked tiwul was carried out using 60 semi-trained local panelists to examine the product regarding its color, aroma, flavor, and texture impression with a descriptive scale that ranged from 1 to 6 (1: inedible, 2: unacceptable; 3: barely acceptable; 4: acceptable; 5: good; 6: excellent). The evaluation was held in the post-harvest laboratory of AIAT Central Java. Each sample was served on a small paper plate coded with three random digits.

2.4 Statistical analysis

A completely randomized factorial design was performed in this study, in which tuber flours and fortification treatment were considered factors. Each treatment consisted of four replication. Data evaluation implemented a two-way analysis of variance (ANOVA) at a significant difference of $p \leq 0.05$, and the Duncan Multiple Range Test was used as further analysis to examine different means. Statistical analysis employed SPSS 20.0 software (SPSS Inc., Chicago, IL, USA).

3 Results and discussion

3.1 Nutritional content

The effects of fortification on the nutritional contents of tiwul made from different tuber flours are shown in Table 1. The result exhibited no significant difference in moisture content between unfortified and fortified tiwul. Tuber flours as raw material also had no significant effects on the moisture content of tiwul. Fortification also had no significant impact on the ash content of tiwul. It indicated that the fortification process did not alter the mineral content of the end product.

Table 1. Effect of fortification on nutritional contents of tiwul made from different tubers

Tuber Flour	Fortification treatment	Attributes				
		Moisture (%)	Ash (%)	Protein (%)	Lipid (%)	Carbohydrate (%)
Cassava	Unfortified	8.33 ± 0.58^{A}	2.73 ± 0.02^{A}	1.83 ± 0.16^{Aa}	0.77 ± 0.11^{Aa}	86.78 ± 0.62^{Aa}
	Fortified	7.83 ± 0.29^{A}	2.71 ± 0.01^{A}	5.03 ± 0.07^{Ab}	1.05 ± 0.20^{Ab}	84.07 ± 0.17^{Ab}
Sweet potato	Unfortified	8.17 ± 0.58^{A}	4.36 ± 0.57^{B}	3.38 ± 0.30^{Ca}	0.74 ± 0.07^{Aa}	84.56 ± 1.31^{Ba}
	Fortified	7.67 ± 0.29^{A}	3.96 ± 0.62^{B}	8.26 ± 0.12^{Cb}	1.03 ± 0.05^{Ab}	80.23 ± 0.66^{Bb}
Canna	Unfortified	7.67 ± 0.76^{A}	2.89 ± 0.85^{A}	2.70 ± 0.08^{Ba}	0.21 ± 0.04^{Ba}	86.98 ± 1.39^{Aa}
	Fortified	7.33 ± 0.29^{A}	2.87 ± 0.29^{A}	6.97 ± 0.06^{Bb}	0.66 ± 0.04^{Bb}	83.09 ± 0.26^{Ab}
P-value	Tuber	0.16	0.00	0.00	0.00	0.00
	Fortification	0.08	0.55	0.00	0.00	0.00
	Tuber x Fortification	0.95	0.76	0.00	0.30	0.29

Note: Means followed by the different letters in the same column are significantly different ($p \leq 0.05$)

On the other hand, it was notable that fortification affected the protein, lipid, and carbohydrate of tiwul. Fortification significantly increased the protein and lipid content of tiwul. This result confirms that soybean fortification efficiently improves tuber-based products' nutritional value. This occurrence is consistent with previous fortification studies in cassava-based products [12,13].

Meanwhile, the carbohydrate of fortified tiwul was significantly lower than unfortified tiwul. Previous reports stated that carbohydrate degradation in fortified products might be related to protein and other nutrients increase during the fortification process [6,14]. However, this low carbohydrate level of fortified tiwul is beneficial because this product would be very worthwhile in controlling weight gain [15].

Among all tuber flours observed in this work, the utilization of sweet potato flour resulted in tiwul with the highest ash and protein content. There was no significant difference in the lipid content of cassava and sweet potato tiwul. However, sweet potato tiwul contained the lowest carbohydrate. This circumstance is related to the original nutrition of the tuber as tiwul raw material.

Table 2 summarizes the impact of fortification on the dietary fiber of tiwul made from different tuber flours. Fortification significantly increased the dietary fiber of all types of tiwul. This finding is analogous to an earlier report explaining that supplementing legume flour could enhance the end product's nutritional quality, including dietary fiber [16]. Dietary fiber is popularly known for its functional properties related to health benefits, particularly in lowering the risk of constipation, obesity, diabetes, cardiovascular disease, and colon cancer [1]. Several studies also claimed that dietary fiber value significantly correlated with glycemic index [17]. The higher dietary fiber would lower the glycemic index of the products.

Table 2. Effect of fortification on the dietary fibers of tiwul made from different tubers

Tuber Flour	Fortification treatment	Soluble Dietary Fiber (%)	Insoluble Dietary Fiber (%)	Total Dietary Fiber (%)
Cassava	Unfortified	4.18±0.65 ^{A}	6.23±0.25 ^{Aa}	10.41±0.88 ^{Aa}
	Fortified	4.90±0.40 ^{A}	8.44±0.24 ^{Ab}	13.34±0.35 ^{Ab}
Sweet potato	Unfortified	5.08±0.69 ^{B}	9.29±1.29 ^{Ba}	14.36±1.01 ^{Ba}
	Fortified	5.70±0.84 ^{B}	11.94±1.44 ^{Bb}	17.63±0.65 ^{Bb}
Canna	Unfortified	3.77±0.18 ^{A}	15.78±1.45 ^{Ca}	19.56±1.35 ^{Ca}
	Fortified	4.19±0.38 ^{A}	19.01±0.74 ^{Cb}	23.20±0.92 ^{Cb}
P-value	Tuber	0.00	0.00	0.00
	Fortification	0.05	0.00	0.00
	Tuber x Fortification	0.89	0.70	0.80

Note: Means followed by the different letters in the same column are significantly different ($p \leq 0.05$)

Among all tuber flour used as tiwul raw material, canna flour resulted in the highest dietary fiber of tiwul, which was related to its insoluble dietary fiber. Earlier studies claimed that canna flour has higher fiber content than other tuber flours [18,19]. Another report also emphasized that insoluble dietary fiber is the main fraction of canna dietary fiber [20], in compliance with this present study. Meanwhile, sweet potato tiwul had the highest soluble dietary fiber than others.

Soluble and insoluble dietary fiber is distinguished based on their physiological effects. Soluble dietary fiber can absorb water and form a gel that hinders emptied stomach [18]. Therefore, soluble dietary fiber intake is frequently associated with a lower risk of obesity, diabetes mellitus type II, and certain gastrointestinal diseases [21]. Meanwhile, insoluble dietary fiber passively holds water, softening the stools and enhancing bulk, thus diminishing the transit time of digested food in the colon and preventing constipation [18].

3.2 Sensory characteristics

The sensory profile of different tiwul samples is summarized in Table 3. There was no significant difference in the color attributes between fortified and unfortified tiwul samples. However, there were significant differences between native and fortified samples in other sensory characteristics such as flavor, taste, and texture, which appeared to decrease because of the addition of soybean flour as fortificant.

Among raw materials used, native (unfortified) cassava tiwul seems to be preferred the most for its color, taste, and texture attributes. Native sweet potato tiwul had the best flavor among other types of tiwul. Meanwhile, canna tiwul had the lowest score for the whole sensory profile.

Table 3. Effect of fortification on the sensory characteristic of tiwul made from different tubers (n=60)

Tuber	Fortification treatment	Color	Flavor	Taste	Texture
Cassava	Unfortified	$5.27{\pm}1.15^{A}$	$4.15{\pm}1.21^{Aa}$	$5.17{\pm}1.18^{Aa}$	$5.63{\pm}1.15^{Aa}$
	Fortified	$5.45{\pm}1.24^{A}$	$3.90{\pm}1.39^{Ab}$	$4.25{\pm}1.45^{Ab}$	$4.52{\pm}1.40^{Ab}$
Sweet potato	Unfortified	$5.35{\pm}1.07^{A}$	$4.82{\pm}1.27^{Ba}$	$4.72{\pm}1.29^{Aa}$	$4.03{\pm}1.28^{Ba}$
	Fortified	$5.03{\pm}1.22^{A}$	$4.68{\pm}1.16^{Bb}$	$4.35{\pm}1.10^{Ab}$	$3.78{\pm}1.26^{Bb}$
Canna	Unfortified	$3.60{\pm}1.21^{B}$	$4.37{\pm}1.13^{Aa}$	$3.57{\pm}1.28^{Ba}$	$3.28{\pm}1.12^{Ca}$
	Fortified	$3.50{\pm}1.33^{B}$	$4.05{\pm}1.38^{Ab}$	$3.23{\pm}1.15^{Bb}$	$3.05{\pm}1.09^{Cb}$
P-value	Tuber	0.00	0.01	0.00	0.00
	Fortification	0.54	0.00	0.00	0.00
	Tuber x Fortification	0.28	0.00	0.01	0.00

Note: Means followed by the different letters in the same column are significantly different ($p \leq 0.05$). The sensory score ranges from 1 (inedible) to 6 (excellent).

4 Conclusion

The addition of soybean flour as fortificant increased the nutritional profile, especially for protein, lipid, and dietary fiber of tiwul as the end-product. Unfortunately, the fortification caused some degradation in the sensory profiles of tiwul, i.e., flavor, taste, and texture. Each tuber used as a raw material of tiwul had its specific advantage. Tiwul from sweet potato flour had the highest protein content, while tiwul from canna flour had the highest dietary fiber. However, the original tiwul product from native cassava flour was the most preferred for sensory attributes.

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