International Journal of Scientific Research and Management (IJSRM)
||Volume||12||Issue||01||Pages||149-157||2024||
Website: https://ijsrm.net ISSN (e): 2321-3418
DOI: 10.18535/ijsrm/v12i01.ft01

Study on the Development of Fiber-Rich Noodles through the Substitution of Wheat Flour with Pregelatinized Tannia Flour

I Nengah Kencana Putra*), I Putu Suparthana, Anak Agung Istri Sri Wiadnyani

Food Technology Study Program, Faculty of Agricultural Technology,
Udayana University, Bali, Indonesia

Abstract

Traditional noodles are often criticized for their low fiber content, a component with numerous health benefits in preventing degenerative diseases. Tannia, a potential food source in Indonesia, is recognized for its richness in fiber. This study evaluated the chemical properties, cooking quality, and sensory aspects of noodles made from a composite of wheat flour and pregelatinized tannia flour (PTF). PTF, obtained by boiling tannia tuber slices at a temperature of 95°C for 10 minutes, drying, mashing, and sieving using a 60-mesh sieve, was used to substitute some of the wheat flour in dry noodles production. Substitution levels ranged from 0% (control) to 30%. Results showed a significant impact on protein, carbohydrate, and crude fiber content, as well as color, cooking quality, and sensory properties. Crude fiber increased with substitution, but above 25%, noodles exhibited lower elasticity compared to the control. In conclusion, a 25% substitution of wheat flour with PTF produced noodles with higher crude fiber content, better cooking quality, and sensory properties comparable to control noodles (without substitution). Noodles with 25% substitution had a crude fiber content of 4.89%, while control noodles were at 3.84%

Keywords**:** Fiber-rich noodles, Pregelatinization, Tannia flour, Substitution

Introduction

Noodles are a staple breakfast food in East Asian countries, and their consumption is steadily increasing daily. The five countries with the highest noodle consumption globally are China, Indonesia, Vietnam, India, and Japan (WINA, 2023). The primary raw material for these noodles is wheat flour. Over the last decade, there has been a growing effort to substitute wheat flour with new food sources, driven by the desire to increase fiber content, reduce gluten content, and decrease reliance on wheat imports. Various tubers, including cassava (*Manihot esculenta* Crantz), sweet potatoes (*Ipomoea batatas*), taro (*Colocasia esculenta*), potatoes (*Solanum tuberosum*), and tannia (*Xanthosoma sagittifolium*), have emerged as inexpensive and promising alternatives to wheat flour in noodle production (Ammar et al. 2009).

Traditional noodles are claimed to lack essential nutritional components such as dietary fiber, vitamins, minerals, and bioactive elements (Choo and Aziz 2010). Dietary fiber in food provides several health benefits, preventing various degenerative diseases such as ischemic heart disease, diverticular disease, gallbladder disease, appendicitis, colon tumors, varicose veins, and hiatal hernias (Burkitt et al. 1974). Numerous studies have been conducted to enhance the fiber content in noodles. Anggraeni and Saputra (2018) supplemented dried noodles with jackfruit banana flour, and the research results showed that the fiber content of the dry noodles increased from 1.36% to 2.84% with the supplementation of 30% jackfruit banana flour. Dnyaneshwar et al. (2017) reported that adding 20% oat flour to the production of dry noodles increased the levels of crude fiber in noodles from 0.41% to 0.93%.

Tannia is a potential food source that can be used to substitute for some of the wheat flour in making noodles. It is widely cultivated in America, Asia, the Pacific Islands, and Africa (Onwueme 1978). Tannia has the potential to produce high tubers, around 10-25 tons per hectare (Moorthy et al., 2018). Tannia flour contains 6.37% protein, 0.88% fat, 5.19% dietary fiber, 3.99% sugar, 68.5% starch, phosphorus of 2.18 mg/100g, 0.03 ppm zinc, and 0.05 ppm iron (Perez et al., 2007). Several researchers have investigated the supplementation of tannia flour in wheat flour-based food products to increase fiber content, such as bread

(Mongi et al., 2011), and cake (Ojinnaka et al., 2018). The results of their study showed that the supplementation of tannia flour could increase the fiber content of the products. The limitation of tannia flour as a supplement in the making of noodles can be improved by modifying its functional properties, which can be achieved through pregelatinization techniques. Pregelatinized tannia tuber flour can be produced using the parboiling method, involving the boiling of tubers before being processed into flour (Putra et al. 2020).

This research aims to develop fiber-rich noodles by substituting the primary raw material of noodles (wheat flour) with pregelatinized tannia flour (PTF). The level of flour substitution needs to be investigated, as excessive substitution can lead to a decrease in the sensory quality of the noodles produced. In this study, the chemical composition, color, cooking quality, and sensory properties of PTF-wheat flour noodles were evaluated. Fiber-rich noodles made from PTF-wheat flour are expected to address public health problems, such as degenerative diseases.

Materials and Methods

Preparation of Pregelatinized Tannia Flour (PTF)

Tannia tubers (*Xanthosoma sagittifolium*) as the basic ingredient for making pregelatinized tannia flour were harvested directly from farmers' gardens in the area of Buleleng, Bali. The harvested tannia tubers were cofermed to be free from mechanical and microbiological damage and had uniform ages. PTF was made in laboratory, according to Palupi et al. (2011), with modifications. The tubers were peeled, washed, and sliced to a thickness of ± 2 mm, then boiled with water at a temperature of 95°C for 10 minutes. Afterward, the cooked sliced tubers were dried in an FDH10 food dehydrator (Maksindo, Indonesia) at a temperature of 70°C until dry. The dried tubers obtained were crushed using a blender, then sieved using a 60-mesh sieve to produce PTF.

Preparation of Composite Flour of Wheat-PTF

Preparation of composite flour (wheat-PTF) involved blending high-protein wheat flour (Bogasari, Indonesia) and TPF in varying ratios as per the tested treatments (100:0, 95:5, 90:10, 85:15, 80:20, 75:25, and 70:30). The resulting mixture was then sieved using a 60-mesh sieve to achieve homogeneity.

Production of Dry Noodles

In this study, dry noodles were prepared following the method outlined by Corke and Bhattacharya (1999) with some modifications. A composite of wheat-PTF flour, eggs, cooking oil, baking powder, water, and salt was blended using an HR7627 food processor (Philips, Indonesia) to achieve a smooth mixture. The dough was then allowed to stand for 30 minutes before being ground, flattened, and processed using an AT150 noodles printer (Shuma Machine Bello, China) to create raw noodles. Subsequently, the raw noodles were steamed for 4 minutes at 90°C, cooled, and dried in a mechanical dryer at 70°C for 3 hours to produce the final dry noodles.

Sample Analysis

The chemical composition of dried noodles was determined using the method according to AOAC (2005). The water content of the sample was calculated based on the weight loss of the sample after it had been dried in a drying oven at 105°C until the dry weight was constant. The ash content of the sample was determined based on the weight loss of the sample after it was incinerated in a furnace at a temperature of 550°C until it turns into ash. The protein content of the sample was calculated based on the percentage of total nitrogen determined by the micro-Kjeldahl method, with protein content calculated as total nitrogen multiplied by 6.25. Fat content was determined by the Soxhlet method. The carbohydrate level was determined using the "by difference" method (100% minus the percentage of water, ash, protein, and fat).

The determination of cooking loss and cooking yield was conducted by boiling 5 g of noodles in 150 ml of boiling water. After reaching the optimum cooking time (5 minutes), the noodles were drained and weighed. Subsequently, the noodles were dried at 100°C until the weight was constant and then re-weighed. Cooking loss (%) was calculated as the dry weight (g) of lost solids (dissolved in boiling liquid) per 100 g of the sample, while cooking yield was calculated as a percentage of the weight of the sample that has been cooked against the weight of the initial sample (AACC, 2000).

The sensory evaluations of noodle samples were carried out using acceptance tests and scoring tests (Watts et al., 1989). The evaluation involved 30 semi-trained panelists (21 women and nine men, aged between 20 and 30 years). Panelists were required to express their level of acceptance for each sample using a 7-point hedonic scale (1, intensely dislike; 7, very like) on the assessment form. The evaluation covered various aspects, including appearance, aroma, texture, taste, and overall acceptance.

For the scoring test, panelists were instructed to assess the elasticity and intensity of the tannia aroma/taste in the noodles. Elasticity was evaluated on a 5-point scale (1, not elastic; 5, very elastic), while the intensity of the tannia aroma/taste was rated on a 5-point scale (1, no aroma/taste of tannia; 5, very strong aroma/taste of tannia). The collected data were tabulated, subjected to variance analysis, and in the presence of a significant treatment effect, further analyzed using Duncan's test at a 5% significance level.

Dry noodles surface color was measured using the HH06 Colorimeter (Accu Probe, USA). The color parameters measured were L* (lightness/darkness), a* (redness/greenness) and b* (yellowness/ blueness). Whiteness index (WI) was calculated based on the formula proposed by Hsu et al. (2003), like Eq. (1).

The surface color of dry noodles was measured using the HH06 Colorimeter (Accu Probe, USA). The color parameters measured included L* (lightness/darkness), a* (redness/greenness), and b* (yellowness/blueness). The Whiteness Index (WI) was calculated using the formula proposed by Hsu et al. (2003), as shown in Eq. (1).

$$WI = 100 - \sqrt{(100 - L)^2 + a^2 + b^2} \quad \text{.........} \quad (1)$$

Results and Discussion

Raw Materials Analysis

Table 1 presents the results of analyzing the chemical composition of wheat flour and PTF used in this study. The wheat flour used is high-protein flour purchased at a local supermarket. The results of the chemical analysis showed that PTF had higher water, ash, carbohydrate, and crude fiber content than wheat flour, but it had lower fat and protein content. Compared to other tuber flours such as cassava, sweet potato, and elephant foot yam flour, PTF has higher levels of protein and crude fiber. Previous studies revealed that cassava flour had a protein content of 1.31% and crude fiber content of 3.78% (Akama et al., 2013), sweet potato flour had a protein content of 2.48% and crude fiber content of 2.1% (Toan and Anh et al., 2018), and elephant foot yam flour had 1.13% protein content and 3.45% crude fiber content (Koni et al., 2017). An interesting finding was that PTF has a higher crude fiber content compared to wheat flour and other tuber flours, suggesting its potential to increase the fiber content of flour-based food products.

Table 1. Differences in chemical composition of wheat flour (WF) and pregelatinized tannia flour (PTF)

Component	WF	PTF
Water (%)	12.43	9.02
Ash (%)	0.06	1.33
Fat (%)	2.78	2.52
Protein (%)	15.55	5.45
Carbohydrate (%)	69.18	81.68
Crude Fiber (%)	6.06	9.33

Chemical characteristics of noodles

The results of the chemical analysis of dry noodles are shown in Table 2. The substitution of wheat flour with PTF at a level of 30% had no significant effect ($P > 0.05$) on water, ash, and fat content but had a significant effect ($P < 0.05$) on protein, carbohydrates, and crude fiber content. The results of this study indicate that the substitution of wheat flour with PTF increased the levels of carbohydrates and crude fiber in the dry noodles. The increase in carbohydrates was evident with a substitution of ≥30%, while the increase in crude fiber was noticeable with a substitution of ≥15%. This change was attributed to the differences in carbohydrate and crude fiber levels between wheat flour and PTF. The wheat flour used in this study had carbohydrate and crude fiber contents of 69.18% and 6.06%, respectively, while PTF had 81.68% and

9.33%, respectively.

Table 2. The effect of ratio of pregelatinized tannia flour (PTF) to wheat flour (WF) on the chemical characteristics of dry noodles

WF:PTF (%)	Moisture	Ash	Fat	Protein	Carbo-hydrate	Crude fiber
100 : 0	8.79±2.46[a]	1.41±0.03[a]	11.82±2.08[a]	17.95±0.76[a]	60.04±1.42[b]	3.84±0.81[b]
95 : 5	8.69±2.72[a]	1.44±0.09[a]	9.80±1.86[a]	17.94±1.42[a]	62.13±2.75[ab]	5.17±0.41[a]
90 : 10	8.32±2.72[a]	1.42±0.14[a]	10.85±2.05[a]	17.56±0.63[a]	61.85±4.54[ab]	4.61±1.17[ab]
85 : 15	6.06±0.90[a]	1.55±0.09[a]	9.91±1.82[a]	16.86±0.79[ab]	65.62±3.10[a]	4.72±0.99[ab]
80 : 20	7.69±2.82[a]	1.57±0.03[a]	10.71±3.23[a]	16.58±0.26[ab]	63.45±3.59[ab]	4.94±0.61[a]
75 : 25	7.48±1.42[a]	1.47±0.28[a]	11.40±3.17[a]	15.67±1.08[b]	63.98±2.67[ab]	4.89±1.33[a]
70 : 30	7.19±3.14[a]	1.64±0.11[a]	10.11±0.78[a]	15.60±0.94[b]	65.46±2.17[a]	5.37±0.87[a]

Note: Data are presented as mean ± standard deviation of three replications. Data followed by a same letter in the same column show no significant difference at the Duncan test level of 5%.

The pattern of changes in carbohydrate content in this study aligns with previous research that mentioned the substitution of wheat flour with sweet potato flour increased carbohydrate levels in dry noodles (Taneya et al., 2014). Carbohydrate levels of WF-PTF dry noodles ranged from 62.13% to 65.62%, slightly lower than the carbohydrate levels of wheat-sweet potato flour dry noodles, which were 72.41% to 73.80% (Taneya et al., 2014). This difference can be attributed to the PTF carbohydrates used in this study, which were lower than the sweet potato flour carbohydrates used by Taneya et al. (2014), i.e., 83.34%.

The pattern of changes in crude fiber content in this study aligned with previous studies, such as the substitution of wheat flour with potatoes (Fen et al., 2017), cassava flour (Sanni et al., 2007), and raw banana flour (Ritthiruangdej et al., 2011), which increased the levels of fiber in the noodles. The crude fiber content of WF-PTF dry noodles ranged from 4.61% to 5.37%, slightly higher than the previously reported crude fiber levels of (wheat-breadfruit starch) dry noodles, which were at 2.13% to 4.83% (Adebowale et al., 2017).

Noodles Color

Color is a significant quality factor in noodles as it influences consumers' visual assessment (Mares and Campbell, 2001). It serves as an indicator of the raw material quality and, in some cases, reveals the duration of product storage. Table 3 presents the color parameters of dry noodles supplemented with PTF. The substitution of wheat flour with PTF had a significant effect ($P < 0.05$) on the values of L* (lightness), b* (yellowness), and WI (whiteness index).

Table 3. The effect of ratio of pregelatinized tannia flour (PTF) to wheat flour (WF) on the color parameters of dry noodles.

WF: PTF (%)	L*	a*	b*	WI
100 : 0	48.0±3.5[a]	-0.9±1.6[a]	9.6±1.8[a]	47.1±3.3[a]
95 : 5	41.4±4.2[b]	-0.1±1.2[a]	7.7±1.0[ab]	40.9±4.3[bc]
90 : 10	41.7±4.7[b]	-0.9±0.0[a]	5.5±2.4[b]	41.4±4.9[b]
85 : 15	42.0±5.3[b]	-1.6±0.4[a]	7.2±1.3[b]	41.5±5.4[b]
80 : 20	40.0±7.0[b]	-1.1±1.5[a]	5.7±0.9[b]	39.7±6.9[bc]
75 : 25	38.8±4.3[b]	-0.6±0.9[a]	6.9±0.8[b]	38.5±4.4[bc]
70 : 30	37.0±4.6[b]	-1.0±0.5[a]	7.8±0.7[ab]	36.5±4.5[c]

Note: Data are presented as mean ± standard deviation of three replications. Data followed by a same letter in the same column show no significant difference at the Duncan test level of 5%. L* (lightness/darkness), a* (redness), and b* (yellowness), WI (whiteness index).

The results of this study indicate that the L* value of noodles supplemented with PTF was lower than that of

100% wheat noodles. This suggests that substituting wheat flour with PTF can reduce the brightness of the noodles. This reduction in brightness may be attributed to the darker color of PTF compared to wheat flour, resulting in less vibrant noodle color. The greyish-white color of PTF is likely due to enzymatic browning reactions occurring during the manufacturing process. According to James et al. (2013), the greyish color in taro flour is a result of enzymatic browning reactions. The findings of this study align with those of previous research reported by Ritthiruangdej et al. (2011) for noodles supplemented with raw banana flour and Zang et al. (2010) for noodles supplemented with sweet potato flour. These studies showed that substituting flour could lead to a decrease in the L* value of the noodles.

In general, the b* value of noodles supplemented with PTF was slightly lower than the b* value of 100% wheat noodles. This indicates that the substitution of wheat flour with PTF also leads to a decrease in the intensity of the yellow color on the noodles. The yellow color of the noodles originates from flavone compounds found in wheat flour (Fortmann and Joiner, 1978). As the composition of wheat flour decreases, the intensity of the yellow color also decreases. These results are consistent with those reported by Foo et al. (2011) in noodles supplemented with raw banana pulp and Akinoso et al. (2016) in noodles supplemented with yam flour.

The results of this study indicated that the whiteness index (WI) of WF-PTF noodles (36.5 - 40.9) was lower than noodles without PTF (47.1). The higher PTF composition in the noodles, the more WI value decreased. These results are similar to the previous results reported by Kumara and Divakar (2017) on noodles supplemented with jackfruit seed flour, and Wahyono, et al. (2018) in noodles supplemented with oyster mushroom flour.

The results of this study indicated that the whiteness index (WI) of PTF-supplemented noodles (36.5 - 40.9) was lower than noodles without PTF (47.1). The higher the PTF composition in the noodles, the more the WI value decreased. These results are similar to previous findings reported by Kumara and Divakar (2017) on noodles supplemented with jackfruit seed flour and Wahyono et al. (2018) in noodles supplemented with oyster mushroom flour.

Cooking quality

In this study, the observed parameters for cooking quality were cooking loss and cooking yield. Cooking loss represents the percentage of solid loss in the noodles during cooking, while cooking yield is the percentage of the weight of the noodles after cooking against the weight of the noodles before cooking. Table 4 illustrates the impact of substituting wheat flour with PTF on cooking loss and cooking yield. The results indicated that the substitution had a significant effect ($P<0.05$) on the cooking loss and cooking yield of noodles. The cooking loss of PTF-supplemented noodles in this study ranged from 9.58% to 6.36%, slightly lower compared to 100% wheat flour noodles. This difference might be attributed to the stronger structure of the PTF-supplemented noodles, resulting in more resistance during the cooking process.

Table 4. The effect of the ratio of wheat flour (WF) and pregelatinized tannia flour (PTF) to cooking loss dan cooking yield of the noodles

WF : PTF (%)	Cooking loss (%)	Cooking yield (%)
100 : 0	9.68 ± 2.92^{a}	161.47 ± 28.17^{b}
95 : 5	9.58 ± 3.24^{a}	165.60 ± 23.86^{b}
90 : 10	9.14 ± 3.25^{ab}	171.12 ± 32.68^{ab}
85 : 15	6.46 ± 1.02^{b}	205.55 ± 13.55^{a}
80 : 20	6.89 ± 0.78^{ab}	189.69 ± 20.63^{ab}
75 : 25	8.10 ± 1.65^{ab}	205.62 ± 27.80^{a}
70 : 30	6.36 ± 1.22^{b}	210.27 ± 41.43^{a}

Note: Data are presented as mean ± standard deviation of 3 replications. Data followed by the same letter in the same column show no significant difference at the Duncan test level of 5%.

According to Anggraeni and Saputra (2018), cooking loss is related to the bond between amylose and protein. The stronger the bonds between protein (gluten) and amylose, the more robust the structure of the noodles. It is believed that the amylose content in PTF-supplemented noodles is higher than that in wheat flour noodles, thereby strengthening the protein-amylose matrix bond. This strengthened bond can effectively retain dissolved solids during the cooking process. Previous studies have shown that the ratio of amylose to amylopectin in wheat flour was 0.14 (Murugadass and Dipnaik, 2018), while for tannia flour, it was 0.33 (Hsu et al., 2003). This suggests that the amylose content in PTF is higher than that in wheat flour.

The cooking yield of PTF-supplemented noodles ranged from 165.60% to 210.27%, which is higher than that of wheat flour noodles (161.47%) (Table 2). This difference is thought to be caused by two factors: lower cooking loss and higher water absorption during the cooking process. The rate of water absorption by noodles during cooking is influenced by protein content (Anggraeni and Saputra, 2018). During the cooking process, the gluten protein present in the noodles will be denatured and form bonds that can prevent water penetration from entering the starch granules at gelatinization temperatures. Thus, the higher the protein content of the noodles, the lower the water absorption. The protein content of PTF-supplemented noodles is lower than that of wheat flour noodles (Table 2), causing the water absorption of PTF-supplemented noodles to be higher than that of wheat flour noodles.

An interesting aspect of this finding is that PTF-supplemented noodles exhibit lower cooking loss and higher cooking yield compared to wheat flour noodles. Cooking yield and cooking loss are essential parameters for assessing noodle cooking quality. High cooking yield and low cooking loss indicate good-quality noodles (Zhang et al., 2012; Chin et al., 2012). According to Giuberti et al. (2015), the quality of noodles decreases when the cooking loss exceeds 12%. In terms of cooking quality, the substitution of wheat flour with PTF slightly enhances the quality of the noodles.

Sensory characteristics of noodles

In this study, sensory tests were conducted on samples of cooked noodles. The noodles were cooked by boiling them for 5 minutes. The sensory tests included acceptance and scoring tests. The results of the acceptance test indicated that the substitution of wheat flour with PTF had a significant effect ($P < 0.05$) on color, aroma, and overall acceptance, but had no significant effect ($P > 0.05$) on texture and flavor acceptance. (Table 5). The results of the scoring test revealed that the substitution of wheat flour with PTF significantly affected ($P < 0.05$) elasticity, the intensity of the tannia taste, and the intensity of the tannia aroma (Table 4). Substitution up to 20% had no significant effect on color acceptance, but substitution ≥25% led to a significant decrease in color acceptance. This could be attributed to substitutions exceeding 20%, causing a reduction in brightness, which was less favored by the panelists. This finding aligns with the results of the noodle color test using a colorimeter, showing that an increase in wheat flour substitution with PTF decreased the L* value (Table 3). Previous studies have also reported that noodles with a brighter color are generally preferred by panelists (Herawati et al., 2017).

Table 5. Influence of the ratio of wheat flour (WF) and pregelatinized tannia flour (PTF) to the reception of cooked noodles

WF : PTF (%)	Color	Aroma	Texture	Flavor	Overall
100 : 0	$5.4±1.2^{ab}$	$4.5±1.1^{b}$	$4.8±1.1^{a}$	$4.8±1.2^{a}$	$4.94±0.87^{ab}$
95 : 5	$6.0±0.7^{a}$	$5.2±0.9^{a}$	$4.6±1.3^{a}$	$5.1±1.0^{a}$	$5.33±0.77^{a}$
90 : 10	$5.2±0.9^{b}$	$5.0±1.3^{ab}$	$4.9±1.3^{a}$	$5.1±1.1^{a}$	$5.00±0.91^{ab}$
85 : 15	$4.8±0.9^{b}$	$4.7±1.0^{ab}$	$5.0±0.9^{a}$	$5.0±1.0^{a}$	$5.11±0.83^{ab}$
80 : 20	$4.7±1.2^{b}$	$4.8±1.0^{ab}$	$4.6±1.1^{a}$	$4.8±1.0^{a}$	$4.72±1.02^{b}$
75 : 25	$4.1±1.4^{c}$	$4.5±0.9^{b}$	$4.4±1.2^{a}$	$4.5±1.1^{a}$	$4.50±1.04^{b}$
70 : 30	$3.6±1.6^{c}$	$4.7±1.0^{ab}$	$4.9±1.0^{a}$	$4.5±1.3^{a}$	$4.56±1.15^{b}$

Note: The data are presented as mean ± standard deviation of 30 replications. Data followed by the same letter in the same column show no significant difference at the Duncan test level of 5%. The acceptance rate was measured using a 7-point hedonic scale (1 for very disliked, to 7 for very preferred).

The substitution of wheat flour with PTF slightly increased the panelists' acceptance of the noodle's aroma. This was attributed to the tannia aroma, which was preferred by the panelists. The results of the scoring test on the intensity of the tannia aroma indicated that the increase in substitution significantly heightened the intensity of the tannia aroma in noodles (Table 6). This trend is similar to the intensity of tannia taste in noodles, where an increase in substitution led to a significant rise in the intensity of tannia taste. However, the presence of tannia taste did not result in a significant change in the level of panelist acceptance of the flavor of the noodles.

The substitution of flour with PTF tends to reduce the elasticity of the noodles. The results of this study corroborate the findings of previous research. Zhang et al. (2010) reported that substitution using sweet potato flour could reduce the elasticity of noodles. Dewi (2011) also observed a decrease in the elasticity of noodles by substituting with seaweed. The decreased elasticity of noodles resulting from substituting wheat flour with PTF may be attributed to a reduction in gluten content. Li et al. (2014) state that gluten plays a role in encouraging the formation of dough and strengthening the protein skeleton, ultimately contributing to an increase in the elasticity of noodles.

Table 6. Effect of ratio of wheat flour (WF) and pregelatinized tannia flour (PTF) to the elasticity, intensity of tannia taste, dan intensity of tannia aroma of cooked noodles

WF: PTF (%)	Elasticity	Tannia taste	Tannia aroma
100 : 0	2.8±1.0[a]	1.4±0.7[d]	1.2±0.4[b]
95 : 5	2.7±1.1[ab]	1.7±1.0[cd]	1.6±0.8[b]
90 : 10	2.6±1.0[ab]	2.2±1.0[bc]	2.4±0.9[a]
85 : 15	2.5±0.7[ab]	2.3±1.0[b]	2.1±1.1[a]
80 : 20	2.3±0.9[b]	2.6±0.8[ab]	2.3±0.6[a]
75 : 25	2.6±0.9[ab]	2.5±0.9[ab]	2.1±0.9[a]
70 : 30	2.3±0.9[b]	3.0±1.2[a]	2.4±1.3[a]

Note: Data are presented in mean ± standard deviation of 30 replications. Data followed by the same letter in the same column show no significant difference at the Duncan test level of 5%. Elasticity was measured using a 5-point scale (1 for not elastic to 5 for very elastic). The intensity of the tannia flavor/aroma was measured using a 5-point scale (1 for no tannia aroma/flavor to 5 for very strong tannia aroma/flavor).

Conclusions

The substitution of wheat flour with PTF influenced the chemical composition, cooking quality, color, and sensory properties of noodles. This substitution has been shown to increase the fiber content of noodles and improve cooking quality. In general, a 25% substitution produces noodles with higher crude fiber content and better cooking quality while maintaining similar sensory quality to control noodles (without substitution).

References

1. AACC. (2000). *Approved methods of the Association of Cereal Chemist*. 10th edition. American Association of Cereal Chemists, Saint Paul, Minnesota.
2. Adebowale, O. J., Salaam, H. A., Komolafe, O. M., Adebiyi, T. A., & Ilesanmi, I. O. (2017). Quality characteristics of noodles produced from wheat flour and modified starch of African breadfruit (*Artocarpus altilis*) blends. *Journal of Culinary Science & Technology*, 15(1), 75-88. https://doi.org/10.1080/15428052.2016.1204973
3. Akama, F. O. (2013). Physiochemical properties of dried cassava flour from balls and chunks. *International Journal of Scientific & Technology Research*, 2(10), 63-70.
4. Akinoso, R., Olatoye, K. K., & Ogunyele, O. O. (2016). Potentials of trifoliate yam (*Dioscorea dumetorum*) in noodles production. *J. Food Process Techno.*, l7(8), 609. DOI:10.4172/2157-7110.1000609
5. Ammar, M. S., Hegazy, A. E., & Bedeir, S. H. (2009). Using of taro flour as partial substitute of wheat flour in bread making. *World Journal of Dairy and Food Sciences*, 4(2), 94-99.
6. Anggraeni, R., & Saputra, D. (2018). Physicochemical characteristics and sensorial properties of dry noodles supplemented with unripe banana flour. *Food Research*, 2(3), 270-278. DOI: 10.26656/fr.2017.2(3).061
7. AOAC. (2005). *Official methods of analysis of the association of official analytical chemists* (18th ed.). AOAC, Maryland.

8. Burkitt, D. P., Walker, A. R. P., & Painter, N. S. (1974). Dietary fiber and disease. *JAMA*, 229(8), 1068-1074. DOI:10.1001/jama.1974.03230460018013
9. Chin, C. K., Huda, N., & Yang, T. A. (2012). Incorporation of surimi powder in wet yellow noodles and its effects on the physicochemical and sensory properties. *Int. Food Res. J.*, 19: 701 – 707.
10. Choo, C. L. & Aziz, N. A. (2010). Effects of banana flour and β-glucan on the nutritional and sensory evaluation of noodles. *Food Chemistry*, 119, 34-40. DOI: 10.1016/j.foodchem.2009.05.004
11. Corke, H., & Bhattacharya, M. (1999). Wheat Product: Noodles. In Ang, C.Y., Liu, K., Huang, Y.W. (Ed.), *Asian Foods: Science and technology* (pp. 43-68). Technomic Publishing Co., Inc., Lancaster
12. Dewi, E. N. (2011). Quality evaluation of dried noodles with seaweeds puree substitution. *Journal of Coastal Development*, 14(2), 151-158.
13. Dnyaneshwar, C. K., Amesh, V. P., & Abhijeet, B. M. (2017). Enrichment of wheat flour noodles with oat flour: effect on physical, nutritional, antioxidant and sensory properties. *International Journal of Current Microbiology and Applied Sciences*, 6(12),: 204-213. DOI: 10.20546/ijcmas.2017.612.026
14. Fen, X., Honghai, H., Xiaofeng, D., Qiannan, L., Yanjie, H., & Hong, Z. (2017). Nutritional compositions of various potato noodles: comparative analysis. *Int. J. Agric. & Biol. Eng.*, 10(1), 218-225. DOI:10.3965/j.ijabe.20171001.2287
15. Foo, W. T., Yew, H. S., Liong, M. T., & Azhar, M. E. (2011). Influence of formulations on textural, mechanical and structural breakdown properties of cooked yellow alkaline noodles. *International Food Research Journal*, 18(4), 1295-1301.
16. Fortmann, K. L., & Joiner, R. R. (1978). Wheat Pigments and Flour Color. In Pomeranz, Y. (Ed.), *Wheat Chemistry and Technology*, 2nd edition (pp. 493-522). American Association Cereal Chemistry, St. Paul, MN.
17. Giuberti, G., Gallo, A., Cerioli, C., Fortunati, P., & Masoero, F. (2015). Cooking quality and starch digestibility of gluten free pasta using new bean flour. *Food Chem.*, 175, 43-49. DOI: 10.1016/j.foodchem.2014.11.127
18. Herawati, E. R. N., Ariani, D., Miftakhussolikhah, Angwar, M., & Pranoto, Y. (2017). Sensory and textural characteristics of noodles made of ganyong flour (*Canna edulis* Kerr.) and arenga starch (*Arenga pinnata* Merr.). *IOP Conf. Ser.: Earth Environ. Sci.*, 101(1), 012020. DOI:10.1088/1755-1315/101/1/012020
19. Hsu, C. L., Chen, W., Weng, Y. M., & Tseng, C. Y. (2003). Chemical composition, physical properties, and antioxidant activities of yam flours as affected by different drying methods. *Food Chemistry*, 83(1), 85-92. DOI: 10.1016/S0308-8146(03)00053-0.
20. James, E. O., Peter, I. A., Charles, N. I., & Joel, N. (2013). Chemical composition and effect of processing and flour particle size on physicochemical and organoleptic properties of cocoyam (*Colocasia esculenta* var. esculenta) flour. *Nigerian Food Journal*, 31(2), 113-122. DOI: 10.1016/S0189-7241(15)30084-9
21. Koni, T. N. I., Rusman, Hanim, C., & Zuprizal. (2017). Nutritional composition and anti-nutrient content of elephant foot yam (*Amorphophallus campanulatus*). *Pakistan Journal of Nutrition*, 16(12), 935-939. DOI: 10.3923/pjn.2017.935.939
22. Kumara, V., & Divakar, S. 2017. Quality analysis of raw jackfruit based noodles. *Asian J. Dairy & Food Res*, 36(1), 45-51. DOI:10.18805/ajdfr.v36i01.7458
23. Li, M., Zhu, K. X., Guo, X. N., Brijs, K., & Zhou, H. M. (2014). Natural additives in wheat-based pasta and noodles products: opportunities for enhanced nutritional and functional properties. *Comprehensive Reviews in Food Science and Food Safety*, 13, 347-357. DOI:10.1111/1541-4337.120 66
24. Mares, D. J. & Campbell, A. W. (2001) Mapping components of flour and noodles color in Australian wheat. *Aust. J. Agri. Res.,* 52: 1297-1309.
25. Mongi, R. J., Ndabikunze, B. K., Chove, B. E., Mamiro, P., Ruhembe, C. C., & Ntwenya, J. G. (2011). Proximate composition, bread characteristics and sensory evaluation of cocoyam-wheat composite breads. African Journal of Food, *Agriculture, Nutrition and Development*, 11(7), 5586-5599
26. Moorthy, S. N., Sajeev, M. S., & Anish, R. J. (2018). Functionality of Tuber Starches. In Sjoo, M. and Nilsson, L. (Ed.), *Starch in Food: Structure, function and applications* (pp. 421-508). Woodhead Publishing, Duxford.
27. Murugadass, G. & Dipnaik, K. (2018). Preliminary study of ratio of amylose and amylopectin as

indicators of glycemic index and in vitro enzymatic hydrolysis of rice and wheat starches. *International Journal of Research in Medical Sciences*, 6(9), 3095-3098. DOI: 10.18203/2320-6012.
28. Ojinnaka, M. C., Shadrack, D. M., Anankware, J. P., & Odinkemere-Davidson, V. N. (2018). Formulation, proximate composition and quality evaluation of cocoyam-wheat cake enriched with edible palm larvae (*Rhynchophorus phoenicis*). *Acta Scientific Nutritional Health*, 2(11), 19-25.
29. Onwueme, I. C. (1978). *The Tropical Tuber Crops: Yams, Cassava, Sweet Potato, and Cocoyams*. John Wiley & Sons, Chichester.
30. Palupi, H., Zainul, A., & Nugroho, M. (2011). The effect of pre gelatinization on the characteristics of cassava flour. *Teknol Pangan*, 1(1), 1-14.
31. Perez, E. E., Gutièrrez, M. E., Pacheco de Delahaye, E., Tovar, J., & Lares, M. (2007). Production and characterization of *Xanthosoma sagittifolium* and *Colocasia esculenta* flours. *Journal of Food Science*, 72(6), 367-372.
32. Putra, I. N. K., Suparthana, I. P. & Ina, N. P. T. (2020). Physicochemical properties and microstructure of the pregelatinized tannia flour prepared by a simple parboiling method. *Asian J Agric & Biol*., 8(2): 138-146.
33. Ritthiruangdej, P., Parnbankled, S., Donchedee, S., & Wongsagonsup, R. (2011). Physical, chemical, textural and sensory properties of dried wheat noodles supplemented with unripe banana flour. *Kasetsart J. (Nat. Sci.),* 45, 500 – 509.
34. Taneya, M. L. J., Biswas, M. M. H., & Shams-Ud-Din, M. (2014). The studies on the preparation of instant noodles from wheat flour supplementing with sweet potato flour. J. *Bangladesh Agril. Univ*., 12(1), 135-142
35. Toan, N. V., & Anh, N. V. Q. (2018). Preparation and improved quality production of flour and the made biscuits from purple sweet potato. *Journal of Food and Nutrition*, 4: 1-14.
36. Wahyono, A., Novianti, & Kasutjianingati. (2018). Physicochemical and sensorial characteristics of noodles enriched with oyster mushroom (*Pleorotus ostreatus*) powder. The 2nd International Joint Conference on Science and Technology (IJCST) 2017. Journal of Physics: Conf. Series 953 (2018), 012120. DOI:10.1088/1742-6596/953/1/012120
37. Watts, B. M., Ylimaki, G. L., Jeffery, L. E., & Alias, L. G. (1989). *Basic Sensory Methods For Food Evaluation*. The International Development Research Centre, Ottawa.
38. WINA. (2023). Global Demand for Instant Noodles. World Instant Noodles Association. available online at https://instantnoodles.org/en/noodles/demand/table/
39. Zhang, W., Sun, C., He, F., & Tian, J. (2010). Textural characteristics and sensory evaluation of cooked dry Chinese noodles based on wheat-sweet potato composite flour. *International Journal of Food Properties*, 13, 294–307. DOI: 10.1080/10942910802338194
40. Zhang, Y. J., Yan, Y. G., Xiao, D. S., Wang, & He, Z. H. (2012). Characteristics and evaluation parameters associated with cooking quality of Chinese fresh noodles. *Proceedings 11th International Gluten Workshop*, Beijing: 12-15 Aug. 2012. pp. 128-136.