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Effects of rice flour, sorghum flour, and arenga starch combination on the physical properties of gluten free dry vermicelli

Setia Budi Sasongko, Mohamad Djaeni, Ririn Puji Hastuti, Febiani Dwi Utari, Maghfira Arum Lestari, Aji Prasetyaningrum, and Siswo Sumardiono*

Faculty of Engineering, Diponegoro University. Semarang, Indonesia

Abstract

The arenga starch does not contain gluten that can be potential option to substitute the wheat flour for free white noodle production. The gluten can lead the unpleasant symptoms and autoimmune response for some consumer. However, the nutritional value of Arenga starch is still low. Hence, it must be combined with the others starch source to obtain the proper nutritional value and physical characteristics. This study examines the formulation of Arenga starch, rice and sorghum flours for white noodle (vermicelli) preparation. The aim of this research is to investigate the physical properties (texture and tensile) of gluten free dry noodles based on rice flour, sorghum flour and Arenga Starch. This research was conducted in several stages, involving vermicelli preparation and drying, followed by physical properties analysis. As main raw material, the Arenga starch was varied from 50% to 100%, while the remained part was filled by variation of rice and sorghum flours percentages. The physical qualities were observed based on texture and tensile strength. The results revealed that the higher the proportion of rice flour added, the higher and lower values for hardness, swelling index, and springiness. Sorghum flour is added to arenga starch vermicelli noodles, and the more sorghum flour added, the harder and more cohesive the vermicelli become. Based on the results of analysis and comparison with another vermicelli study, overall, the best treatment can be found at arenga starch 70%, with combination of rice flour 20%, sorghum flour 10%.

Keywords: Arenga pinnata; rice flour; sorghum flour.

Full length article **Corresponding Author*, e-mail: moh.djaeni@live.undip.ac.id

1. Introduction

Noodles made of white flour are popular food consumed over 4000 years [1]. However, in a country like Indonesia, the wheat does not grow. Finding Indonesian native materials to replace wheat flour in the making of noodles is crucial. Recently, the study of noodles production has been done to find the materials form the local ingredients with good taste and high nutritional value. One of the local ingredients is arenga starch. The noodles made of arenga starch are usually called as vermicelli. Compared to tapioca, potatoes, wheat, corn and sweet potato, arenga starch has a greater amylose level (37–37.6%) [2]. Based on this information, arenga starch has the potential to substitute the wheat flour usage and resulted the non-gluten product. Gluten can make unpleasant symptoms and autoimmune response for some consumer, so in the main food it must be hindered. However, the nutritional value in arenga starch such as protein is still low, about 0.1% [3]. The high nutritional ingredients such as rice flour and sorghum can be an option raw material for gluten-free products. The rice flour are the cheap materials and easy to find [4]. The nutritional value of rice flour depends on its variety [5]. But this flour contains the higher protein than the arenga starch, amount 5.21-7.27% [6]. While the sorghum contains bioactive compounds such as phenolics including phenolic acids, flavonoids and tannins which have high antioxidants [7]. Additionally, sorghum has a high protein content of 4.4% to 21.1% [8]. Vermicelli made from arenga starch may additionally have rice flour and sorghum to increase its nutritional content. In previous research, the vermicelli based on only arenga starch exhibited a low nutritional value [3]. The development research of noodles made from local raw materials still needs to be developed. Based on the literature study, the vermicelli production using materials such as: arenga starch and taro flour [9], arenga starch and arrowroot flour [10], and rice flour [11]. To the best of our knowledge, the formulation of gluten free noodle based on the local ingredients such as rice flour, sorghum flour, and arenga starch has not been investigated. The addition of sorghum and rice flour can be an option to enhance the nutritional value of vermicelli. The different composition of flour resulted the different characteristic of vermicelli product. The aim of this research

is to find the best physical properties (texture and tensile) of gluten free dry noodles based on rice flour, sorghum flour and arenga starch.

2. Materials and methods

2.1. Materials

Budi Starch & Sweetener Ltd. in Subang, Indonesia provided the rice flour, while Kusuka Ubiku in Yogyakarta, Indonesia provided the sorghum (Sorghum spp.) flour. The arenga (Arenga pinnata) starch was supplied by the Dua Naga Ltd. arenga starch facility in West Java, Indonesia. The xanthan gum was purchased. from Fufeng Group Ltd. in Shandong, China.

2.2. Preparation of vermicelli

The prior technique was used to create the vermicelli samples, but with several of improvements [12]. This research combines the arenga starch with of rice flour and sorghum. The composition of raw materials was listed in Table 1.The mixture was made up of two forms, dried form and gel form, in an 8:2 ratio. Using a vermicelli extruder (Multi Maker OX-123, Oxone, Indonesia), the xanthan gum (1% of the total weight), the gel, and the dry form were combined and cast. For 30 seconds, the vermicelli was submerged in hot water heated at a constant 90°C in an electric pan. The vermicelli was then chilled for 3 minutes in cold water with a temperature of 8.03 ± 0.15°C before being drained for 5 minutes. Every sample of vermicelli noodles was laid out on an aluminium tray and allowed to dry in the sun. Figure 1 depicted the steps involved in making vermicelli.

2.3. Analysis of dried vermicelli

2.3.1. Fourier-transform infrared spectroscopy (FTIR) analysis

A Frontier spectrometer (made by PerkinElmer, USA) was used to record the dried vermicelli's Fourier transform infrared (FTIR) spectrum. The functional groups were observed using wavenumbers between 4,000 and 400 cm-1.

2.3.2. Texture Properties

The vermicelli noodles were cooked and were cooled for 10 minutes. After that the texture properties (hardness, cohesiveness, springiness, and adhesion) of the samples were tested based on the previous research [12]. The cooked vermicelli noodles were evaluated for the texture properties using TA-XTplus Texture Analyzer (Stable Micro System Ltd., Surrey, UK).

2.3.3. Tensile Properties

The tensile properties test was carried out using a Texture Analyzer TA.XT2i (Texture Technologies Corporation, USA). The noodle samples tested were noodles that had been rehydrated beforehand. Then the sample used is noodle sheets with a thickness of about 1 cm and a minimum length of 5 cm. The initial separation handle and separation speed were set at 2 cm and 25 mm/s, respectively. The tensile properties value of the sample were evaluated by tensile strength and elongation at break and displayed on the monitor tool [13].

3. Results and Discussions

3.1. FTIR properties of dried vermicelli

The FTIR investigation was done to look at potential interactions between the ingredients used to make the vermicelli noodles. Figure 2 exhibits the FTIR spectrum of transmittance enhancement of the OH vibration at around 3,300–3,400 cm^{-1} of the dried vermicelli. As seen in Figures 2, At a wavenumber range of 1,200 cm^{-1}, the Amide III vibration (C-N stretching, N-H bending) may be seen. Vermicelli contains protein, as shown by the presence of Amide III vibration in sample spectra.. The amount protein in sorghum was higher, about 6 - 18 % [14]. As expected, a higher portion of sorghum caused the transmittance of the Amide III vibration to increase. In addition, protein in the sorghum can increase the flexibility of vermicelli due to the interaction between protein and starch.

3.2. Texture properties of dried vermicelli

Based on the texture properties test that has been carried out, hardness, springiness, cohesiveness and adhesiveness data were obtained which can be seen in Figure 3. Data on the hardness of noodles reveal that the higher the percentage of rice flour used, the lower the hardness value. The decreased hardness value of vermicelli noodles can be influenced by cooking time, the longer the cooking time for the noodles, the more water will become hydrated into the surface of the noodles, thereby reducing the hardness of the noodles. The longer the optimum cooking time for noodles causes the amount of hydrated water in the noodles to increase and affects the stickiness and toughness of the noodle sheets [15]. This phenomenon is caused by the interaction of hydrophilic, carbohydrate, fat, and protein groups in well-hydrated protein networks [16]. The high values of springiness, cohesiveness and hardness are expected characteristics of noodle products [17]. A high cohesiveness value indicates a greater degree of polymerization of the amylose fraction in controlling noodles to make the noodle texture more cohesive [18]. Based on Figure 3, the highest hardness value was in the treatment of adding 10% sorghum flour. The hardness value tends to decrease when the concentration of added sorghum flour is higher. This can be caused by the protein content in sorghum flour which is added to vermicelli noodles. The hardness and elasticity of noodles are strongly influenced by the strength of protein bonds and the protein content of the flour [19] . Another factor that can affect the texture of the noodles is the amylose content in the ingredients added. The noodle structure is influenced by amylose bonds [20]. The amylose content in sorghum flour is 19.59% and arenga starch is 37-37.6%, so that when the percentage of added sorghum flour is higher, it causes the amylose content in the dough to decrease, thereby reducing the texture or hardness of the noodles. The data in the table shows that the higher the concentration of added sorghum flour, the cohesiveness, springiness, and adhesion values of vermicelli noodles decreased. A low adhesiveness value is an important characteristic for consumers [21]. This is influenced by the production method and the quality of protein binding in binding starch to the dough. The protein and starch molecules are binding well so the adhesiveness become lower. This phenomenon were in line with FTIR analysis, it can be seen that the higher Amide III groups in higher concentration of added sorghum flour.

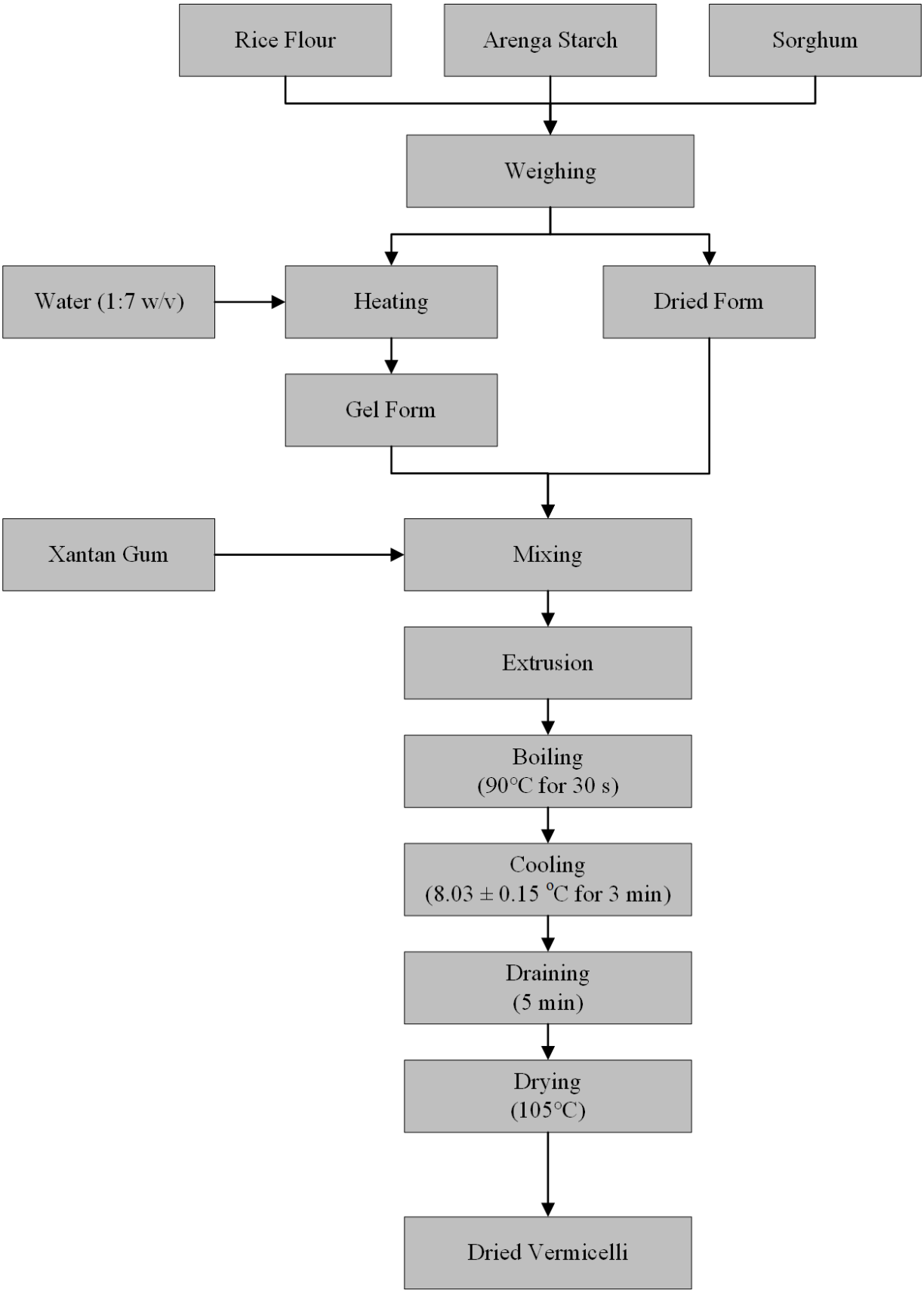

Figure 1: The procedure of vermicelli preparation

Table 1: Formulation of vermicelli

Arenga Starch (%)	Rice Flour (%)	Sorghum Flour (%)	Code
90	10		R10
80	20		R20
70	30		R30
60	40		R40
50	50		R50
90		10	S10
80		20	S20
70		30	S30
60		40	S40
50		50	S50

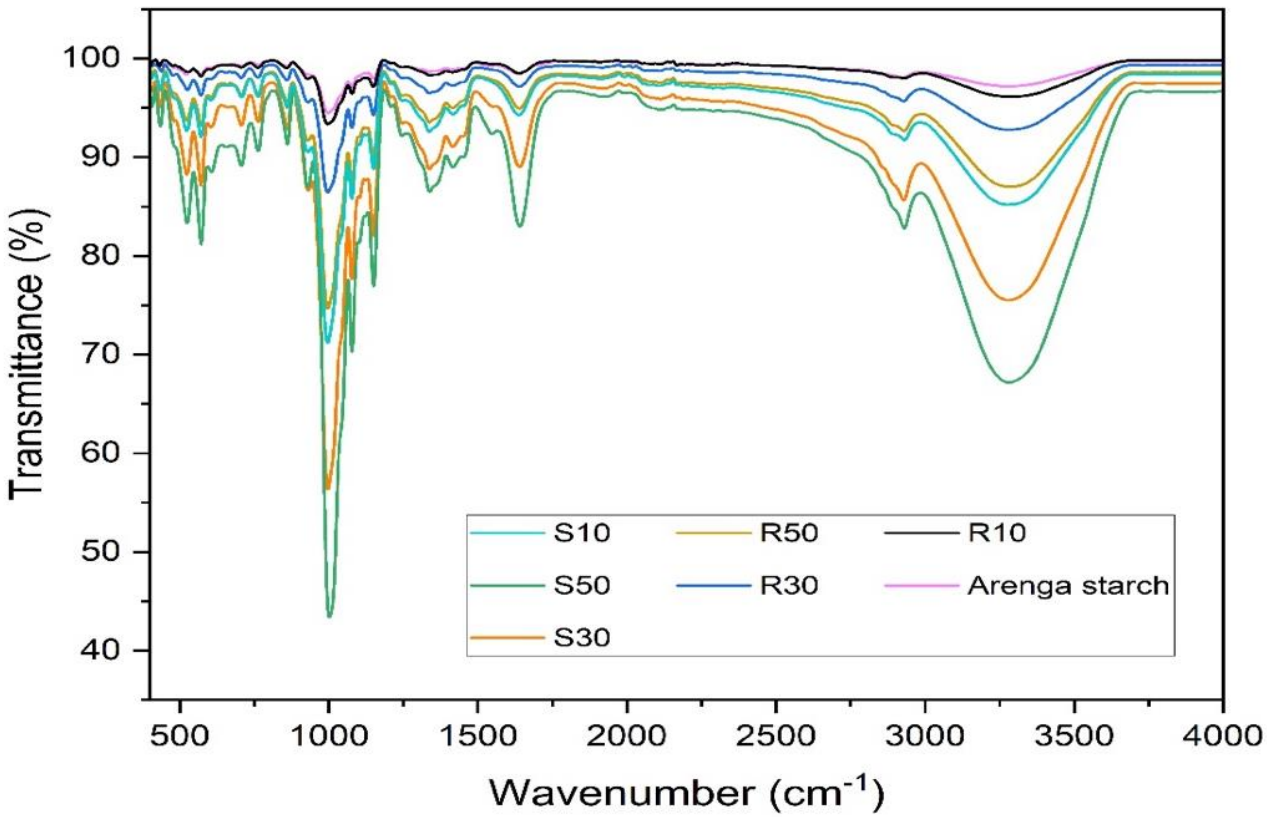

Figure 2: Fourier transform infrared (FTIR) spectroscopy of vermicelli

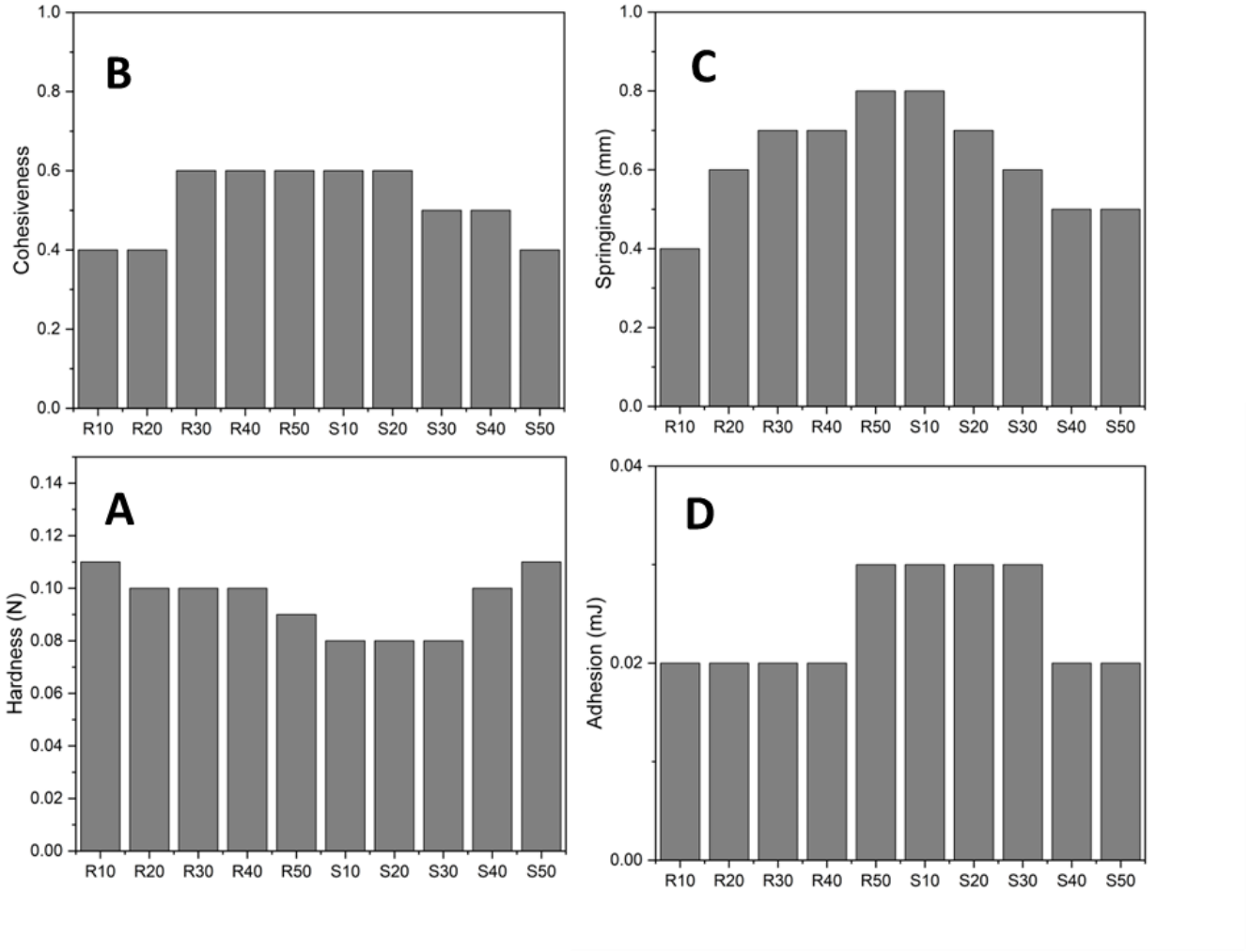

Figure 3: Texture of vermicelli : (A) Hardness, (B) Cohesiveness, (C) Springiness, and (D) Adhesion

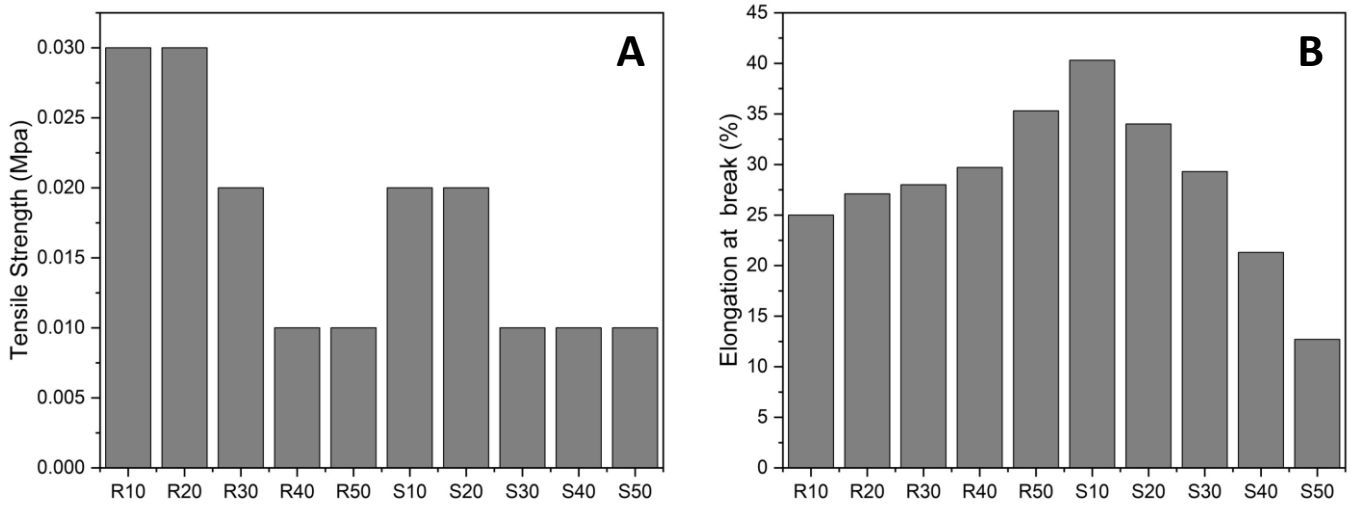

Figure 4: Tensile properties of vermicelli : (A) Tensile strenght and (B) Elongation at break

The decrease in the cohesiveness value was affected by the higher gelatinization temperature of sorghum flour compared to arenga starch.

3.3. Tensile properties of dried vermicelli

The tensile strength test for vermicelli can be seen in Figure 4. The phenomenon that occurs in the treatment of adding rice flour to starch aren vermicelli noodles is that vermicelli noodles with low tensile strength have a high percentage of elongation break. Factors that influence this are the amylose and protein content of the raw materials used. The amount of broken amylose affects the strength of the tissue in the noodle sheets [22]. In addition, protein in the raw material can increase the flexibility of noodles with a weak structure due to the interaction between protein and starch. This reduces tensile strength while increasing elongation break. The fact is that as the concentration of additional sorghum flour increases, the elongation break value decreases (Figure 4). This is because sorghum flour has less amylose than arenga starch flour. As a result, when the percentage of sorghum flour increases, the amylose level in the noodles decreases, as does the elasticity of the noodles produced. Lowering amylose content resulted in a reduced percentage of elongation [23].

3.4. Comparison with another vermicelli product

The vermicelli obtained from this study have recently been characterized. The best treatment can be found, namely the addition of 20% rice flour and 10% sorghum flour to arenga starch vermicelli noodles. The vermicelli obtained from this study resulted the comparable tensile strength value with another vermicelli study. While the elongation at break was still higher than that of the others vermicelli study such as by a combination of arenga and arrowroot starch [24], arrowroot flour [10], and arenga and canna flour [25].

4. Conclusions

This study examines to determine the the addition of rice flour and sorghum flour affects the properties of arenga starch vermicelli noodles. The results revealed that the higher the proportion of rice flour added, the higher and lower values for hardness, swelling index, and springiness. Sorghum flour is added to arenga starch vermicelli noodles, and the more sorghum flour added, the harder and more cohesive the vermicelli become. Based on the results of analysis and comparison with another vermicelli study, overall, the best treatment can be found, namely the addition of 20% rice flour and 10% sorghum flour to arenga starch vermicelli noodles.

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