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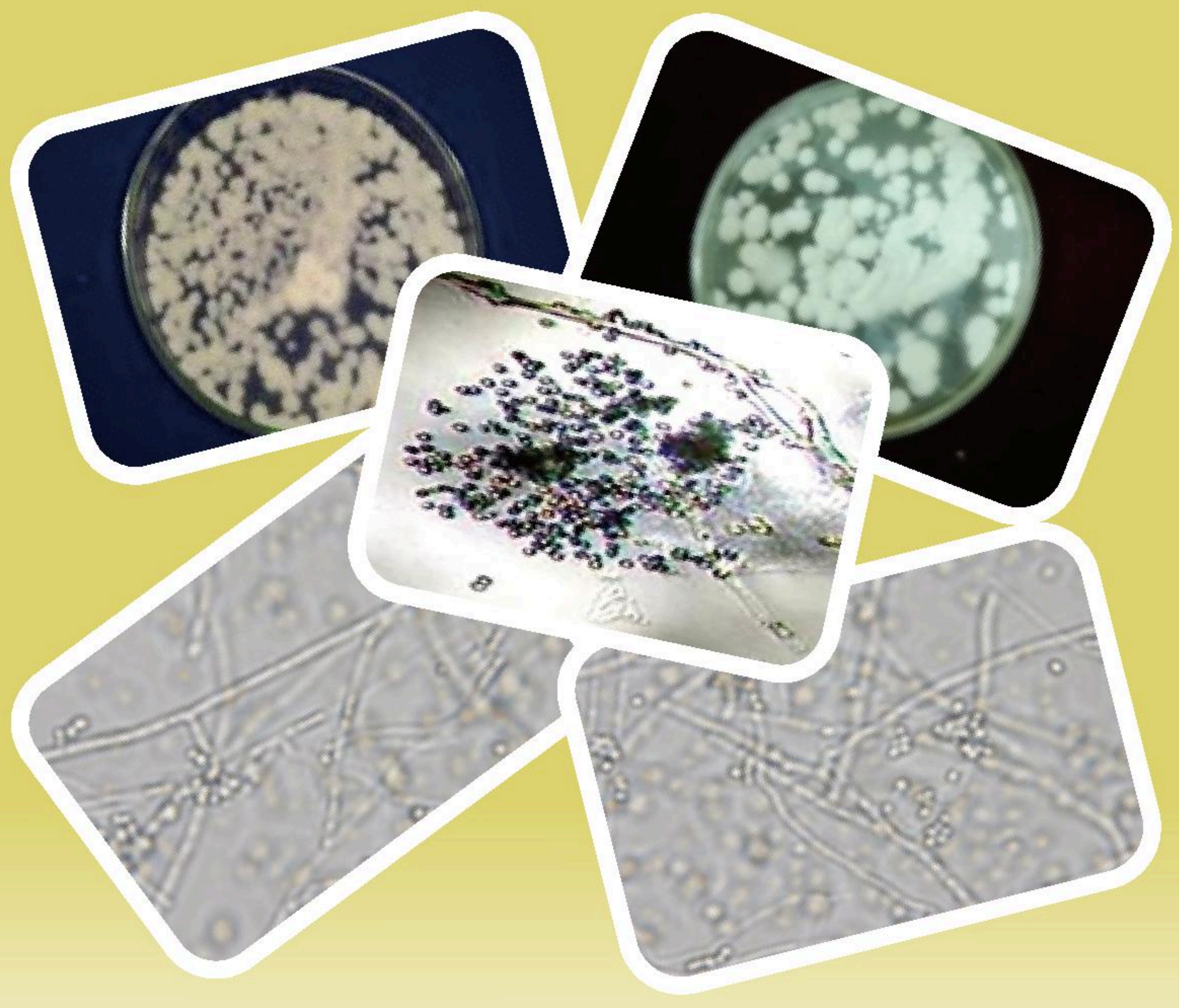

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Keterangan foto cover depan: Morfologi jamur *Beauveria* spp. A dan B= koloni Beuveria pada agar media, Sesuai dengan makalah pada halaman 175.

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COOKING CHARACTERIZATION OF ARROWROOT *(Maranta arundinaceae)* NOODLE IN VARIOUS ARENGA STARCH SUBSTITUTION [Karakteristik Pemasakan Mie Garut (*Maranta arundinaceae*) Pada Variasi Subtitusi Pati Aren]

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ABSTRAK

Garut (*Marantha arundinaceae L.)* merupakan umbi yang tersebar di berbagai wilayah Indonesia dan dapat diolah untuk berbagai produk pangan, salah satunya mie. Kandungan amilosa umbi garut relatif rendah, sehingga untuk mendapatkan mie dengan karakteristik yang baik perlu disubstitusi dengan bahan lain yang mempunyai kadar amilosa relatif tinggi. Pati aren dapat digunakan sebagai substitusi karena memiliki kandungan amilosa yang tinggi. Penelitian ini bertujuan untuk mengetahui pengaruh substitusi pati aren terhadap kualitas mie tepung garut yang dihasilkan seperti penampakan, sifat pemasakan, sifat tekstural, dan sifat sensoris. Pembuatan produk dilakukan dengan lima variasi pati aren: tepung garut yaitu 0:100, 25:75, 50:50, 75:25, dan 100:0.. Hasil penelitian menunjukkan bahwa substitusi pati aren pada mie garut mempengaruhi warna, kuat patah, waktu pemasakan, kehilangan padatan akibat pemasakan, *swelling index*, rasio pengembangan, *tensile strength,* elongasi dan kelengketan. *Noodle* komposit yang memiliki karakteristik mendekati produk komersial adalah *noodle* komposit pati aren:tepung garut 75:25 dan 100:0. Produk *noodle* komposit yang paling disukai panelis adalah *noodle* komposit pati aren:tepung garut 75:25.

Kata kunci: garut, tepung, mie, pati aren

ABSTRACT

Arrowroot (*Maranta arundinaceae*) tuber has traditionally been used by Indonesian people as a source of carbohydrate in their food diet. It will be likely more preservable and flexible when the tuber is processed into flour as an alternative raw food material. Arrowroot flour should be mixed with other material that have high amylose content for making noodles, thus the noodles have good quality almost same as commercial product. The objective of this study was to investigate the effect of arenga starch substitution on the arrowroot flour noodle qualities including appearance, cooking, textural and sensory properties. Noodle was made with five variation of arrowroot flour and arenga starch composition *i.e.* 0:100, 25:75, 50:50, 75:25, 100:0. Characterization of noodle qualities and hedonic test of noodle were analyzed. The results show that arrowroot flour substitution affects noodle qualities such as color, brittleness, cooking time, cooking loss, swelling index, expantion ratio, tensile strength, elongation and stickiness. Noodles that have characteristic nearest to commercial products and the most favored product by panelists was the mixture of arrowroot flour 25: arenga starch 75.

Keywords: arrowroot, flour, noodle, arenga starch

INTRODUCTION

Tuber is one of alternative carbohydrate food sources. Tubers are usually fried, boiled, steamed or baked to consume. There are a lot of tubers in Indonesia such as cocoyam, arrowroot, canna, long yam, and black potato. Processing tuber to flour could increase tuber shelf life and economic value (Richana and Sunarti, 2004). Arrowroot (*Maranta arundinacea*) as a carbohydrate food source is potential to substitute wheat and rice, to diversivy staple food, and as raw material for industry.

Arrowroot is an herbaceous, tropical perennial plant, with a creeping rhizome, indigenous from tropical America. It has fleshy cylindrical tuber with scar rings; these are leftovers of large thin scales. The stem reaches 6 feet and has creamy white flowers. It has numerous, ovale leaves, 2 to 10 inches, with long sheaths that often envelope the stem. Arrowroot needs 6-12 months to harvest. Starch is usually extracted from rhizomes not older than 1 year. Arrowroot starch as high quality starch can be used as a thickener for sauce and gravies. It thickens at a lower temperature than corn flour or cornstarch does and also used to make clear glazes for fruit pies (Anonymous, 2013).

Arrowroot can be found in almost all islands in Indonesia, scattered from the coast to the mountains. Based on arrowroot potential as carbohydrate source, study to processing arrowroot flour to specific food such as noodle was important. Noodle is one of popular food in Indonesia, because its taste and practical in preparation. According to BPS (2013),

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noodle consumption in Indonesia reached 80 grams/ capita/week both in rural and urban areas. Indonesia is the 2nd largest noodle consuming country in the world after China. While raw material for noodle production were still imported. Utilization *Arrowroot* as a noodles was expected could increase economic and benefit value of this tuber. In noodle production, amylose and amylopectin give big impact on product characteristic. Characteristic of amylose and amylopectin in water and their structure has a specific function. Noodle need raw materials with high amylose content because it will make noodle properties more supple and elastic (Radityo, 2010).

Though it is known that amylose content of starch tubers including arrowroot relatively low. So that need substitution from other materials with relatively high amylose content to be raw material for noodle.Arenga starch used mainly for making vermicelli, hung kwe, and cendol (Haryadi, 2002). Amylose content in arenga starch is 33.95% and it was relatively high. Arenga starch has type C amylograph curve, with limited inflation rate of granules and low breakdown so suitable for noodle raw material (Rahim, 2007). Substitution of arenga starch is expected to improve the characteristics of arrowroot noodle. Therefore the aim of this research was to investigate the effect of arenga starch substitution on arrowroot flour noodle qualities include appearance, cooking properties, textural properties and sensory properties.

MATERIALS AND METHOD

Material

Arrowroot obtained from Mertelu Village, Gedangsari, Gunungkidul, Yogyakarta and then processed into flour by grating tuber followed by pressing and drying. Arenga starch was bought from home industry at Klaten, Central Java.

Noodle making

Noodle-making was done by modifying the noodle-making method on a large scale factory according Haryadi (2006). Five variations flour mixture *i.e.* 100% arenga starch; 25% *Arrowroot* flour:75% arenga starch; 50% *Arrowroot* flour:50% arenga starch; 75% *Arrowroot* flour:25% arenga starch; and 100% *Arrowroot* flour made into dough by adding water to flour with ratio mixture flour and water was 1:0.5. Dough was molded into pellets using Food Extruder PD-45N, La. Pramigianaa 15 mm diameter mold. Pellets steamed for 4 minutes to gelatinize starch. Gelatinization occurs only on the surface of pellet so that it can serve as an adhesive when it was made as noodle. Pellets then molded into noodle with diameter 0.7 mm and obtained raw noodle strands. Raw noodle steamed in a steamer for ±20 minutes. Noodle then dried in the cabinet dryer at 60°C for 6 hours until water level was ± 10%.

Cooking time

Determination of cooking time was conducted according to Collado*et al* (2001). Noodle samples were weighed 5g, then cut into 5 cm. Noodle was cooked in 200 ml of boiling distilled water in a glass cup with a lid. The optimum cooking time was determined by taking 1 piece of noodle every 15 second sand then pressed between two pieces of glass watch. The noodle became cooked when the middle of noodle was transparent and the noodle texture was softer.

Cooking loss

Cooking loss of noodles were determined according to Tan *et al* (2009). Noodle was weighed as much as 5 g, then cut into pieces 5 cm length. Noodle was cooked in 200 ml of boiling distilled water in a beaker glass with a lid for 1 minute above the optimum cooking time. Cooking noodle stopped by rinsed using cold water, then noodle was dried using filter paper. Cooking loss was determined by evaporating the water that was used for cooking and washing at 110°C. The residue obtained was weighed and determined as percent cooking loss.

Cooking loss (%) =((Weight dry residue)/ (weight before cooking)) × 100

Rehydration

Rehydration was determined according to Tan *et al* (2009). Noodle was weighed as much as 5 g (cut 2 cm) and then cooked in 150 ml of distillate water 1 minute above the optimum cooking time. Sample was then drained and dried with filter paper to remove water on the surface of noodle, then immediately weighed (W1 g). Noodle was dried againat

130°C until got constant weight (W2, g). Rehydration is determined based on the ratio of the amount of water from the noodle after cooking and the weight of dry material.

$$\text{Rehydration (\%)} = (W1-W2)/W2\times100$$

Swelling ratio

Diameter dry noodle and noodle after cooking was measured using a micrometer screw gauge type (Mitutoya, Japan). Swelling ratio (expansion ratio) of noodle defined as percentage ratio of diameter dry noodle and cooked noodle.

Textural Test

- Noodle samples that have been cooked in the optimum cooking time is clamped in the universal testing machine tools, then pulled with 5 kg force speed 1.00 mm / sec to drop. Maximum force at the time of breaking noodle expressed as tensile strength, while the elongation at break compared beginning noodle expressed as elongation percent.
- Adhesiveness (Chen et al., 2002)
  Adhesiveness noodle determined by taping two strands of noodle that has been cooked and removed from water, then pulled to separate them each other using universal testing machine. Measurements were made with speed 1.00 mm / sec and 5 kg load.

Sensory Test

Noodle composite was tested hedonic using human senses as a tool. The hedonic test is performed test with scoring method. This test was conducted to determine the level of panelist on sensory properties of aren - arrowroot noodle such as overall favorite, color, robustness, elasticity, adhesiveness, and surface smoothness. This test using 30 panelists and giving score 1-7 (1 = strongly dislike, 2 = dislike, 3 = slightly dislike, 4 = neutral, 5 = slightly like, 6 = like, 7 = very like). The purpose of the panelist were not trained was to predict the level of product acceptance in the market. Samples were presented to panelists representing 7 cooked noodle, consist of 5 samples were arrowroot flour noodle and 2 commercial noodle samples for comparison. Seven samples were served in a plastic bowl with the same color, along with neutralizing and accreditation forms.

Data Analysis

The experimental design used for the analysis of physicochemical and sensory properties are completely randomized design and 3 repetitions for each analysis. Data were analyzed One Way ANOVA analysis at a significance level of 95%, followed by Duncan method to distinguish the average value of each treatment.

RESULTS

Cooking time of noodle made from 100% arenga starch was longer due to more compact of high bonds between starch molecules. From the results of statistical analysis with $p<0.05$ (Table 1) indicates that there is a significant difference cooking time between commercial product and noodle sample, this was due to differences in raw materials used and the diameter of dried noodle. Commercial product has dried noodle with diameters smaller than diameter of sample noodle. The smaller noodle will facilitate faster water penetration during cooking, so cooking time will be shorter.

The higher concentration of *arrowroot* flour, cooking loss will be even greater. From the results of statistical analysis with $p<0.05$, it is concluded that mixing *arrowroot* starch and arenga starch in noodle-making influence on cooking loss. Cooking loss was influenced by raw materials used for noodle. Noodle produced from *arrowroot* flour with ratio 0%, 25%, 50%, 75%, and 100% had a higher cooking loss when compared to samples commercial noodles (Table 1). The higher number of *arrowroot* flour in the noodle, then the loss of dissolved solids (cooking loss) will be higher.

Higher weight of noodle after cooking desired by consumers (Guo et al., 2003). Statistical analysis showed that the ratio of flour mixture significantly affect the noodle rehydration. Rehydration properties of noodle was not significantly different from maize commercial noodle and rice commercial noodle (Table 1).

The higher ratio of arenga starch in the flour mixture will produce noodle with higher swelling ratio because the higher arenga starch has a low amylose content (Table 1). Results of statistical analysis with $p<0.05$ showed that arenga starch that used to substitute arrowroot flour in noodle did not significantly affect swelling ratio of noodle. The higher

COOKING PROPERTIES

Table 1. Cooking properties of *Arrowroot flour* and arenga starch noodle (Sifat pemasakan mie dari tepung garut yang disubstitusi dengan pati aren)

Noodle (Mie)	Cooking time (min) (Waktu pemasakan (menit))	Cooking loss (%) (Kehilangan padatan akibat pemasakan (%))	Rehydration (%) (Rehidrasi (%))	Swelling ratio (%) (Rasio pengembangan (%))
Arenga starch 100% (Pati aren 100%)	335[c]	10.1000[b]	174.93[e]	284.63[e]
Arrowroot flour 25%: arenga starch 75% (Tepung garut 25%:pati aren 75%)	345[c]	8.3000[b]	170.83[d]	258.56[d]
Arrowroot flour 50%: arenga starch 50% (Tepung garut 50%:pati aren 50%)	320[bc]	12.3100[c]	167.22[d]	244.84[cd]
Arrowroot flour 75%: arenga starch 25% (Tepung garut 75%:pati aren 25%)	305[b]	17.6800[d]	156.70[c]	235.20[bc]
Arrowroot flour 100% (Tepung garut 100%)	295[b]	31.0733[e]	144.21[a]	228.54[bc]
Maize commercial noodle (Mie pati jagung komersial)	70[a]	0.6667[a]	148.57[b]	226.87[b]
Rice commercial noodle (Mie beras komersial)	65[a]	1.4500[a]	160.00[c]	188.16[a]

The mean values (standard deviations) within the same row followed by different superscript letters differ significantly (P <0.05). (*Rata-rata nilai pada kolom yang sama dengan huruf yang berbeda mempunyai signifikansi yang sama*)

concentration of *arrowroot* flour in the noodle mixture resulting lower swelling ratio but gives no real difference. All samples noodle has swelling ratio value greater than maize commercial noodle and rice commercial noodle Results of statistical analysis with $p < 0.05$ shows the results of tensile strength were not significantly different for all composites except noodle arenga starch and arrowroot flour (100: 0). Noodle arenga starch and arrowroot flour (100:0) have higher tensile strength than other composite noodle. The higher arenga starch in the flour mixture, then the amylose content will be also higher. High amylose content causes more compact structure and higher tensile strength. Maize and rice commercial noodle have a tensile strength that is not significantly different from the composite noodle except palm starch noodle and arrowroot flour (100:0). Arrowroot flour substitution on starch noodle were significantly affect noodle elongation after cooking (Table 2).

The lower of arrowroot flour substitution on starch noodle were tend to have higher elongation. This was due to an increased amylose content in flour mixture. The higher amylose content, the bonds between starch molecules will be increased so elongation noodle was higher. All noodle composites have significantly different elongation with commercial products A and B. Results of statistical analysis (Table 2) shows a tendency that lower arrowroot flour substitution on arenga starch noodle, then the value of adhesiveness decrease. Noodle arenga starch and arrowroot flour (0: 100) have significantly different adhesiveness with noodle palm starch and arrowroot flour (100: 0). The high value of cooking loss and amylopectin in arenga starch and arrowroot flour (0: 100) noodle causes the surface of the noodle was very sticky. The higher value of adhesiveness on cooking loss suffered as a result of leaching from the surface starch noodle (Shiau and Yeh in Chin *et al*., 2012). Arenga starch has a high amylose content resulting noodle with low tackiness. Amylose have inter molecular bonding force stronger than the amylopectin thereby inhibiting leaching (Kim *et al*., 1996). Noodle arenga starch and arrowroot flour

Table 2. Textural properties *of arrowroot flour* and arenga starch noodle (*Sifat tekstural mie tepung garut dan pati aren*)

Noodle (Mie)	Stickiness (N) (Kelengketan (N))	Tensile strength (N) (Kuat tarik (N))	Elongation (%) (Kemampuan merenggang (%))
Arenga starch 100% (Pati aren 100%)	0.0056^{ab}	0.1938^{b}	28.75^{b}
Arrowroot flour 25% : arenga starch 75% (Tepung garut 25% : pati aren 75%)	0.0075^{abc}	0.1008^{a}	23.98^{ab}
Arrowroot flour 50%: arenga starch 50% (Tepung garut 50% : pati aren 50%)	0.0089^{cd}	0.0807^{a}	21.18^{ab}
Arrowroot flour 75%: arenga starch 25% (Tepung garut 75% : pati aren 25%)	0.0106^{d}	0.0779^{a}	17.70^{ab}
Arrowroot flour 100% (Tepung garut 100%)	0.0148^{e}	0.0684^{a}	11.54^{a}
Maize commercial noodle (Mie pati jagung komersial)	0.0053^{a}	0.0963^{a}	85.91^{c}
Rice commercial noodle (Mie beras komersial)	0.0078^{bc}	0.0707^{a}	83.78^{c}

The mean values (standard deviations) within the same row followed by different superscript letters differ significantly (P <0.05). (*Rata-rata nilai pada kolom yang sama dengan huruf yang berbeda mempunyai signifikansi yang sama)*

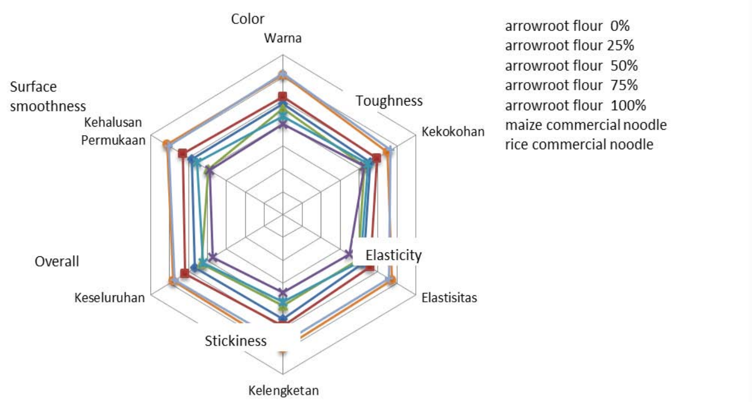

Figure 1. Spiderweb hedonic test by 30 panelists (*spiderweb tes hedonic bagi 30 panelis*)

(75:25) has a value of stickiness that not significantly different from maize and rice commercial noodle.

Hedonic test resulted by 30 panelists for attribute color, robustness, elasticity, tackiness, surface smoothness, and general acceptance/overall of composite noodle that can be used to predict the level of consumer acceptance when marketed (Figure 1). Noodle is expected to have a high level of preference. Further away from the center point of the graph indicates a higher level of preference. Maize commercial noodle and rice commercial noodle was preferred over composite noodle produced among attributes elasticity, tackiness, surface smoothness, and overall. While rice commercial noodle was prferred by panelist for color and robustness attributes. The most preferred composite noodle was composite noodle from arenga starch and arrowroot flour (75:25). While the composite noodle products that least favored was a composite noodle form arenga starch and arrowroot flour (25:75). This is indicated by the value of all attributes were low compared to other composite noodle.

DISCUSSION

Cooking time determined subjectively based on texture and appearance of noodle. The development of transparent appearance and disappearance in the middle of noodle indicates cooking quality of noodle (Hou, 2011). Water penetration in amylose form three-dimensional structures that trap water is also influenced by particle size of raw materials used (arrowroot starch and arenga starch). Smaller size of flour particle will lead easier penetration of water into noodle. Amylose can form hydrogen bonds between molecules and cause gel formation, and high solubility, whereas amylopectin is difficult to form hydrogen bonds between molecules (Hodge and Osman, 1976).

According to Rahim *et al*. (2009), starch with high amylopectin content will be difficult to form a gel, and may cause the product to be sticky, then the noodle absorbs less water, so it takes a long time to cook. This is consistent with the study of Alam (2008) which compares noodle made with arenga starch mixed with tapioca starch. Tapioca starch has low amylose and arenga starch has high amylose. The higher level of tapioca starch in noodle causing higher cooking time as well.

At cooking stage, the solid fraction will be separated into noodle cooking water. Robustness of noodle will be reduced and more slippery, while the cooking water will become cloudy. Quantitatively, it can becounted as "Cooking loss" (Tan *et al*., 2009). Cooking loss and rehydration is influenced by degree of recrystallization of starch and by gel formed properties (Tan *et al*, 2009). This situation is undesirable because it would lead to decrease quality of cooking noodle. Starch with low amylose content cause low retrogradation rate, resulting in a weak gel structure and not strong in pulling (Lii and Chang, 1981).

Li and Vasanthan (2003) states that the greater amylose content of material then the cooking loss is relatively smaller. High amylose content in starch will produce a strong gel structure to hold water so less solids lost to cooking water. Swelling ratio and rehydration will proportional to total solid loss. Therefore, high value of cooking loss was unwanted in the quality of noodle. During cooking or when in water, noodle will absorb water so it will swell and become softer (Chen *et a*l, 2002). Rehydration is percent weight gain due to noodle water absorption during cooking, commonly referred as swelling index or cooking weight (Tan *et al*, 2009). The lower value of rehydration noodle, the noodle texture will be firm. The high proportion of short chain amylopectin can cause a decrease in crystallinity of starch granule. This decreasing causing granule density loss, and fast water diffuses into granules (Huang, 2010). Thus the higher amylopectin, will resulting higher swelling ratio. Guo, *et al* (2003) stated that the higher amylopectin causing water absorption rate will be high and weight of noodle after cooking will increase. Chen *et al*., 2002 also stated that when starch gel formation was solid, the value of swelling index was lower.

Noodle is cooked at 100°C in boiling water, the starch gelatinization was occurred. During gelatinization process of starch, amylose starch molecules will leaching to the water and water will more penetrated into the noodle. The more amylose, the greater loss and rehydration noodle during cooking. Amylose molecules form crystalline regions are compact so it is difficult to be penetrated by water, enzymes and chemicals. The opposite occurs in the amorphous or less compact (Alam, 2008). The amorphous regions are composed of many amylopectin.

The swelling ratio is strongly influenced by the noodle ability to absorb water. Swelling ratio (expansion ratio) is ratio of development diameter dry noodle and cooked noodle (Nwabueze and Anoruoh, 2011). The higher noodle rehydration, the greater value of swelling ratio as noodle will absorb more water and noodle becomes fluffy. The higher swelling ratio, the product will be softer, but the strength and elasticity of the product will be reduced (Sandhu *et al*, 2010). Guo *et al* (2003) stated that an increase in swelling ratio, decreased gel consistency, decreased levels of gelatinization and noodle becomes soft and easily broken caused by amylose content

One factor that affect swelling ratio of noodle is the ratio of amylose and amylopectin. Huang (2010) mentions that amylopectin has higher ability to bind water than amylose. The higher amylose content, the lower swelling ratio. This was due to the amylose molecules are linear thus strengthening its internal network. The strong internal network blockmore difficult to break up when withdrawn and not easily destroyed during the cooking process. Xu *et al* (2005) states that tensile strength increases with the addition of starch. One constituent amylose starch that affect the strength of the product when withdrawn (Chansri *et al*, 2005). Low straight structures in red bean starch cause low retrogradation of starch on noodle (Tan *et al*, 2009). Rahim (2008) states that high levels of amylose retrogradation causing noodle structure more rigid, robust and compact.

Research Li and Vasanthan (2003) also showed that the native starch noodle of field pea has a higher tensile strength than the noodle from the oxidized starch. The low tensile strength in noodle from oxidized starch caused by depolymerization of starch that is hindering the process of retrogradation of amylose. Zhang *et al* (2011) reported that elevated levels of amylose cause an increase in peak viscosity flour. Charles *et al.* (2007) stated that the addition of gum into starch suspension causes an increase in peak viscosity which plays a role in the increase in tensile strength. In addition, protein content in raw materials also affect tensile strength due to the formation of gluten (Ritthiruangdej *et al*., 2011).

Elongation shows comparison of noodle maximum length before and after tensile. Noodle elongation is proportional to the tensile strength. Elongation noodle influenced by the content of amylose and amylopectin. Amylose ability to form a crystalline structure which is more compact causing increased power creep noodle strands. Research by Muhandri *et al*. (2013) showed that the addition of guar gum can increase the elongation noodle. It is caused by the binding ability of guar gum in water so that the water is distributed evenly and the bonds between the starch granules become stronger. Elongation values are also influenced by cooking time and water absorption. Both of these factors have different responses to noodle textural properties (Roisah, 2009).

Stickiness test is used to determine the noodle surface adhesion by attaching two strands of noodle, and then given a tensile force to remove noodle mutually attached. High adhesiveness cause noodle strands attached to each other making it difficult to separate. Noodle which has a low adhesiveness value is expected to have good eating quality (Subarna *et al*., 2012). Adhesiveness noodle gelatinization influenced by the level and ratio of amylose-amylopectin. The higher degree of gelatinization, the more amylose out of the starch granules. This causes the hydrogen bonds between amylose increasingly formed when retrogradation thereby reducing the stickiness of noodle (Subarna et al., 2012). Research by Subarna *et al*. (2012) showed that high temperatures can increase the stickiness of noodle gelatinization. Amylopectin forming amorphous structure less compact so it was easy to absorb water (Haryadi, 2006). Excessive water absorption causing noodle soft and sticky (Tan *et al*., 2009). Research by Chung *et al*. (2012) stated that high cooking loss on the noodle of germinated brown rice has a more sticky surface. This is caused by starch was susceptible to leaching during cooking so water molecules easily penetrate into noodle.

Conclusion

The higher concentration of arrowroot flour caused F break, swelling index, expansion ratio, tensile strength and elongation getting low. The water content, cooking loss, cooking time and cohesiveness were increased as the arrowroo*t* flour substitution ratio increase. Noodle from 25% arrowroot flour and 75% arenga starch has better characteristic than other arrowroot noodles.

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Pedoman Penulisan Naskah Berita Biologi

Berita Biologi adalah jurnal yang menerbitkan artikel kemajuan penelitian di bidang biologi dan ilmu-ilmu terkait di Indonesia. Berita Biologi memuat karya tulis ilmiah asli berupa makalah hasil penelitian, komunikasi pendek dan tinjauan kembali yang belum pernah diterbitkan atau tidak sedang dikirim ke media lain. Masalah yang diliput, diharuskan menampilkan aspek atau informasi baru.

Tipe naskah

1. **Makalah lengkap hasil penelitian (*original paper*)**
   Naskah merupakan hasil penelitian sendiri yang mengangkat topik yang *up-todate*. Tidak lebih dari 15 halaman termasuk tabel dan gambar. Pencantuman lampiran seperlunya, namun redaksi berhak mengurangi atau meniadakan lampiran.
2. **Komunikasi pendek (*short communication*)**
   Komuniasi pendek merupakan makalah hasil penelitian yang ingin dipublikasikan secara cepat karena hasil termuan yang menarik, spesifik dan baru, agar dapat segera diketahui oleh umum. Artikel yang ditulis tidak lebih dari 10 halaman. Hasil dan pembahasan boleh digabung.
3. **Tinjauan kembali (*review*)**
   Tinjauan kembali merupakan rangkuman tinjauan ilmiah yang sistematis-kritis secara ringkas namun mendalam terhadap topik penelitian tertentu. Hal yang ditinjau meliputi segala sesuatu yang relevan terhadap topik tinjauan yang memberikan gambaran '*state of the art*', meliputi temuan awal, kemajuan hingga issue terkini, termasuk perdebatan dan kesenjangan yang ada dalam topik yang dibahas. Tinjauan ulang ini harus merangkum minimal 30 artikel.

Struktur naskah

1. **Bahasa**
   Bahasa yang digunakan adalah bahasa Indonesia atau Inggris yang baik dan benar.
2. **Judul**
   Judul harus singkat, jelas dan mencerminkan isi naskah diikuti oleh nama dan alamat surat menyurat penulis. Nama penulis untuk korespondensi diberi tanda amplop cetak atas (*superscript*).
3. **Abstrak**
   Abstrak dibuat dalam dua bahasa, bahasa Indonesia dan Inggris. Abstrak memuat secara singkat tentang latar belakang, tujuan, metode, hasil yang signifikan, kesimpulan dan implikasi hasil penelitian. Abstrak berisi maksimum 200 kata, spasi tunggal. Di bawah abstrak dicantumkan kata kunci yang terdiri atas maksimum enam kata, dimana kata pertama adalah yang terpenting. Abstrak dalam bahasa Inggris merupakan terjemahan dari bahasa Indonesia. Editor berhak untuk mengedit abstrak demi alasan kejelasan isi abstrak.
4. **Pendahuluan**
   Pendahuluan berisi latar belakang, permasalahan dan tujuan penelitian. Sebutkan juga studi terdahulu yang pernah dilakukan.
5. **Bahan dan cara kerja**
   Pada bagian ini boleh dibuat sub-judul yang sesuai dengan tahapan penelitian. Metoda harus dipaparkan dengan jelas sesuai dengan standar topik penelitian dan dapat diulang oleh peneliti lain. Apabila metoda yang digunakan adalah metoda yang sudah baku cukup ditulis sitasi dan apabila ada modifikasi harus dituliskan dengan jelas bagian mana dan apa yang dimodifikasi.
6. **Hasil**
   Sebutkan hasil-hasil utama yang diperoleh berdasarkan metoda yang digunakan. Apabila ingin mengacu pada tabel/grafik/diagram atau gambar uraikan hasil yang terpenting dan jangan menggunakan kalimat 'Lihat Tabel 1'. Apabila menggunakan nilai rata-rata harus menyebutkan standar deviasi.
7. **Pembahasan**
   Jangan mengulang isi hasil. Pembahasan mengungkap alasan didapatkannya hasil dan apa arti atau makna dari hasil yang didapat tersebut. Bila memungkinkan, bandingkan hasil penelitian ini dengan membuat perbandingan dengan studi terdahulu (bila ada).
8. **Kesimpulan**
   Menyimpulkan hasil penelitian, sesuai dengan tujuan penelitian, dan penelitian berikut yang bisa dilakukan.
9. **Ucapan terima kasih**
10. **Daftar pustaka**
    Tidak diperkenankan untuk mensitasi artikel yang tidak melalui proses peer review. Apabila harus menyitir dari "Laporan" atau "komunikasi personal" dituliskan *'unpublished'* dan tidak perlu ditampilkan di daftar pustaka. Daftar pustaka harus berisi informasi yang *up to date* yang sebagian besar berasal dari *original papers*. Penulisan terbitan berkala ilmiah (nama jurnal) tidak disingkat.

Format naskah

1. Naskah diketik dengan menggunakan program Word Processor, huruf New Times Roman ukuran 12, spasi ganda kecuali Abstrak. Batas kiri -kanan atas-bawah masing-masing 2,5 cm. Maksimum isi naskah 15 halaman termasuk ilustrasi dan tabel.
2. Penulisan bilangan pecahan dengan koma mengikuti bahasa yang ditulis menggunakan dua angka desimal di belakang koma. Apabila menggunakan bahasa Indonesia, angka desimal menggunakan koma (,) dan titik (.) bila menggunakan bahasa Inggris. Contoh: Panjang buku adalah 2,5cm. Lenght of the book is 2.5 cm. Penulisan angka 1-9 ditulis dalam kata kecuali bila bilangan satuan ukur, sedangkan angka 10 dan seterusnya ditulis dengan angka. Contoh lima orang siswa, panjang buku 5 cm.
3. Penulisan satuan mengikuti aturan *international system of units*.
4. Nama takson dan kategori taksonomi merujuk kepada aturan standar termasuk yang diakui. Untuk tumbuhan *International Code of Botanical Nomenclature* (ICBN), untuk hewan *International Code of Zoological Nomenclature* (ICZN), untuk jamur *International Code of Nomenclature for Algae, Fungi and Plant* (ICFAFP), *International Code of Nomenclature of Bacteria* (ICNB), dan untuk organisme yang lain merujuk pada kesepakatan Internasional. Penulisan nama takson lengkap dengan nama author hanya dilakukan pada bagian deskripsi takson, misalnya pada naskah taksonomi. Sedangkan penulisan nama takson untuk bidang lainnya tidak perlu menggunakan nama author.
5. Tata nama di bidang genetika dan kimia merujuk kepada aturan baku terbaru yang berlaku.
6. Ilustrasi dapat berupa foto (hitam putih atau berwarna) atau gambar tangan (*line drawing*).
7. Tabel
   Tabel diberi judul yang singkat dan jelas, spasi tunggal dalam bahasa Indonesia dan Inggris, sehingga Tabel dapat berdiri sendiri. Tabel diberi nomor urut sesuai dengan keterangan dalam teks. Keterangan Tabel diletakkan di bawah Tabel. Tabel tidak dibuat tertutup dengan garis vertikal, hanya menggunakan garis horisontal yang memisahkan judul dan batas bawah. Paragraf pada isi tabel dibuat satu spasi.
8. Gambar
   Gambar bisa berupa foto, grafik, diagram dan peta. Judul ditulis secara singkat dan jelas, spasi tunggal. Keterangan yang menyertai gambar harus dapat berdiri sendiri, ditulis dalam bahasa Indonesia dan Inggris. Gambar dikirim dalam bentuk .jpeg dengan resolusi minimal 300 dpi.
9. Daftar Pustaka
   Sitasi dalam naskah adalah nama penulis dan tahun. Bila penulis lebih dari satu menggunakan kata 'dan' atau *et al.* Contoh: (Kramer, 1983), (Hamzah dan Yusuf, 1995), (Premachandra *et al.,* 1992). Bila naskah ditulis dalam bahasa Inggris yang menggunakan sitasi 2 orang penulis

maka digunakan kata 'and'. Contoh: (Hamzah and Yusuf, 1995).

a. Jurnal
   Nama jurnal ditulis lengkap.
   Premachandra GS, H Saneko, K Fujita and S Ogata. 1992. Leaf Water Relations, Osmotic Adjustment, Cell Membrane Stability, Epi-cutilar Wax Load and Growth as Affected by Increasing Water Deficits in Sorghum. *Journal of Experimental Botany* **43,** 1559-1576.
b. Buku
   Kramer PJ. 1983. *Plant Water Relationship*, 76. Edisi ke-(bila ada). Academic, New York.
c. Prosiding atau hasil Simposium/Seminar/Lokakarya.
   Hamzah MS dan SA Yusuf. 1995. Pengamatan Beberapa Aspek Biologi Sotong Buluh *(Sepioteuthis lessoniana)* di Sekitar Perairan Pantai Wokam Bagian Barat, Kepulauan Aru, Maluku Tenggara. *Prosiding Seminar Nasional Biologi XI,* Ujung Pandang 20-21 Juli 1993. M Hasan, A Mattimu, JG Nelwan dan M Litaay (Penyunting), 769-777. Perhimpunan Biologi Indonesia.
d. Makalah sebagai bagian dari buku
   Leegood RC and DA Walker. 1993. Chloroplast and Protoplast. In: *Photosynthesis and Production in a Changing Environment.* DO Hall, JMO Scurlock, HR Bohlar Nordenkampf, RC Leegood and SP Long (Eds), 268-282. Champman and Hall. London.
e. Thesis dan skripsi.
   Keim AP. 2011. Monograph of the genus *Orania* Zipp. (Arecaceae; Oraniinae). University of Reading, Reading. [PhD. Thesis].
f. Artikel online.
   Artikel yang diunduh secara online mengikuti format yang berlaku misalnya untuk jurnal, buku atau thesis, serta dituliskan alamat situs sumber dan waktu mengunduh. Tidak diperkenankan untuk mensitasi artikel yang tidak melalui proses *peer review* atau artikel dari laman web yang tidak bisa dipertangung jawabkan kebenarannya seperti wikipedia.
   Forest Watch Indonesia[FWI]. 2009. Potret keadaan hutan Indonesia periode 2000-2009. *http://www.fwi.or.id*. (Diunduh 7 Desember 2012).

Formulir persetujuan hak alih terbit dan keaslian naskah

Setiap penulis yang mengajukan naskahnya ke redaksi Berita Biologi akan diminta untuk menandatangani lembar persetujuan yang berisi hak alih terbit naskah termasuk hak untuk memperbanyak artikel dalam berbagai bentuk kepada penerbit Berita Biologi. Sedangkan penulis tetap berhak untuk menyebarkan edisi cetak dan elektronik untuk kepentingan penelitian dan pendidikan. Formulir itu juga berisi pernyataan keaslian naskah, yang menyebutkan bahwa naskah adalah hasil penelitian asli, belum pernah dan sedang diterbitkan di tempat lain.

Penelitian yang melibatkan hewan

Untuk setiap penelitian yang melibatkan hewan sebagai obyek penelitian, maka setiap naskah yang diajukan wajib disertai dengan '*ethical clearance approval*' terkait *animal welfare* yang dikeluarkan oleh badan atau pihak berwenang.

Lembar ilustrasi sampul

Gambar ilustrasi yang terdapat di sampul jurnal Berita Biologi berasal dari salah satu naskah. Oleh karena itu setiap naskah yang ada ilustrasi harap mengirimkan ilustrasi dengan kualitas gambar yang baik disertai keterangan singkat ilustrasi dan nama pembuat ilustrasi.

Proofs

Naskah *proofs* akan dikirim ke author dan diwajibkan membaca dan memeriksa kembali isi naskah dengan teliti. Naskah proofs harus dikirim kembali ke redaksi dalam waktu tiga hari kerja.

Naskah cetak

Setiap penulis yang naskahnya diterbitkan akan diberikan 1 eksemplar majalah Berita Biologi dan reprint. Majalah tersebut akan dikirimkan kepada *corresponding author*.

Pengiriman naskah

Naskah dikirim dalam bentuk .doc atau .docx.

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