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# Modification of Rice Noodle Physical, Cooking Properties and Microstructure through Xanthan Gum and Moisture Control

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**ABSTRACT:** Noodles have been a staple dish in Asia since ancient times, taking numerous shapes and forms. Presentation, texture, eating quality, and cooking qualities are all factors that influence its quality. Noodles can be made using either traditional or extrusion methods. Pasta extruders are modern machines that create pasta in a variety of shapes. Xanthan gum is a hydrocolloid that enhances the physical properties of rice. Its functions include enhancing texture quality, increasing air binding ability, and stabilizing dough structure. The amount of xanthan gum used influences not just the physical properties of rice, but also the feed composition. The air feed content is a crucial factor influencing the flavor of noodles. Using a pasta extrusion machine, this study investigated the influence of xanthan gum (0%, 1%, 1.5%, and 2%) and feed moisture (35%, 40%, and 45%) on rice noodle characteristics. This study found that the optimum treatment was xanthan gum 1.5% and feed moisture 40%. This treatment has the following values: cooking time 5.83 minutes, cooking loss 5.95%, water absorption 274.12%, hardness 0.3887, adhesiveness = -0,0027 L = 75.51, a = -0.53 and b = 8.92.

**KEYWORDS:** Cooking qualities, pasta extrusion, traditional method, water absorption, xanthan gum

## INTRODUCTION

Rice noodles are the second-most consumed rice product in Asia after plain. Rice noodles have been a staple in the East and Southeast Asian countries since ancient times. Rice noodles varieties and qualities are easily variable by modifying the type of ingredients, formula compositions, and processing conditions (Fu, 2008). In a market research published by Grand View Research Inc. (2016), it was estimated that the market size for rice noodles inEurope and Asia Pacific would reach USD 1.69 billion in 2014 with a forecasted increaseto USD 3.6 billion by 2022. It is interesting to note that China and India are expected to lead the market expansion to other parts of the world. The key factors influencing the expansionof this rice noodles market may be attributed to the awareness of consumers to maintaining ahealthy lifestyle.

Different rice cultivars have different ratios of amylose and amylopectin in their starch granules, which in turn determine the structural network strength of the noodles. The rice starch gel network is weaker than other types of starch gel, especially compared to those made of wheat. This is due to the lack of gluten in rice starch, which requires amylose and amylopectin crystallites to link strongly at the junction zones to create a continuous network (Mestres, 1988). Porang (*Amorphophallus Muelleri* B) is one of the local raw material that has potential for improving rice noodle textures in gel texture formation. This material acts as the hydrocolloid in konjac flour. Due to the presence of hydroxyl groups, it can increase the affinity for binding water molecules. Hydroxyl group that contain in a polymer, makes become more hydrophilic (USDA, 2020). The gel formed by water bound in glucomannan is more stable with the addition of $Ca(OH)_2$, which converts the gel into a thermo-irreversible state which is expected to prevent rice noodles from deforming.

Extrusion technique is hereby suggested for rice noodles production to overcome the drawbacks of the traditional methods. Therefore, this study was performed to obtain an appropriate formulation in the use of Porang Glucomannan Gel and Calcium Hydroxide to produce rice noodles with good physical and cooking characteristics. In this study, rice noodles will be prepared using pasta extrusion technology with additional ingredients are expected to improve the physicochemical attributes of rice-based extrudates.

## MATERIALS AND METHODS

### Location and Time

This research was carried out in the AR 112 Laboratory, FP 108 Laboratory, and FP 202Laboratory, Department of Food Science, National Pingtung University of Science and Technology. The study began in January 2021 – August 2021.

## MATERIALS AND METHODS

### Materials

Materials used for the production of noodle are white rice Japonica, Xanthan Gum, Emulsifier and Calcium hydroxide.

### Methods

Cooking quality of rice noodle: Cooking Properties (cooking time and loss), Water Absorption Index (WAI), Color, and Laser Microscope.

### Experiment Designs

This research has two factors. Those are amount of xanthan gum (X) and amount of feed moisture (F). Amount for the xanthan gum are 1, 1.5 and 2%. Meanwhile for the feed moisture are 35%, 40%, and 45%. The control treatment that used in this experiment is treatment without xanthan gum and with feed moisture factor that already used. The results are statistically analyzed using Minitab 17 Software. Analysis of variance (ANOVA) is used to determine significant difference between the results and Duncan's test was used to separate the mean with a significance level of 0.05. Each experiment is analyzed by responses.

| **Feed Moisture (%)** | | | |
|---|---|---|---|
| Xanthan Gum (%) | 35 | 40 | 45 |
| 0 (Control) | X0F1 | X0F2 | X0F3 |
| 1 | X1F1 | X1F2 | X1F3 |
| 1,5 | X2F1 | X2F2 | X2F3 |
| 2 | X3F1 | X3F2 | X3F3 |

Treatments:
X0F1: Xanthan gum 0% and feed moisture 35%; X1F1: Xanthan gum 1% and feed moisture 35%;
X2F1: Xanthan gum 1,5% and feed moisture 35%; X3F1: Xanthan gum 2% and feed moisture 35%;
X0F2: Xanthan gum 0% and feed moisture 40%; X1F2: Xanthan gum 1% and feed moisture 40%;
X2F2: Xanthan gum 1,5% and feed moisture 40%; X3F2: Xanthan gum 2% and feed moisture 40%;
X0F3: Xanthan gum 0% and feed moisture 45%; X1F3: Xanthan gum 1% and feed moisture 45%;
X2F3: Xanthan gum 1,5% and feed moisture 45%;X3F3: Xanthan gum 2% and feed moisture 45%.

### Dough and Rice Noodles Making

In this research, rice noodle is made by mixing rice flour (300 g), calcium hydroxide 0,1%(0,3 g), and shortening 2,5% (7,5 g) with xanthan gum and water used for the factors. The amount of xanthan gum that is used is 0% (as control), 1%, 1,5% and 2%. Total water content that used for making the dough are 35%, 40%, and 45%. The first step of makingrice noodle, mixed the rice flour and other materials manually by spoon for 5 minutes. Then, the dough is transferred into pasta extruder machine. The noodle came out through the die and will be shaped long based on the die that is used. After the noodles, be taken out from pasta extruder, the noodle is dried using cabinet dryer on $55^0$ C for 4 hours. After that, the dried noodle stored under ambient conditions for the subsequent use of the study.
The dried rice noodle is obtained, and applied for the measurement of cooking properties (cooking time and loss), Water Absorption Index (WAI), Texture Profile Analysis, color (L, a, b), and Laser Microscope.

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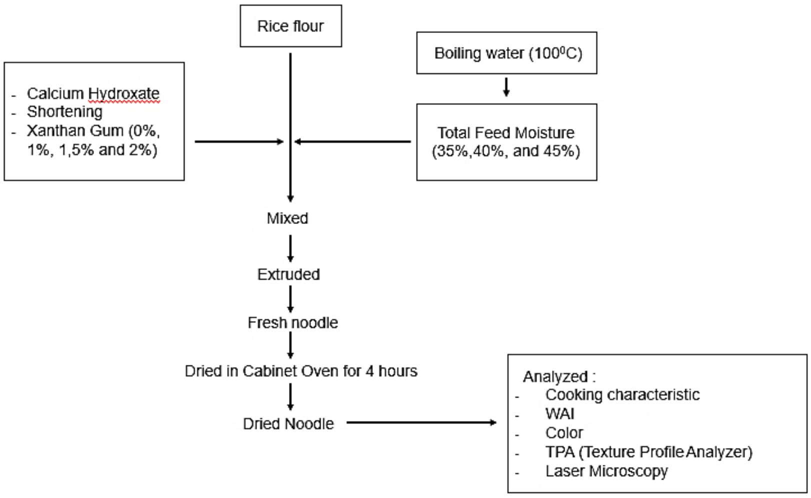
**FLOW CHART**




**RESULTS AND DISCUSS**

**Table 1. Effect of extrusion process on physical characteristics**

| Sample | Hardness (kgf) | Adhesiveness | Springness |
|---|---|---|---|
| X0F1 | - | - | - |
| X0F2 | - | - | - |
| X0F3 | - | - | - |
| X1F1 | 0,176 ± 0,038 | -0,0015 ± 0,0002 | 0,7558 ± 0,195 |
| X1F2 | 0,359 ± 0,026 | -0,0033 ± 0,0021 | 0,8720 ± 0,033 |
| X1F3 | 0,372 ± 0,254 | -0,0038 ± 0,0031 | 0,8232 ± 0,093 |
| X2F1 | 0,210 ± 0,060 | -0,0012 ± 0,0001 | 0,7289 ± 0,181 |
| X2F2 | 0,389 ± 0,263 | -0,0027 ± 0,0008 | 0,7546 ± 0,202 |
| X2F3 | 0,446 ± 0,133 | -0,0038 ± 0,0003 | 0,7772 ± 0,068 |
| X3F1 | 0,311 ± 0,078 | -0,0002 ± 0,0000 | 0,5141 ± 0,054 |
| X3F2 | 0,471 ± 0,214 | -0,0018 ± 0,0002 | 0,6247 ± 0,026 |
| X3F3 | 0,531 ± 0,013 | -0,0008 ± 0,0001 | 0,6540 ± 0,080 |

**Hardness**

The effect of xanthan gum and feed moisture on the hardness of rice noodle can be seen inthe table 3. The hardness value is range between 0,176 – 0,531. Hardness is physical properties that is related to the strength of gel structure under compression and is the peak force during the first compression cycle (Chandra, 2015). The result shows that hardness value tend to increase as the addition of xanthan gum and feed moisture. While the tensile strength control sample (without xanthan gum) was not detected which might because of weak rice protein noodle in the absence of gluten. Kim & Yoo (2006) stated that xanthan gum has been reportedly be able to help gel matrix formation. The gel matrix will develop and getting better as the addition of xanthan gum. Water has big role in the noodle making process.

Starch granule present in the rice noodle, when heated above its gelatinization temperature with the present of excess water, starch granule imbibe water and swelled (Zhou *et al*., 2002). Due to that phenomenon, will make a formation of a strong intermolecular structure within the noodle string. This might be the factor that can increase the hardness of structure.

**Adhesiveness**

Table 1 shows the results for adhesiveness of rice noodle. According to Chandra (2015) themeaning of adhesiveness is the negative force area for the first bite and represents the work required to overcome the sticky forces between the surface of a food and the surface of probe with which the food comes into contact. The value of adhesiveness range between -0,0002 and -0,0038. The addition of xanthan gum is increasing the adhesiveness in the cooked rice noodle. This is opposite with the addition of feed moisture that as the level of feed moisture is added, the value of adhesiveness will decrease. Kasunmala *et al*., (2020) reported that the addition of xanthan gum caused increasing of adhesiveness in noodle strings and it also contribute to the stickiness properties of rice noodle. This also supported by Kraithong (2020) explain that xanthan gum has ability to absorb water (higher rehydration), this might be the cause of increasing adhesiveness or stickiness in rice noodle. The addition of feed moisture was using hot water ($100^0$ C) caused gelatinization that improves the bond inside starch granules. This will lead to the physical properties of noodles such adhesive, high firm, cohesiveness and chewable noodles.

**Springiness**

Table 1 shows the results for springiness of rice noodle. Springiness is textural parameter that related to elasticity of the food. It defines about the rate at which a deformed sample returns to its original size and shape. The higher value of springiness, it means require more mastication energy in the mouth (Chandra, 2015). The springiness value rangebetween 0,5141 – 0,8720. The addition of xanthan gum decreases the springiness value of rice noodle. Hydrocolloids have ability to facilitate the water absorption, increase the viscosity of the dough also the density of the treatments and decrease the springiness (Gomez *et al*., 2007).The addition of feed moisture will increase the springiness value of rice noodle. This result is related with Indiarto (2012) that explain about springiness or elasticity will increase with increasing water content.

**Table 2. Color Measurement**

| Sample | L | a | b |
|---|---|---|---|
| X0F1 | 81.01 ± 0.83 | -2.32 ± 0.17 | 15.79 ± 1.77 |
| X0F2 | 80.17 ± 2.25 | -2.05 ± 0.11 | 17.39 ± 0.44 |
| X0F3 | 85.64 ± 2.11 | -2.26 ± 0.08 | 14.92 ± 0.38 |
| X1F1 | 77.59 ± 1.34 | -0.56 ± 0.05 | 9.14 ± 0.24 |
| X1F2 | 75.51 ± 1.15 | -0.53 ± 0.05 | 8.92 ± 0.16 |
| X1F3 | 81.53 ± 1.98 | -1.05 ± 0.12 | 11.27 ± 0.03 |
| X2F1 | 82.44 ± 3.67 | -0.62 ± 0.00 | 11.11 ± 0.85 |
| X2F2 | 82.61 ± 0.73 | -0.27 ± 0.08 | 10.20 ± 0.07 |
| X2F3 | 85.48 ± 0.94 | -0.41 ± 0.01 | 7.34 ± 0.11 |
| X3F1 | 87.08 ± 3.32 | -0.29 ± 0.06 | 7.27 ± 0.57 |
| X3F2 | 86.14 ± 0.39 | -0.33 ± 0.01 | 7.73 ± 0.07 |
| X3F3 | 88.17 ± 1.60 | -0.23 ± 0.04 | 6.10 ± 0.28 |

The effects of xanthan gum and feed moisture on the color parameter of rice noodle can be seen in Table 2. The addition of xanthan gum and feed moisture can change the characteristic of rice noodle. Lightness (L) value of rice noodle range between 77,59 - 88,17. There is increasing in L value as the xanthan gum added. The addition of feed moisture cause increasing of L value rice noodle.

The value of a* represent variation from green to red. Rice noodle has value of a* color ranged from -2,32 to -0,23. Rice noodle has negative a* value, it implied that the color of noodle become greener. The addition of xanthan gum and feed moisture increase the value of a*.

The value of b* represent variation from yellow to red. Rice noodle has value of b* color ranged from 6,10 – 17,39. The rice noodle with xanthan gum addition has lower b* value compared with the control rice noodle (without xanthan gum). The addition of xanthan gum increased the b* value and reached its highest point at addition of 1,5% xanthan gum and lower b* value in 2% of xanthan gum addition. Xanthan gum had more effect on noodle color by increasing L and lowering b. Xanthan gum becomes an opaque colloid after being dissolved in water; this resulted in more opaque, whitish-color noodles.

**Table 3. Effect of extrusion process on cooking characteristics**

| Sample | Cooking Time (min) | Cooking Loss (%) | Water Absorption (%) |
|---|---|---|---|
| X0F1 | 3,83 ± 0,29 | 6,91 ± 3,22 | 250,91 ± 25,93 |
| X0F2 | 4,00 ± 0,00 | 7,35 ± 2,70 | 289,34 ± 46,40 |
| X0F3 | 4,50 ± 0,50 | 8,33 ± 2,54 | 323,68 ± 20,36 |
| X1F1 | 4,00 ± 0,29 | 8,52 ± 4,05 | 242,88 ± 0,707 |
| X1F2 | 4,50 ± 0,87 | 6,17 ± 1,68 | 250,30 ± 34,77 |
| X1F3 | 5,83 ± 0,29 | 2,36 ± 0,62 | 329,10 ± 47,40 |
| X2F1 | 4,50 ± 1,15 | 5,47 ± 1,14 | 273,37 ± 12,45 |
| X2F2 | 5,83 ± 1,44 | 5,95 ± 1,90 | 274,12 ± 71,08 |
| X2F3 | 5,50 ± 0,58 | 2,58 ± 0,75 | 303,04 ± 76,47 |
| X3F1 | 5,83 ± 0,58 | 4,16 ± 0,86 | 222,14 ± 0,81 |
| X3F2 | 5,50 ± 0,58 | 2,50 ± 0,57 | 216,22 ± 13,90 |
| X3F3 | 4,17 ± 0,76 | 2,83 ± 0,26 | 213,99 ± 45,64 |

**Water absorption (WA)**

The results of water absorption as shown in table 3, shows that the range between 213,99 - 329,10. As we can see from the table, the value of water absorption is increasing as addition of xanthan gum and then decrease after it reached addition ofxanthan gum 1,5%. The addition feed moisture will increase the value of water absorption. The results prove that xanthan gum be able to interact with amylopectin and cause to increase of viscosity and water absorption during heating process (Srikaeo et al., 2018). Inside the xanthan gum structure has double helical structure and multiple spiral polymer secondary structure form that in charge for improvement of water holding capacity (Pan, Ai, Wang, Wang, & Zhang, 2016). The increasing of water absorption value during addition of feed moisture shows that the water can penetrate well during cooking process and rice noodle can absorb the water.

**Cooking Time**

The effect of xanthan gum and feed moisture addition cooking time of rice noodle asseen on table 3 is average between 3,83-5,83 minutes. Addition of xanthan gum will increase the cooking time of the noodle. According to Kaur et al. (2015) the usage of hydrocolloid shows the result of dense matrix to the noodle structure. The increasing of feed moisture causes a longer cooking time. The more feed moisture added, will make the noodle become dense and it takes longer time for water tocook the noodle.

**Cooking Loss**

A noodle that has high cooking loss value indicates inferior quality that can be a result from low cohesiveness of raw materials which imparts to have high starch solubility and thereby turbid color in cooking water along with the sticky mouth feel. Table 3 shows the result of the cooking loss. The average value of cooking loss range between 2,36 - 8,53. The value of cooking loss in treated sample tend to decrease as xanthan is added, compared to control sample. The same phenomenon occurs to the sample that is added feed moisture, cooking loss is keeping decrease as addition of feed moisture. Hydrocolloids has ability to attach water molecules by its hydroxyl groups in their polymer chains. Hydrogen bonding that is formed among the polymer chains of hydrocolloids has ability to reduce the amount solid loss from the cooked noodle due to the formation between the polysaccharide and starch molecules (Kaur et al., 2015).

Temperature has an important role in gelatinization process. Hot water ($100^0$C) that is usedin this experiment, as more amount of hot water is added, the dough will get more gelatinized. According to Marti et al. (2010) cooking loss of gluten free noodles mostly caused by leaching the lightly bound gelatinized flour particles from the surface of noodles. This may occur depends on the gelatinization level of starch and strength of intermolecular starch network within the noodles.

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**Microstructure**

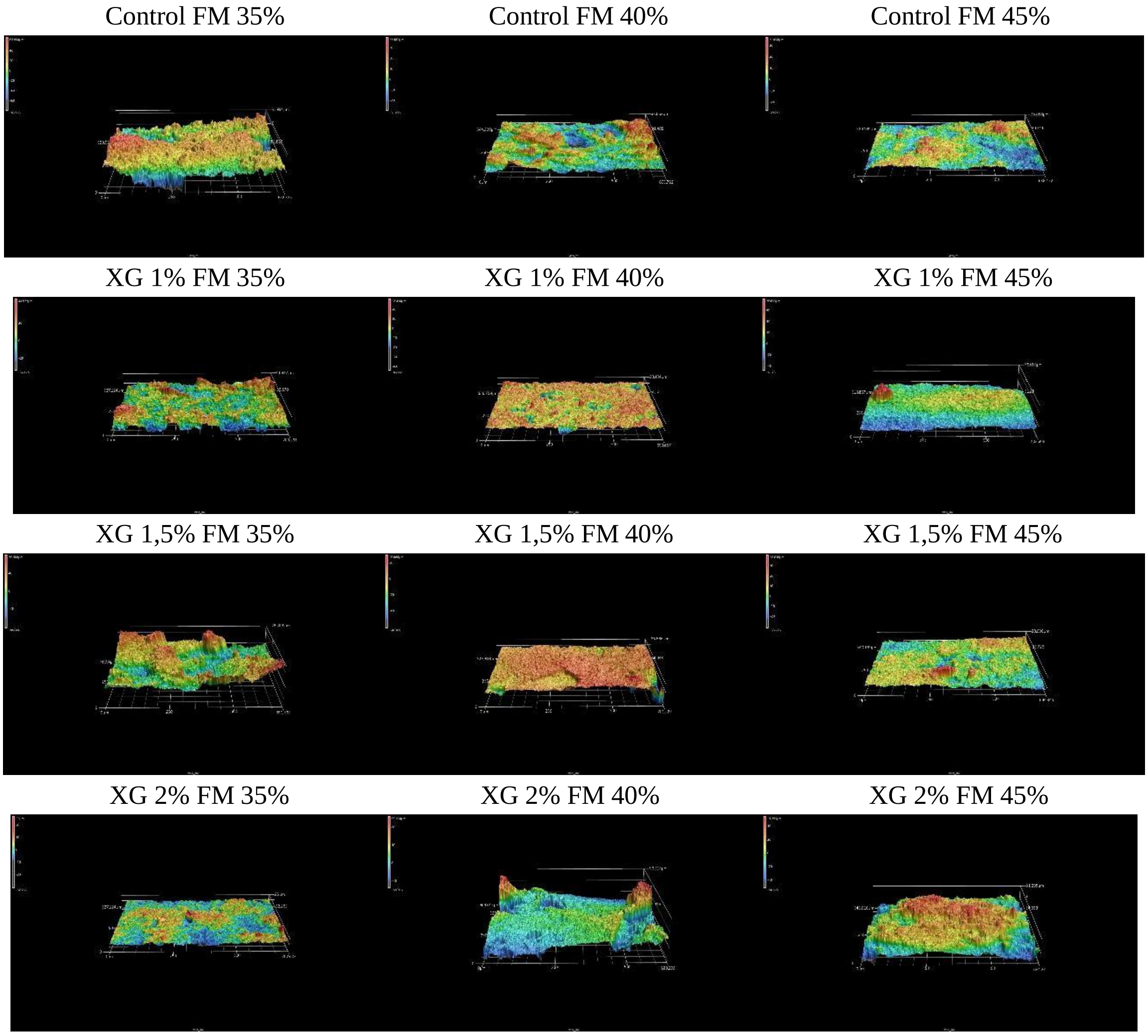


**Figure 1. Microstructure of rice noodles control and rice noodles added with xanthan gum surface**

Fig. 1 shows that microstructure surface of rice noodles control and rice noodles added with xanthan gum under laser microscopy. Compared with control, rice noodle with xanthan gum presents a more level and durable texture on its surface. Its correlated by the statement of Kasunmala (2020) that Xanthan Gum incorporated into rice noodles contributed to improve all TPA parameters significantly ($P < 0.05$) comparatively other gums and mucilaginous materials addition of gum and mucilage make cohesive noodles compared to other process variables. Gums and mucilaginous materials help to make rice flour particles stick together and to form cohesive dough in preparing of rice noodles. Yalcin and Basman (2008) reported that addition of Locust bean gum and Xanthan gum in to rice noodles significantly increased the maximum force required to rupture a cooked noodle strand compared to control sample and thereby they contributed to improve the texture of the rice noodles as well. Those statement support the reason that addition of xanthan gum give strength to the structure of rice noodle for having more even and resilient surface texture.

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