Evaluating Arrowroot Starch Modification and Application in Wet Noodles

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Abstract
Increasing the Resistant Starch (RS) level in food products containing naturally high starch content is important as RS has been acknowledged as a functional food ingredient. The purpose of this study is to determine the effect of steam-cooling treatment on the characteristic of arrowroot starch and to investigate the feasibility of arrowroot-based RS application on wet noodles. The study used a Completely Randomized Design (CRD) with one factor which was the steam-cooling cycle. Later, the substitution of 5%, 10%, and 20% of modified arrowroot starches on wet noodles was used, and then the consumer test was carried out. The results showed that the RS content of arrowroot starch remained after steam-cooling treatment. The treatment, however, reduced the water content and the brightness of the starch. Subsequently, arrowroot starch substitution without or with modification also reduced the lightness and tensile strength of wet noodles. Also, wet noodles with modified arrowroot starch substitution were significantly different in color, taste, and aroma parameters but were still acceptable to the panelists at a maximum substitution of 20%. The formulated wet noodles with modified arrowroot starch content RS of 34.02% (d/b), and therefore they can be categorized as foodstuffs with high RS levels.

Keywords: arrowroot starch, resistant starch, steam-cooling, wet noodles.

INTRODUCTION
Resistant Starch (RS) is one of the potential ingredients to create functional food. RS is defined as starch that cannot be absorbed in the digestive tract. According to Meenu et al. [1], RS can reduce the glycemic and insulin responses in diabetic, hyperinsulinaemic, and dyslipidemic patients. RS reaches the large intestine and thus is fermented by anaerobic bacteria. The fermentation process of RS also has many positive effects on human health, such as increasing the absorption of magnesium and calcium, improving insulin sensitivity, stimulating the immune system, and reducing the risk factors for colon cancer. RS allows a low glycemix response, so it has a low glycemix index (GI), which is useful in slowing down the absorption of glucose into the blood. RS can be classified into four types [2]. RS type I is a natural starch that is physically trapped between the cell walls of foodstuffs. RS type II is a starch granule that is naturally resistant to digestive enzymes. Type III is retrograded starch which is produced through food processing, and type IV is chemically modified starch. RS type III possesses advantages compared to other types of RS as it is stable during heating, and so it can be used as a food ingredient. Its functional properties remain unchanged during the processing.

Arrowroot starch (Maranta arundinacea L) is a potential material processed into a source of RS. Marsono [3] explained the amylose content of arrowroot starch reaches 25.94% per 100 grams of flour. The high amylose content in arrowroot has the potential as an alternative source of producing RS. In the development of commercial RS, it is advisable to use starch which naturally contains high levels of amylose. Moreover, arrowroot is a local food ingredient containing a fairly high economic value and has the potential as an alternative food source. Arrowroot can grow well in humid areas, making it easy to cultivate and produce high yields up to 30 tons ha⁻¹. Referred to Faridah et al. [4], RS in arrowroot starch is type II. Nevertheless, the content of RS type III starch can be enhanced through processing.

It has been widely acknowledged that cooking with the steam method can help increase RS. Sajilata et al. [5] mentioned that starch isolated from legumes heated by steam is rich in RS content (19% to 31%, wet weight), while the raw materials did not contain RS. Prolonged steaming and dry pressure heating in a short period may promote the formation of indigestible starch. This formation occurs due to the retrogradation process of starch from cooling, in which retrogradation can change the structure of starch leading to the formation of new insoluble crystals.

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that affect the digestibility of starch in the small intestine [6]. Thus, a formation of indigestible starch may occur during steaming-cooling treatment of arrowroot starch, and thus it is hypothesized to significantly increase the RS content of the material.

Formulating RS in popular food is one of the strategies to promote healthy food to the community. Noodles are one of the most widely consumed and popular foods in the community, and thus supplementing RS-rich ingredients is a strategic approach to increase RS consumption in society. From a regulation viewpoint, this strategy is legal, referred to the National Standard of Indonesia released in 1992. Wet noodles can be defined as food products made from flour either with or without the addition of other raw materials and have a maximum water content of 35%.

In this study, the modified arrowroot starch is intended to add into wet noodles, and thus it is hypothesized to increase the level of resistant starch. The purpose of this study, therefore, is to determine the effect of steam-cooling treatment on physical and chemical characteristic of arrowroot starch and also to determine the effect of modified arrowroot starch substitution on physical and chemical properties.

**MATERIAL AND METHOD**

**Preparation of Modified Arrowroot Starch**

The production of modified arrowroot starch followed the protocol of Lehmann et al. [7]. Arrowroot starch (Ganep’s shop, Surakarta, Indonesia) was suspended in a minimum of water and then heated at a temperature of 70°C with continuous stirring. Then it was steamed for 20 minutes. After that, arrowroot starch was cooled down for 1 hour at room temperature, then stored for 24 hours at 4°C. This procedure was repeated for as many variations of the formula, where F1 = 1 steam-cooling cycle, F2 = 2 steam-cooling cycles, and F3 = 3 steam-cooling cycles. After that, the starch was dried in an oven at 50°C, ground, and sieved.

**Production of Wet Noodles**

The production of wet noodles followed the protocol published by Bogasari [8]. Wheat flour (Cakra Kembar™ flour, PT. Indofood CBP, Indonesia) was used as the raw material in the making of wet noodles. It was then substituted with arrowroot starch and modified arrowroot starch at a level of 20%. The composite flour was mixed with salt (“Segitiga Emas” salt, PT. Multi Warna Rasa, Bogor) and soda ash in a bowl. Afterward, water was added gradually and then kneaded until it became a dough. Once it reached the required dough consistency, it was shaped into sheets using a noodle maker machine and then pressed into noodle strands. In the meantime, tapioca flour (Rose Brand™, PT. Budi Acid Jaya, Tbk, Lampung) was subtly sprinkled so that the noodle strands did not stick each other. The finished noodle strands were then boiled in boiling water for 40 seconds. Then, it was drained and dried. Cooked noodles were smeared with cooking oil (Fitri™ cooking oil, PT. Bina Karya Prima Tbk, Tangerang) at about 10 mL per kg of noodles to prevent them from sticking.

**Analysis of Resistant Starch Content**

The analysis of resistant starch content followed the method of Goni et al. [9]. First, 100 mg of the sample was measured into a 25 mL test tube with a screw cap. Then, 10 mL of KCl-HCl buffer (pH 1.5) was added and stirred. Pepsin solution of 0.2 mL (1 g of pepsin. 10 mL\(^{-1}\) of KCL-HCL) was poured and then mixed/shaken for 60 minutes at 40°C. The sample was cooled at room temperature, and then 9 mL of tris maleate buffer (0.1 M, pH 6.9) was added. Amylase solution of 1 mL (40 mg-amylase. mL\(^{-1}\) buffer tris maleate) was poured, then incubated at 37°C for 16 hours with constant shaking. After that, the sample was centrifuged for 15 minutes, as much as 3000 g supernatant was discarded.

The precipitate was added to 10 mL of distilled water and centrifuged, then the supernatant was discarded. The residue was added with 3 mL of distilled water and 3 mL of KOH (4M), and then mixed well and shaken constantly for 30 minutes. HCl of 5.5 mL (2M), 3 mL sodium acetate buffer (0.4 M; pH 4.75), and amylglucosidase (80 µL, E.c. 3.2.1.3) were then added. The mixture was blended well and incubated at 60°C for 45 minutes and shaken steadily. Later, it was centrifuged for 15 minutes at 3000 g. The supernatant was collected in a 25 mL or 50 mL (S1) volumetric flask. The residue was added with 10 mL of aquadest, mixed, and centrifuged for more. The supernatant (S2) was mixed with the S1 supernatant. Distilled water was added to a certain volume (25 mL or 50 mL) (SA).

Total glucose was determined by the GOD-POD reagent. A standardized glucose solution (10-60 g.mL\(^{-1}\)) was used. A total of 1 mL of the GOD-POD reagent solution was added to 20 mL of the supernatant (SA). Then, it was stirred and...
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incubated in a 37°C water bath for 10 minutes. The absorbance was read at 510 nm. Then, it was compared with blank. RS levels were calculated by Equation 1 and Equation 2:

\[
\%RS (wb) = \frac{50 \times \text{absorbance}}{\text{initial weight} \times 100} 
\]

\[
\%RS (db) = \frac{\%RS (wb) \times 100}{(100 - KA (wb))} 
\]

Chemical Analysis
The three variations of the steam-cooking formulation were subjected to physical and chemical analysis. Physical and chemical analyses were carried out on samples of wet noodles with 100% wheat flour, wet noodles with unmodified arrowroot starch substitution, and wet noodles with modified arrowroot starch substitution. The analysis of water, fat, ash, protein and carbohydrate content used thermogravimetric, Soxhlet extraction, dry-ashing, Kjeldahl, and by different methods, respectively, following the standard method of AOAC [10].

Physical Analysis
Color evaluation (Lightness, \(L^*\)) of the noodles was conducted using a Chromameter (Minolta CR-400, Japan) in CIELAB system. The tensile strength was calculated using Universal Testing Machine (Model Zwick I Z0.5, United Kingdom) according to the ASTM D882-00 standard method [11]. The initial grip distance was set at 50 mm and the crosshead speed was customed at 10 mm/min\(^{-1}\). The tensile strength value was calculated using Equation 3 where \(F\) is the force (N) at maximum load and \(A\) is the initial cross-sectional area (m\(^2\)) of the sample. The tensile strength is expressed as MPa.

\[
TS = \frac{F}{A} 
\]

Sensory Analysis
In the sensory analysis, 25 panelists were used to evaluate the consumer acceptance of wet noodles. The panelists used in this study are students with a range of age between 18 and 22 years old. A 5-scale evaluation form was used where 1=very much dislike, 2=dislike, 3=neutral, 4=like and 5=very much like [12]. Parameters assessed in this test included color, aroma, taste, texture, and overall.

Data analysis
The research design used a Completely Randomized Design (CRD) with one factor, which was the variation of the steam-cooking cycle as the basis for making highly modified arrowroot starch RS. One Way ANOVA statistical analysis was administered for the steam-cooking cycle, physical and chemical properties of wet noodles, and sensory results of wet noodles. Then, it was continued with Duncan’s analysis for the significance of more than \(\alpha\) (0.05) to observe whether there was a difference between treatments. A significance level of >0.01 was particularly used for the statistical analysis of the RS content of arrowroot starch before and after steam-cooking treatment.

RESULT AND DISCUSSION
Steam-Cooling Cycle on Arrowroot Starch
The results of the analysis of RS and color of arrowroot starch are displayed in Table 1. In Table 1, the RS contents of arrowroot starch without treatment in 1 cycle of steam-cooling to 3 cycles were 11.63, 11.76, 10.0, and 11.56%, respectively. Based on the results of the ANOVA test (\(P<0.01\)), the modified arrowroot starch did not have a significant difference in all samples shown from the location of the same subset. In other words, the steam-cooling treatment was not able to significantly increase the RS content in the arrowroot starch. It is not in line with the statement by Rosida and Yulistiani [13] that the best treatment is steam-cooling which possibly increased the RS level from 3.27% to 6.67% in breadfruit compared to other treatments, which are boiling-cooling (3.27% to 3.82%) and frying-cooling (3.27% to 3.68%).

Table 1. Resistant Starch content and color of arrowroot starch with and without steam-cooking treatment

<table>
<thead>
<tr>
<th>Arrowroot Starch</th>
<th>Resistant Starch Content (% db)</th>
<th>Color (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Treatment</td>
<td>11.63±</td>
<td>93.33±</td>
</tr>
<tr>
<td>1 cycle</td>
<td>11.76±</td>
<td>82.54±</td>
</tr>
<tr>
<td>2 cycles</td>
<td>10.00±</td>
<td>82.12±</td>
</tr>
<tr>
<td>3 cycles</td>
<td>11.56±</td>
<td>80.93±</td>
</tr>
</tbody>
</table>

Note: In the same column, different notations show a significant difference between alpha 0.01 for RS content and alpha 0.05 for color.

The finding in this study did not meet the aforementioned hypothesis. Theoretically, the level of RS in starch-rich material after the steam-cooking treatment increased significantly, mainly due to the amyllose content in the starch. Amylose is easily retrograded due to the influence of temperature. The rate of retrogradation will increase as the temperature decreases. The lower the temperature, the faster the retrogradation process will be and the more resistant starch is formed. Cooling after cooking.
will change the physical state of polysaccharides, thereby reducing their digestibility [6]. The higher the starch amylose content, the higher the resistant starch content is. Starch granules that are rich in amylose have a greater ability to crystallize due to the higher intensive hydrogen bonding. As a result, starch cannot expand or undergo complete gelatinization during cooking so that it is digested slower.

The disparity may emerge because the starch contained in arrowroot starch is not fully gelatinized during the steaming process. Starch heating with excess water will result in starch gelatinization. Reheating and cooling of the gelatinized starch alters the starch structure, which leads to the formation of new insoluble crystals in the form of retrograded starch [14]. In this study, the incorporation of water was minimal until the arrowroot starch became paste. The use of minimal water content was achieved because during the trial, with excessive water, the gelatinization time will become longer and the gelatinization results will be defective.

Furthermore, as studied by Cham and Suwannaporn [15] using rice flour, hydrothermal treatment (heating) of the flour can suppress swelling and inhibit gelatinization of the granules, so that the starch granules become rigid and more stable during the heating process. The heating treatment can increase the crystallinity region and tend to re-associate to form a precipitate or gel during the drying process (retrogradation). It can also explain the phenomenon in each sample where arrowroot starch was inhibited in gelatinization so that in cycles 1 and 3, arrowroot starch did not have a significant difference in the RS content.

Table 1 also presents the lightness level of arrowroot starch without treatment, 1 cycle to 3 cycles, which were found at 93.33, 82.54, 82.115, and 80.93, respectively. The L value decreased along with the number of steam-cooling cycles in arrowroot starch, implying that the lightness level of arrowroot starch was lower than control. The results of the ANOVA test (P <0.05) present significant differences in each arrowroot starch sample, denoting that the lightness level of arrowroot starch with different treatments will produce significantly different lightness levels.

**Physical and Chemical Properties of Wet Noodles**

Based on the results of arrowroot starch modified by the steam-cooling treatment with various cycles, no significant effect on the levels of resistant starch was found. Nonetheless, it is essential to investigate the physical and chemical features of the product application, which are wet noodles with wheat flour substitution of treated arrowroot starch. The wet noodles made consisted of three types; control wet noodles (100% wheat flour), wet noodles with 20% arrowroot starch substitution, and 20% modified arrowroot starch substitution. Substitution as many as 20% on the previous study opted as acceptable wet noodles to the panelists. The wet noodles were with a ratio of flour 70%, arrowroot flour 20% with the addition of soy flour 10% [16]. In this study, as the emphasis was laid on the effect of arrowroot starch, soy flour was not used. Also, it is widely recognized that the basic recipe of wet noodles is wheat-based flour without any substitution for other types of flour.

The physical characteristics of wet noodles tested in this study included color and texture (tensile strength). Color and texture are the determinants for the quality of wet noodles since they determine the level of consumer acceptance. A Tensile Strength test was performed, which is the maximum force required to break noodles. The greater the force required, the harder the noodles to break. The results of the test of brightness and tensile strength of control wet noodles are wheat flour, wet noodles with arrowroot starch substitution of 20%, and wet noodles with modified arrowroot starch substitution of 20% are provided in Table 2.

**Table 2. Physical properties of wet noodles**

<table>
<thead>
<tr>
<th>Formula</th>
<th>Lightness</th>
<th>Tensile Strength (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Control</td>
<td>64.47&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.18&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>- 80% wheat flour + 20% arrowroot starch</td>
<td>55.36&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.12&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>- 80% wheat flour + 20% modified arrowroot starch</td>
<td>60.19&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.11&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Note: In the same column, different notations indicate a significant difference alpha 0.05.

Table 2 shows the lightness level of control wet noodles (100% of wheat flour) was higher than that of wet noodles with 20% arrowroot starch substitution and wet noodles with 20% modified arrowroot starch substitution. It also showed that the lightness levels among samples of wet noodles were significantly different. Interestingly, even though the previous finding shows that modification led to a decrease in the lightness level of arrowroot starch, in this study, the wet noodle formulated with modified starch was lighter than that with unmodified starch.
This phenomenon strongly indicated that many other factors affect the physical properties of wet noodles instead of the color of the raw material.

As for the tensile strength of wet noodles, Table 2 shows a decrease in wet noodles compared to wet noodles with arrowroot starch substitution without treatment and modified arrowroot starch which were 0.18 0.12, and 0.11, respectively. The tensile level of wet noodles decreased due to the substitution of wheat flour with arrowroot starch by 20%, either without treatment or modification. The use of arrowroot starch will reduce the availability of gluten protein, thereby reducing the tensile value of the noodles. Moreover, statistical analysis found that there was a significant difference between control and wet noodles with modified arrowroot starch substitution of 20%. The smaller the gluten protein content in noodles, the lower the elongation ability will be. Gluten protein plays a role in the elasticity of noodles, hence elongation ability decreases [17].

The nutritional compositions of control wheat wet noodles and arrowroot starch substituted wet noodles without treatment and modification are shown in Table 3. It can be seen that the moisture content of wet noodles with modified arrowroot starch substitution was higher than that of control wet noodles, and arrowroot starch substituted wet noodles without treatment. It indicates that the substitution of modified arrowroot starch caused an increase in the moisture content of wet noodles. However, the water content of wet noodles in this study still met the standards set by SNI, where the water content in all wet noodle samples showed less than 35%. The results of the water content imply a significant difference between each sample, which means that either with or without substitution of modified arrowroot starch, it affected the moisture content of wet noodles.

From the analysis, it was found that the ash content in the control wet noodles was 4.41%, in wet noodles with substitution of unmodified arrowroot starch was 1.06%, and the ash content in wet noodles with substitution of modified arrowroot starch of 20% was 4.45%. The value of the ash content in wet noodles with or without substitution of modified arrowroot starch experienced declining in the reduction in the mineral content of arrowroot starch during the steam-cooling cycle. Statistical results showed that the ash content did not have a significant difference between samples. The ash content qualifies the quality requirements set by SNI at a maximum of 3% (w/b).

The protein content in wet noodles is generally influenced by the type of wheat flour used and the addition of modified arrowroot starch. The wheat flour used is hard wheat, wheat flour that contains a high protein content of ±12-13. This type produces dough that has high absorption, is strong, and has good swelling power [17]. Table 3 presents that the protein contents of wet noodles with modified arrowroot starch substitution and ordinary arrowroot starch substitution had a lower content than control wet noodles. It is due to the decrease in gluten content and simultaneously with the decrease in the proportion of wheat flour. In the statistical analysis, significant differences among the samples of control and arrowroot starch substitution without treatment and wet noodles with modified arrowroot starch substitution were found. The protein content of wet noodles in this study qualified the SNI quality standard, at a minimum of 3.

Table 3. Chemical properties of wet noodles

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control</th>
<th>Unmodified Arrowroot Starch Substitution</th>
<th>Modified Arrowroot Starch Substitution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (%wb)</td>
<td>54.97b</td>
<td>52.37b</td>
<td>56.8b</td>
</tr>
<tr>
<td>Ash (%wb)</td>
<td>0.57</td>
<td>1.06</td>
<td>0.34</td>
</tr>
<tr>
<td>Protein (%wb)</td>
<td>5.3</td>
<td>4.06</td>
<td>3.77</td>
</tr>
<tr>
<td>Protein (%db)</td>
<td>11.76b</td>
<td>8.76a</td>
<td>8.73a</td>
</tr>
<tr>
<td>Fat (%wb)</td>
<td>2.33</td>
<td>1.79</td>
<td>2.99</td>
</tr>
<tr>
<td>Fat (%db)</td>
<td>5.17b</td>
<td>3.975a</td>
<td>6.65c</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>36.83</td>
<td>39.37a</td>
<td>36.0a</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>81.79a</td>
<td>85.07a</td>
<td>83.56a</td>
</tr>
<tr>
<td>RS (%wb)</td>
<td>11.06</td>
<td>15.18b</td>
<td>14.70b</td>
</tr>
<tr>
<td>RS (%db)</td>
<td>24.55b</td>
<td>16.59a</td>
<td>34.02c</td>
</tr>
</tbody>
</table>

Note: In the same row, different subsets show a significant difference alpha 0.05 *) at a moisture content of 8.925.
However, indeed, given the nutritional value, noodles contain a lot of carbohydrates and energy with relatively low protein content. The nutritional content of noodles varies, greatly relying on the type, amount, and quality of the ingredients.

In Table 3, the fat content of wet noodles with modified arrowroot starch substitution was surprisingly higher than that of control wet noodles and wet noodles with unmodified arrowroot starch substitution. The substitution was expected to have no significant influence on the fat content of the wet noodles. The difference might be due to the uncontrolled use of cooking oil for smearing the wet noodles to prevent them from sticking.

As for the carbohydrate, wet noodles with substitution of unmodified arrowroot starch had higher content than control wet noodles and wet noodles with modified arrowroot starch substitution, which was 85.07%. It was occurred due to differences in the composition of wheat flour in wet noodles. Wet noodles with modified or unmodified arrowroot starch will contribute more carbohydrates than wet noodles with 100% wheat flour, which contains more protein (gluten). Meanwhile, for resistant starch, wet noodles with modified arrowroot starch substitution had higher resistant starch content than the control, and wet noodles with unmodified arrowroot starch substitution, from 24.55% (db) to 34.02% (db).

These results were obtained because of differences in the composition of wheat flour in wet noodles. Arrowroot starch treated with steam-cooling in the previous analysis resulted in a resistant starch content of 11.76%, which is categorized very high. Goni et al. [9] classify foodstuffs based on their resistant starch content in dry weight. Foodstuffs with resistant starch content <1% are classified as very low, 1-2.5% are in the low group, 2.5-5% are in the medium group, 5-15% are in the high class, and >15% are in the very high group. Therefore, due to the very high content of modified arrowroot starch, it will directly affect the wet noodle end product.

**Consumer acceptance of wet noodles**

Table 4 shows the consumer acceptance of wet noodles formulated with modified arrowroot starch substitution using formulations of 5%, 10%, and 20%. The use of modified arrowroot starch substitution, instead of unmodified arrowroot starch, was based on the fact that modified arrowroot starch substitution in wet noodles resulted in a higher RS content (db) as shown in Table 3, but had a closer lightness level as compared to unmodified arrowroot starch substitution, as shown in Table 2.

Based on the sensory evaluation, the score given by the panelist on the color parameter of wet noodles formulated with modified arrowroot starch substitution of 5%, 10%, and 20% were 3.40, 3.70, and 2.98, respectively. The 10% substitution obtained the highest score of panelist acceptance. The results of the aroma parameter values were 3.03, 3.00, and 3.10, respectively, where all samples of wet noodles had no significant difference. In the taste parameter, consecutive values of 3.10, 3.70, and 3.47 were obtained.

Samples of wet noodles with a formulation of 95% of wheat flour with 5% of modified arrowroot starch and wet noodles of 90% wheat flour with 10% of modified arrowroot starch have a significant difference. Meanwhile, samples of wet noodles with the formulation of 95% of wheat flour with 5% of modified arrowroot starch, wet noodles with 80% wheat flour with 20% modified arrowroot starch, wet noodle with 90% wheat flour with 10% modified arrowroot starch, as well wet noodles with 80% of wheat flour with 20% of modified arrowroot starch were not significantly different. In the texture parameter, the scores of 3.13, 3.47, and 3.67 were obtained, respectively.

Interestingly, the 20% substitution obtained the highest score of panelist acceptance in this attribute. The results of the sensory test in the overall parameter were 3.30, 3.53, 3.57, respectively, and all samples of wet noodles had no significant difference.

**Table 4. Consumer acceptance of wet noodles**

<table>
<thead>
<tr>
<th>Flour Formulation (Wheat Flour : Modified Arrowroot Starch)</th>
<th>Color</th>
<th>Aroma</th>
<th>Taste</th>
<th>Texture</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>95 : 5</td>
<td>3.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.03&lt;sup&gt;+&lt;/sup&gt;</td>
<td>3.10&lt;sup&gt;+&lt;/sup&gt;</td>
<td>3.13&lt;sup&gt;+&lt;/sup&gt;</td>
<td>3.30&lt;sup&gt;+&lt;/sup&gt;</td>
</tr>
<tr>
<td>90 : 10</td>
<td>3.70&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.00&lt;sup&gt;+&lt;/sup&gt;</td>
<td>3.70&lt;sup&gt;+&lt;/sup&gt;</td>
<td>3.47&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.53&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>80 : 20</td>
<td>2.98&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.10&lt;sup&gt;+&lt;/sup&gt;</td>
<td>3.47&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.67&lt;sup&gt;+&lt;/sup&gt;</td>
<td>3.57&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Note: In the same column, different subsets show a significant difference alpha 0.05
Results found in this study are significant for scientists to give a direction for further research, particularly on the process modification for increasing the RS content of modified arrowroot starch. For the food industry, this research shows that substitution of 10% of arrowroot starch in wet noodles obtained the highest score of consumer acceptance, while 20% of arrowroot starch in wet noodles was still acceptable. This information is important for consideration of wet noodle reformulation.

CONCLUSION
To sum up, the steam-cooling treatment had no effect on the resistant starch content of arrowroot starch but significantly affects the decrease in water content and brightness level of arrowroot starch. The more steam-cooling cycles of arrowroot starch, the lower the brightness level of arrowroot starch will be. Modified arrowroot starch substitution had an effect on the physical properties of wet noodles, comprising a decrease in the brightness and tensile strength of wet noodles and had an effect on the chemical properties of wet noodles, which are increasing in water content and RS compared to wet noodles with 100% wheat flour. Variations in the formulation of modified arrowroot starch affected the level of consumer preference on the parameters of color, taste, and texture, in which wet noodles with 20% modified arrowroot starch substitution were accepted by panelists. Given the results of this study, it is suggested to do further research in the form of a combination of chemical modifications or enzymes to increase RS levels and selection of raw materials with high amylase.

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