Enrichment of analogue sago rice with various sources of vegetable protein

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Abstract. Analogue sago rice, which currently has a low glycemic index value, but low protein content (3%). Enrichment with vegetable protein to the formula of analog sago rice was expected to be increased its protein content. This study aims to achieve the protein content of analogue sago rice, which similar to rice (7-9%) and can be accepted by consumers. Vegetable protein such as oyster mushroom flour, soybean hydrolyzate, a mixture of oyster mushroom and straw mushroom, and ISP (Isolated Soy Protein) at a concentration of 5-10% were added to the formulas. A hedonic test showed that from the 6 formulations, sago rice with the addition of ISP as a protein source had a better character than sago rice with the addition of mushroom flour in terms of color, aroma, taste, texture and overall. Whereas sago rice with the addition of oyster mushroom flour and straw mushroom has a dark color, a distinctive aroma and flavor of mushrooms and a slightly chewy texture. The formula by the composition of sago starch (70%), red rice flour (20%), ISP flour (5%) and oyster mushroom flour (5%) showed a protein content of 7.46% and received by the hedonic test.

1. Introduction
The staple food of the Indonesians is rice then the need for rice will increase along with population growth. This shows the enormous dependence of the Indonesian people on rice. Diversification of foods such as analogue rice is expected to be one of the options for reducing dependence on rice. Sago starch has a high carbohydrate content but lacks nutrients, especially protein. For this reason, it is necessary to enrich the protein in making analogue rice derived from sago starch.

Enrichment is the addition of nutrients to one or several food ingredients in order to increase the nutritional value of food ingredients. Sources of vegetable proteins (mushroom flour, Isolate Soy Protein (ISP) and Soy Protein Hydrolysate (SPH) are options to be explored in premium analogue sago rice formulations. Mushroom fruit bodies containing nutrients contain around 39.9% carbohydrates, 17.5% protein, 2.9% fat, the rest fiber and minerals based on dry weight [1]. Isolate soy protein is a soybean flour protein isolate that is eliminated by fat, carbohydrates and dissolved minerals that contain 90% protein. Isolate protein is a form of processed protein that contains more protein with greater digestibility. Based on the previous study, added ISP 7% into artificial rice from fermented cassava has a protein level of 8.98% [2].

This observation aims to achieve the protein content of analogue sago rice which similar to rice (7-9%) and can be accepted by consumers, using the four flours protein and selection based on physical tests using protein analysis, texture, color, and organoleptic parameters. As a control, analogue sago rice without the addition of protein flour.
2. Materials and methods

Materials for the observation of analogue rice consisted of sago starch (*Metroxylon sagu*) from Riau, brown rice (*Oryza nivara*) flour was purchased from market, Isolated Soy Protein (ISP) non GMO (Qingdao crown, China), Soy Protein Hydrolysate (SPH) by research, oyster mushroom pure flour (Javacocoaartisan, Indonesia), straw mushroom flour (Kaldu sehat, Indonesia), and water. Instruments were used are single screw extruder (BPPT, Indonesia), chromameter (CR 300 Minolta, Japan), disk mill (Dust Collecting Fine Crushing Set, Jiangyin Hongda Powder Equipment, China), siever shaker (RX 863 serial I2950, W.S Tyler, USA), fluidized dryer (BPPT, Indonesia), texture analyzer (Perten 4500, USA), steamer (Akebonno MSP 10107, China), Kjedahl analyzer (Behr Labor-Germany) and other glass tools.

This study is a follow-up study from previous studies of analog sago rice which has a low glycemic index value of 40 but has a small protein content. To meet the needs of people for nutrition, which is quite like eating ordinary rice with an average protein content of 7%, it is necessary to enrich the protein in sago rice with several alternative sources of protein that can produce nutritious sago rice and a low glycemic index and are preferred. This observation consisted of several stages, i.e: (1) analogue sago rice formulations; (2) protein analysis by Kjedahl analysis; (3) sensory and physical characteristics analysis. Based on the previous study, there were six analogue rice formulations, in 1000 g there are 70% sago starch and 20-22% brown rice starch, enrichment with 4 source of protein flour (ISP, SPH, oyster pure mushroom flour, and straw mushroom flour) with additions ranging from 1-7.5% according to the character of flour to get sago rice with a protein content of 7%. Water and additives added to the formulation are 25-30% and 1.5%. Sensory testing on the samples was in attributes of colour, texture and hedonic test. Hedonic tests were from panelists as many as 15 people. Besides that, measurements of texture, color, and protein content were also measured. The premium sago rice formulation with the addition of protein sources of mushroom flour, oyster mushroom flour and soybean protein isolate flour is presented in the following table 1.

| Sample | Sago | Brown rice flour | ISP | Straw mushroom flour | Oyster mushroom flour | SPH |
|--------|------|------------------|-----|----------------------|----------------------|-----|
| F1     | 70   | 20               | 5   | -                    | 5                    | -   |
| F2     | 20   | 5                | 1   | -                    | -                    | -   |
| F3     | 21   | 5                | -   | -                    | -                    | -   |
| F4     | 24   | 5                | 1   | -                    | -                    | -   |
| F5     | 22.5 | -                | -   | -                    | -                    | 7.5 |
| F6     | 20   | -                | 1   | 1.5                  | 7.5                  | -   |

3. Result and discussion

The process of making analog rice consists of several stages, namely material preparation, mixing, extrusion, and drying [3]. The preparation of raw materials is done by weighing the material according to the formulation. The mixing process is done by mixing dry ingredients for 5-10 minutes, then add 30% of water and the mixing process resuming for 5 minutes. The addition of 30~40% of water is included in the category of wet extrusion and is called dry extrusion if the addition of water is only 12-18% [4]. The pragelatinization process is then carried out by steaming for 30 minutes and formed with a cold extrusion machine, then dried using a fluidized dryer.

Sago analogue rice is fortified by adding protein sources such as soft flour and mushroom flour. Based on the previous study, the addition of mushroom flour should not be more than 5% because it creates unpleasant taste and color. Based on the analysis of protein content in the six formulations, sago analogue rice added by ISP had a higher protein content than by mushroom flour (table 2). The six
formulations then were analyzed on their texture, color and sensory. Pure analogue sago rice (containing 70% sago and 30% brown rice) was used as a control.

### Table 2. Protein content of six formulations of sago analog rice*.

| Sample | % Protein |
|--------|-----------|
| F1     | 7.46±0.02* |
| F2     | 7.50±0.05* |
| F3     | 7.32±0.11* |
| F4     | 7.12±0.08* |
| F5     | 5.95±0.05* |
| F6     | 5.05±0.13* |
| control| 3.16±0.12  |

*Values are mean of duplicate analyses. Different superscript letter in the same column indicates a significant difference (P<0.05).

### Table 3. Texture profile analysis of analog rice sago*.

| Sample | Hardness | Gumminess | Chewiness |
|--------|----------|-----------|-----------|
| F1     | 781.49±1.39* | 531.91±2.21* | 434.56±3.47* |
| F2     | 605.34±9.06* | 426.94±1.71* | 410.19±0.70* |
| F3     | 993.09±1.73* | 676.47±2.78* | 570.33±1.73* |
| F4     | 848.87±4.12 | 573.75±2.18 | 457.15±6.53 |
| F5     | 996.30±0.15* | 561.80±4.80* | 517.28±0.93* |
| F6     | 959.17±4.26* | 655.50±4.25* | 614.27±3.78* |
| Control| 806.35±1.56 | 559.16±4.94 | 489.26±3.14 |

*Values are mean of duplicate analyses. Different superscript letter in the same column indicates a significant difference (P<0.05).

Among the six rice formulas, analogue sago rice which was added 7.5% SPH showed high hardness values as shown in samples F5 and F6 with values of 996.30 g and 959.17 g (table 3). Based on the results of the texture analysis in the table above, premium sago rice with ISP (F2) has a lower hardness, gumminess, and chewiness than control rice and mushroom flour addition (F1, F3, F4) and soybean concentrates (F5, F6). The adding ISP to the formula of sago rice has an effect on the texture of rice which results in slightly soft rice. The character of premium sago rice texture with ISP has a better character than control sago rice, is softer and its adhesiveness decreases.

The color analysis of analogue sago rice was analyzed using Konica Minolta Chromameter by measuring the values of L, a and b. The value of L is the "light" brightness of the sample, the higher the L value of the sample is brighter. The letter shows the chromatic colors of mixed red - green and the letter b shows the chromatic colors of mixed yellow - blue. Analogue sago rice samples have high on a and b values, which shows all samples have red and yellow colors. Because raw materials for brown rice flour, mushroom and soybean flour which affect the color of analogue rice sago.

### Table 4. Results of testing the color of sago rice samples.

| Sample | L    | a    | b    |
|--------|------|------|------|
| F1     | 55.32| 5.88 | 10.77|
| F2     | 56.76| 5.69 | 10.39|
| F3     | 59.89| 5.37 | 9.76 |
| F4     | 54.18| 6.22 | 8.49 |
| F5     | 56.56| 5.18 | 9.25 |
| F6     | 54.73| 5.50 | 8.17 |
| Control| 53.21| 5.15 | 8.27 |
The following is the result of processing organoleptic test results from 15 panelists. Based on the results of the 5 organoleptic parameters (figure 1), it was seen that the panelists chose 3 samples of premium sago rice, namely F1, F4 dan F5. From the 6 formulations, analogue sago rice with the addition of ISP as a protein source has a better character than with the addition of mushroom flour in terms of color, aroma, taste, texture and overall. Rice with the addition of ISP has a lighter color, no distinctive aroma, soft texture, and plain taste. Whereas sago rice with the addition of oyster mushroom flour and straw mushroom flour has a dark color, a distinctive aroma of mushrooms and a slightly chewy texture. The slightly brownish color of oyster mushroom flour can affect the color of the product produced, the more the addition of oyster mushroom flour, the darker the color of the product [5]. The straw mushroom flour has an L-value or lower brightness compared to the oyster mushroom flour so it will produce a product with a darker color [6].

4. Conclusion
The addition of ISP on analogue rice sago has improved protein content and better texture softly like rice. The chosen formula is F1 with 70% sago flour, 20% brown rice, 5% ISP and 5% pure mushroom flour, in terms of protein content (7.46%) equal with rice. Sensory hedonic analysis gives a significant difference among the made formulas. The addition of ISP flour in analogue sago rice results in a better character of sago rice, which is softer, lighter colors, no distinctive aroma and less adhesiveness compared to sago rice with the addition of straw mushroom flour and SPH.

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