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A Preliminary Study on The Rehydration Characteristics and Cooking Time of Analog Rice from The Formulation of Modified Nagara Bean Flour through *L. plantarum* Fermentation and Sago Starch

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Abstract. Analog rice was expected to have characteristics that similar to native rice, particularly on level of stickiness. Therefore, formulation of ingredients is important for the consideration. Nagara bean flour fermented by *L. plantarum* have a high amylose content of 23-25 percent, in the formulations, nagara bean flour is combined with sago flour to balance amylose and amylopectin content. This combination is expected to result on good rehydration and texture that similar to to native cooked rice. This research was examined formulation of nagara bean flour, sago starch and glycerol monostearate concentration as emulsifier to facilitate the extrusion process. The analog rice from proportion nagara bean flour and sago starch of 50: 50 have high levels of rehydration and have small solid losses. This characteristic was not different from the proportion nagara bean flour and sago starch of 60 : 40. Increasing the proportion of nagara bean flour to sago starch will increase the cooking time of analog rice. In addition, the addition of glycerol monostearate concentration of 2% to 5% could result good extrusion quality.

Keyword: *nagara bean, sago starch, glycerol monostearate, rehydration, cooking time.*

1. Introduction

Rice currently becomes a staple food in some developing countries and other countries in the world. It is able to provide 20% of energy needs from its starch content. On the other hand, as the staple food, rice has low protein. It will result in protein deficiency. The extrusion technology can be used for processing the fortification rice or analog rice to obtain adequate nutrient type rice or rice with a certain amount of micronutrient [1]

Analog rice is the food product that has a shape as rice with a carbohydrate content that is close to or exceeds the carbohydrate content in ordinary rice. The analog rice can increase the diversification of staple food by manipulating the mindset as if consuming cooked rice from ordinary rice.

Nagara bean that has been fermented using *L. plantarum* will have high protein content up to 24% and it will increase the starch and protein digestibility in vitro [2]. The fermentation process is also able to improve the characteristic of beans [3], modify the structure and the physic-chemical characteristic of starch [4], affect the solubility characteristic, the granule swelling, and starch viscosity [5] and eliminating the anti-nutrient compounds [7,8].

To obtain the rice analog with a character that is close to the characteristic of ordinary rice in the stickiness level, and the good tasting, while, nagara bean flour has the amylose content of 23% to 25% [2], therefore, in formulating the analog rice, nagara flour is fermented using *L. plantarum* is composed with sago starch as the counterbalancing component for the amylose and amylopectin contents. Thereby, the best rehydration capacity and texture that is similar to rice can be obtained.

This research aimed at analyzing the rehydration level and the cooking time of analog rice from the formulation of nagara bean flour fermented using *L. plantarum* and sago starch by adjusting the proportion of nagara bean flour and sago flour.

2. Materials And Method

Materials and Instruments

Nagara bean was obtained from Nagara, *Hulu Sungai Selatan* Regency, South Kalimantan, sago starch and glycerol monostearate. The instrument used here comprising water bath, oven (memmert), and glassware for chemical analysis.

Fermentation Process

The fermentation process was done by using nagara bean: solvent ratio i.e. 1: 4. The amount of *L. plantarum* that was inoculated in the treatment was 1% (v/b the basis of nagara bean). The nagara bean was fermented for 48 hours and then the bean skin was peeled and washed. Next, it was dried in the oven at a temperature of 60ºC for 48 hours, and it was ground to produce flour of 80 mesh.

The Process of Analog Rice Production [8]

a. The Test on The proportion of Nagara bean flour and sago starch

The mixing process was done through two stages i.e. mixing the dry materials (nagara bean flour and sago flour) with several nagara bean flour : sago flour ratios i.e. 80: 20, 70: 30, 60: 40, 50: 50, 40: 60, 30: 70, 20: 80. The mixture was mixed using a mixer for 5 minutes and then adding 10% of water at 60°C and the process of mixing was done again for 5 minutes. The dough was put into the extruder of analog rice using cold extrusion system. Pregelatinization was applied to extruded rice for 10 minutes and it was dried at 60°C to reach the water content that was less than 14%.

b. The Test on Glycerol Monostearate Concentration

This stage was used for testing the use of glycerol monostearate at the concentration of 1%, 2%, 3%, 4%, and 5% only at one proportion i.e. nagara bean flour: sago flour ratio i.e. 50: 50. Then, it would be processed using a similar process as stage a.

The Parameter of Analysis

The water content [9], ash content [9], bulk density, water absorption, swelling volume, total dissolved solids, and the cooking time of the analog rice that had been obtained would be tested. The capacity of water absorption [10], solubility, and s*welling volume* (the modification [11].

Data Analysis

The collected data was tested using ANOVA at an error rate of 5%. If it had a significant impact, *Duncan*'s Least Significant Difference was conducted afterward.

3. Result And Discussion

Analog rice as the result of the formulation of modified nagara bean flour through *L.plantarum* fermentation and sago starch had various characteristics of the extrudate. It depended on the proportion of flour that was being used. The more proportion of nagara bean flour (80: 20) than sago starch, the easier the cold extrusion process in analog rice extruding machine compared to the proportion with more sago flour (20: 80). The extrudate would be easy to come out from the hole of the machine because the resistance of mixture toward the extrusion force of screw was not as big as the mixture with a high proportion of sago starch.

The application of the pregelatinization process for 10 minutes toward the extrudate showed that the higher the proportion of sago starch was, the stickier the extrudate to one another was. Thereby, it would be difficult to be separated. Meanwhile, the higher the proportion of nagara bean was, the less sticky the extrudate to one another was. Thereby, it could be separated easily. The proportion of nagara bean flour of 50%, 60%, 70%, and 80% toward sago starch was relatively easy to be separated (less sticky).

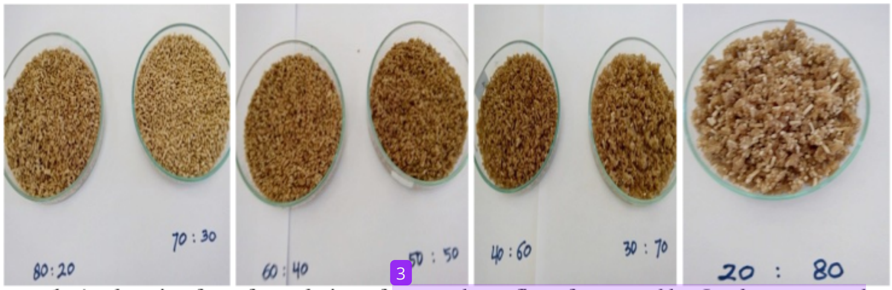

Figure 1. Analog rice from formulation of nagara bean flour fermented by *L. plantarum* and sago starch

Figure 1 showed that, physically, the shape of rice is quite similar to pellet with various size from the small size of the broken shape up to the long one of 1 cm. The color of analog rice was around yellowish-brown up to brown. The proportion of nagara bean flour around 70% – 80% was relatively yellowish-brown, the proportion of nagara bean flour around 40% – 60% was relatively brown, and the proportion of nagara bean flour around 20% – 30% was relatively bright brown. The proportion of nagara bean of 20% had an agglomeration of extrudates. It happened because several extruded rice stuck on each other after the application of the pregelatinization process and it was difficult to be separated.

The variables that were analyzed in analog rice comprising water content, bulk density, ash content, water absorption, swelling volume, and density loss. It was conducted to find out the quality of cooking of the analog rice that had been produced.

Effect of The Proportion of Nagara Bean Flour and Sago Starch Water Content

The result of the analysis of variance (α= 5%) showed that the treatment of nagara bean flour and sago starch ratio had no significant impact on the water content. The water content of analog rice was around 5.61% to 8.23%. This value was lower than the maximum limit in milled rice (white rice) i.e. 14%. There was a tendency i.e. by the increasing proportion of sago starch toward nagara bean flour proportion, the water content of analog rice would increase too. It was strongly related to the ability of sago starch to bind more water. The water used in the formulation was the water from the steaming process when pregelatinization was conducted (Figure 2).

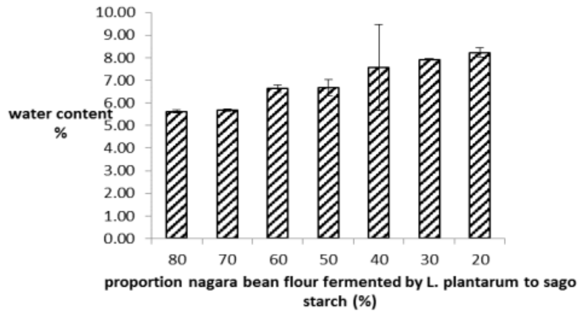

Figure 2. Water content of analog rice from formulation of nagara bean fermented by *L. plantarum* and sago starch

The sago starch granule has an oval shape with a bigger size. If it is compared to other starch types, sago starch granule has relatively big size i.e. it reaches the average size of 24.8 μm [12] or 25 μm [13]. The big size of granule indicated the high ability to absorb water during the process of gelatinization. It was correlated with the increase of sago starch proportion on analog rice formulation. The water absorption would increase too. Therefore, when it was dried, the water content value was bigger.

Bulk Density

The bulk density of analog rice was around 0.58– 0.74 g/cm^3. The result of the analysis of variance (α = 5%) showed that the treatment of nagara bean flour to sago starch ratio had no significant impact toward the bulk density (Figure 3)

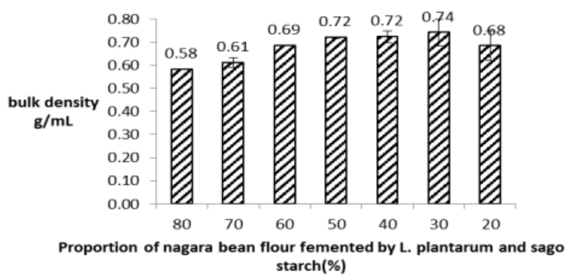

Figure 3. Bulk density of analog rice from formulation of nagara bean fermented by *L. plantarum* and sago starch

[14] stated that the material with higher bulk density would result in more amounts of material that was packaged using a certain packaging.

Water Absorption Capacity

The pregelatinization treatment resulted in heating that caused the water absorption and swelling in starch granule. The use of the heat that was gradually increased caused the intermolecular hydrogen bond between the amylose chain and amylopectin branch chain to weaken so that the starch granule was swollen rapidly.

This analog rice was produced by formulating nagara bean flour and sago starch. Figure 4 shows that the increased proportion of sago starch caused the water absorption of analog rice to increase. The sago starch had some characteristics that were similar to the characteristics of tuber starches. Those characteristics were having big size of the granule [12], having a swelling index (swelling power), high solubility [13] and the characteristic of type A gelatinization (having a high peak viscosity). However, it would decrease drastically when it was heated continuously at a high temperature (95°C).

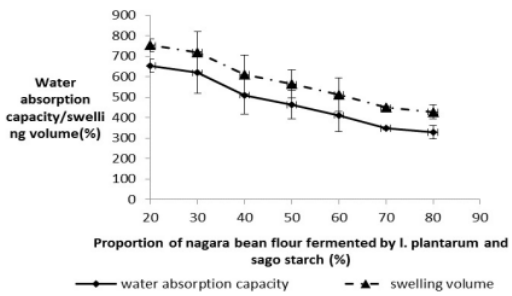

Figure 4. Water absorption capacity and swelling volume of analog rice from formulation of nagara bean fermented by *L. plantarum* and sago starch

Swelling Volume

The swelling volume of analog rice along with the water absorption level showed that the increase of sago flour proportion caused the increase in water absorption level and the swelling volume in rice analog (Figure 4).

Besides the relatively big size of sago starch granule, the low amylose content also caused the increase of swelling volume in the starch [15]. The amylose would suppress the swelling of granule and maintain the integrity of swollen starch granule. The ability to swell was affected by amylopectin. The starch with a high amylopectin content would be swollen easily.

When starch molecules heated in excess water, the semi-crystalline structure is broken, and water molecules combine with hydrogen to hydroxyl bonds groups exposed to amylose and amylopectin molecules. This relationship causes swelling and increases the size of the granule and solubility [16]. Swelling capacity and solubility starch describes polymeric chain interactions consists of amorphous and crystal granule fractions [17].

Solid Loses

The solid loses of analog rice from the formulation of nagara bean and sago starch was around 0.76% - 3.50%. The result of the analysis of variance showed that the proportion of nagara bean flour toward sago starch had no significant impact on solid loses of analog rice.

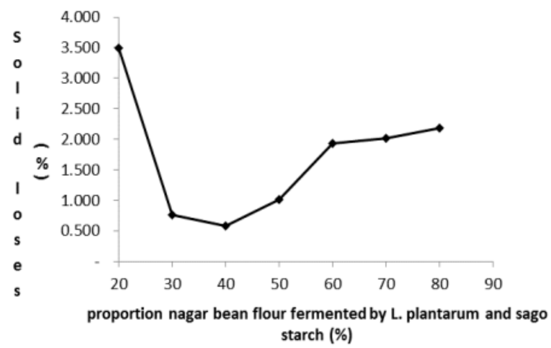

Figure 5. Solid loses of analog rice from formulation of nagara beanfermented by *L. plantarum* and sago starch

Figure 5 showed that the highest value of solid loses during the cooking process was at the proportion of nagara bean of 20%, and then it would be decreased up to the proportion of 40%. Meanwhile, at the proportion of 50%, it would start to increase again after the density loss. The low content of sago flour caused the adhesion of rice granule particle to weaken, crumbly texture, and during the cooking process, the analog rice was easily separated. Similarly, the low proportion of nagara bean flour and dominant sago starch caused the analog rice would be easily gelatinized during the cooking process. If the sago starch were cooked over the gelatinization temperature, the solubility of starch granule would increase.

Cooking Time

Cooking time is a duration needed to cook the analog rice. The duration needed for cooking was around 2.11 – 11.95 minutes. The result of the analysis of variance showed that the ratio of nagara bean flour to sago provided a significant impact on the duration of for cooking the analog rice. Duncan's test showed that the cooking time of analog rice at each proportion of nagara bean flour and sago was various, except for the nagara bean flour: sago ratio of 70: 30 and 80: 20, it had no much difference. The more amount of the nagara bean flour was, the longer the cooking time would (Figure 6)

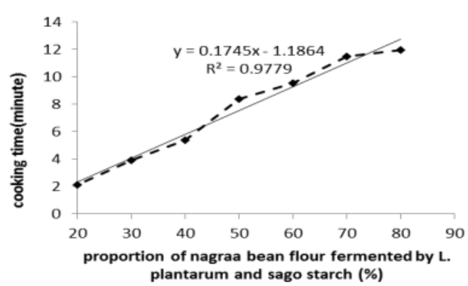

Figure 6. Cooking time of analog rice from formulation of nagara bean fermented by *L. plantarum* and sago starch

The starch that had high amylose content would be difficult to be gelatinized. Hence, the cooking time needed more times. It was because of the amylose molecule had a tendency to be at the parallel position. This condition caused the hydroxyl groups to be able to bind freely and the starch could

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form a strong crystal aggregate. In contrary, the starch that had a high amylopectin component would be difficult to be bound to one another due to the branch chain. Thereby, the starch with high amylopectin would be easily gelatinized. Naturally available amylose and lipids in starchy materials can inhibit swelling under conditions of formed amylose-lipid complexes. The complexity of lipids with starch is a very important reaction in the extrusion and texture of the extruded product [18, 19]

In seven combinations of nagara bean flour to sago starch ratio, it was obtained the highest level of solid loses at the proportion of nagara bean flour of 20% and 80%. The proportion of nagara bean flour of 80% had dry texture, low water absorption capacity. In addition, the rice that had been cooked and left at room temperature would easily undergo retrogradation, and it would easily dry because the water content in analog rice would evaporate. At the proportion of nagara bean flour of 20%, which means the 80% was sago starch, during the cooking time that was over the gelatinization temperature would easily be crumbled due to the amylopectin structure that was easily gelatinized. The physical quality of analog rice that has been cooked can be seen in Figure 7.

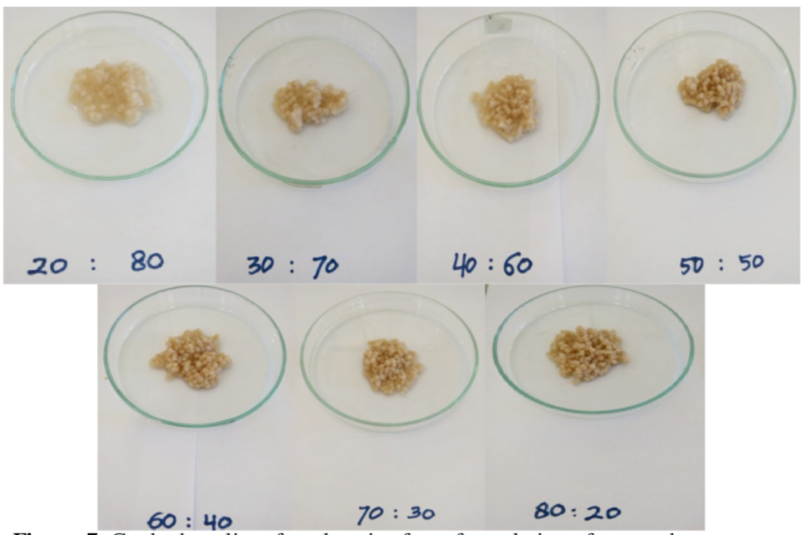

Figure 7. Cooked quality of analog rice from formulation of nagara bean fermented by *L. plantarum* and sago starch

The ratio of starch that was less than 30% from the flour would make the analog rice product had low rehydration characteristic. Meanwhile, if the ratio of starch was more than 70%, it would affect the extrusion characteristic; and the control toward the shape and the size of analog would be difficult to be done [20]. In the analog rice that contained amylose around 25% would result in hard gel since the molecule of starch formed a tissue. On the other hand, the starch with low amylose would result in soft texture and had no tissue [21].

Effect of Glycerol Monostearate Concentration Toward The Capacity of Water Absorption and Swelling Volume

The study on the use of glycerol monostearate as emulsifier aimed to facilitate the extrusion process in the extruder (lubricant) and to decrease the stickiness level of extruded rice to one another. Therefore, during the pregelatinization process, it was easy to be separated from one another. Glycerol monostearate as a lubricant would able to decrease the friction force between the particle in the mixture and between the surface of the screw and the dough [22]. The use of monoglycerides

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could strengthen the water contained in the dough that had a function as a plasticizer. Thereby, the plasticity characteristic of the dough in the barrel could be maintained.

This research was conducted by taking one formulation of nagara bean flour to sago starch ratio i.e. 50: 50 and examining the GMS concentration at 1%, 2%, 3%, 4%, and 5%. The functional characteristics (water absorption level and swelling volume) were tested to the product that had been produced.

Water Absorption and Swelling Volume

The research finding showed that by adding GMS emulsifier during the analog rice production could make the extrusion process in the extruder easier and there was no stickiness between one extrudate to another after the pregelatinization process. At a concentration of 1% GMS, the rice was still stuck to one another. Meanwhile, at a concentration of 2% GMS, the rice product was not stuck to one another. The increase of GMS concentration of 2% to 5% showed that the physical quality had no significant difference (Figure 8). According to [25], the concentration of lipid more than 3% would not affect the expansion characteristics. However, it would affect the expansion rate if the concentration was more than 5%.

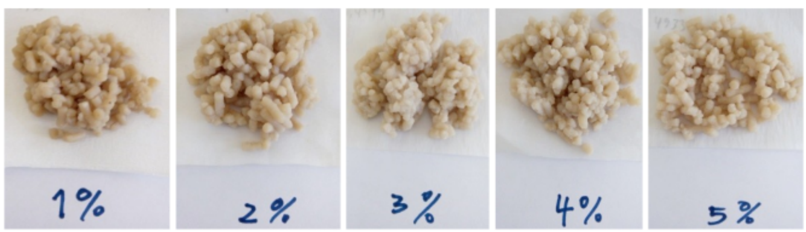

Figure 8 Swelling of analog rice by various of glycerol monostearate concentration

Figure 9 shows that the increase of glycerol monostearate concentration would increase the water absorption and swelling volume of analog rice. Nonetheless, the difference of water absorption level and swelling volume in rice analog by adding GMS at the concentration of 3% to 5% was not significant. Therefore, further research was conducted by adding the GMS concentration of 1%, 2%, and 3%. The picture of analog rice after the result of water absorption test at some concentrations is presented in Figure 8.

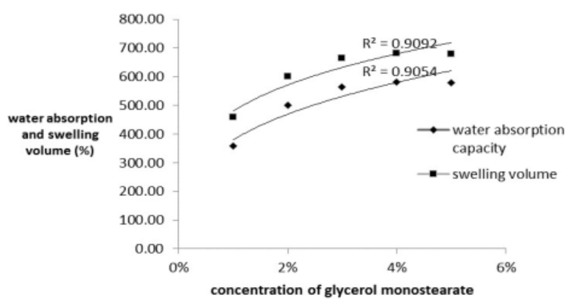

Figure 9. Effect of glycerol monostearate on water absorption capacity and swelling volume of analog rice from formulation nagara bean flour fermented by *L. plantarum* and sago starch

The level of starch swelling was beneficial for explaining the intermolecular bond. The starch swelling was correlated to the amylopectin content. In this case, amylose had a function as a diluent and an inhibitor of swelling, especially when the existence of lipid could form insoluble complex using amylose during the swelling process. In cereal starch granule, it did not show a complete swelling level until the amylose was out of granule [23]. Thus, the increase of GMS concentration that was added could make the lipid amylose complex increasingly increase. It would be the barrier for water-binding so that the swelling capacity of granule became limited.

The amount of lipid and protein in starch could also affect the swelling level. [24] stated that the complex between lipid and amylose in the granules had been formed during the swelling process. The protein and the starch interacted to each other due to the attraction of opposite charges. Furthermore, it formed the complex during the gelatinization and it inhibited the swelling.

4. Conclusion

The formulation of analog rice between the modified nagara bean flour through *L. plantarum* fermentation and sago starch results in a high rehydration characteristic with the lowest solid loses level at the proportion of nagara bean flour to sago starch of 40%. However, it is not relatively different from the proportion of nagara bean flour of 50%. The increase of glycerol monostearate concentration up to 5% still gives an increase in water absorption capacity, but the glycerol monostearate concentration of 2% can be extruded well.

Reference

[1] Riaz, MN. 2012. Cereal extrusion technology for small food processing enterprises. Quality Assurance and Safety of Crops & Foods 4(3):156. https://doi.org/10.1111/j.1757-837X.2012.00168.x
[2] Susi S, Agustina, L. dan Wibowo C. 2018. Modifikasi tepung kacang nagara melalui fermentasi bakteri asam laktat untuk produksi beras analog dalam rangka meningkatkan ketahanan pangan. [In Press]
[3] Niba L. 2003. The relevance of biotechnology in the development of functional foods for improved nutritional and health quality in developing countries African. *J Biotechnol*. 2 (12): 631-635. https://doi.org/10.5897/AJB2003.000-1117.
[4] Chinsamran K.. Piyachomkwan K. Santisopasri V. and Sriroth K. 2005. Effect of lactic acid fermentation on physico-chemical properties of starch derived from cassava, sweet potato and rice. *Kasetsart J Nat Sci*. 39: 76-87. https://www.researchgate.net/publication/281897657
[5] Abia R, C.J. Buchanan, F. Saura-Calixto, and M.A. Eastwood. 1993. Structural changes during the retrogradation of legume starches modify *in vitro* fermentation. *J Agric Food Chem*. 41(1)1: .1856–1863.DOI:10.1021/jf00035a010
[6] Osundahunsi OF, Aworh OC. 2003. Nutritional evaluation, with emphasis on protein quality, of maize-based complementary foods enriched with soya bean and cowpea tempe. International *J. Food Sci. Technol*. 38: 809-813. http://dx.doi.org/10.1046/j.1365-2621.2003.00736.x
[7] Jasser, ASH. 2011. Chemical and biological properties of local cowpea seed protein grown in gizan region, Saudi Arabia. *Int J. Nutr. Food Engineering* 5 (8) :466-472 .https://waset.org/publications/11997/
[8] Budijanto, S dan Yuliyanti 2012. Studi persiapan tepung sorgum (*Sorghum bicolor* L. Moench) dan aplikasinya pada pembuatan beras analog. *J Tek. Pert*.13 (3) : 177-186. https://www.researchgate.net/publication/285651587
[9] AOAC. 2000. Official Methods of Analysis. 17th Edition, The Association of Official Analytical Chemists, Gaithersburg, MD, USA
[10] Indriyani F, Nurhidajah, Suyanto A. 2013. Karakteristik fisik, kimia dan sifat organoleptik tepung beras merah berdasarkan variasi lama pengeringan. *J Pangan dan Gizi*.04 (08):27-34. https://media.neliti.com/media/publications/116231-ID

[11] Collado L., Corke H. 1998. Pasting properties of commercial and experimental starch pearls. *Carbohydrate Polymers* 35(1):89-96. DOI: 10.1016/S0144-8617(97)00127-6

[12] Yiu, P.H., Loh, S.L, Rajan, A., Wong, S.C., Bong, C.F.J.2008. Physicochemical properties of sago starch modified by acid treatment in alcohol. *Am. J. Appl. Sci*. 5:307-311, 2008. https://pdfs.semanticscholar.org/377c/0dc7854fd177d6c255629a099ca43fa8fe33.pdf

[13] Wattanachant S, Muhammad SKS, Hashim DM, Rahman RA. 2002. Characterisation of hydroxypropylated crosslinked sago starch as compared to commercial modified starches. *Songklanakrin J Sci Technol* 24:439-450. http://rdo.psu.ac.th/sjstweb/journal/24-3/10.pdf

[14] Fagbemi TN. 1999. Effect of blanching and ripening on functional properties of plantain (*Musa aab*) flour. *Foods Hum. Nutr*. 54 (3): 261- 269. https://link.springer.com/article/10.1023/A:1008153404357

[15] Tester, R. F., And Morrison, W. R. 1990. Swelling and gelatinization of cereal starches: Effects of amylopectin, amylose, and lipid. *Cereal Chem*. 67:551-557.http://www.aaccnet.org/publications/cc/backissues/1990/documents/67_551.pdf

[16] Singh, N., Singh, J., Kaur, L., Sodhi, N. S., Gill, B. S. 2003. Morphological, thermal and rheological properties of starches from different botanical sources. *Food Chemistry*, 81(2), 219-231. http:// dx.doi.org/10.1016/S0308-8146(02)00416-8.

[17] Zhang, P., Whistler, R. L., BeMiller, J. N., Hamaker, B. R. 2005. Banana starch: production, physicochemical properties, and digestibility — a review. *Carbohydrate Polymers*, 59(4), 443-458. http://dx.doi.org/10.1016/j.carbpol.2004.10.014.

[18] Bhatnagar, S., Hana, M. A., 1994. Amylose-lipid complex formation during single-screw extrusion of various corn starches. *Cereal Chem*. 71 (6) : 582- 587. http://199.86.26.57/cerealchemistry/backissues/1994/71_582.pdf

[19] De Pilli T, Derossi A., Talia R.A, Jouppila K, Severini C. 2011. Study of starch-lipid complexes in model system and real food produced using extrusing-cooking technology. *Innovative Food Science and Emerging Technologies* 12(4): 610-616. http://dx.doi.org/10.1016/j.ifset.2011.07.011

[20] Harrow, A.D. dan Martin, J.W. 1982. Reformed Rice Product. US Patent 4325975.

[21] Copeland Les, Jaroslav Blazek, Hayfa Salman, dan Mary Chiming Tang. 2009. Form and functionality of starch. *Food Hydrocolloids* 23:1527–1534. DOI: 10.1016/j.foodhyd.2008.09.016

[22] Guy, R. 2001. Extrusion cooking: Technologies and applications. Cambridge: Woodhead Publishing. 288 p. https://books.google.co.id/books

[23] Bowler, P., Williams, M.R., Angold, R. E. 1980. A hypothesis for the morphological changes which occur on heating lenticular wheat starch in water. *Starch/ Staerke* 32:186-189. https://doi.org/10.1002/star.19800320603

[24] Morrison WR. 1988. Lipid in cereal starches : A review. Journal of Cereal Science 8(1):1-15. https://doi.org/10.1016/S0733-5210(88)80044-4

[25] Harper, J.M. 1992. Extrusion processing of starch. In: Alexander, R.J. and Zobel, H.F. (Eds), Developments in carbohydrate chemistry. American Association of Cereal Chemists inc., St. Paul, MN. pp. 37-64.

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