Physicochemical characteristics of tuber modified by acetylation method and its application in dry noodle product

Sisilia Florina Yanti¹, Herla Rusmarilin²*, Elisa Juliandi², SDR Tampubolon³ and Dewi Restuana Sihombing³

¹Department of Food Science, Universitas Nahdlatul Ulama Sumatera Utara, Indonesia
²Department of Food Science, Universitas Sumatera Utara, Indonesia
³Faculty of Agriculture, Universitas Katolik Santo Thomas, Indonesia

*e-mail : sisiliyanti@gmail.com
Correspondent author: herla_surabaya@yahoo.com

Abstract. Sebaring taro is a source of carbohydrate in the form of starch so it can be used as starch food based on starch like dry noodles. The objective of this study was to study the physical, chemical and functional characteristics of Sebaring Tarostarch modified by acetylation method and its effect on the physical, chemical and organoleptic characteristics of dry noodles prepared from the mixture of flour and acetylated starch from Sebaring taro with the addition of sodium tripolyphosphate. The study was conducted in two (2) stages; Phase I is characteristic of tubers, flour and acetylated taro starch, and Phase II is the application of acetylated starch on dry noodles, which is carried out using a Factorial Complete Random Design consisting of two (2) factors. The results showed that acetylated starch from sebaring taro had 11.12% resistant starch content, 7.20% oxalate content, Swelling power 68.40%, but water absorption and oil absorption on acetyl starch was similar to natural starch.

Keywords: acetylation, characteristics, dried noodles, taro tuber acetylated starch (TTAS), STPP

1. Introduction
Various agricultural commodities have a good enough feasibility to be developed in Indonesia, one of which is the tubers [1-3]. Tubers are food that has unique flavor and good nutritional content, so it has potential to be developed as an alternative food source [3]. Keladi sebaring is a type of tuber that has great potential as food source of fiber which is good enough but not yet developed [3-5].

Modified starch is a starch whose hydroxyl group has been converted by a chemical reaction (esterification, etherification or oxidation) or by disrupting its original structure [6-9]. Chemical modification can be done by adding a particular chemical or reagent with the purpose of replacing the hydroxyl (OH⁻) group on starch [10-12]. For example, in the presence of acetyl group distribution replacing the OH group by acetylation reaction will reduce the strength of the hydrogen bond between
the starch and cause the starch granules to be more fluid (much water-holding), easily soluble in water, and increase the freeze-thaw stability of starch [12-14].

Acetylation method is a very important method to modify the characteristics of starch because this method can give thickening effect (as thickening agent) in various foods [15-17]. The quality of products produced from acetylated starch is more stable and resistant to retrograde. The physico-chemical properties of acetylated starch are affected by the amount of acetyl group distribution which replaces the hydroxyl (OH-) group in starch [18-20].

Noodle is one of the most popular foods in Asia especially in East Asia and Southeast Asia [21-23]. Noodle is usually made from wheat flour, so the need for wheat for the manufacture of flour is needed very much. But the current condition, the availability of wheat flour is getting less and more expensive. Therefore, in the manufacture of instant noodles the use of wheat flour is substituted with taro starch [24]. The method used in this study uses Factorial RAL which consists of two factors, namely the ratio of starch acetylation: wheat flour (P1 = 0: 100; P2 = 25:75; P3 =50; P4 = 75:25), and concentration sodium tripolipospate (F1 = 0.4%, F2 = 0.5%, F3 = 0.6%).

2. Materials and methods

![Diagram of Starch modification scheme with the acetylation method](image1)

![Diagram of Dry noodle making scheme](image2)
Materials used were tuber taro, wheat flour, salt, cooking oil, garlic, soy sauce, CMC, STPP, eggs, sodium metabisulfite. The research consisted of two phases: the preliminary research and the major research. Preliminary research in the form of observations of the characteristics of the tuber, taro flour and NTS and its starch which were performed in three (3) replicates.

The method performed in the major research was using a random used design (RAL), which consists of two factors, namely: Factor I. Ratio of TTAS with wheat flour (%) consisting of four levels, namely: P1 = 0: 100; P2 = 25:75; P3 = 50: 50; P4 = 75: 25 and Factor II. STPP concentration (F) consisted of three levels, namely: F1 = 0.4%; F2 = 0.5%; F3 = 0.6%.

The process of making dried noodles

TTAS was mixed with wheat flour and STPP in accordance with a predetermined proportion. The mixture was mixed with salt (1%), water (35%) of the total weight of flour, 1 egg (40g), and CMC (2g). The mixture was then stirred up into dough, rolled, and printed using noodle maker. The noodle was boiled at a temperature of 90°C for 2 minutes, and then dried in an oven at 50°C for 22 hours, packed in sealed plastic containers.

3. Results and discussion

Characteristics of physical, chemical, functional taro flour, NTS and TTAS, we can see on Table 1.

Table 1. Characteristics of physical, chemical, functional flour, starch and sebaring acetylation starch

| Parameter                  | Flour Taro          | Tuber Starch       | Acetylation Starch |
|----------------------------|---------------------|--------------------|--------------------|
| Amylose content (%)        | 13.02±0.10          | 20.50±0.12         | 22.77±0.05         |
| Resistant Starch (%)       | -                   | 4.79±0.14          | 11.12±0.09         |
| Oxalate Content (mg/100g)  | 34.19±0.31          | 17.33±0.07         | 7.20±0.33          |
| Swelling Power (g/g)       | -                   | 38.44±0.34         | 68.40±0.35         |

Table 1 shows that acetylated modified tuber roots have different physical, chemical and functional characteristics with their natural starches. Acetylated starch from sebaring taro starch has 11.12% resistant starch content higher than the starch content resistant to natural starch which only 4.79%. Breaking branch bonds will increase amylose levels, so the resistant starch will also be higher. The higher the amylose content of the starch the higher the starch content is resistant. Amylose rich starch granules have greater crystallizing ability due to intensive hydrogen bonding [25].

Acetylation starch oxalate levels were lower (7.2 mg) than natural starch (17.3mg). Decreased oxalate levels occur because of the reaction between NaCl and CaC₂O₄. NaCl dissolved in water decomposes into Na⁺ and Cl⁻ ions. The Na⁺ ion attracts negatively charged ions and Cl⁻ ions attract positively charged ions. While CaC₂O₄ in water decomposes into Ca²⁺ and C₂O₄²⁻ ions. Na⁺ binds C₂O₄²⁻ ions - forms Na₂C₂O₄. The Cl⁻ binding Ca²⁺ ion forms a water-soluble CaCl₂ white precipitate [26].

Amylose content on acetylation starch was 22.77% higher than natural starch (20.50%). An increase in the number of amylose occurs due to the breaking of the branches of amylopectin in the bonds 1Æ 1-6 glucoside. This means that the chain of amylopectin branches will decrease and the increase of straight chain amylose as a result of the breaking of the branches of amylopectin [27].

Swelling power in acetylation starch was 68.40g / g higher than natural starch (38.4g / g). The increase of swelling power in acetylated starch is caused by the substitution of acetyl group which replaces the hydroxyl group so that the hydrogen bond becomes weak and finally cause the starch granula structure
becomes less tightly. Water absorbed in each starch granule will make starch granules expand and coincide so as to increase the value of its swelling power [28].

**Characteristics of dry noodle quality**
The observation result of dry noodle cooking loss due to the proportion of wheat flour and modified starch of taro with concentration of STPP ranged from 7.15-12.35%.

Figure 3 shows that the more acetylated starch addition and the higher the concentration of STPP the cooking loss increases. This is because the starch is not good enough in binding to existing solids. The high cooking loss is caused by less optimum of starch matrix gelatinized in binding starch is not gelatinised [29].

![Figure 3](image1.jpg)

The result of observation on dry noodle fiber content due to the proportion of wheat flour and modified starch of taro with the concentration of STPP ranged from 1.35 to 2.78%

Figure 4 shows that the more acetylated starch addition and the higher the concentration of STPP the water absorption decreases. The lower the water absorption value, the noodles will absorb less water and the noodle will not expand.[30].

![Figure 4](image2.jpg)

The average value of panelist preferences to dry mature noodle color due to the treatment of wheat flour and modified starch proportions with concentration of STPP ranged from 2.75 to 4.54. Figure 5 shows that the more acetylated starch addition and the higher the concentration of STPP the noodles will decrease. This is due to the non-enzymatic browning of Maillard's reaction so that the dry ripe noodle results in browning which causes the panelist's favored level to decrease [31].

The average value of panelist preferences to dry mature color due to the treatment of the proportion of wheat flour and modified starch taro with concentration of STPP ranged from 4.11 to 5.65.
Figure 6 shows that the more acetylated starch addition and the higher the concentration of STPP the noodle texture will decrease. This is because the more acetylation starch the texture is very difficult to be formed into dough so that the texture decreases [32]. This is because starch acetylation does not contain gluten. Gluten has elastic and plastic properties, which will produce noodles not easily broken[33]. The addition of STPP concentration does not affect dry noodle products.

4. Conclusion
Acetylated starch can change the physical, chemical and functional properties of taro flour. This change can be seen with the increasing characteristics of taro starch such as swelling power, resistant starch, and amylose. On the other hand, acetylated starch may lower the oxalate content of the taro starch. Acetylated starch from taro can be used as an ingredient for the substitution of wheat flour in the manufacture of dry noodles. The best dried noodles were obtained at acetylated starch and wheat flour ratio (25:75) with 0.4% STPP concentration.

References
[1] Ermanyuli, Hanung I and Sri S 2011 Technical and financial analysis of small scale agroindustry in various processes of making taro chips in West Lampung Regency
[2] Saputro N, Akkaya K and Uludag S 2012 A Survey of routing protocols for smart grid Communications Comput network, 56 (11) 2742-2771
[3] Haliza W, Kailaku S I and Yuliani S 2012 The use of Mixture Response Surface Methodology in the optimization of Bantam taro flour based brownie formula (Xanthosoma undipes K. Koch) as an alternative source of fiber food. A Postharvest 9 (2) 2012: 96-106
[4] Bulkabi 2009 Tubers (Taro). http://bukabi.wordpress.com/2009/01/27/tubers/taro/ Accessed June 10, 2018
[5] Widiawan M E, Nocianitri K A and Son N K 2012 Characteristics of Physico-Chemical Properties of Modified Turmeric Taro (Xanthosoma sagittifolium) With Acetylation Method. Journal.
[6] Fleche G 1985 Chemical Modification and Degradation of Starch. In the G.M.A. Van Beynum and J.A. Roels, ed. Starch Conversion Technology. Applied Science Publ., London.
[7] BeMiller J N 1997 Starch modification: Challenges and prospects. Starch-Stärke 49: 127-131
[8] Kaur B, Ariffin F, Bhat R and Karim A A 2012 Progress in starch modification in the last decade. Food Hydrocolloids 26: 398-404.
[9] Zia-ud-Din, Hanguo X and Peng F 2015 Physical and chemical modification of starches. A review, Critical Reviews in Food Science and Nutrition, 57:12, 2691-2705, DOI: 10.1080 / 10408398.2015.1087379
[10] Kusnendar F 2010 Pati Modification Technology and Its Application in Food Industry
[11] Kinanti P S K, Bambang S A and Windi A 2014 Study of physical and chemical characteristics of sorghum flour (sorghum bicolor l) modified mandau varieties produced with variations in concentration and soaking time of lactic acid, Published Online January 1, 2014.Koswara S, 2009. Starch modification technology. EbookPangan.com
[12] Koswara, S, 2009. Starch modification technology. EbookPangan.Com
[13] Adebowale K O, Olawumi E K and Lawal O S 2005 Functional properties of native, physically and chemically modified breadfruit (Artocarpus arilis) starch: Industrial Corps and Products 21: 343-351.
[14] Srichuwong S, Naoto I, Hongxin J, Takashi M and Makoto H 2012 Freeze-thaw stability of starches from different botanical sources: Correlation with structural features. Carbohydrate Polymers. Volume 87, Issue 2, 15 January 2012, Pages 1275-1279
[15] Raina C, Singh S, Bawa A and Saxena D 2006 Some Characteristics of Acetylated, Cross-Linked and Dual Modified Indian Rice Starches. European Food Research and Technology. 223: 561-570
[16] Varavinit, P. D. S. S. W. V. P. C. O. N. S 2008 Preparation, pasting properties and freeze-thaw stability of dual modified crosslinks-phosphorylated rice starch: Carbohydrate Polymers, v. 73, p. 351-358

[17] Teja A W, Sindi I P, Ayucitra A and Setiawan L E K 2007 Characteristics of Sago Starch with Acetylation and Cross-Linking Methods. Unika Widya Mandala. Surabaya.

[18] Yeh A I Y S L 1993 Some Characteristics of Hydroxypropylated and Cross-Linked Rice Starch. Carbohydrate Polymers. Vol.70, p.596-601.

[19] Herawati H 2012 Technology production process for food ingredients from modified tapioca, Bogor Agricultural Postharvest Research and Development Center

[20] Dwiastarini N N 2010 Effect of different acetate acid concentration on acetylated corn starch modification process on the characteristics of starch and its application as edible films Scientific writings of the Academy of Pharmacy and Putra Indonesia Malang Academy of Sciences

[21] Rachman M A, Fithri C N and Teti E 2015 Noodles from coconut yam (Dioscorea alata L.): literature review Noodles from Greater Yam (Dioscorea alata L.): A Review. Journal of Food and Agro-Industry Vol. 3 No. 2 p.631-637

[22] Astawan M 2006 Making Noodles and Vermicelli. Self-helpers. Jakarta

[23] Sutomo B 2006 History and Various Types of Noodles http://www.Budiboga.com/2006/sejarah-dan-anych-jenis-mie.html. Access date: July 15, 2018

[24] Fawzan S A and Dian A A E 2015 Formulations of taro and sweet potato composite flour as raw materials for dry noodles substitute some flour

[25] Marsono Y 1998 Changes in resistance levels of starch (RS) and chemical composition of several carbohydrate-rich foods in the processing process. Proceedings of PATPI National Seminar. Yogyakarta.

[26] Rindasmaray S 2008 Itching Disappearances in Taro. www.google.com/2008/02/18.

[27] Laga A 2006 Development of modified starch from tapioca substrates by optimization of branch chain cutting using pullulanase enzyme. Proceedings of PATPI National Seminar. Yogyakarta.

[28] Pudjihastuti I 2010 Development of an Innovative Process for Combination of Acid Hydrolysis Reactions and UV Photochemical Reactions for Modified Starch Production of Tapioca. Thesis Masters in Chemical Engineering. Diponegoro University, Semarang.

[29] Merdiyanti A 2008 Package Technology for Making Dry Mi by Utilizing Raw Materials of Corn Flour. IPB-Press. Bogor

[30] Ellliason A C and Kim H R 1992 Changes in reological properties of hydroxypropyl potato starch pastes during freeze-thaw treatments. In A reological approach for evaluation of freeze thaw stability. J. of Texture Studies 23: 279 - 293.

[31] Yokotsuka T 1986 Soy Sauce Biochemistry. Adv. Food. Res. (30): 195-329.

[32] Suyanti 2008 Making Nutritious and Preservative Healthy Noodles. Penebar Swadaya. Jakarta

[33] Widatmoko R B 2015 Physiochemical and organoleptic characteristics of dried noodles based on purple sweet potato flour at various levels of gluten addition. Malang: FTP Brawijaya University Malang.

Acknowledgement
The author would like to thank the University of North Sumatra for its support during the research, and the Catholic University of Santo Thomas in North Sumatra for allowing the use of facilities to conduct research.