ASM Sc. J., 13, Special Issue 4, 2020 for NCAFM2018, 53-58

Processing of Functional Food from Purple Sweet Potato Starch

Sedarnawati Yasni[1*]

[1]*Department of Food Science and Technology, Faculty of Agriculture Engineering and Technology, Bogor Agricultural University, 16002 Bogor, West Jawa, Indonesia*

The production of purple sweet potato starch uses the postharvest technology that produces intermediate products, aiming at reducing fresh product postharvest losses and increasing its utilization as an alternative product. Hydrothermal process on starch with 50% moisture content and temperature of 75°C can increase the slowly digested starch (SDS) content. Furthermore, SDS is used to develop functional food products in the form of biscuits by substitution of wheat flour with purple sweet potato starch. Biscuit products containing high level of dietary fibres (9.81%) were then tested to see whether they could decrease blood glucose and cholesterol levels by using an alloxan-induced Sprague dawley strain rats of 110 mg/kg body weight which were given the standard diet and biscuit diet for 18 days ad libitum. The results showed that blood glucose significantly decreased by 30.32%, and there was a tendency that serum cholesterol and triglyceride levels for the rats group of biscuit diet became lower. The functional foods made from SDS of purple sweet potato can be used as a model for small and medium enterprises development products as well as supports for the government programs in the field of public health, especially in preventing the increasing prevalence of diabetics.

Keywords: biscuits; starch; purple sweet potato; glucose; cholesterol; diabetes

I. INTRODUCTION

Fresh foods are perishable, seasonal and in primary forms, they have a low economic value. The problems of fresh foods distribution can be solved by postharvest technology, including postharvest handling and postharvest processing. In addition, the number of populations that increases rapidly demands an increase in the supply of staple food as well. Therefore, the utilization of local foods is an alternative solution to reduce consumption of staple foods and increase food security.

Utilization of agricultural products as a source of carbohydrate is still limited to certain processed food forms whereas their utilization can be improved as raw materials of various food products. For example, fresh sweet potato can be eaten by a simple processing such as steamed or fried, or it can be further processed into paste, flour and/or starch.

Starch is one source of carbohydrate that can be distinguished based on the speed of digestion, namely, rapidly digested starch, slowly digested starch (SDS), and resistant starch (Englyst *et al.*, 1992). The absorption of starch is related to glycaemic index, and resistant starch and slowly digested starch have beneficial effects on health.

SDS is absorbed for a long time in the small intestine, thus slowing the absorption of sugar in the blood resulting in a low glycaemic response. It is reported that consuming slow digestible starch on instant pudding can lower the glycaemic index (Gourineni *et al.*, 2017).

Sweet potato (Ipomea batatas) is a type of food that has a high carbohydrate content (96.26%) so it can be utilized as an alternative staple food (Syarfaini, 2017). Productivity of sweet potatoes in Indonesia during the period of 2011-2016 tended to increase by 4.83% per year, and their export average volumes from 2003 to 2016 increased by 91.47% per year with an annual export value increased by 108.35% (Ministry of Agriculture, 2016).

High levels of sweet potato carbohydrates make this ingredient an alternative source of slowly digested starch.

*Corresponding author's e-mail: sedarnawati@yahoo.com

There are 12 varieties of sweet potatoes in which most of them have yellow skin and flesh. The levels of anthocyanin in purple sweet potatoes are higher than those of white, yellow, and orange varieties. The variations of anthocyanin levels are dependent on the sweet potato varieties (Terahara *et al*., 2004; Ginting *et al*., 2009). Therefore, the intermediate product in the form of starch can be an option to utilize purple sweet potato more widely.

In regard to the explanation above, this paper describes the study results of the development of biscuits made from slow digestible starch of purple sweet potato as a functional food, an alternative solution to reduce the use of wheat flour. Furthermore, the testing of the efficacy specifically the ability to reduce sugar and blood cholesterol levels was conducted using experimental animals. Biscuits consumed as snacks in Indonesia reached 2 kg per capita in 2017 (Ministry of agriculture, 2017); therefore, those biscuits with substitute wheat flour with slow digested starch from purple sweet potato can be a functional food alternative, and they not only increase the use of potential local products but also support the government's public health program.

II. MATERIALS AND METHODS

A. Materials

Purple sweet potatoes of Ayamurazaki variety used were obtained from the Research Centers of Bean Plants and Tubers in Malang, East Java, and the male Sprague Dawley rats came from National Agency for Drug and Food Control. The raw materials for making animal feed were obtained from the local market. The tools used included glass equipment for chemical analysis, spectrometer, centrifuge, oven, rat maintenance equipment, surgical instrument, glucometer, mixer, and other tools used in the making of biscuits.

B. Methods

1. Processing of Purple Sweet Potato Starch

Starch processing was conducted in the following method: purple sweet potato was washed, peeled with abrasive peeler, shredded, and added with water in a ratio of 1:10 (w/w). Then, it was filtered using 100 mesh filter, and the filtrate was placed in plastic containers (buckets) and kept overnight. The starch deposition obtained was separated from the liquid and was dried in the oven at 50°C for 5 hours or until it was dry.

2. Slowly Digested Starch Processing by Hydrothermal Modification Process

The water content of purple sweet potato starch was adjusted to 50%, 60% and 70% with the addition of distilled water. The samples were packed tightly in containers and stored at room temperature for 24 hours to reach the equilibrium. Then, it was heated in an oven for 24 hours at the temperatures of 55°C and 75°C. The starch sample was then filtered out up to 100 mesh filter.

3. Determination of Starch Fraction

The determinations of the percentages of rapidly digested starch, slowly digested starch and resistant starch fraction were conducted using the method by Englyst *et al.* (1992). The starch sample was weighed as much as 250 mg (wet weight base), and 7.5 mL of sodium acetate buffer (pH 5.2) was added. The Erlenmeyer flask was equilibrated in water bath swaying at 150 rpm and 37°C for 10 minutes. An enzyme solution (amyloglucosidase and pancreatin) of 5 mL was added to each of the Erlenmeyer flask. After 20 minutes, 1 mL of sample solution was taken for the analysis of glucose levels and calculated as starch digestibility. A 100-minute interval was taken for the second sample to measure the slowly digested starch. Glucose analysis was performed using the DNS method. The remaining samples were analysed by the Brumovsky and Thompson (2001) methods. The value of resistant starch was obtained from the result of the reduction of the total starch with rapidly digested starch and the slowly digested starch. The highest percentage of slowly digested starch fraction was utilized for biscuit production, and then they were fed to the diabetic rat's oral without regarding the amount or dose called *ad libitum*.

4. Biscuit Production Process

The starch sample was then filtered out up to 100 mesh filter. The slowly digested starch of purple sweet potato was used in biscuit production process to substitute the wheat flour in the ratios of 50:50; 75:25; and 100:0 (w/w). The biscuit processing started from the mixing of fat, sugar, and emulsifier with mixer for 5 minutes. Later, the dry ingredients such as salt, flour, sweet potato starch, vanilla flavour, skim milk, and egg yolk dye were also mixed. All the ingredients were mixed, and the dough was treated with the direct mold (P1), tempering (P2), and steaming (P3).

5. Consumption Effect of Biscuit Made from Purple Sweet Potato Starch in Animal Experiments using Rats

Determination of antihyperglycemic activity of biscuits was performed by alloxan-induced Sprague Dawley strains of 110 mg/kg in intraperitoneal weight, and within 3-5 days the rats with blood glucose levels greater than 300 mg/dL were obtained. The diabetic rats were grouped into two i.e. control group rats given standard diet and the other group of rats treated with biscuit diet for 18 days. The blood sugar levels were measured using blood sugar check test kit of Accu Check at a 2-day interval.

III. RESULT AND DISCUSSION

The yield of purple sweet potato starch processing was 17.5%, and the starch had water content of 68.5%, ash content of 1.94%, protein of 5.31%, fat of 0.53%, carbohydrates of 84.19% and crude fibre of 5.59%.

A. Determination of Starch Fraction

Hydrothermal modification process by heating at temperature of 55°C had a tendency not to alter the structure of starch, thus the percentage of the starch fraction was not significantly different from that of the natural starch. On the other hand, the starch that was heated at temperature of 75°C appeared to have a percentage of starch significantly different from that of the natural starch. The highest increase of the slowly digested starch fraction obtained from the hydrothermal process with 50% moisture content and 75°C heating temperature was 150% (Table 1). In this study, the hydrothermal process lowered the RS levels and tended to increase the RDS and SDS fractions. The hydrothermal process enhanced starch digestibility. The decrease of RS content in starch with hydrothermal process at temperature 75°C was greater than that of the starch with hydrothermal process at temperature of 55°C. This decrease was accompanied by elevated levels of RDS and starch SDS. The hydrothermal process is reported to lead the formation of porous structures which subsequently expand access to enzyme hydrolysis (Chung *et al.*, 2009).

Table 1. Starch Fractionation Results of Purple Sweet Potato

Starch	RDS	SDS	RS
Natural starch	16,876 ^{a}	25,417 ^{a}	55,098 ^{d}
Hydrothermal starch 50%-55°C	18,347 ^{ab}	25,545 ^{a}	45,881 ^{cd}
Hydrothermal starch 50%-75°C	26,987 ^{c}	38,994 ^{b}	28,973 ^{a}
Hydrothermal starch 60%-55°C	18,053 ^{ab}	26,667 ^{a}	45,789 ^{cd}
Hydrothermal starch 60%-75°C	27,530 ^{c}	38,409 ^{b}	28,482 ^{a}
Hydrothermal starch 70%-55°C	20,173 ^{b}	27,708 ^{a}	39,360 ^{bc}
Hydrothermal starch 70%-75°C	27,801 ^{c}	37,489 ^{b}	29,003 ^{ab}

Note: The value followed by the same letter in the same column is not significantly different by the Duncan test (P <0.05).

B. Characteristics of Purple Sweet Potato Starch

The results showed that natural starch had amylose content of 30.21 %. The hydrothermal process tended to increase amylose levels although the results of the statistical analysis indicated that the increase in amylose levels was not significant. Amylose content of purple sweet potato starch after hydrothermal process ranged from 30.56 % to 34.58 %.

The breakdown values and set back of hydrothermal starch process with heating at 75°C were quite low, i.e. 182 and 677 with pasting temperature of 52.70°C. The lower breakdown value means that the starch granules are more stable during stirring and heating. On the other hand, the low set back value indicates that the starch has stable viscosity properties during the cooling phase and will form a good fresh thaw stability (Ehtiati *et al.*, 2016).

C. Physicochemical Characteristics of Biscuit made from Slowly Digested Purple Sweet Potato starch

Biscuit products made from slowly digested purple sweet potato starch (in ratio 50:50 w/w) obtained water content of 4.63%, ash of 0.99%, fat of 20.86%, 7.27% of protein, 66.25% of carbohydrate, and 9.81% of fibre (consisting of 4.43% water soluble fibre and 5.38% water insoluble fibre), and had an antioxidant capacity of 89.70 of Ascorbic Acid Equivalent Activity.

The visual observations of biscuits by substitution of hydrothermal starch with direct mold, tempering, and steaming indicated that biscuits had a brownish colour to dark chocolate with a variety of textures, distinctive aromas, and sweetness in general. In addition, tempering and steaming process had no significant effects on colour (Table 2). The three processing types of biscuits of direct mold (P1) and steaming (P3) had a ranking score of 1.83, and tempering (P2) had a ranking score of 2.13. These three types of biscuits had the same quality because the scores were not significantly different.

Table 2. Statistical Analysis of Organoleptic Test

Sample	**Organoleptics attributes**			
	Color	**Aroma**	**Texture**	**Taste**
P1	3.67^{b}	5.60^{a}	5.80^{a}	5.53^{a}
P2	4.47^{a}	5.03^{a}	5.17^{b}	5.17^{a}
P3	4.93^{a}	5.53^{a}	5.80	4.97^{a}

Note: The value followed by the same letter in the same column is not significantly different by the Duncan test (P <0.05).

Although the direct mold biscuits (P1) and steaming biscuits (P2) had the ranking score of 1.83, and tempering biscuit (P2) had a ranking score of 2.13, the qualities of three types of processing were not significantly different.

D. Consumption Effect of Biscuit Made from Purple Sweet Potato Starch in Animal Experiments using Rats

The consumption of diet increased between the rat's group. The rat fed biscuit diet was slightly higher (14.46%) than the rats fed standard diet (11.04%). The diabetic rats consumed more than the control group of diabetic rats. The same trend was also observed in the group of non-diabetic rats (Figure 1). The consumption of biscuit diet per day was 87% of the total fed provided. The amount of starch indigestion contained in the biscuit diet was 54%.

The results showed that the consumption of 47% of slowly digested starch from the amount of fed consumed for 18 days can maintain the stability of carbohydrate metabolism in diabetic rats and tend to lower blood glucose levels. Slowly digested starch can lead to lower postprandial glucose and insulin concentrations, and there were no effects on appetite as compared to the consumption of rapidly digested starch (Aller *et al.*, 2011).

The average blood glucose of control group of diabetic rats was 449 mg/dL, while the group of diabetic rats, fed-biscuit diet was 369.33 mg/dL (Figure 2). The average blood glucose of diabetic rats fed biscuit diet decreased and was lower than the average blood glucose levels of rats fed standard diet.

The percentage of decreased blood glucose level in control group of diabetic rats was 21.31%, while that in the group fed-biscuit was 30.32%. In non-diabetic rats, the blood glucose tended to be stable during observations.

Biscuit diet cannot lower blood cholesterol levels in both diabetic and non-diabetic rats. Although cholesterol levels did not show a significant decrease, triglyceride levels in the rats fed biscuit diet were lower than those of the control group (Figure 3). These results can be explained by comparing a research report on consumption of boiled sweet potatoes that could minimize postprandial blood glucose spikes, and therefore, it may prove to be more efficient in the management of type 2 diabetes mellitus (Singh *et al.*, 2011).

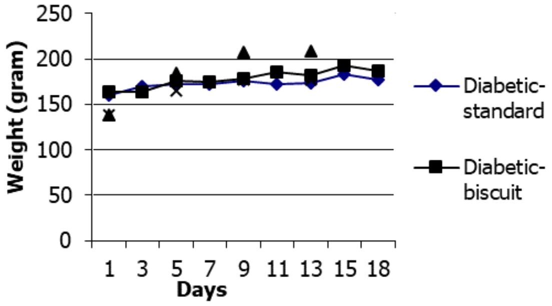

Figure 1. Amount of Diet Consumption in Diabetic and Non-Diabetic Rats Fed with Biscuit and Standard Diet

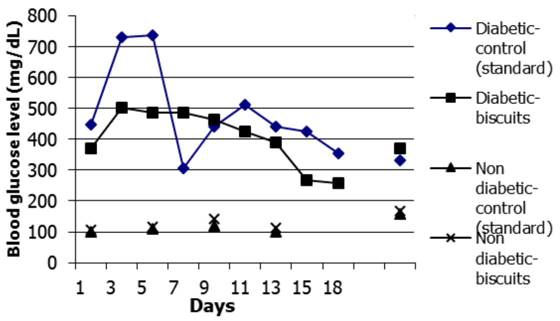

Figure 2. Blood Glucose Level of Diabetic and Non-Diabetic Rats Fed with Biscuit and Standard Diet

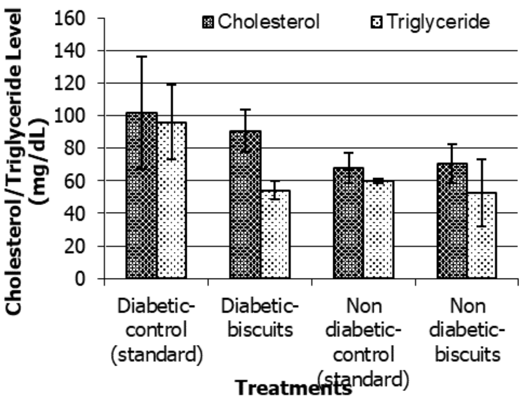

Figure 3. Cholesterol and Triglyceride Level of Diabetic and Non-Diabetic Rats Fed with Biscuit and Standard Diet

IV. CONCLUSION

The hydrothermal modification process of sweet potato starch using 50% moisture content and heating at 75°C showed the highest amount of slowly digested starch fraction (38.99 %). The slowly digested starch fraction had stable characteristics during stirring, heating and cooling.

The biscuit product that contains slowly digested starch (in ratios of wheat flour substitution 50:50 w/w) has a fibre content of 9.81% and is able to reduce blood sugar levels in Sprague Dawley diabetic rats by 30.32% and tends to lower serum cholesterol and triglyceride levels.

The functional food in the form of biscuits made from slowly digested starch of purple sweet potato can be promoted to Small Medium Enterprises as a new product development and can contribute to the government programs in public health sector, especially in preventing the onset of diabetes.

V. REFEREENCES

Aller, E.E.J.G. Abete, I. Astrup, A. Martinez, J.A. and Baak, M.A.V. (2011). Starches, sugars and obesity. *Nutrients* 3:341-369. Aller, E.E.J.G. Abete, I. Astrup, A. Martinez,

Chung, H.J. Liu, Q. and Hoover, R. (2009). 'Im- pact of annealing and heat moisture treatment on rapidly digestible, slowly digestible and resis- tant starch levels in native and gelatinized corn, pea and lentil starches', *Carbohydratpolymers*, 75: 436-447.

Ehtiati, A. Koocheki, A. Shahidi, F. Razavi, S.M.A. and Majzoobi, M. (2016). 'Pasting, rheological, and retrogradation properties of starches from dual-purpose sorghum lines', *Starch in Health and Diseases*, 69:1-30. Starch in Health and Diseases 69:1-30

Englyst, H.N. Kingman, S.M. and Cumming, J.H. (1992). 'Classification and measurement of nutritionally important starch fractions', European *Journal of Clinical Nutrition,* 46:S33-S50.

Ginting *et al.* (2006). 'Pemanfaatan ubi jalar kaya antosianin dan beta karoten'. Laporan Hasil Penelitian Balai Penelitian Tanaman Kacang-kacangan dan Umbi-umbian.

Gourineni, V. Stewart, M.L. Skorge, R. and Sekula, B.C. (2017). 'Slowly digestible carbohydrate for balanced energy: in vitro and in vivo evidence'. *Nutrients*, 9:1-10.

Ministry of Agriculture. 2017. 'Statistics Consumption of Year (2017)', 133 p. Jakarta: Ministry of Agriculture.

Ministry of Agriculture. (2016). 'Outlook Agricultural Commodity of Sweet Potatoes 2016', 87 p. Jakarta: Centre for Agricultural Information Systems and Data of the Ministry of Agriculture.

Singh, P.S.B. Riley, C.K. Wheatley, A.O. and Lowe, H.I.C. (2011). 'Relationship between processing method and the glycaemic indices of ten sweet potato (Ipomea batatas) cultivars commonly consumed in Jamaica'. *Journal of Nutritional and Metabolism*, 2011:1-6.

Syarfaini. Satrianegara, M.F. Alam, S. and Amriani. (2017). 'Analisis kandungan zat gizi biskuit ubi jalar ungu (Ipomea batatas L. Poiret) sebagai alternatif perbaikan gizi di masyarakat'. *Al-Sihah: Public Health Science Journal* 9(3):138-152.

Terahara, N. Konczak, I. Ono, H. Yoshimoto, M. and Yamakawa, O. (2004). 'Characterization of acylated anthocyanins ini callus induced from storage root of purple-fleshed sweet potato (Ipomoea batatas)'. *Journal of Biomedicine and Biotechnology* 5: 279-286.