

Alternative Snack for Diabetic Patients from Sago (*Metroxylon Sp.*) Starch and Tempeh

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ABSTRACT

This study aimed to develop food products made from sago starch (*Metroxylon sp.*) and tempeh as alternative snacks for diabetics. This study used a completely randomized design (CRD) with two treatment ratios of sago starch to tempeh, F1 (2:1) and F2 (1:1), and two replications for three products, namely puddings, muffins, and cookies. The organoleptic attributes of the products were evaluated by forty semi-trained panelists. The results of the hedonic test showed that F2 was the formula selected for the puddings and muffins and that F1 was the formula selected for the cookies. The puddings had hardness of 83.47 gf, 92.28% water, 0.28% ash, 1.04% protein, 0.64% fat, 5.76% carbohydrate, 3.95% dietary fiber, and 0.81% resistant starch. The muffins had hardness of 3,861,87 gf, 56.18% water, 0.79% ash, 6.49% protein, 10.26% fat, 26.28% carbohydrate, 7.13% dietary fiber, and 3.59% resistant starch. The cookies had hardness of 1,655,02 gf, 5.05% water, 0.90% ash, 4.90% protein, 19.66% fat, 69.49% carbohydrate, 9.57% dietary fiber, and 6.00% resistant starch. These products contained different levels of dietary fiber and resistant starch. Puddings are categorized as a high-fiber food with a negligible level of resistant starch, the muffin as a high-fiber food with an intermediate level of resistant starch, and the cookie as a high-fiber food with a high level of resistant starch. In conclusion, these products had relatively high fiber content and need a further study to confirm the health benefits for glucose control in diabetics.

Keywords: diabetes mellitus, dietary fiber, sago, snack, tempeh

INTRODUCTION

Type 2 diabetes mellitus (DMT2) is a complex metabolic disorder with both short- and long-term undesirable complications (Mirmiran *et al.* 2014). If it is not managed properly, it will cause various organ damages (Deepa *et al.* 2014) manifested in many types of health problems. In addition to proper medical care, diet regulation, including that of snacks, can be used in managing DMT2.

Main foods and snacks are needed by diabetics to control the blood glucose levels. The food ingredients for diabetics should be high in fiber content and low in glycemic index. Scheduling for snack is between two main meal times. It aims to meet adequate calorie intake and nutritional needs, prevent hypoglycemia that usually occurs at night, achieve or maintain normal weight, and control blood glucose in an effort to prevent the risk of complications in diabetics (Almatsier 2010).

A meta-analysis study by Post *et al.* (2012) showed that increased fiber consumption (4–40

mg/day) could reduce fasting blood glucose and HbA1c in patients with type 2 diabetes by 0.05 mmol/L and 0.26%, respectively. Resistant starch, which is part of fiber, can also control blood glucose in the diabetic rats given an intervention of resistant starch of 2 g/day for 4 weeks (Zhou *et al.* 2015).

Several studies related to snack development for diabetics with the use of various high-fiber, low-glycemic-index ingredients have been carried out, such as those developing black rice and black soybean flour cookies (Widiawati & Anjani 2017), bagel bread from the substitution of sorghum and sweet potatoes (Ashfiyah 2019), and pudding made from corn starch and tapioca (Gourineni *et al.* 2017). However, sago starch is rarely developed as snack for diabetics despite the fact that sago starch (*Metroxylon sp.*) contains 3.69–5.96% dietary fiber (Ahmad *et al.* 1999) and 11% resistant starch (Purwani 2011) and has a low glycemic index (<55) (Wahjuningsih *et al.* 2016).

The local ingredient sago starch has a potential to be developed to be snacks

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for diabetics. In addition to sago, as stated by Rudkowska (2009), beneficial additional sources in food products for diabetics will be able to help control blood glucose. Therefore, tempeh, which has been proven to improve blood glucose, will be added in the making of food products (Ghozali *et al.* 2010). Meanwhile, food processing by roasting, steaming, boiling, or burning is recommended for patients with type 2 diabetes with the aim of reducing calorie intake (Almatsier 2010). Therefore, puddings, steamed muffins, and cookies from sago starch and tempeh offer some options for the development of snacks for patients with type 2 diabetes.

This study aimed to explore the nutrient content, dietary fiber content, and resistant starch content of puddings, steamed muffins, and cookies made from sago starch and tempeh to confirm the benefits of the products.

METHODS

Design, location, and time

This study used a completely randomized design (CRD) with two treatment ratios of sago starch to tempeh, F1 (2:1) and F2 (1:1), with two replications for three products. The products' formulation was conducted in the Processing and Food Experiment Laboratory of the Department of Community Nutrition, IPB University. Sensory evaluation was conducted in the Organoleptic Laboratory of the Department of Community Nutrition, IPB University. Product texture analysis was conducted in the Food Processing Laboratory of the Department of Food Science and Technology, IPB University. The analysis of nutritional and fiber content was conducted in the Laboratory of Saraswanti Indo Genetech, Bogor. Analysis of resistant starch was conducted in the Biochemistry Laboratory of the Department of Food Science and Technology, IPB University. The study was conducted in March–October 2018.

Materials and tools

The main materials used to manufacture puddings, muffins, and cookies were sago starch derived from the Meranti Islands Regency, Riau, and tempeh obtained from Rumah Tempe Indonesia. The additional ingredients used were pumpkin of the bokor variety (*Cucurbita moschata* Durh), sorbitol and erythritol, full

cream milk, chicken eggs, margarine, baking soda, baking powder, carrageenan, vanilla powder, salt, succade cherry, water, and cinnamon powder. The materials for the proximate analysis were selenium, H₂SO₄, distilled water, 40% NaOH, 2% boric acid (H₃BO₃), methyl red indicator, 0.1 N HCl, and hexane. The materials for the dietary fiber analysis were pH 8.2 buffer solution, α -amylase, protease, HCl, amyloglucosidase, 95% ethanol, and 78% acetone. The materials for the resistant starch analysis were KCl-HCl buffer, pepsin, phosphate buffer, α -amylase, KOH, HCl, and sodium acetate buffer.

The tools used to make puddings, muffins, and cookies were pans, oven, pudding and muffin cups, and cookie molds. The analytical tools were TA-XT2i texture analyzer, oven, Kjeldahl flask, and Soxhlet extractor.

Procedures

Product preparation. The foods product formulation (Table 1) was based on the calculation of the nutritional need of diabetics per Perkeni (2015). Assuming that adult women would measure 51 kg in weight and 155 cm in height, the energy need would be 1,700 calories/day. The main limitation in determining the product formula was the carbohydrate content of foods (45–65% of total energy requirements) (Perkeni 2015). The complete formula is under registration for patent.

The foods developed in this study were puddings, muffins, and cookies. The preparation of ingredients such as sago starch, tempeh, and pumpkin was performed in the same way, but the processing was different for each food type. Sago starch was roasted first with an addition of pandan leaves for reduced acid aroma. Tempeh and pumpkin were cut to a thickness of ± 0.2 cm and steamed for 10 minutes, then mashed.

Pudding. Pudding processing began with determining the amount of water and carrageenan used. The proportion of water to sago starch in the pudding making was 20:1, while the carrageenan used amounted 1% of the total weight. The pudding was processed by boiling to $\pm 80^\circ\text{C}$ until the dough became thick.

Muffin. The muffin formula was modified from Kementan (2012). The first step was to mix eggs, sorbitol, and erythritol using a hand mixer at a medium speed until the mixture turned white. Next, tempeh, pumpkin, and some other

Table 1. Formulation of puddings, muffins, and cookies from sago starch and tempeh

Materials	Comparison of sago starch and tempeh					
	Pudding		Muffin		Cookies	
	2:1	1:1	2:1	1:1	2:1	1:1
Sago starch (g)	380	190	320	160	350	175
Tempeh (g)	190	190	160	160	175	175
Pumpkin (g)	180	180	150	150	150	150
Sorbitol and erythritol (g)	80	80	80	80	80	80
Full cream milk (ml)	150	150	150	150	50	50
Chicken egg (g)	-	-	150	150	-	-
Egg yolk (g)	-	-	-	-	20	20
Margarine (g)	-	-	100	100	150	150
Carrageenan (g)	85.81	45.91	-	-	-	-
Water (ml)	7,600	3,800	-	-	-	-
Miscellaneous (g)	3	3	4.8	4.8	27	27

ingredients were added into the mixture using the hand mixer at a low speed. The next step was to put some dough into muffin cups, which was then steamed for 30 minutes at 100°C.

Cookie. The cookies formula was modified from Saputri and Damayanti (2015). The process of cookie making consisted of several stages, namely weighing ingredients, mixing, molding of dough, baking with an oven at 120°C for 80 minutes, and cooling.

Sensory evaluation. The formula selected for the three products was determined based on the results of the hedonic test analysis. Sensory evaluation was conducted on 40 semi-trained panelists, who were students of the Department of Community Nutrition, Faculty of Human Ecology, IPB University. Sensory attributes analysis of the three products was conducted using a line scale. The scale used in the hedonic test was as follows: (1) dislike extremely, (2) dislikes very much, (3) dislikes moderately, (4) dislikes slightly, (5) neither dislike nor like, (6) like slightly, (7) like moderately, (8) like very much, and (9) like extremely. Panelists were considered to accept a product if the value given was greater than 4.5 (Peryam & Pilgrim 1957).

The nine-point quality hedonic scale for the pudding's color attribute was as follows: (1) pale white, (5) pale yellow, and (9) brownish yellow. The nine-point quality hedonic scale for the muffin's color attribute was as follows: (1) bright beige, (5) golden yellow, and (9) golden brown. The nine-point quality hedonic scale for the cookie's color attribute was as follows: (1) extremely brown, (5) beige, and (9) extremely

yellow. The nine-point quality hedonic scale for unpleasant aroma and aftertaste attribute was as follows: (1) extremely weak, (5) normal, and (9) extremely strong. The nine-point quality hedonic scale for the sweetness attribute was as follows: (1) not sweet at all, (5) normal, and (9) extremely sweet.

The nine-point quality hedonic scale for the pudding's texture attribute was as follows: (1) chewy and extremely brittle, (5) normal, and (9) chewy and extremely elastic. The nine-point quality hedonic scale for the muffin's texture attribute was as follows: (1) extremely dense, (5) normal, and (9) extremely hollow. The nine-point quality hedonic scale for the cookie's texture attribute was as follows: (1) extremely brittle, (5) normal, and (9) crunchy.

Physicochemical analysis of selected products. The 74-09 method was employed for the analysis of product hardness (AACC 2001). The analysis of water content (gravimetric method), ash content (dry ashing method), protein content (micro-Kjeldahl method), and fat content (Soxhlet method) was based on SNI 01-3775-2006 (BSN 2006). The carbohydrate content was calculated by difference. The enzymatic method was used for the analysis of dietary fiber (AOAC 1995) and resistant starch (Goni *et al.* 1996).

Data analysis

Data processing was undertaken using Microsoft Excel 2010 and SPSS 15.0 for Windows. The data from the sensory evaluation were analyzed by a difference test of Mann Whitney with a 95% confidence interval to

determine the hedonic difference of each product. If the analysis result was $p < 0.05$, the difference would be considered statistically significant.

RESULTS AND DISCUSSION

Panelists' acceptance of the sensory attributes of the puddings, muffins, and cookies from sago starch and tempeh

Hedonic test. The hedonic test was used to find out the panelists' responses about product likes or dislikes. The sensory attributes evaluated in the pudding hedonic test were color, taste, aroma, texture (surface press), chewing texture (mealiness), and aftertaste. The sensory attributes evaluated in the muffin and cookie hedonic tests were color, taste, aroma, texture, and aftertaste.

The data in Table 2 show that the F2 pudding was the most acceptable product based on the color sensory attribute. The F2 formula used a ratio of sago starch to tempeh of 1:1. This study shows that a difference in the amount of sago used resulted in a significant difference in the panelists' preference in the pudding color ($p < 0.05$). The average values of the panelists' preference in the color, taste, aroma, texture, and overall attributes of the F2 pudding were significantly higher than those of the F1 pudding. The average value of the panelists' preference in the color, taste, aroma, texture (press surface), chewing texture, aftertaste, and overall attributes of the F2 pudding were 6.2 (like slightly), 5.0 (neither dislike nor like), 6.1 (like slightly), 6.0 (like slightly), 5.3 (neither dislike nor like), 4.3 (dislike slightly), and 5.3 (neither dislike nor like), respectively.

The F2 muffin was the most acceptable product based on the sensory attributes (taste, texture, aftertaste, and overall) (Table 2). The F2 formula was used a ratio of sago starch to tempeh of 1:1. This study shows that a difference in the amount of sago used resulted in significant differences in the panelists' preference in the taste, texture, aftertaste, and overall attributes of the muffin ($p < 0.05$). The average values of the panelists' preference in the color, taste, aroma, texture, and aftertaste of the F2 muffin were significantly higher than those of the F1 muffin. Increasing the amount of non-wheat flour in the muffin making would produce an increasingly dense texture. This would affect the level of preference for other attributes, resulting in reduced acceptance of the muffin (Goswami *et al.* 2015; Rismaya 2016).

The average values of the panelists' preference in the color, taste, aroma, texture, aftertaste, and overall attributes of the F2 muffin were 6.4 (like slightly), 6.6 (like slightly), 6.3 (like slightly), 6.2 (like slightly), 5.9 (neither dislike nor like), and 6.5 (like slightly), respectively.

The use of 100% sago flour and no wheat flour in the making of muffins was presumably the cause of the decrease in the value of the panelists' preference for muffins (like slightly). The high fiber and resistant starch content in sago would affect the amount of air trapped in the dough's matrix, causing the muffin softness to reduce or the texture to become rather dense (Struck *et al.* 2016). This would affect the panelists' preference for the muffins mainly in the texture attributes.

The data in Table 2 showed that the F1 cookie was the most acceptable product based

Table 2. Panelists' mean hedonic scales of the sensory attributes of the puddings, muffins, and cookies from sago starch and tempeh

		Sensory attributes						
Products		Colour	Taste	Aroma	Texture (surface press)	Chewing texture (mealiness)	After-taste	Over-all
Pudding	F1	4.8 ^a	4.5	5.7	5.8	5.1	4.9	5.0
	F2	6.2 ^b	5.0	6.1	6.0	5.3	4.3	5.3
Muffin	F1	5.4	5.2 ^a	5.2	3.5 ^a	-	4.8 ^a	4.3 ^a
	F2	6.4	6.6 ^b	6.3	6.2 ^b	-	5.9 ^b	6.5 ^b
Cookies	F1	6.4 ^a	6.3	6.2	5.9 ^a	-	5.6	6.3
	F2	6.5 ^b	5.6	6.2	4.3 ^b	-	5.4	5.4

Description: Attribute scales from 1 (dislike extremely) to 9 (like extremely); Different letters in the same column show significant differences ($p < 0.05$)

on the sensory attributes (color and texture). The F1 formula used a ratio of sago starch to tempeh of 2:1. This study shows that an addition of sago resulted in significant differences in the panelists' preference in the attributes of color and texture of the cookie ($p < 0.05$). The average values of the panelists' preference in the colour, taste, aroma, texture, aftertaste, and overall attributes of the F1 cookie were significantly higher than those of the F2 cookie. The dough structuring of the cookies was affected by the amount of water used in the formulation of the cookies (Norhidayah *et al.* 2014). The use of a small proportion of sago starch in the F2 cookie raised the water content of the cookie, leaving an effect on the texture (Budzaki *et al.* 2014) and decreasing the level of acceptance of the F2 cookie. The average values of the panelists' preference in the colour, taste, aroma, texture, aftertaste, and overall attributes of the F1 cookie were 6.4 (like slightly), 6.3 (like slightly), 6.2 (like slightly), 5.9 (neither dislike nor like), 5.6 (neither dislike nor like), and 6.3 (like slightly), respectively.

Hedonic quality test. The hedonic quality test was used to find out the panelists' responses based on good or bad impression of the puddings, muffins, and cookies from sago starch and tempeh.

The results of the hedonic quality test show that the puddings were yellowish white (F1) and yellow (F2) in color, the muffins golden yellow (F1) and yellow (F2), and the cookies beige (F1) and yellowish (F2) (Table 3). This study shows that a difference in the amount of

sago used resulted in a significant difference in the muffins' color ($p < 0.05$). The factors that might contribute to the color of the final products were the ingredient composition and cooking time (Cronin & Preis 2000). The muffins used cinnamon in the ingredient composition, while the puddings and cookies did not. This shows that the use of different amounts of sago and the use of cinnamon in making muffins would presumably produce different colors of the muffins. The use of cinnamon in conjunction with a greater amount of sago starch (F1 muffin) would produce less bright color than would the use of a smaller amount of sago starch (F2 muffin). Cinnamon can function as coloring agents in food (Hernández-Ochoa *et al.* 2011). The color of the puddings, muffins, and cookies itself was obtained from the pumpkin added as a natural food coloring.

The *langu* (unpleasant) aroma of the puddings, muffins, and cookies ranged from weak to rather weak. The process of steaming tempeh and pumpkin for 10 minutes was thought to reduce the unpleasant aroma of tempeh and pumpkin, causing the unpleasant aroma of the product to be weak and rather weak. The use of certain processing methods was one way to reduce the unpleasant aroma of food (Liu 1997), for example, by boiling or steaming. This study shows that the difference in the amount of sago used resulted in a significant difference in the muffins' unpleasant aroma ($p < 0.05$).

The results of the hedonic quality test show that the puddings were not sweet (F1) and

Table 3. Panelists' mean hedonic quality scales of the sensory attributes of the puddings, muffins, and cookies from sago starch and tempeh

		Sensory attributes				
Products		Colour	<i>Langu</i> aroma	Sweetness	Texture	Aftertaste
Pudding	F1	4.0 ^a	3.8	3.9 ^a	5.1	5.1 ^a
	F2	6.0 ^b	4.0	5.3 ^b	5.0	6.0 ^b
Muffin	F1	5.3 ^a	4.3 ^a	5.1 ^a	2.2 ^a	5.1
	F2	4.1 ^b	3.3 ^b	6.1 ^b	5.8 ^b	4.8
Cookies	F1	5.5	3.5	6.0	5.5 ^a	4.5
	F2	6.0	3.5	6.3	4.0 ^b	4.8

Description: The overall pudding's colour of the scale 1=pale white to 9=brownish yellow; Muffin's colour scale 1=bright beige to 9=golden brown; Cookies' colour scale 1=brown extremely to 9=yellow extremely; *Langu* aroma and aftertaste scale 1=weak extremely to 9=strong extremely; Sweetness scale 1=not sweet at all to 9=sweet extremely; Pudding's texture 1=chewy and brittle extremely to 9=chewy and elastic extremely; Muffin's texture 1=dense extremely to 9=hollow extremely; Cookies' texture 1=brittle extremely to 9=crunchy; Different letters in the same column show significant differences ($p < 0.05$)

normal (F2) in taste, the muffins normal (F1) and rather sweet (F2), and the cookies rather sweet (both F1 and F2) (Table 3). This study shows that the difference in the amount of sago used resulted in a significant difference in the sweetness of the puddings and muffins ($p < 0.05$) but no significant difference in the sweetness of the cookies. Lesser amount of sago starch used in making the products would produce a sweeter taste. The sweetness of the cookies of the two formulas did not show any significant difference, but the F2 cookie had a higher sweetness value (6.3) than the F1 cookie (6.0).

The results of the hedonic quality test show that the puddings had a normal (both F1 and F2) texture, the muffins very dense (F1) and normal (F2), and the cookies normal (F1) and rather brittle (F2) (Table 3). This study shows that a difference in the amount of sago used resulted in a significant difference in the texture of the muffins and cookies ($p < 0.05$). Sago starch as the main ingredient of the muffins is a source of non-gluten starch. The research by Rismaya (2016) shows that an increased amount of non-gluten flour results in a dense muffin texture. The gluten network retains the fermentation gas and determines the stability of gas cells during expansion, contributing soft (spongy) and flexible (elastic) crumbs and also influencing the characteristic appearance of bread products like muffins (Wrigley *et al.* 2006). In making cookies, the higher level of use of non-wheat flour will result in better texture and hardness of the cookies (Ajila *et al.* 2008). This study shows that a difference in the amount of sago used did not result in a significant difference in the texture of the puddings ($p > 0.05$) due to the controlled

amount use of water and carrageenan for each formula.

Aftertaste is the trace, hint, smack, relish, and savor food leaves behind (World Food and Wine 2005). The results of the hedonic quality test show that the puddings had normal (F1) and rather strong (F2) aftertaste, the muffins normal (F1) and rather weak (F2), and the cookies rather weak (both F1 and F2) (Table 3).

Percentage of panelists' acceptance

The formula for each product was chosen by considering the results of the sensory evaluation, namely the hedonic test, especially on the percentage of panelists' acceptance in the overall attributes and panelists' mean hedonic scales of the overall attributes.

Percentage of panelists' acceptance in the overall attributes of the F2 pudding (70.0%) and F2 muffin (91.2%) were significantly higher than the F1 pudding and F1 muffin (Table 4). Beside that, panelists' mean hedonic scales of overall attributes for the F2 pudding and F2 muffin were significantly higher than the F1 pudding and F1 muffin too (Table 2). Therefore, F2 was the selected formula for puddings and muffins. The F2 formula used a ratio of sago starch to tempeh of 1:1. The low level of acceptance of the F1 muffin was presumably caused by the use of a greater proportion of sago starch than that used in the F2 formula. An increased concentration of non-wheat flour would produce increasingly dense muffin textures, which caused a reduction in the level of acceptance (Goswami *et al.* 2015; Rismaya 2016).

The percentage of panelists' acceptance in the overall attributes of the F1 cookie (91.2%) was

Table 4. Percentage of panelists' acceptance on the sensory attributes of the puddings, muffins, dan cookies from sago starch and tempeh (%)

		Sensory attributes						
Products		Colour	Taste	Aroma	Texture (surface press)	Chewing texture (mealiness)	Aftertaste	Over-all
Pudding	F1	57.5%	45.0%	90.0%	85.0%	70.0%	56.2%	61.2%
	F2	88.7%	60.0%	90.0%	81.2%	66.2%	35.0%	70.0%
Muffin	F1	78.7%	70.0%	73.7%	18.7%	-	61.2%	33.7%
	F2	90.0%	90.0%	87.5%	86.2%	-	83.7%	91.2%
Cookies	F1	85.0%	88.7%	87.5%	76.2%	-	81.2%	91.2%
	F2	95.0%	75.0%	96.2%	31.2%	-	73.7%	72.5%

significantly higher than the F2 cookie (72.5%) (Table 4). Moreover, the panelists' mean hedonic scales of overall attributes for the F1 cookie was also significantly higher than the F2 cookie (Table 2). Therefore, F1 was the selected formula for cookies. The F1 formula used a ratio of sago starch to tempeh of 2:1. A smaller proportion of sago starch in the F2 cookie produced high water content, which influenced the texture of the cookie (Budzaki *et al.* 2014) and resulted in a decrease in the level of acceptance of the F2 cookie.

Physical characteristics of selected products (hardness)

Hardness is one of the important indicators should be taken into account in analyzing food texture, and it has an impact on the level of consumer acceptance of the food products. The hardness value of the pudding was 83.47 gf. This value is lower compared to those of the puddings in other research, such as the mocaf dextrin pudding with hardness of 151.78–657.93 g/cm². The low strength of the pudding gel produces soft pudding (Darmawan *et al.* 2014). This means that the sago pudding's chewy but brittle texture was due to the low gel strength value. This result was presumably caused by the distinct proportion of the composition, including the carrageenan, in each pudding. An increased carrageenan concentration in the pudding mixture would increase the strength of the pudding gel (Trckova *et al.* 2004).

The hardness value of the muffins was 3,861,87 gf. Fiber content and resistant starch in non-wheat flour can produce a high muffin hardness value. Food fiber and resistant starch

would affect the amount of air trapped in the dough matrix, reducing the muffin tenderness (Struck *et al.* 2016).

The hardness value of the cookies was 1,655,02 gf. The high amylose content (27%) in sago starch (Ahmad & Williams 1998) affected the hardness of the cookies (Horstmann *et al.* 2016). Higher amylose content would produce a good texture of cookies, but starch containing high amylopectin tends to produce breakable cookies (Claudia & Widjanarko 2016).

Nutrient content, dietary fiber, and resistant starch of selected products

The serving size of the sago pudding is 80 g (2 small cups), which refers to the food serving size for diabetics by Poetker (2010). A small cup of sago muffin weighs 38–39 g, which refers to the serving size of a muffin for diabetics by DHHS and USDA (2015) (1 small cup). One sago cookie weighs 6–7 g. The serving size for sago cookie is 20 g (3 pieces) as per the serving size of commercial cookies (sugar-free cookies). Nutrient content, dietary fiber, and resistant starch of pudding, muffin, and cookie per serving size are shown in Table 5.

The results in Table 5 show that the percentage of contribution of the puddings, muffins, and cookies (per serving size) as snacks to diabetics' needs (1,700 kcal) was very low and failed to meet the 10–15% needs of energy, protein, carbohydrate, fat, and dietary fiber. The puddings, muffins, and cookies per serving size consumed as daily snacks (2–3 times per day) will contribute more than 1.4 g of resistant starch. Lockyer and Nugent (2016) showed that a

Table 5. Nutrient content, dietary fiber, and resistant starch of selected puddings, muffins, and cookies from sago starch and tempeh

Components	Nutrient content per serving			Diabetics' needs*	Nutritional needs of snack (10-15%)	Contribution to nutritional needs (%)		
	Pudding (80g)	Muffin (38g)	Cookies (20g)			Pudding (80g)	Muffin (38g)	Cookies (20g)
Energy (kcal)	26	84	95	1,700	170–255	6.54–9.81	2.02–3.04	1.79–2.68
Carbohydrate (%)	4.61	9.98	13.89	275	27.50–41.25	5.97–8.95	2.76–4.13	1.98–2.97
Fat (%)	0.51	3.89	3.93	55.5	5.50–8.25	10.78–16.18	1.41–2.12	1.40–2.10
Protein (%)	0.83	2.46	0.98	3.5	3.60–5.40	4.34–6.51	1.46–2.20	3.67–5.51
Dietary fiber (%)	3.16	2.70	1.91	25.0	2.50–3.75	0.79–1.19	0.93–1.39	1.31–1.96
Resistant starch (%)	0.65	1.36	1.20	-	-	-	-	-

decrease in blood glucose in diabetics can occur by eating foods containing 1.4–48 g of resistant starch daily. Other studies have also shown that consumption of 2 g resistant starch for 4 weeks in diabetic rats affected the postprandial insulin repair and glucose response (Zhou *et al.* 2015).

Fiber intake can maintain the satiety level that will lead to a decrease in calorie intake, beneficial for weight loss as well as improving insulin resistance. The fiber mechanism in glucose metabolism is related to the function and characteristics of fibers. Water-soluble fiber can absorb fluids and form gels in the stomach. Gel slows down the gastric-emptying process and absorption of nutrients. Gel can slow the peristalsis of nutrients (glucose) from the small intestine to the absorption area so that it can stabilize the blood glucose levels (Weickert & Pfeiffer 2018).

In addition, the undigested part of the fiber will go into the large intestine and will be converted into a substrate that can be fermented by bacteria. Fiber fermentation by bacteria produces short-chain fatty acids such as acetate, propionate, and butyrate. These fatty acids will be absorbed back into the bloodstream. Acetate may reduce free fatty acids in the bloodstream for a long time. Propionate can inhibit HMG-CoA reductase, inhibit fat mobilization, prevent the process of gluconeogenesis in the liver, and reduce the reduction of free fatty acids in the blood. This will improve the blood glucose levels and insulin sensitivity (Todesco *et al.* 1991; Luo *et al.* 2000).

Consumption of food with high resistant starch content is the most effective prevention to maintain normal blood glucose concentration and prevent secondary complications resulting from sustained hyperglycemia (Koh & Rowling 2017). Resistant starch can also increase satiety because it can increase genetic expression stimulating satiety associated with GLP-1 and PYY hormones in the large intestine (Okoniewska & Witwer 2007). Resistant starch also functions in increasing insulin sensitivity and reducing abdominal adiposity in obese diabetics (Koh & Rowling 2017).

CONCLUSION

Based on the hedonic test, the pudding and muffin formulas selected were those with a

ratio of sago starch to tempeh of 1:1, and for the cookies the selected formula was that with the ratio of sago starch to tempeh of 2:1. Puddings are categorized as a fiber-source food with a negligible level of resistant starch, muffins as a high-fiber food with an intermediate level of resistant starch, and cookies as a high-fiber food with a high level of resistant starch. In conclusion, these products had fulfilled the expectation that they are able to help control diabetics' blood glucose. Further research related to preclinical testing of puddings, muffins, and cookies needs to be conducted to determine the positive role of the products in controlling the blood glucose levels in diabetics.

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