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The Use of Flour from Fraction of Parboiled Paddy Milling Results and Low-Calorie Sweeteners on the Quality and Glycemic Index of Biscuits

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Abstract. The number of diabetic patients in Indonesia continues to increase, while the availability of edible snacks for them is still limited. Therefore, this study aims to produce biscuits with low glycemic index that are favored by panelists using rice, broken rice, and bran flours from milled parboiled paddy and mixture of low-calorie sweeteners. This study was conducted with a completely randomized design using two factors, namely, type of flour (rice, broken rice, and bran), and a mixture of low-calorie sweeteners. The rice, broken rice, and bran flours used were 40%, 30%, and 20%, respectively. Meanwhile, the sweetener was made in 6 variations, namely: sweetener 1 consists of isomalt, sorbitol, and acesulfame, sweetener 2 consists of isomalt and acesulfame, sweetener 3 consists of sorbitol and acesulfame, sweetener 4 consists of refined sugar and sorbitol, sweetener 5 consist of stevia (powder), and sweetener 6 consists of refined sugar. The analysis covered the chemical and physical properties, as well as panelists' preference level for the biscuits. The results showed that biscuits made using 40% rice, 30% broken rice, and 20% bran flours with a mixture of sweetener 4 (40% sorbitol and 60% refined sugar) were all favored and accepted by the panelists. Meanwhile, the most preferred are biscuits with 40% rice flour and a mixture of sweetener 4; these particular biscuits, have 5.69% water content, 6.65% protein, 20.57% sugar, the texture of 1249 g, lightness of 72.72, total phenol content of 2549 mg GAE/kg, and glycemic index of 31. These biscuits are suitable as snacks for diabetics due to their low glycemic index (< 55).

INTRODUCTION

Diabetes mellitus (DM) is one of the degenerative diseases whose prevalence continues to increase in the world, including Indonesia. According to data from the International Diabetes Federation Ninth Edition 2019, the prevalence of DM in Indonesia is 10.7 million people, and it is estimated that in 2045 as many as 16.7 million people will be affected by DM. Indonesia is in the top 10 countries with the most diabetes in the world [1]. Based on the results of 2018 health research conducted by the Ministry of Health of the Republic of Indonesia [2], the largest DM sufferers in Indonesia are in the age range of 55-64 years (6.3%) and 65-74 years (6.03%). Meanwhile, based on their domicile area, more people with diabetes mellitus live in urban areas (1.9%) than in rural areas (1.0%). The main causes include lifestyle (including diet) and urbanization [3].

An effective strategy to manage the blood glucose of diabetics is by consuming foods with a low glycemic index (GI) (< 55), which is slow to increase blood sugar. The main products of parboiled rice milling fortified with Cr, Mg, and cinnamon extract are known to have a low GI, while the by-products: broken rice (rich in Cr and Mg), and rice bran (rich in Cr, Mg, and dietary fiber) are suitable ingredients for making biscuits as a snack for diabetics [4]. However, until now, these foods have been of limited availability. Biscuits are dry food products made from wheat

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flour and are enjoyed by almost all age groups, however, this baked good (Nabisco) has a GI of 77 (glucose standard = 100), and is, therefore, classified as a high glycemic index food [5, 6].

Based on the previous study [4], substituting wheat flour with flour from a fraction of parboiled rice milling products (parboiled rice, broken rice, and bran) produces biscuits with a relatively low glycemic index. The most preferred biscuits produced from each type of flour from the fraction of parboiled rice milling products comprise 40% rice flour, 30% broken rice flour, and 20% rice bran powder.

So far, the sweeteners commonly used in the manufacture of biscuits are sucrose and HFCS (high fructose corn syrup) which have high calorific value. Therefore, a sweetener with a low calorific value, and consequently, a low rate of increasing blood glucose is required for products intended for diabetics. Examples of sweeteners with low calories, high sweetness level compared to sucrose (100), and low glycemic index value compared to glucose (100), include isomalt (2.4 kcal/g, 45-50, 9), acesulfame K (0 kcal/g, to 13000, 0), sorbitol (2.4 kcal/g, 50-60, <5), and stevia (0 kcal/kg, 120-250.0), respectively. [6, 7, 8]. Acesulfame K has a good shelf life, heat resistance, stability under normal food preparation, as well as processing, and is, therefore, suitable for products requiring cooking and baking. Meanwhile, sorbitol, as well as xylitol and lactitol, including polyol compounds, are suitable sweeteners for diabetics [6]. Stevia is safe for consumption and a natural, unfermented sweetener, with heat resistance of up to 200°C, as well as a suitable alternative for saccharose in the production of several beverages and baked goods [9].

Food products containing a single sweetener tend to have poor sensory properties, including the emergence of aftertaste and an increase in the rate of off-flavor, therefore, the multiple sweetener approaches are often preferred. In addition, sweeteners vary not only in intensity but also in mouthfeel, onset, and duration of sweetness, perceived aftertaste, as well as solubility and stability at various levels of pH and temperature [10]. Non-nutritive sweeteners are often combined with polyols and other low-calorie carbohydrates to partially and completely replace sucrose in several types of baked goods [7].

In the development of a low-sugar baked product from non-wheat ingredients, reduced sucrose content causes detectable losses in appearance, texture, flavor, and mouthfeel. This study, therefore, aims to evaluate the effect of substituting wheat flour with flour from a fraction of parboiled rice milling products (rice, broken rice, and bran), as well as the addition of various mixtures of low-calorie sweeteners on the quality, the panelists' preference and the glycemic index of biscuits.

MATERIAL AND METHODS

Material and Equipment

The main ingredients used were rice flour, broken rice flour, and rice bran flour from parboiled Ciherang rice milling products fortified with Cr, Mg, and cinnamon powder. Ciherang paddy (as seed) was obtained from an agricultural shop in Sleman, Yogyakarta. Meanwhile, the other ingredients include Kunci Biru wheat flour for pastry, cake, and biscuits (Bogasari), Blue Band margarine, skimmed milk powder (Indoprima), salt (Refina), egg yolks, baking soda (Point), powdered sugar (Rose Brand), acesulfame (B&TS), isomalt (Isomalt Refinate), sorbitol (Brataco), and stevia (New Stevia).

The main equipment used in the biscuit production includes a mill, 60 mesh sieve, mixer, oven, mold, and cabinet dryer. Meanwhile, the analytical apparatus was a UV-VIS spectrophotometer (Shimadzu UV Mini 1240), vortex (Health), centrifuge (Hermle), analytical balance (Ohaus), plastic cuvette (Brand), and a micropipette (Socorex).

Experimental Stages

This study was performed in several stages and the first stage involved parboiling rice based on the method described by Yulianto *et al*., [11], then adding 5.39 mg/L CrCl, 1.75 g/L Mg acetate, and 10% cinnamon extract. In the second stage, flour was produced from a fraction of the parboiled rice milling products (rice, broken rice, and bran) by milling the part and then sieving through a 60 mesh. Meanwhile, in the third stage, biscuits were baked using 40% parboiled rice flour, 30% groat flour, as well as 20% rice bran flour, as a replacement for wheat flour, and 5 different sweetener combinations. These combinations were isomalt-sorbitol-acesulfame, isomalt-acesulfame, sorbitol-acesulfame, refined sugar-sorbitol, and stevia powder.

Biscuit Production

The dough was made with a modified formulation derived from preliminary studies comprising wheat + non-wheat flour (100 g), margarine (37.51 g), egg yolks (13.51 g), skim powder (10.51), salt (0.76 g), vanilla flavor (0.51 g), baking soda (1.41 g), and water (10 g). The percentage of wheat flour to rice, broken rice, and rice bran flour were 60:40, 70:30, and 80:20, respectively. Meanwhile, about 33.6 g (isomalt 16.7 g, sorbitol 16.7 g, acesulfame K 0.2 g), 30.2 g (isomalt 30 g, acesulfame K 0.2 g), 22.08g (sorbitol 22 g, acesulfame 0.08 g), 40 g (24 g refined sugar and sorbitol 16 g), and 0.3 g (stevia powder) of sweetener combinations 1, 2, 3, 4, and 5, respectively were used, consequently, obtaining total dough weights of 207.81 g, 204.41 g, 196.29 g, 214.21 g, and 174.51 g, respectively. In addition, 53.13 g of refined sugar was used as the control sweetener (total weight 227.34 g) for the preference level and glycemic index analyses.

Biscuit production involves 4 phases of mixing. Firstly, margarine (shortening), sweetener combination, fine salt, baking soda, and skim powder were stirred with a mixer at medium speed for 3 minutes until the dough expands. Subsequently, the vanilla flavor was added, and the mixture was stirred for 1 minute at medium speed. This was followed by adding egg yolks and stirring at high speed for 1 minute. Lastly, wheat flour as well as the substitutes of parboiled rice milling products (40% rice, 30% broken rice, and 20% bran flours), and mixing was continued until the dough became quite fluffy. The dough was then rolled with a wooden roller to obtain a 0.5 cm thick sheet, then printed with a 4.5cm diameter mold, and baked at 150 ^{0}C for 20 minutes. Subsequently, the biscuits were cooled at room temperature for 15 minutes, then subjected to quality and preference analyses.

Experimental Design and Analysis

This study used a completely randomized design with a factorial pattern comprising 2 factors. The first factor was the treatment of fractions of rice, broken rice, and bran flours, while the second factor was a mixture of low-calorie sweeteners: sweetener combinations 1, 2, 3, 4, and 5. The experiments were carried out thrice and powder sugar was used as a control for the preference level and GI analysis.

The chemical properties analyzed include water content using the thermogravimetric method [12]; protein, starch, and total sugar contents using the Nelson Somogyi method [12], and total phenol content using the Folin-Ciocalteau method [13]. Meanwhile, the physical properties analyzed include color and lightness using a colorimeter, and texture using a texture analyzer. Furthermore, the organoleptic test was conducted using the preferred test method (hedonic scoring test) [14] while the glycemic index was determined using the procedure established by BPOM (National Food and Drug Agency) [15]. Subsequently, the data obtained were subjected to a one-way analysis of variance (ANOVA), using SPSS software with a 95% confidence level. This was followed by Duncan's Multiple Range Test for cases where a significant difference occurred between treatments.

RESULT AND DISCUSSION

Water Content

Table 1 shows the statistical results of the effect of various sweetener combinations and substituting wheat flour with rice (40%), broken rice (30%), and bran (20%) flours on the water content of the resulting biscuits.

TABLE 1. Moisture content (% wb) of biscuits substituted with 40% rice flour, 30% broken rice flour, and 20% bran flour and various mixtures of low-calorie sweeteners

Type of Flour (%)	Sweetener Combination				
	1	2	3	4	5
Rice (40)	7.30^{ij}	5.78^{de}	6.95^{h}	5.69^{de}	7.12^{hi}
Broken Rice (30)	5.03^{c}	4.38^{a}	7.16^{j}	5.55^{d}	4.68^{b}
Bran (20)	6.44^{fg}	6.15^{f}	6.96^{h}	6.59^{g}	6.63^{g}

Numbers followed by different letter notations in the same column and row showed significant differences at the 95% confidence level (P<0.05). Mixture of sweetener type 1: isomalt 16.7 g, sorbitol 16.7 g, acesulfame K 0.2 g (33.6 g); 2: isomalt 30 g, Acesulfame K 0.2 g (30.2 g); 3: sorbitol 22 g, acesulfame K 0.08 g (22.08 g); 4: 24 g powdered sugar, 16 g sorbitol (40 g); 5: stevia 0.3 g

According to the statistical analysis, there was an interaction between the use of rice, broken rice, as well as bran flours, and the addition of low-calorie sweeteners, on the water content of the biscuits. The water contents ranged from 4.38 to 7.30% and were, therefore, below the quality standard (SNI 2973-2011) of 5% maximum [16]. This is possibly due to the non-optimal oven temperature and duration. The least water content (4.38% (wb) was recorded for biscuits made with broken rice flour, while the highest (7.30%) was recorded for rice flour with sweetener 1. Therefore, broken rice flour seems to have a relatively weak water-binding capacity. It is not easy to explain the water content data obtained because each type of sweetener (isomalt, sorbitol, acesulfame, powdered sugar, stevia) has different hydrophilic property, as well as the amount of sweetener used in the combination is also different. The hydrophilic property of the sweetener can interact with the starch and protein components of rice flour, broken rice, and rice bran during dough making and during baking so that it affects the moisture content of the biscuits produced. Although there was interaction between the two factors, namely the type of flour and the combination of sweeteners, there was no pattern or trend towards the moisture content of the biscuits. In general, it can be said that the sweetener used is dissolved in the mixture and is strong enough to bind water so that when baking, some of the water is still bound or relatively difficult to evaporate. Based on Table 1, it is known that only broken rice flour with sweetener 2 (isomalt and acesulfame) as the best treatment and sweetener 5 (stevia) have a water content below 5%. However, the use of flour with a certain portion and type of sweetener and the right baking method (time and temperature) will be able to improve the quality attributes, especially the moisture content of the biscuits.

Protein Content

Based on the statistical analysis, there was no interaction between these 2 factors on the protein content of biscuits. However, the type of flour or sweetener significantly influenced the protein content. The highest contents of 8.42 - 9.03% (db) were recorded for the biscuits produced using broken rice and bran flours. Meanwhile, in terms of sweeteners, the highest contents of 8.88-9.37% were recorded for combinations 3 (sorbitol and acesulfame) and 5 (stevia) (Table 2). In this study, the biscuits' protein ranged from 6.65 to 9.92% (db) or 6.27 to 9.46% (wb), and this met the SNI 2973-2011 requirements of 5% (wb) minimum. Furthermore, the biscuits produced using rice flour had the least content because this flour has the least protein content and was used in the highest proportion (40%). The protein contents of parboiled rice, bran, and Kunci Biru wheat flours were 6.18%, 13-14.4%, and 11% (db), respectively [17, 18, 19]. By referring to the protein content of the flour and the proportions used, the results of this study indicate that the protein content of biscuits from broken rice flour and rice bran is 9.03-8.42% and is not significantly different, but the protein content is higher than biscuits from rice flour. This could be due to the higher portion of rice flour used (40%) with a relatively low protein content (6.18%), while the smaller portion of wheat flour used (60% with 11% protein content) so that the protein content of the biscuits was lower. The use of sweeteners mostly did not affect the protein content of biscuits, and the highest protein content was achieved with the use of stevia powder although it was not significantly different from the addition of sweeteners 3 (sorbitol and acesulfame). The protein content of the biscuits is related to the amount of sweetener used. The less sweetener used, the greater the protein content of the biscuits produced, because they experienced the least dilution of the protein content in the dough. The protein content of biscuits with stevia sweetener reached 9.37% because the amount added was only 0.3 g, while other sweeteners were quite large, namely 22.6 g of sweetener 1, 30.2 g of sweetener 2, 22.08 g of sweetener and 40 g of sweetener 4. The best treatment was obtained from rice flour or broken rice flour, while the type of sweetener was sweetener 5 or 3.

TABLE 2. Protein content (% db) of biscuits substituted with 40% rice flour, 30% broken rice flour, and 20% bran flour and various mixtures of low-calorie sweeteners

Type of Flour (%)	Sweetener Combination					Average (%)
	1	2	3	4	5	
Rice (40)	7.89	7.81	8.30	6.65	8.91	7.91^{a}
Broken Rice (30)	9.23	8.47	8.99	8.56	9.92	9.03^{b}
Bran (20)	8.03	8.57	9.37	6.87	9.28	8.42^{ab}
Average	8.38^{b}	8.28^{b}	8.88^{bc}	7.36^{a}	9.37^{cd}	

Numbers followed by different letter notations in the same column or row showed significant differences at the 95% confidence level (P<0.05). Description of the type of sweetener as Table 1.

Total Sugar Content

The statistical analysis showed the flour type and sweeteners added had no interaction with the biscuits' total sugar content. However, each factor had a significant influence on the total sugar content (Table 3), with the highest contents of 11.28% and 22.5% recorded for the biscuits containing broken rice flour and sweetener 4 (refined sugar and sorbitol), respectively. The differences in results are probably due to variations in the dough composition, particularly the sugar content. Therefore, the high sugar content of biscuits containing sweetener 4 (refined sugar 24 g and sorbitol 16 g per 214.21 g of dough), while other biscuits used high-intensity sweeteners (without sugar). The total sugar contents of parboiled rice and bran were reported to be 2.05 - 5.10% (db) and 5% (db), respectively [20, 21], consequently the use of broken rice flour resulted in higher sugar content, compared to other flours. Considering that these biscuits are intended for diabetics, the best biscuits are chosen with the lowest sugar content, namely treatment with rice flour and bran (7.91-8.42%) and types of sweeteners 2 (isomalt 30 g, acesulfame K 0.2 g per 204.41 g of dough) and sweetener 5 (stevia powder 0.3 g per 174.51 g of dough).

TABLE 3. Total sugar content (% db) of biscuits substituted with 40% rice flour, 30% broken rice flour, and 20% bran flour and various mixtures of low-calorie sweeteners

Type of Flour (%)	Sweetener Combination					Average (%)
	1	2	3	4	5	
Rice (40)	9.35	2.75	12.57	20.57	2.87	9.62^{a}
Broken Rice (30)	9.95	2.32	13.50	24.49	6.15	11.28^{b}
Bran (20)	9.12	2.85	11.42	22.59	2.92	9.51^{a}
Average	9.47^{b}	2.64^{a}	12.49^{c}	22.55^{d}	3.98^{a}	

Numbers followed by different letter notations in the same column or row showed significant differences at the 95% confidence level (P<0.05). Description of the type of sweetener as Table 1.

Total Phenol

According to the statistical analysis, there was no interaction between the flour type and sweetener combination on the biscuits' phenolic content (Table 4). However, the flour type had a significant effect, while the combination of low-calorie sweeteners had no significant effect.

TABLE 4. Total phenol content (mg GAE/kg) of biscuits substituted with 40% rice flour, 30% broken rice flour, and 20% bran flour and various mixtures of low-calorie sweeteners

Type of Flour (%)	Sweetener Combination					Average (%)
	1	2	3	4	5	
Rice (40)	2158	1584	1993	2549	2658	2188^{ab}
Broken Rice (30)	2219	1740	2681	2787	3409	2567^{b}
Bran (20)	2452	2369	2522	3146	4132	2924^{c}

Numbers followed by different letter notations in the same column showed significant differences at the 95% confidence level (P<0.05). Description of the type of sweetener as Table 1.

The phenolic content of biscuits containing bran flour was significantly higher (2924 mg GAE/kg), compared to the rice and broken rice flours counterparts (2188-2567 mg GAE/kg). Bran flour has a much higher phenolic content, compared to rice flour, with a high content of phenolic antioxidant compounds in the aleuron section [22] and is associated with a high antioxidant capacity [23]. In this study, the total phenol ranged from 1583.5 - 4132.3 mg GAE/kg, and this is quite high because the raw material was fortified with cinnamon extract. The *Cinnamomum burmanii* bark extract contains the main polyphenol antioxidants (tannins and flavonoids), as well as essential oils of the phenol group [24]. The result of a similar study has been reported that there is an increase in the antioxidant activity of biscuits by increasing the substitution of wheat flour with purple rice flour. The DPPH radical scavenging activity ranged from 1.07 to 49.19 mol trolox/g (dw). Compared with biscuit control, the use of purple rice flour increased antioxidant activity significantly ($p < 0.05$) even at the lowest substitution level, 25% purple rice flour substitution [25]. Some studies also reported a high correlation between DPPH radical scavenging activities and antioxidant contents [26–27]. The results of the study of pigmented rice cultivars, namely Venere and Artemide, showed that rice samples of Artemide cultivars were richer in total phenol index (17.7–18.8 vs. 8.2–11.9 g gallic acid/kg in Venere rice), total flavonoids (13.1 vs. 5.0– 7.1 g catechin/kg rice for Venere rice) and total anthocyanins (3.2–3.4 vs. 1.8–2.9 g cyanidin 3-O-glucoside/kg for Venere rice) in comparison to those of Venere cultivar; as well, they showed higher antioxidant capacity (46.6–47.8 vs. 14.4–31.9 mM Trolox/kg for Venere rice) [28].

Biscuit Texture

Table 5 shows the statistical analysis regarding the effect of various sweetener combinations and substituting wheat flour with rice (40%), broken rice (30%), as well as bran (20%) flours, on the biscuits' texture. Based on the results, these 2 factors affect the texture, with the softest texture of 1075 g recorded for biscuits containing bran flour (20%) and sweetener 1. High-fat (bran) biscuits are relatively easy to break, compared to low-fat counterparts. This low break strength also occurs due to a reduction in the proportion of gluten content from wheat flour, because gluten is a texture constituent component and a source of structural strength [29].

TABLE 5. The texture (g) of biscuits substituted with 40% rice flour, 30% broken rice flour, and 20% bran flour and various mixtures of low-calorie sweeteners

Type of Flour (%)	Sweetener Combination				
	1	2	3	4	5
Rice (40)	1188.2^{b}	1205.5^{b}	1402.5^{b}	1249^{b}	1772.5^{hi}
Broken Rice (30)	1260.5^{b}	2486.0^{d}	2475.2^{d}	3712.5^{e}	2418.5^{cd}
Bran (20)	1075.0a	1539.7^{b}	1660.2^{b}	1270.0^{b}	1847.7^{bc}

Numbers followed by different letter notations in the same column and row showed significant differences at the 95% confidence level ($P<0.05$). Description of the type of sweetener as Table 1.

Biscuit Color *(Lightness)*

Based on the statistical analysis, there was an interaction between the sweeteners and the parboiled rice, broken rice, as well as bran flours, on the biscuits' color or lightness (Table 6). The L* (lightness) value indicates the level of lightness or darkness within a range of 0-100, where 0 indicates a tendency to be black or very dark, while 100 indicates a tendency for light/white colors [30]. In this study, the highest and the least lightness of 74.54 and 56.38 were recorded for the biscuits containing rice flour with sweetener 1and bran flour with sweetener 3, respectively. This was due to the differences in the sweeteners' heat resistance during baking. The color produced by substituting wheat flour with rice flour was lighter, compared to the broken rice flour counterpart, and these in turn were lighter, compared to the bran flour counterpart. In addition to the flour type and sweetener combination used, process conditions also affected the quality and the color of biscuits. In biscuit production, the Maillard reaction is important to create brown hues on the surface and contribute to the pastries' texture, as well as flavor. This reaction is a type of non-enzymatic browning common among reducing sugars and mostly free amino acids, as well as peptides (usually from proteins), in the presence of heat [31].

TABLE 6. The color (lightness) of biscuits substituted with 40% rice flour, 30% broken rice flour, and 20% bran flour and various mixtures of low-calorie sweeteners

Type of Flour (%)	Sweetener Combination				
	1	2	3	4	5
Rice (40)	74.54^{l}	71.76^{h}	63.71^{cdef}	72.71^{i}	68.08^{g}
Broken Rice (30)	61.79^{cd}	65.64^{fg}	65.08^{ef}	68.2^{g}	60.72^{b}
Bran (20)	62.83^{cde}	63.97^{def}	56.38^{a}	63.44^{cdef}	61.02^{c}

Numbers followed by different letter notations in the same column and row showed significant differences at the 95% confidence level ($P<0.05$). Description of the type of sweetener as Table 1.

Test of Preference

Table 7 shows the organoleptic analysis carried out by 25 untrained panelists on the biscuits' taste, color quality, texture, aroma, and overall preference. The substitution of flour with parboiled rice milling fractions (rice, broken rice, and bran) and the addition of low-calorie sweetener combinations had a significant effect on the organoleptic parameters. According to the statistical analysis, the use of 40% rice flour or 30% broken rice flour with sweetener 4 (60% refined sugar-40% sorbitol) did not differ significantly from the control sweetener (refined sugar). This means the panelists have the same preference level of highly preferred, for the quality attributes of color, aroma, taste, texture, and overall preference. However, this did not apply to 20% bran flour treatment, implying this treatment is less preferred, compared to the control. In this study, biscuits with bran substitution plus sweetener combinations 1 and 4 tended to be preferred to moderately **prefer** by the panelists (2.20-2.36 score). However, a report by Majeed *et al.* [32] showed the use of sorbitol as a sugar substitute by 20% produced biscuits with a maximum overall preference level.

TABLE 7. Preference levels of biscuits substituted with 40% rice flour, 30% broken rice flour, and 20% bran flour and various mixtures of low-calorie sweeteners

Type of Flour	Sweetener Combination	Parameter				
		Color	Aroma	Taste	Texture	Overall
Wheat (Control)	Refined Sugar	1.48^{a}	1.84^{a}	1.92^{a}	1.56^{a}	1.56^{a}
Rice	1	2^{b}	2.12^{abc}	2.84^{bc}	2.20^{bc}	2.36^{b}
	2	2.88^{c}	2.6^{d}	2.64^{bc}	3.08^{d}	3.12^{c}
	3	2.28^{b}	2.48^{bc}	3.08^{c}	2.76^{d}	2.84^{c}
	4	$\mathbf{1.96^{ab}}$	$\mathbf{2.04^{ab}}$	$\mathbf{2.16^{a}}$	$\mathbf{1.88^{a}}$	$\mathbf{2^{ab}}$
	5	2.88^{c}	3^{d}	3.04^{c}	2.68^{cd}	2.88^{c}
Broken Rice	1	2.12^{ab}	2.24^{ab}	2.72^{bc}	2.40^{a}	2.48^{b}
	2	2.36^{b}	2.56^{b}	2.76^{bc}	2.72^{ab}	2.5^{b}
	3	2.40^{b}	2.48^{b}	3.16^{cd}	2.88^{ab}	3.12^{c}
	4	$\mathbf{2.16^{ab}}$	$\mathbf{2^{a}}$	$\mathbf{2.20^{ab}}$	$\mathbf{2.24^{ab}}$	$\mathbf{2.12^{ab}}$
	5	3^{c}	3.24^{c}	3.72^{d}	3.24^{b}	3.76^{d}
Bran	1	2.68^{b}	2.36^{ab}	2.36^{b}	2.68^{bc}	2.36^{b}
	2	3^{b}	2.48^{b}	3.16^{c}	2.76^{bc}	3.08^{c}
	3	2.76^{b}	2.52^{b}	2.88^{c}	3.24^{c}	2.96^{c}
	4	$\mathbf{2.56^{b}}$	$\mathbf{2.20^{ab}}$	$\mathbf{2.32^{b}}$	$\mathbf{2.40^{ab}}$	$\mathbf{2.20^{b}}$
	5	3.08^{c}	3^{c}	3.15^{c}	3.16^{c}	3.16^{c}

Values with the same superscript in the same column are not significantly different (P<0.05). Description of the type of sweetener as Table 1. 1 = like very much, 2 = like, 3 = like slightly, 4 = dislike slightly, 5 = dislike, 6 = dislike extremely.

Glycemic Index

To determine the glycemic index (GI), volunteers were administered control (wheat) and treatment (40% rice, 30% broken rice, 20% bran flours) biscuits containing a mixture of low-calorie sweeteners equivalent to 50 g of glucose. Subsequently, fasting and postprandial blood glucose levels of 30, 60, 90, and 120 minutes were determined, and the results were presented as a curve of the relationship between glucose levels (X-axis) and time of blood sampling (Y-axis). This was followed by calculating the area below the curve and determining the GI by dividing the area of the glucose response curve (biscuits) by the 50 grams pure glucose (standard) (Table 8). Biscuit GI can be determined by dividing the area of the glucose response curve (biscuits) by the area of the pure glucose response curve of 50 grams (standard), presented in Table 8.

Table 8 shows the GI values obtained ranges from 35.22 to 23.98. Based on the statistical analysis, the flour fraction from parboiled rice milling (40% rice, 30% broken rice, and 20% bran) had an interaction with the low-calorie sweetener combinations on the biscuits' glycemic index. Generally, all the biscuits had GI values below 55, and were, therefore, classified as low glycemic index foods [6].

TABLE 8. The glycemic index of biscuits substituted with 40% rice flour, 30% broken rice flour, and 20% bran flour and various mixtures of low-calorie sweeteners

Type of Flour (%)	Sweetener Combination					
	Control	**1**	**2**	**3**	**4**	**5**
Rice (40)	46.6[j]	31.58[fg]	31.78[fgh]	31.57[fg]	31[efg]	25.67[b]
Broken Rice (30)	46.6[j]	35.22[i]	31.57[fg]	32.7[h]	31.94[gh]	27.32[c]
Bran (20)	46.6[j]	27.32[c]	30.76[ef]	28.74[d]	30.47[e]	23.98[a]

Numbers followed by different letter notations in the same column and row showed significant differences at the 95% confidence level (P<0.05). Description of the type of sweetener as Table 1.

Biscuits substituted with rice, broken rice, and bran flours with the least glycemic index levels of 25.67, 27.32, and 23.98, respectively, were obtained using sweetener 5 (stevia: IG = 0). In addition to having a low calorific value (2.42 kcal/g), stevia contains phenolic and flavonoids as a source of antioxidants [9]. In addition to these types of sweeteners, the use of rice bran which is rich in crude fiber (11.4%) and dietary fiber (25.3%), and water-soluble fiber 2.1% (dw) [21] helps to reduce the glycemic index of the biscuits produced.

CONCLUSION

The combination of flour and sweetener types affected the moisture content, texture, color, preference level and glycemic index of biscuits, and each treatment factor affected protein content, total sugar, and total phenol. The use of broken rice flour and rice bran resulted in a less light biscuit color, and the use of rice bran produced the highest total phenol. The biscuits made by substituting wheat flour with 40% rice, 30% broken rice, and 20% bran flours, and using 5 different sweetener combinations were all accepted by the panelists. However, the treatments with rice or broken rice flour, and sweetener 4 (refined sugar and sorbitol) were most preferred and had the same preference level, compared to the control. These biscuits all had glycemic indexes below 55. Thus, the treatment of using rice flour and groats with sweetener 4 can be chosen as a method for making biscuits for diabetics.

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