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Effect of Stevia and Erythritol on Sensory, Microbiological, and Physicochemical Characteristics of Black Glutinous Rice Cookies

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Abstract. *Cookie is a popular and well-liked food but is high in calories and low in fiber. Replacing sugar by artificial sweeteners in cookies is expected to reduce the calorific value of cookies. This study aimed to evaluate the effect of adding artificial sweeteners on the physical, sensory, microbiological characteristics, and functional benefits of cookies. A completely randomized design with sweeteners (stevia and erythritol) and concentrations (0.2%, 0.4%, and 0.5%) was used. The results showed that stevia and erythritol had significantly affected all test parameters, except in the mold/yeast parameters of cookies. The adding of stevia and erythritol significantly decreased L*, a*, b*, hedonic scores, caloric values, dietary fiber contents, total microbial values but significantly increased hardness and antioxidant capacities (IC50) of final cookies. All sensory ratings of the sucrose and formulated cookies were >3 points, which demonstrated that stevia and erythritol can be sugar replacers that can reduce calorie cookies. The findings can guide in the reformulation of low-calorie, high-fiber, and non-gluten cookies.*
Keywords: *black glutinous rice; erythritol; low-calorie cookies; stevia; sugar replacement.*

Type of the Paper: Regular Article.

1. Introduction

The demand for healthy food products is increasing rapidly worldwide. Products that are low in sugar and enriched with dietary fibers are currently popular healthy foods [1]. Several studies have proven that low-sugar and high-fiber foods can improve metabolic and dental health, reduce blood sugar and hepatic implantation, and prevent obesity and some degenerative diseases [2–6]. The types of food products that have been widely investigated as low-calorie and high fiber foodis cookies. This is because cookies are popular to people of all ages and backgrounds, have low production costs, and have a long shelf life [7]. Nevertheless, cookies are often added with sugar and wheat flour, so they are high in calories and poor in dietary fibers. Thus, cookies have the potential to be utilized as a vehicle to boost functional values such as reduce calories, high in dietary fiberand antioxidants [8,9]. Reducing calories and enriching dietary fiber could be prepared by replacing sugar with sweeteners and replacing wheat flour with non-wheat flour such as chickpea, chestnut, sweet potato flour, mocaf flour [7,10,11]. Black glutinous flour could be used to produce non-gluten cookies which is rich in dietary fibers. According to Hu et al. and Moviana et al. [12,13], black glutinous rice is a functional ingredient to enrich dietary fiber and antioxidants

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in food products.

Refined sugar is responsible for the sweetness, nutritional value, aromatic flavor, appropriate hardness, color, and appearance of cookies [14]. Artificial sweeteners and nonnutritive sweeteners could be used as a substitute for sugar to reduce calorie value while still providing a sweet taste [15]. Replacing sucrose sugar with sweeteners is an ongoing challenge for researchers and industries because reformulation must produce cookies with at least the same quality as sucrose cookies [16]. According to Garrido-Romero et al. [17], there is a tradeoff between functional value enhancements such as lowering calories and enriching dietary fiber with sensory quality reduction. The sucrose replacement must be colorless, non-carcinogenic, and odorless [18].

In the food industry, stevia and erythritol are sweeteners that have been widely used, especially in bakery products, because they are more stable [5,14,19]. Stevia have been consumed by humans for centuries without any negative effect [20]. Stevia is very beneficial because it is 100% natural, is nonnutritive with zero calories [21], does not affect blood sugar level, is 250–300 times sweeter than table sugar [22,23], is heat stable even at 200°C, is non-fermentable, enhances flavor, prevents cavities, is nontoxic, and is recommended for diabetes [24]. The daily doses, acceptable daily intake, and maximum intake value of stevia are 0.18–5.82 g/day, 4 mg/kg, and 2 sachets/3 kali/1 day, respectively [23,25]. Stevia has functional benefits given its anti-diabetic, anti-obesity, antitumor, antihypertensive, antimicrobial, anticaries, and antioxidant qualities [23]. Erythritol is a nutritive sweetener [24] containing 0.2 kcal/g calories [16,19], used as table-top sweetener, 60–80 times sweeter than sucrose, suitable for use in bakery and beverage products, and resistant to acidic and alkaline pH [26]. Erythritol can become the future daily oral care [27] and is suitable for patients with *autism spectrum disorder* [28].

Some authors stated that reducing sucrose with artificial sweeteners is not only reduced calories, but also influence the sensory values, physicochemical quality, and microbiological characteristics of the final product [29]. [8] found that partial substitution of sucrose with stevia aqueous extract increased angiotensin-converting enzyme (ACE) and a-amylase inhibitor activity and antioxidant activity and decreased the energy value, dietary fiber, and level of sensory acceptance of cookies. The addition of stevia to cookies not only decreases sugar content, caloric value, and blood sugar level but also reduces the sensory quality of cookies [14,16,30]. Several studies have evaluated the effect of various types of sweeteners on the quality characteristics of wheat cookies; however, studies on high-fiber and non-gluten cookies are still limited. Thus, this study aimed to evaluate the effects of replacing sucrose (35%) with sweeteners (stevia and erythritol) at various concentration levels (0.2%, 0.4%, and 0.5%) on the physical properties (color and texture), sensory characteristics (color, aroma, taste, texture, and overall), microbial properties (total plate count [TPC] and mold/yeast), and functional benefits (calories, antioxidants, and dietary fiber) of black glutinous cookies.

2. Materials and methods

2.1. Materials

Black glutinous rice flour (Ketanku), sago flour (Sagu Tani), refined sugar, stevia powder (Tropicana Slim), Erythritol (Sweetch), margarine (Blueband), and eggs, which are used as raw materials for cookies, were purchased from traditional markets and online markets. Black glutinous rice flour and sago flour were in a fine fraction of 80 meshes.

2.2. Processing of black glutinous cookies

Sucrose sugar cookies and six cookies with sugars reduced by stevia and erythritol at three different concentrations were made. Based on flour weight, stevia and erythritol were used to replace sugar at concentrations of 0.4 (0.2%), 0.6 (0.4%) and 0.8 g (0.5%), referring to Vatankhah et al. [14] who added 0.2%–0.4% of stevia to biscuit and Yildiz and Gocmen [31] who stated that every 8 g of sucrose can be replaced with 0.04 g of stevia powder. The processes in making black glutinous rice cookies included sifting, weighing of ingredients, mixing of ingredients (mixtures I and II), dough making, and baking. In mixture I, sugar, margarine, and eggs were stirred with a mixer (Philips HR 1505). In the treated cookie formula, sugar was replaced with stevia and erythritol. In mixture II (flour ingredient mixing), black glutinous rice flour and sago flour, which were previously sifted and weighed, were mixed. The mixed flour (mixture II) was gradually added to the mixer bowl containing mixture I and then stirred using a mixer at low speed until evenly mixed. The dough was molded to the desired shape. The molder cookie dough was baked in an oven (Oven Toaster KWS1546ALQ-S1, China) at 170°C for 15 min. The ingredients of the sucrose and formulated cookies are presented in Table 1.

Table 1. Ingredients of the sucrose and formulated cookies with stevia and erythritol

Material	Amount of ingredients in each formula (g)						
	F1	F2	F3	F4	F5	F6	F7
Black glutinous rice flour	62	62	62	62	62	62	62
Sago flour	108	108	108	108	108	108	108
Margarine	125	125	125	125	125	125	125
Eggs	52	52	52	52	52	52	52
Sucrose	60	-	-	-	-	-	-
Stevia	-	0.4	0.6	0.8	-	-	-
Erythritol	-	-	-	-	0.4	0.6	0.8

2.3. Sensory evaluation of black glutinous cookies

In the sensory evaluation of cookie samples of the same size, color, aroma, taste, texture, and overall attributes were evaluated by 12 trained panelists (10 women and 2 men, aged 20–45 years) who had experience in sensory evaluation of food products. The sensory attributes of the cookie samples were tested 1 day after baking. Before evaluating the products, the test sample was given a random 3-digit code, and the panelist was then instructed verbally not to compare test samples. This sensory evaluation used hedonic ratings with a 5-point scale, namely, 1, dislike very much; 2, dislike moderately; 3, neither like nor dislike; 4, like moderately; 5, like very much [31,32].

2.4. Physical analysis of control and formulated cookies

2.4.1. Color determination

Cookie color was measured using a Chromameter CR 400 (Konica Minolta, Sensing, Inc., Sakai, Japan) according to the method of Lang et al. [33]. The instrument was calibrated before being used for analysis with white and black standards. There were seven cookie formulas for color analysis. Measurement results in various notation systems were recorded or printed. Color measurement results in L*, a*, b*. L indicates lightness with values 0 (black) and 100 (white), a* values indicate green (−a*) to red (+a*) and b* values indicate blue (−b*) to yellow (+b*).

2.4.2. Texture profile analysis

Cookie hardness was evaluated 1 day after baking. Cookie texture analysis referred to the analytical method of Li et al. [34] which used (TA-TX2i Texture Analyzer, Stable Micro System Ltd., Godalming, Surrey, UK) with a spherical probe equipment (P/0.25 s, 2.5 mm in diameter). A total of seven different treatment cookies with the same size were placed in the middle of the probe and then compressed to 40% the height of the cookies, pre-test speed of 1.50 mm/s, test speed of 2.00 mm/s, post-test speed of 10.0 mm/s. 3.0 mm of distance and 25-g trigger force. The hardness value is expressed in Newtons.

2.5. Microbiological analysis of black glutinous cookies

The total microbial test through TPC was conducted referring to the method of SNI ISO 4833-1:2015: Microbiology of food chain–horizontal method for the enumeration of microorganisms – part 1: colony counting at 30°C using the pouring cup technique (ISO 4833-1:2013, IDT), whereas the total yeast test used the spread plate method that referred to SNI ISO 21527-2:2012: Microbiology of food and animal feeding ingredients – horizontal method for the enumeration of molds and yeast – part 2: Colony counting techniques in products with water activity less than or equal to 0.95.

2.6. Chemical analysis of black glutinous cookies

Antioxidant activity was measured using the AOAC 2012.04–Antioxidant activity in foods and beverages, reaction with 2,2'-diphenyl-1-picrylhydrazyl (DPPH). The analysis of total dietary fiber (TDF) referred to the AOAC 991.43–total, soluble, and insoluble dietary fiber in foods, enzymatic–gravimetric method, MES–TRIS buffer.

2.7. Calory calculation of black glutinous cookies

Calories were calculated based on the results of the proximate test, namely, protein, fat, and carbohydrates in 100 g of sample cookies. The total calories of cookies calculated by the calorific value per g of protein, fat, and carbohydrates were 4, 9, and 4 kcal, respectively [35] using Eq. (1), where E = energy value (Kcal/100 g product), f = fat content (g/100 g product), p = protein content (g/100 g product), and c = carbohydrate content (g/100 g product).

$$E = (f\ x\ 9kcal) + (p\ x\ 4\ kcal) + (c\ x\ 4\ kcal) \quad (1)$$

2.8. Statistical analysis

This study used a completely randomized design with a combination of types of sweeteners and concentration levels (0.2%, 0.4%, and 0.5%). The experiment was conducted four times. All data were analyzed by one-way analysis of variance (ANOVA) at the level of $p < 0.05$ using IBM SPSS Statistics version 21.0 for windows (IBM Corp., Armonk, NY, USA). If the ANOVA results were significant, Duncan's multiple range comparison test was used to distinguish treatment averages.

3. Results and Discussion

3.1. Physical properties of black glutinous cookies

3.1.1. Texture Assessment

Hardness is a textural property that significantly attracts attention in sensory evaluation of baked products which is closely related to human perception [36]. The results of texture profile analysis for sucrose cookies, stevia cookies and erythritol at different concentration levels are presented in Table 2. Analysis of variance showed that the addition of different sweetener types and concentration combinations showed a significant effect on the hardness of cookies compared to sucrose ($p<0.05$). Table 2 showed that the two different types of sweeteners (stevia and erythritol) at different concentrations led to increase the hardness of cookies. As shown in Table 2, the minimum hardness value was found in sucrose cookies (291.90 N), followed by stevia cookies (369.15-722.40 N), then erythritol cookies (671.55-887.85 N).

These data were similar to the study of Yildiz & Gocmen [31], Yazdi et al. [37] Yoo & Hong [38] who found that stevia and also erythritol can increase the hardness of cookies. Replacement of sucrose by sweeteners decreased the volume of biscuits and increased the bulk density which correlates with an increase in the hardness value of the product [14,30]. According to Woodbury et al. [16], alternative sweeteners (truvia and erythritol) had lower starch gelatinization temperature (Tgel), pasting properties and swelling capacities than sucrose, thus affecting baking performance which results in an increase in cookie hardness values. According to Vatankhah et al. [14], increased stevioside in the biscuit formulation lowered the sucrose sugar content in the dough causing earlier gelatinization of starch during baking, thereby limiting biscuit volume expansion. The research of Gong et al. [39] stated that cookies formulated with erythritol had the highest hardness in all test samples because erythritol had a low solubility level and had a higher tendency to crystallize. Cookies with erythritol sweeteners had a lower aeration matrix than sucrose cookies, resulting in a hard texture [40].

Table 2. The average values and standard deviations for the hardness and color of sucrose and formulated cookies with stevia and erythritol

Treatments	Level concentration (%)	Hardness (N)	Color		
			L*	a*	b*
Sucrose	35	291.90±9.10^{a}	43.02±7.22^{a}	2.38±0.89^{a}	14.21±0.89^{a}
Stevia	0.2	369.15±10.95^{b}	40.04±3.18^{ab}	0.75±0.62^{b}	8.65±0.89^{b}
	0.4	601.60±0.70^{c}	39.65±0.24^{ab}	0.66±0.02^{b}	7.75±0.16^{bc}
	0.5	722.40±7.63^{d}	33.65±5.33^{abc}	0.59±0.26^{b}	7.43±0.07^{bc}
Erythritol	0.2	671.55±4.60^{e}	33.30±0.99^{bc}	0.84±0.22^{b}	7.03±0.28^{cd}
	0.4	781.05±7.42^{f}	29.20±2.16^{bc}	0.54±0.11^{b}	6.45±0.44^{cd}
	0.5	887.85±0.21^{g}	30.47±2.05^{c}	0.51±0.28^{b}	5.75±0.13^{d}

In each same column, values with different superscript letter are significantly different ($p<0.05$)

3.1.2. Color Assessment

Color is an important parameter that can arouse consumer appetite for the product as well as being an indicator of the roasting process [41]. Positive L* values indicated brightness and negative L* values indicated darkness, positive a* and b* values indicated redness and yellowness, and negative a and b* values indicated greenness and blueness [39]. The color parameters of the sucrose, stevia and erythritol with various level of concentration cookies were presented in Table 2. The analysis of variance ($p < 0.05$) revealed the significant effect of all independent variables (type and concentration of sweetener) on the color parameters (L*, a*, and b* chromaticity coordinates). As is obvious from Table 2, replacing sucrose with erythritol significantly decreased L*, a*, and b*. Stevia only significantly decreased a* and b*, but it didn't significantly affect the L* value. Stevia cookies had an L* value (33.65-40.04) which was not significantly different from the L* value of sucrose cookies (43.02), while the a* and b* values of final stevia cookies (a*=0.59-0.75; b*=7.43-8.65) was significantly lower than the sucrose (a*= 2.38; b*=14.21). Likewise, the replacement of sucrose by erythritol had L*, a*, and b* values of final cookies (L*= 33.30-33.47, a*= 0.51-0.84, and b*= 5.75-7.03) which were significantly lower than with sucrose cookies (L*= 43.02, a*= 2.38, b*= 14.21). Stevia and erythritol cookies were less lightness, less reddish and less yellowish compared to sucrose cookies.

Several authors found different results that sugar substitution by artificial sweeteners influenced the color parameters of cookies by increasing the L* value and decreasing the a* and b* values. The study of Yazdi et al. [37] stated that the substitution of sucrose with stevia significantly increased the L* value, and significantly decreased the a* and b* values of cookies. Research by Gong et al. [39] stated that the lightness (L*) of cookies erythritol was significantly higher than sucrose, but the a* and b* values of were not significantly different. Based on research by Rao et al. and Vatankhah et al. [14,42], sucrose cookies have a low L* value, which was correlated with the fact that sucrose played a reducing sugar in providing golden brown color to cookies through a non-enzymatic browning reaction (Maillard reaction). The process of adding sweeteners decreased the amount of total reduced sugar which led to reduce the formation of brown color in the Maillard reaction which would increase the brightness parameter in cookies with sweeteners. Based on research findings of Yazdi et al. [37] and Gong et al. [39], an increase in the L* value in stevia and erythritol cookies is due to the sweetener not containing reducing sugar, so it is not involved in the Maillard reaction during baking. This condition resulted in the formation of a weak brown color thus increasing the L* value of stevia and erythritol cookies with a lighter color than the sucrose cookies.

In this study, the addition of stevia and erythritol sweeteners to black glutinous rice cookies showed the opposite result which significantly lowered the L*, a* and b* values. Our findings were similar to Hajas et al. [41] who developed cookies from green lentil flour with the addition of xylitol showed a decrease in all parameters L*, a* and b*. Hajas et al. [41] stated that the Maillard reaction hypothesis which leads to a darker color has a good role in cereal raw materials but is limited to green lentil raw materials. This hypothesis may also be limited to the black glutinous rice raw material used in this study. In addition, the authors found that the use of 35% of refined sugar in the control black glutinous rice cookie formula caused the dough color and cookie color to be lighter than the stevia and erythritol cookie dough. The differences in the values of the color parameters observed in this study may also be due to differences in the formulas and processing processes besides the raw materials.

Table 3. Means and standard deviation of hedonic ratings on the sensory attributes of the sucrose and formulated cookies with stevia and erythritol.

Treatment	Level concentration (%)	Hedonic ratings				
		Color	**Aroma**	**Taste**	**Texture**	**Overall**
Sucrose	35	3.07±0.47^{c}	4.73±0.49^{a}	4.53±0.52^{a}	4.60±0.51^{a}	4.67±0.49^{a}
Stevia	0.2	4.20±0.41^{b}	4.07±0.60^{b}	3.53±0.64^{bc}	3.73±0.70^{b}	3.93±0.70^{bc}
	0.4	4.67±0.49^{a}	4.20±0.49^{b}	3.67±0.49^{bc}	3.67±0.62^{b}	4.27±0.70^{ab}
	0.5	4.73±0.46^{a}	4.33±0.52^{ab}	3.87±0.64^{b}	3.53±0.52^{b}	4.33±0.49^{ab}
Erythritol	0.2	4.40±0.51^{ab}	4.33±0.49^{ab}	3.20±0.68^{c}	3.60±0.63^{b}	3.67±0.62^{c}
	0.4	4.53±0.52^{ab}	4.40±0.51^{ab}	3.53±0.52^{bc}	3.53±0.64^{b}	4.00±0.54^{bc}
	0.5	4.67±0.49^{a}	4.40±0.51^{ab}	3.80±0.68^{b}	3.47±0.62^{b}	4.27±0.46^{ab}

In each same column, values with different superscript letters are significantly different ($p < 0.05$). Hedonic ratings are: 1, dislike very much; 2, dislike moderately; 3, neither like nor dislike; 4, like moderately; 5, like very much.

3.2. Sensory characteristics of black glutinous cookies

Sensory characteristics are critical aspects that must be considered because they affect the success of products in the market [43]. Products with good sensory characteristics tend to be liked by consumers who will likely order these products again. The hedonic scores of the sucrose, stevia, and erythritol cookies are presented in Table 3.

Fig. 1. Appearance of black glutinous cookies with different formulations, namely, (F1) sucrose as control, (F2) 0.2% of stevia, (F3) 0.4% of stevia, (F4) 0.5% of stevia, (F5) 0.2% of erythritol, (F6) 0.4% of erythritol, and (F7) 0.5% of erythritol.

The ANOVA ($p < 0.05$) illustrated the effect of the combination of the types and concentrations of sweeteners on the sensory attributes tested. The addition of sweeteners at different concentrations significantly affected all sensory attributes tested, namely, aroma, color, taste, texture, and overall cookies. Sucrose cookies showed a higher acceptance score for almost all sensory attributes tested (aroma, 4.73; taste, 4.53; texture, 4.60; and overall, 4.67), followed by cookies added with stevia at different concentration levels (aroma, 4.07–4.33; taste, 3.53–3.87; texture, 3.53–4.73; and overall, 3.93–4.33) and then erythritol cookies at different concentration levels (aroma, 4.33–4.40; taste, 3.20–3.80; texture, 3.47–3.60; and overall, 3.67–4.27). However, cookies with refined sucrose sugar had a lower sensory assessment score on the color attribute (color, 3.07), followed by erythritol cookies (color, 4.40–4.67), and stevia cookies (color, 4.20–4.73). Sucrose cookies with sucrose were identified by 17% of the panelists as having a browner color, which indicated the product was overbaked. The appearance of the sucrose and formulated cookies is presented in Fig. 1.

In general, the addition of stevia and erythritol sweeteners was found have reduced level of acceptance by the panelists. These results were similar to those of Aggarwal et al. [4], Rana et al. [30], and Pranyusha et al. [9] who stated that the addition of stevia reduced the sensory acceptance score of biscuits/cookies and those of Laguna et al. [40] who stated that the addition of erythritol decreased the customer's acceptance of cookies. The authors attributed the sensory loss to the lack of sweetness and an aftertaste of bitterness that reduced the panelist's acceptance of the final cookies. According to Salazar et al. [8], cookies substituted by stevia at 75% and 100% (sugar base) had lower sensory acceptance scores because they are considered hard, bland, not very sweet, and slightly bitter. The substitution of sugar with stevia has led to a bitter and unpleasant flavor [44,45]. According to Rana et al. [30], replacing sugar by artificial sweeteners reduced the desired flavors of bakery products. Products added with stevia had a less favorable perception in terms of taste [46]. This finding was in accordance with our researcher's comments, i.e., cookies with stevia and erythritol sweeteners had a less strong baking aroma, less sweet taste, grittier, and slightly harder texture; however, the panelists did not find bitterness in stevia cookies.

3.3. Microbiology characteristics of black glutinous cookies

The microbiological characteristics of cookie products were analyzed objectively to study the quality of a product [47]. The microbiological qualities of the cookies tested were total microbes and total mold/yeast. Microbiological quality and functional benefits were evaluated in three cookie products, namely, sucrose cookies, stevia cookies, and erythritol cookies, which were the most preferred based on the sensory evaluation results. The results of total microbial measurements (TPC) and total yeast/molds on sucrose cookies, 0.5% stevia cookies, and 0.5% erythritol cookies are presented in Table 4.

Table 4. Microbiological characteristics of the sucrose and stevia and erythritol cookies

Parameter	**Samples of cookies**		
	Sucrose	**0.5% Stevia**	**0.5% Erythritol**
Total plate count (CFU/g)	$(1.9 \times 10^2)^a$	$(8.0 \times 10^1)^c$	$(1.5 \times 10^2)^b$
Total mold and yeast count (CFU/g)	$<10^a$	$<10^a$	$<10^a$

*In each same row, values with different superscript letters are significantly different ($p < 0.05$)

The microbiological quality characteristics of cookie samples were evaluated <24 h after baking. Based on the ANOVA, substituting sucrose with artificial sweeteners (stevia and erythritol) at a concentration of 0.5% significantly affected the TPC but not the measurements of molds and yeast. The highest total microbial value was found in sucrose cookies (1.9×10^2 CFU/g), followed by erythritol cookies (1.5×10^2 CFU/g) and stevia cookies (8×10^1 CFU/g), and the number of yeast molds in the three cookie samples (sucrose, 0.5% stevia, and 0.5% erythritol cookies) was <10 CFU/g.

These findings are consistent with those of a previous study [47], which stated that cookies added with sweeteners (xylitol) had the lowest total microbes than other samples. Cookies added with xylitol have a long shelf life. Xylitol is considered to play the same role as calcium propionate, which is commonly used as an antimicrobial agent in bakeries because the ability of microorganisms to metabolize xylitol is somewhat rare compared with those of microorganisms that utilize hexose (sucrose). The decrease in the number of microbes in stevia and erythritol cookies was thought to be due to their ability to inhibit bacterial growth. Several authors have stated that erythritol can inhibit the growth of two bacteria causing periodontal disease associated bacteria, namely, *Porphyromonas gulae* and *P. macacae* [27], *Clostridium histolyticum, Bacteroides vulgatus,* and *Bifidobacterium longum*, and two strains each of *Clostridium bolteae* and *difficile* that have been associated with the development of autism spectrum disorder [28]. Meanwhile, stevia was reported to have the ability to inhibit the growth of *Enterococcus faecalis, Staphylococcus aureus*, Bacteroides *thetaiotaomicron* [48], *Lactobacillus reuteri* [49], and

Escherichia coli [50]. The difference in results may be also related to the different initial microbial counts in the materials used.

3.4. Chemical properties of black glutinous cookies

3.4.1. Dietary fiber content of black glutinous cookies

Over the last few decades, dietary fiber has received attention because of its proven health benefits [51]. To maintain health, especially the digestive tract, dietary fiber was recommended to be added in the diet [52]. The results of the dietary fiber parameter test for the sucrose and sweetener cookies (stevia and erythritol) at a concentration level of 0.5% are presented in Table 5.

Table 5. Total dietary fiber, antioxidant activity, and calorie of sucrose and cookies formulated with stevia and erythritol.

Parameter	Average Measurement Results		
	Sucrose	**0.5% Stevia**	**0.5% Erythritol**
Total dietary fiber (%)	5.90±0.13^{a}	4.67±0.08^{b}	4.42±0.10^{c}
Antioxidant capacity (IC_{50} μg/mL)	37.95±0.01^{a}	53.73±13.42^{c}	42.05±0.05^{b}
Calorie (kcal)	562.65±0.83^{a}	547.99±1.14^{c}	554.55±0.65^{b}

In each same raw, values with different superscript letters are significantly different ($p < 0.05$)

Based on the ANOVA ($p < 0.05$), the addition of stevia and erythritol at a concentration of 0.5% significantly affected the dietary fiber content of the final cookies. Based on Table 5, the addition of stevia and erythritol significantly reduced the dietary fiber content. The highest dietary fiber was found in sucrose cookies (5.90%), followed by stevia cookies (4.67%) and erythritol cookies (4.42%). In Indonesia, the recommended dietary fiber intake for the general population is 30 g per day [53]. These levels represent 13%–20% of the daily intake recommended for adults by the Republic of Indonesia Ministry of Health.

The results of this study were in line with those of a previous study [8] stating that the replacement of sucrose with 50% stevia reduced the dietary fiber content. This study didn't explain However, Handa et al. [54], Hajas et al. [41] and Yildiz and Gocmen [31] stated that the substitution of sucrose with sweeteners including fructo-oligosaccharides (FOS), inulin, and stevia increased the dietary fiber content of cookies because FOS and inulin are soluble dietary fiber, so they can increase the TDF content of food products. Yildiz and Gocmen [31] also stated that stevia had an adjuvant effect on increasing the dietary fiber content of the final products. The difference in these findings is perhaps related to the different materials used as raw materials, i.e., black glutinous rice, which was reported to have quite high dietary fiber content (6.54%). Other differences may be attributed to the added materials, formulas, and processing conditions.

3.4.2. Antioxidant capacity of black glutinous cookies

Antioxidants are important substances found in vegetables and fruits, which increase the functional values of food products [55]. Antioxidants play important roles in counteracting free radicals and provide a defense mechanism against oxidative stress [56]. The antioxidant capacities of sucrose cookies as a sucrose, 0.5% stevia, and 0.5% erythritol cookies are presented in Table 5. Based on the ANOVA, substituting sucrose with sweeteners (stevia and erythritol) at a concentration of 0.5% significantly affect ($p < 0.05$) on increasing the antioxidant capacity of cookies. The highest antioxidant capacity was observed in 0.5% stevia cookies (53.73 µg/mL), followed by 0.5% erythritol cookies (42.05 µg/mL) and sucrose sucrose cookies (37.95 µg/mL).

Our findings were in accordance to those of a previous study [38], revealing that stevia cookies had high antioxidant activities because stevia contains phenols. Stevia has an antioxidant property [57]. Stevia leaf water extract has an IC_{50} value as a DPPH radical scavenger of 83.45 µg/mL [58]. Erythritol has been shown to act as an antioxidant [59,60] and an excellent HO* radical scavenger, is very good at inhibiting 2,20-azo-bis-2-amidinopropane dihydrochloride-induced hemolysis [61], and counters oxidative stress [62]. Scrob et al. [63] stated that lingonberry jam added with stevia had the highest antioxidant stability, total phenolic content, and total anthocyanin content, followed by lingonberry jam with sucrose and lingonberry jam with erythritol. The difference in these findings may be due to the different materials added, formulas, and processing conditions.

3.5. Calorie of black glutinous cookies

Calorie intake is very important for health. Calories in food supply the energy that the body needs to sustain life. Excess or less energy intake can affect the level of health [64]; thus, a balance is needed. Changes in the calorific value of sucrose, 0.5% stevia, and 0.5% erythritol cookies are presented in Table 5. The ANOVA results showed that the addition of 0.5% of stevia and erythritol reduced the calorie levels significantly ($p < 0.05$) compared with that of sucrose cookies. In **Error! Reference source not found.** the highest calorie value was found in sucrose cookies with sucrose sugar (562.65 kcal), followed by erythritol cookies (554.55 kcal) and stevia cookies (547.99 kcal). These results were similar to those of Vatankhah et al. [14] who stated that substituting sucrose with 100% stevia reduced 15% of calories, which was related to the absence of sugar in the cookie recipe. Our findings were also in accordance with the results of Rana et al. [30] who stated that replacing 50% fat and sugar with 3 g of polydextrose and 5 mL of 2.5% stevia solution reduced 12.59% of cookie calories. This decrease in calories was also possible due to differences in the caloric value of the sweeteners used, namely, sucrose (3.9kcal/g), erythritol (0.2 kcal/g), and stevia (0 kcal/g) [16].

4. Conclusions

These findings showed that replacing sucrose withstevia and erythritol has a significant effect oon all test parameters, except the mold/yeast parameters. The replacing sucrose with stevia and erythritol in the cookie recipe significantly increased color hedonic score, hardness, and the antioxidant capacities of the final cookies, but tended to reduce L*, a*, b* values, the hedonic scores (taste, aroma, texture, and overall), and dietary fiber contents of final cookies. The functional benefits such as the antioxidant capacities the caloric values and microbial characteristic qualities of of stevia and erythritol cookies were (better than sucrose cookies. Based on this research, all sensory ratings of stevia and erythritol cookies were above 3 points. Therefore, these results demonstrated that stevia and erythritol can be alternative sugar replacers that can improve functional benefit by reducing calorie values and enriching antioxidant cookies that were still preferred by panelists.

Abbreviations

Not applicable.

Data availability statement

Data will be shared upon request by the readers.

CRediT authorship contribution statement

E.Y.E.S: Preparation, Conceptualization, Methodology, Resources, Funding acquisition, Resources, Formal analysis, Investigation, Data curation, Writing – review & editing. R.R: Preparation, Conceptualization, Methodology, Resources, Funding acquisition, Resources, Formal analysis, Investigation, Validation, Data curation, Formal analysis, Project administration, Writing – original draft. A.F: Preparation, Resources, Funding acquisition, Formal analysis, Investigation, Writing – review & editing. M.U: Preparation, Resources, Funding acquisition, Formal analysis, Investigation, Writing – review & editing.

Declaration of Competing Interest

The authors of this manuscript declare no conflict of interest or competing interest.

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References

[1] Garrido-Romero M, Montilla A, Moreno FJ. Dietary carbohydrates: a trade-off between appealing organoleptic and physicochemical properties and ability to control glucose release and weight management. Curr Opin Food Sci 2023;49:100976. https://doi.org/10.1016/j.cofs.2022.100976.

[2] Sandoval-Peraza M, Chel-Guerrero L, Betancur-Ancona D. Some physicochemical and functional properties of the rich fibrous fraction of hardened beans (Phaseolus vulgaris L.) and its addition in the formulation of beverages. Int J Gastron Food Sci 2021;26:100440. https://doi.org/10.1016/j.ijgfs.2021.100440.

[3] Arshad S, Rehman T, Saif S, Rajoka MSR, Ranjha MMAN, Hassoun A, et al. Replacement of refined sugar by natural sweeteners: focus on potential health benefits. Heliyon 2022;8:1–12. https://doi.org/10.1016/j.heliyon.2022.e10711.

[4] Aggarwal D, Sabikhi L, Sathish Kumar MH. Formulation of reduced-calorie biscuits using artificial sweeteners and fat replacer with dairy-multigrain approach. NFS Journal 2016;2:1–7. https://doi.org/10.1016/j.nfs.2015.10.001.

[5] Castro-Muñoz R, Correa-Delgado M, Córdova-Almeida R, Lara-Nava D, Chávez-Muñoz M, Velásquez-Chávez VF, et al. Natural sweeteners: Sources, extraction and current uses in foods and food industries. Food Chem 2022;370. https://doi.org/10.1016/j.foodchem.2021.130991.

[6] Valle M, St-Pierre P, Pilon G, Marette A. Differential effects of chronic ingestion of refined sugars versus natural sweeteners on insulin resistance and hepatic steatosis in a rat model of diet-induced obesity. Nutrients 2020;12:1–14. https://doi.org/10.3390/nu12082292.

[7] Giri NA, Sakhale BK. Development of sweet potato flour based high protein and low calorie gluten free cookies. Current Research in Nutrition and Food Science 2019;7:427–35. https://doi.org/10.12944/CRNFSJ.7.2.12.

[8] Salazar VAG, Encalada SV, Cruz AC, Campos MRS. Stevia rebaudiana: A sweetener and potential bioactive ingredient in the development of functional cookies. J Funct Foods 2018;44:183–90. https://doi.org/10.1016/j.jff.2018.03.007.

[9] Pranyusha D, Priya MH, Tanzeem S, Radhamma G, Meda P. Development and standardization of stevia (Stevia rebaudiana) incorporated multigrain cookies. Int J Chem Stud 2020;8:750–2. https://doi.org/10.22271/chemi.2020.v8.i5k.10387.

[10] Torra M, Belorio M, Ayuso M, Carocho M, Ferreira ICFR, Barros L, et al. Chickpea and chestnut flours as non-gluten alternatives in cookies. Foods 2021;10:1–13. https://doi.org/10.3390/foods10050911.

[11] Luh N, Sherly P, Nugrahani R, Pertanian TH, Pertanian F, Wathan UN. Kualitas sensoris kue kering dari tepung buncis (Phaseolus Vulgaris L .) dan mocaf sebagai cemilan non-gluten. Jurnal Agrotek UMMAT 2024;11:81–92.

[12] Moviana Y, Rastina D, Fauziyah RN, Rosmana D, Isdiany N, Ningrum D. Cookies Oat Tape Ketan Hitam Sumber Antosianin Dan Serat Untuk Alternatif Makanan Selingan Bagi Obesitas. Jurnal Riset Kesehatan Poltekkes Depkes Bandung 2022;14:181–90. https://doi.org/10.34011/juriskesbdg.v14i1.2097.

[13] Hu K, Chen D, Sun Z. Structures, physicochemical properties, and hypoglycemic activities of soluble dietary fibers from white and black glutinous rice bran: A comparative study. Food Research International 2022;159:111423. https://doi.org/10.1016/j.foodres.2022.111423.

[14] Vatankhah M, Garavand F, Elhamirad A, Yaghbani M. Influence of sugar replacement by stevioside on physicochemical and sensory properties of biscuit. Quality Assurance and Safety of Crops and Foods 2015;7:393–400. https://doi.org/10.3920/QAS2014.0396.

[15] Nadolsky KZ. COUNTERPOINT: artificial sweeteners for obesity—better than sugary alternatives; potentially a solution. Endocrine Practice 2021;27:1056–61. https://doi.org/10.1016/j.eprac.2021.06.013.

[16] Woodbury TJ, Lust AL, Mauer LJ. The effects of commercially available sweeteners (sucrose and sucrose replacers) on wheat starch gelatinization and pasting, and cookie baking. J Food Sci 2021;86:687–98. https://doi.org/10.1111/1750-3841.15572.

[17] Garrido-Romero M, Montilla A, Moreno FJ. Dietary carbohydrates: a trade-off between appealing organoleptic and physicochemical properties and ability to control glucose release and weight management. Curr Opin Food Sci 2023;49:100976. https://doi.org/10.1016/j.cofs.2022.100976.

[18] Vigneshwari K, Manonmani K. Effect of Sugar Replacer (Stevia and Maltitol) on Quality Characteristics of Bread. Asian Journal Of Dairy and Food Research 2020;39:159–63.

[19] Singh P, Kashyap L. Sugar and Sugar Derivatives: Changing Consumer Preferences. 2020. https://doi.org/10.1007/978-981-15-6663-9.
[20] Lemus-Mondaca R, Vega-Gálvez A, Zura-Bravo L, Kong AH. Stevia rebaudiana Bertoni, source of a high-potency natural sweetener: A comprehensive review on the biochemical, nutritional and functional aspects. Food Chem 2012;132:1121–32. https://doi.org/10.1016/j.foodchem.2011.11.140.
[21] Fagundes MG, Smith Taillie L, Zancheta Ricardo C, Amaral Mais L, Bortoletto Martins AP, Duran AC. Prevalence of Low-Calorie Sweeteners and Related Front-of-Package Claims in the Brazilian Packaged Food Supply. J Acad Nutr Diet 2022;122:1296–304. https://doi.org/10.1016/j.jand.2021.12.009.
[22] Hashem MM, AbdelHamid RI, AbuelMaaty S, Elassal SS, ElDoliefy AEFA. Differential UGT76G1 and start codon-based characterization of six stevia germlines in Egypt. Biocatal Agric Biotechnol 2021;33. https://doi.org/10.1016/j.bcab.2021.101981.
[23] Naik V, Poyil T. Application of stevia (Stevia rebaudiana Bertoni .) in food products. The Pharma Innovation Journal 2022;11:2056–60.
[24] Kulthe AA, Pawar VD, Kotecha PM, Chavan UD, Bansode VV. Development of high protein and low calorie cookies. J Food Sci Technol 2014;51:153–7. https://doi.org/10.1007/s13197-011-0465-2.
[25] Suez J, Cohen Y, Valdés-Mas R, Mor U, Dori-Bachash M, Federici S, et al. Personalized microbiome-driven effects of non-nutritive sweeteners on human glucose tolerance. Cell 2022;185:3307-3328.e19. https://doi.org/10.1016/j.cell.2022.07.016.
[26] Rice T, Zannini E, K. Arendt E, Coffey A. A review of polyols–biotechnological production, food applications, regulation, labeling and health effects. Crit Rev Food Sci Nutr 2020;60:2034–51. https://doi.org/10.1080/10408398.2019.1625859.
[27] Shimizu M, Miyawaki S, Kuroda T, Umeta M, Kawabe M, Watanabe K. Erythritol inhibits the growth of periodontal-disease-associated bacteria isolated from canine oral cavity. Heliyon 2022;8:e10224. https://doi.org/10.1016/j.heliyon.2022.e10224.
[28] Cannon ML, Merchant M, Kabat W, Unruh B, Ramones A. Inhibition of autism spectrum disorder associated bacteria and c. difficile by polyols. Edelweiss Applied Science and Technology 2020;4:33–6. https://doi.org/10.33805/2576-8484.173.
[29] Al-Dabbas MM, Al-Qudsi JM. Effect of partial replacement of sucrose with the artificial sweetener sucralose on the physico-chemical, sensory, microbial characteristics, and final cost saving of orange nectar. Int Food Res J 2012;19:679–83.
[30] Rana MS, Das PC, Yeasmin F, Islam MN. Effect of polydextrose and stevia on quality characteristics of low-calorie biscuits. Food Res 2020;4:2011–9. https://doi.org/10.26656/fr.2017.4(6).223.
[31] Yildiz E, Gocmen D. Use of almond flour and stevia in rice-based gluten-free cookie production. J Food Sci Technol 2021;58:940–51. https://doi.org/10.1007/s13197-020-04608-x.
[32] Gao X, Zhang W, Zhou G. Effects of glutinous rice flour on the physiochemical and sensory qualities of ground pork patties. Lwt 2014;58:135–41. https://doi.org/10.1016/j.lwt.2014.02.044.
[33] Lang GH, Kringel DH, Acunha T dos S, Ferreira CD, Dias ÁRG, Zavareze E da R, et al. Cake of brown, black and red rice: Influence of transglutaminase on technological properties, in vitro starch digestibility and phenolic compounds. Food Chem 2020;318:126480. https://doi.org/10.1016/j.foodchem.2020.126480.
[34] Li Y, Sun Y, Zhong M, Xie F, Wang H, Li L, et al. Digestibility, textural and sensory characteristics of cookies made from residues of enzyme-assisted aqueous extraction of soybeans. Sci Rep 2020;10:1–8. https://doi.org/10.1038/s41598-020-61179-9.
[35] Janowicz M, Ciurzyńska A, Karwacka M, Kowalska J, Galus S. Mathematical estimation of the energy, nutritional and health-promoting values of multi-layer freeze-dried vegetable snacks. Applied Sciences (Switzerland) 2022;12. https://doi.org/10.3390/app12136379.

[36] Kuchtová V, Kohajdová Z, Karovičová J, Lauková M. Physical, Textural and Sensory Properties of Cookies Incorporated with Grape Skin and Seed Preparations. Pol J Food Nutr Sci 2018;68:309–17. https://doi.org/10.2478/pjfns-2018-0004.
[37] Yazdi AG, Hojjatoleslamy M, Keramat J, Jahadi M, Amani E. The Evaluation of saccharose replacing by adding stevioside-maltodextrin mixture on the physicochemical and sensory properties of Naanberenji (an Iranian confectionary). Food Sci Nutr 2017;5:845–51. https://doi.org/10.1002/fsn3.463.
[38] Yoo S-S, Hong Y-J. Quality Characteristics and Antioxidant Activity of Cookies with Stevia Powder. Korean J Food Cookery Sci 2012;28.
[39] Gong S, Xu B, Gu X, Li W, Yu Y, Zhang W, et al. Study on the effects of sugar alcohols and Angelica keiskei flour on cookie quality, antioxidant, and nutrition. Cereal Chem 2020;97:714–22. https://doi.org/10.1002/cche.10287.
[40] Laguna L, Primo-Martín C, Salvador A, Sanz T. Inulin and erythritol as sucrose replacers in short-dough cookies: Sensory, fracture, and acoustic properties. J Food Sci 2013;78. https://doi.org/10.1111/1750-3841.12119.
[41] Hajas L, Benedek C, Csajbókné Csobod É, Juhász R. Development of Protein- and Fiber-Enriched, Sugar-Free Lentil Cookies: Impact of Whey Protein, Inulin, and Xylitol on Physical, Textural, and Sensory Characteristics. Foods 2022;11. https://doi.org/10.3390/foods11233819.
[42] Rao ES, Meena PL, Barwa MS. Development of sugar free cookies with novel biodegradable packaging film. Journal of Applied and Natural Science 2021;13:316–26. https://doi.org/10.31018/jans.v13i1.2532.
[43] Stone H. Example food: What are its sensory properties and why is that important? NPJ Sci Food 2018;2:2017–9. https://doi.org/10.1038/s41538-018-0019-3.
[44] Schiatti-Sisó IP, Quintana SE, García-Zapateiro LA. Stevia (Stevia rebaudiana) as a common sugar substitute and its application in food matrices: an updated review. J Food Sci Technol 2022. https://doi.org/10.1007/s13197-022-05396-2.
[45] Lima Ribeiro AP, Guimarães JS, Teixeira Lago AM, Cardoso de Angelis Pereira M, Ronaldo de Abreu L, Pinto SM. Oat bran and sweeteners in petit-suisse cheese: Technological and nutritional properties and consumer acceptance. Lwt 2021;146. https://doi.org/10.1016/j.lwt.2021.111318.
[46] Prada M, Saraiva M, Sério A, Coelho S, Godinho CA, Garrido M V. The Impact of Sugar-Related Claims on Perceived Healthfulness, Caloric Value and Expected Taste of Food Products. Food Qual Prefer 2021:166. https://doi.org/10.1016/j.foodqual.2021.104331.
[47] Winkelhausen E, Jovanovic-Malinovska R, Velickova E, Kuzmanova S. Sensory and Microbiological Quality of a Baked Product Containing Xylitol as an Alternative Sweetener. Int J Food Prop 2007;10:639–49. https://doi.org/10.1080/10942910601098031.
[48] Boling L, Cuevas DA, Grasis JA, Kang HS, Knowles B, Levi K, et al. Dietary prophage inducers and antimicrobials: toward landscaping the human gut microbiome. Gut Microbes 2020;11:721–34. https://doi.org/10.1080/19490976.2019.1701353.
[49] Deniņa I, Semjonovs P, Fomina A, Treimane R, Linde R. The influence of stevia glycosides on the growth of Lactobacillus reuteri strains. Lett Appl Microbiol 2014;58:278–84. https://doi.org/10.1111/lam.12187.
[50] Wang QP, Browman D, Herzog H, Gregory Neely G. Non-nutritive sweeteners possess a bacteriostatic effect and alter gut microbiota in mice. PLoS One 2018;13:1–13. https://doi.org/10.1371/journal.pone.0199080.
[51] Saini P, Islam M, Das R, Shekhar S, Sinha ASK, Prasad K. Wheat Bran as Potential Source of Dietary Fiber: Prospects and Challenges. Journal of Food Composition and Analysis 2022;116:105030. https://doi.org/10.1016/j.jfca.2022.105030.
[52] Yu M, Gao T, Liu Z, Diao X. Effects of dietary supplementation with high fiber (stevia residue) on the fecal flora of pregnant sows. Animals 2020;10:1–22. https://doi.org/10.3390/ani10122247.

[53] Permenkes. Angka Kecukupan yang Dianjurkan bagi Bangsa Indonesia. Jakarta: Menteri Kesehatan RI; 2013.

[54] Handa C, Goomer S, Siddhu A. Physicochemical properties and sensory evaluation of fructoligosaccharide enriched cookies. J Food Sci Technol 2012;49:192–9. https://doi.org/10.1007/s13197-011-0277-4.

[55] Jideani AIO, Silungwe H, Takalani T, Omolola AO, Udeh HO, Anyasi TA. Antioxidant-rich natural fruit and vegetable products and human health. Int J Food Prop 2021;24:41–67. https://doi.org/10.1080/10942912.2020.1866597.

[56] Nimal R, Selcuk O, Kurbanoglu S, Shah A, Siddiq M, Uslu B. Trends in electrochemical nanosensors for the analysis of antioxidants. TrAC - Trends in Analytical Chemistry 2022;153. https://doi.org/10.1016/j.trac.2022.116626.

[57] Peteliuk V, Rybchuk L, Bayliak M, Storey KB, Lushchak O. Natural sweetener stevia rebaudiana: Functionalities, health benefits and potential risks. EXCLI J 2021;20:1412–30. https://doi.org/10.17179/excli2021-4211.

[58] Shukla S, Mehta A, Mehta P, Bajpai VK. Antioxidant ability and total phenolic content of aqueous leaf extract of Stevia rebaudiana Bert. Experimental and Toxicologic Pathology 2012;64:807–11. https://doi.org/10.1016/j.etp.2011.02.002.

[59] De Cock P, Bechert CL. Erythritol. Functionality in noncaloric functional beverages. Pure and Applied Chemistry 2002;74:1281–9. https://doi.org/10.1351/pac200274071281.

[60] Chiriac AP, Ghilan A, Serban AM, Macsim AM, Bargan A, Doroftei F, et al. Preparation of an Antioxidant Assembly Based on a Copolymacrolactone Structure and Erythritol following an Eco-Friendly Strategy. Antioxidants 2022;11. https://doi.org/10.3390/antiox11122471.

[61] den Hartog GJM, Boots AW, Adam-Perrot A, Brouns F, Verkooijen IWCM, Weseler AR, et al. Erythritol is a sweet antioxidant. Nutrition 2010;26:449–58. https://doi.org/10.1016/j.nut.2009.05.004.

[62] Yokozawa T, Kim HY, Cho EJ. Erythritol attenuates the diabetic oxidative stress through modulating glucose metabolism and lipid peroxidation in streptozotocin-induced diabetic rats. J Agric Food Chem 2002;50:5485–9. https://doi.org/10.1021/jf020168z.

[63] Scrob T, Varodi SM, Vintilă GA, Casoni D, Cimpoiu C. Estimation of degradation kinetics of bioactive compounds in several lingonberry jams as affected by different sweeteners and storage conditions. Food Chem X 2022;16. https://doi.org/10.1016/j.fochx.2022.100471.

[64] Osilla E V, Safadi AO, Sharma S. Calories. StatPearls [Internet], StatPearls Publishing; 2021.