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Color and texture analysis of glucomannan modified growol cookies for diabetic

Analisis warna dan tekstur cookies growol modifikasi glukomanan untuk pasien diabetes

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Abstract

Background: Foods high in dietary fiber can provide good glycemic control for diabetics. Growol cookies have been developed as a healthy snack high in dietary fiber.
Objectives: Colors and texture examination of Growol cookies need to be done to see the potential for product development.
Methods: There are five variants of cookies: negative control growol cookies (cookies A), positive control growol cookies (cookies B), inulin-modified growol cookies (cookies C), 3% glucomannan-modified growol cookies (cookies D), and 7% glucomannan-modified growol cookies (cookies E). Color and texture were examined in triplicate using a chromameter and texture analyzer. Difference tests were carried out using ANOVA and Kruskal-Wallis.
Results: There was no difference in brightness among cookies, but there was a difference in the a-value which describes the red color (p=0,001), and the b-value which describes the yellow color among cookies (p=0,038). There were differences in hardness in the first bite (p=0,004) and second bite (p=0,005), cohesiveness (p=0,032), gumminess (p=0,005), fracture (p=0,001), springiness (p=0,035), crispiness peak (p=0,021), crispiness (p=0,005), and crunchiness (p<0,001) among cookies.
Conclusion: Colors and textures of cookies B, cookies C, and cookies D tend to be similar to control cookies, so these cookies have the potential to be developed for diabetics.

Keywords
Color and texture, growol cookies, product development

Abstrak

Latar Belakang: Konsumsi makanan yang tinggi akan serat pangan mampu memberikan kontrol glikemik yang baik bagi diabetesi. Cookies growol telah dikembangkan sebagai makanan selingan sehat tinggi serat pangan.
Tujuan: Kajian terkait warna dan tekstur pada cookies growol perlu dilakukan untuk melihat potensi pengembangan produk.
Metode: Terdapat lima varian cookies yakni cookies growol kontrol negatif (cookies A), cookies growol kontrol positif (cookies B), cookies growol modifikasi inulin (cookies C), cookies growol modifikasi glukomanan 3% (cookies D), dan cookies growol modifikasi glukomanan 7% (cookies E). Pengujian warna dan tekstur dilakukan secara triplo menggunakan chromameter dan texture analyzer. Uji beda dilakukan menggunakan ANOVA dan Kruskal-Wallis.
Hasil: Tidak terdapat perbedaan tingkat kecerahan di antara varian *cookies*, namun terdapat perbedaan nilai a yang menggambarkan warna merah (p=0,001) dan nilai b yang menggambarkan warna kuning di antara varian *cookies* (p=0,038). Terdapat perbedaan kekerasan pada gigitan pertama (p=0,004) maupun gigitan kedua (p=0,005), daya kohesif (p=0,032), kelengketan (p=0,005), kerapuhan (p=0,001), elastisitas (p=0,035), puncak kegaringan (p=0,021), tingkat kegaringan (p=0,005), dan kerenyahan (p<0,001) di antara varian *cookies*.

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Kesimpulan: Warna dan tekstur cookies B, cookies C, dan cookies D cenderung serupa dengan cookies kontrol sehingga cookies tersebut potensial untuk dikembangkan bagi diabetesi.

Kata Kunci
cookies growol, pengembangan produk, warna dan tekstur

Introduction

Globally, the prevalence of diabetes in 2019 was 9,3% (equivalent to 463 million people) and is expected to increase to 10,2% (around 578 million) in 2030 and 10,9% (around 700 million) in 2045. The prevalence of diabetes was found to be 3,6% higher in urban communities (10,8%) than in rural communities (7,2%). In addition, the prevalence of diabetes was found to be 6,4% higher in people with high incomes compared to low incomes. Globally, the prevalence of impaired glucose tolerance was estimated at 7,5% (equivalent to 374 million) in 2019 and is projected to approach 8% (equivalent to 454 million) in 2030 and 8,6% (548 million) in 2045 (Saeedi et al., 2019).

Various food products have been developed as healthy snack solutions that maintain stable blood glucose levels, one of which is fermented food, namely growol. Growol is a traditional fermented food from Yogyakarta made from cassava. Fermentation of cassava into growol takes naturally involving lactic acid bacteria which are beneficial for health (Afrianto & Wariyah, 2020; Sari & Puspaningtyas, 2019; Wicaksono et al., 2022). Growol has been developed into various processed products, one of which is Growol cookies. Growol cookies is one of the high-fiber snack food products (Puspaningtyas et al., 2020). Various modifications to increase the potential of growol cookies have been made, one of which is using inulin, where these cookies have a low glycemic index (Puspaningtyas et al., 2022a; Styaningrum et al., 2023).

These cookies can potentially provide good glycemic control for people with diabetes. However, the hygroscopic characteristic of inulin can potentially change the physical characteristics of cookie products, especially the color and texture (Styaningrum et al., 2023). The use of inulin can be substituted by glucomannan. Glucomannan can be used as an emulsifier, thickener agent, binder agent, and surfactant (Mura, 2021). Like inulin, glucomannan has been widely used in various food products such as noodles, jelly, tofu, sausages, and rice (Saputri et al., 2021; Setyono et al., 2021). Therefore, glucomannan is thought to apply to cookie products.

In terms of its physiological effects, glucomannan is also able to match the role of inulin, considering that glucomannan is a type of water-soluble fiber that can provide a positive effect on glycemic control through improving blood glucose control and insulin sensitivity as well as positive control of the lipid profile. This is because glucomannan can increase the sensation of fullness which can control the desire to eat and the amount of food that enters the body (J. K. Keithley et al., 2013; J. Keithley & Swanson, 2005; Mashudi et al., 2022; Susanti et al., 2015).

However, to determine product acceptability, it is necessary to assess the physical characteristics, especially in terms of color and texture, compared to the physical characteristics of the control (comparative) product considering that glucomannan is a compound that is capable of forming a thick solution in water and forming a gel (Setyono et al., 2021). Adding glucomannan to cookies may change the texture and color of the cookies. Texture and color testing in product development needs to be carried out so that the product being developed can meet consumer expectations (Irianto & Giyatmi, 2021; Tarwendah, 2017). This study aims to objectively examine the effect of adding inulin and glucomannan on physical characteristics, especially color and texture. The results of this study can provide an overview of the feasibility of developing snack food products, especially cookies made from growol modified with inulin and glucomannan.

Methods

This laboratory observation study was conducted from August to September 2023 at Universitas Respati Yogyakarta and Gadjah Mada University. Various variants of growol cookies were made at

the Culinary and Dietetics Laboratory, Universitas Respati Yogyakarta. Meanwhile, testing of the physical properties of color and texture was carried out at the Food and Nutrition Laboratory, Gadjah Mada University. This study has received an ethical letter 0146.3/FIKES/PL/VII/2023 from the Health Research Ethics Commission, Universitas Respati Yogyakarta.

The making process of growol cookies was carried out through various stages: a) making growol, b) making growol flour, and c) making growol cookies. The manufacture of growol was carried out independently, referring to previous studies (Puspaningtyas et al., 2019). Growol was made through a spontaneous fermentation process from the basic ingredients of Klentengan Cassava or Darul Hidayah Cassava (Manihot esculente) (Helsius SB et al., 2023a, 2023b).

Next, growol was dried in a cabinet dryer for six hours at a temperature of 80 degrees Celsius. Dried growol was hereinafter referred to as chip growol. Chip growol was then destroyed with a grinder and sifted using a 60-mesh sieve (Puspaningtyas et al., 2019). Growol flour was then used as a basic ingredient for making cookies. Other ingredients for making cookies referring to previous studies (Puspaningtyas et al., 2022a, 2022b; Sari et al., 2023; Styaningrum et al., 2023).

There are five variants of cookies, namely negative control growol cookies, which use granulated sugar (cookies A), and positive control growol cookies with the addition of non-calorie sugar (cookies B). Inulin-modified growol cookies (cookies C), 3% glucomannan-modified growol cookies (cookies D), and 7% glucomannan-modified growol cookies (cookies E). The basis for using inulin refers to previous studies (Sari et al., 2023; Styaningrum et al., 2023), and the basis for using glucomannan is in accordance with the safe limit for glucomannan use, namely 1-4 grams per day (J. K. Keithley et al., 2013; J. Keithley & Swanson, 2005; Mohammadpour et al., 2020).

Color and texture testing was carried out sequentially in triplicate using a Chromameter Konica Minolta CR-400 and Texture Analyzer Lloyd type TAI (Masmoudi et al., 2010; Styaningrum et al., 2023). The color indicators examined in this study include the “L” value for the brightness level of the product, the “a” value for seeing red and green color images, and the “b” value for seeing yellow to blue color images. The texture indicators studied in this study include the hardness of the cookies at the first and second bite, cohesiveness, adhesiveness, gumminess, fracture, stringiness, springiness index, crispiness peaks, crispiness, and crunchiness.

Color and texture data are first assessed at the level of data distribution using Kolmogorov-Smirnov. Brightness (“L” value), gumminess, fracture, and crispiness are not normally distributed ($p<0,05$). Meanwhile, the data of “a” value, “b” value, first bite hardness, second bite hardness, cohesiveness, adhesiveness, stringiness, springiness index, crispiness peaks, and crunchiness are normally distributed ($p\geq0,05$).

Next, a homogeneity of variance test is carried out for normally distributed data using the Levene Test. Only data of cohesiveness, adhesiveness, stringiness, springiness index, crispiness peaks, and crunchiness have homogeneous variance ($p\geq0,05$). Next, a different test was carried out with ANOVA on that data. If the test results are significant, continue with the Tukey HSD. Meanwhile, other data is tested using Kruskal-Wallis. If the test results are significant, continue with the Mann-Whitney. The significance level used is 95%.

Result

Table 1 presents the results of color analysis between variants of cookies. There is no difference in brightness level (“L” value) between variants of cookies. Brightness levels of the five variant cookies are at number 70. However, there is a difference in the value of “a”, which describes the red color, and the value of “b”, which describes the yellow color in between variant cookies.

Table 2 shows a difference in cookies' hardness on the first bite and second bite among various variants of cookies, with the highest hardness at cookies A. In addition, there are differences in cohesiveness, gumminess, fracture, springiness index, crispiness peaks, crispiness, and crunchiness. The highest texture test value is at cookies A.

Table 1. Color analysis results for various variants cookies

Cookies Sample	L			A			b		
	Mean±SD	Mean Rank	p-value	Mean±SD	Mean Rank	p-value	Mean±SD	Mean Rank	p-value
Cookies A	70,99±0,07	16,50		1,57±0,90	9,50[a]		40,91±1,54	12,67[a]	
Cookies B	71,56±2,77	14,00		3,13±0,92	20,00[b]		40,70±0,75	8,50[a]	
Cookies C	74,43±3,88	22,00	0,261	0,82±0,31	5,00[a]	0,001*	43,68±2,48	23,00[b]	0,038*
Cookies D	71,51±1,73	14,00		3,11±0,15	22,50[b]		42,40±1,21	19,42[ab]	
Cookies E	70,68(70,64-71,21)[#]	11,00		3,08±0,35	20,50[b]		41,34±0,19	13,92[ab]	

Table 2. Texture analysis results on various variants cookies

Texture Testing		Cookies Sample					p-value
		Cookies A	Cookies B	Cookies C	Cookies D	Cookies E	
Hardness bite 1	Mean±SD	70,80±19,59	25,40±1,90	25,70±7,11	23,07±5,95	27,76±4,37	0,004^
	MR	27,50[a]	12,83[b]	11,67[b]	10,00[b]	15,50[b]	
Hardness bite 2	Mean±SD	54,14±19,97	16,00±2,06	18,03±5,75	16,50±5,00	18,18±2,24	0,005^
	MR	27,50[a]	10,67[b]	12,67[b]	11,33[b]	15,33[b]	
Cohesiveness	Mean±SD	0,27±0,04[a]	0,20±0,05[b]	0,20±0,03[b]	0,22±0,03[ab]	0,22±0,06[ab]	0,032[#]
Adhesiveness	Mean±SD	0,32±0,44	0,16±0,29	0,48±0,42	0,17±0,25	0,48±0,71	0,584
Gumminess	Mean±SD	19,86±7,86	5,09±1,18	5,11±1,86	5,11±1,15	6,49 (4,17-7,44)*	0,005^
	MR	27,50[a]	11,33[b]	11,17[b]	11,67[b]	15,83[b]	
Fracture	Mean±SD	12,92±6,07	5,18±1,53	5,93±0,98	3,94 (3,39-6,22)*	3,65 (2,52-6,65)*	0,001^
	MR	27,50[a]	13,50[b]	17,50[b]	10,83[c]	8,17[c]	
Stringiness	Mean±SD	0,83±1,10	0,55±1,84	1,71±1,47	2,88±2,05	1,86±1,78	0,160
Springiness index	Mean±SD	0,81±0,004[ab]	0,81±0,004[ab]	0,81±0,003[a]	0,81±0,003[ab]	0,82±0,002[b]	0,035[#]
Crispiness peaks	Mean±SD	12,17±2,04[a]	9,83±1,47[ab]	11,67±1,86[ab]	10,17±1,33[ab]	9,00±1,79[b]	0,021[#]
Crispiness	Mean±SD	270,66±81,96	88,40±6,11	84,84 (73,37-141,31)*	85,69±24,00	97,20±13,19	0,005^
	MR	27,50[a]	12,50[b]	11,33[b]	11,00[b]	15,17[b]	
Crunchiness	Mean±SD	58,43±16,85[a]	26,15±5,73[b]	27,81±4,76[b]	21,34±6,53[b]	29,69±6,67[b]	<0,001[#]

Discussion

Color is one of the characteristics that can influence the level of liking or acceptability and product selection decisions (Gebregziabher et al., 2021). Color testing is translated into "L" values or brightness a product from 0 to 100, the "a" value which describes the red color between 0 to 60 and the green color between 0 to -60, and the "b" value which describes the yellow color between 0 to 60 and the blue color between 0 to -60 (Gebregziabher et al., 2021; Styaningrum et al., 2023; Widiantara et al., 2018).

Inulin-modified growol cookies (cookies C) has the same "a" value as negative control growol cookies (cookies A). Glucomannan-modified growol cookies (cookies D and cookies E) has the same "a" value as the positive control growol cookies (cookies B). The red indicator on cookies B, cookies D, and cookies E is higher than the red indicator on cookies A and cookies C. Furthermore, the "b" value on control growol cookies (cookies A and cookies B) is equal to 3% glucomannan-modified growol cookies (cookies D) and 7% glucomannan-modified growol cookies (cookies E). Cookies C has the highest "b" value (yellow indicator) among other cookies.

This shows that the variance cookies developed have a bright yellowish color. The combination of a high "L" value followed by a low "a" value and a high "b" value will show a bright yellow color (Kaemba et al., 2017). This bright yellowish color comes from the ingredients used in making cookies, including wheat flour, growol flour, cornstarch, skim milk, inulin, and glucomannan. Meanwhile, the reddish color comes from caramelization by using sugar in cookies.

Apart from that, the reddish color may be caused by the Maillard reaction that occurs during the baking process of cookies, where a reaction occurs between the amino groups of proteins and the carboxyl groups of reducing sugars which produces a brownish color (Miranti, 2020).

Cookies A has the highest hardness, gumminess, crispiness, and crunchiness compared to other cookies. There is no difference in the level of hardness, gumminess, crispiness, and crunchiness among cookies B, cookies C, cookies D, and cookies E. The cohesiveness of cookies A tends to be the same as cookies D and cookies E. The lowest cohesiveness is owned by cookies B and cookies C. There is a difference in the fracture value between cookies A and other cookies. There is no difference in the fracture value between cookies B and cookies C and also between cookies D and cookies E. Only the springiness index of cookies C and cookies E is different. Cookies A has the highest crispiness peaks compared to other cookies. However, the crispiness peaks between cookies A, cookies B, cookies C, and cookies D were not significantly different.

The hardness value describes the maximum peak given in the first and second bites, described in Newton units (N). Springiness index is the recovery time between the end of the first bite and the start of the second bite. Cohesiveness is the ratio of the pressure area during the second pressing to the first pressing or describes the condition that the material can be destroyed mechanically. Gumminess reflects cohesiveness and hardness (Indiarto et al., 2012; Iswara et al., 2019). The hardness testing results are in line with the testing level of crispiness, crunchiness, fracture, and crispiness peaks. The results of this texture test may be related to chemical characteristics, especially the water content in the cookies product considering that inulin is a hygroscopic compound (Styaningrum et al., 2023) and glucomannan can form a thick solution in water and form a gel (Setyono et al., 2021). Further studies are needed regarding analyzing the water content of various variants of these cookies.

Inulin and glucomannan are widely used as food-binding agents. Inulin is generally used as a source of prebiotics, especially dietary fiber, which can potentially be used to develop healthy food products. Moreover, adding inulin does not change the food structure significantly (Abed et al., 2016; Puspaningtyas et al., 2022a; Wilson & Whelan, 2017). Glucomannan also acts as a source of dietary fiber and can potentially be used in food development in diabetes diets. Glucomannan can form a thick solution in water and form a gel (Setyono et al., 2021). The addition of inulin and glucomannan did not significantly change the product's physical properties. This can be seen from the products of the inulin-modified growol cookies and the 3% glucomannan-modified growol cookies, which do not have significantly different physical properties from the control cookies. The results of this research provide an illustration that in developing healthy food products it is necessary to consider the potential nutritional compounds or active compounds that are favored without ignoring the physical properties of the product considering that the physical properties of the product determine the acceptability of the product.

Conclusion

Cookies B, cookies C, and cookies D have colors and textures that tend to be similar to the control cookies (cookies A), so these cookies have the potential to be developed in terms of the physical properties of cookies.

However, it is recommended to test the chemical properties (nutritional content analysis) to prove the suitability of cookies as a healthy snack for diabetes.

Conflict of Interest Declaration

Authors declared that there is no conflict of interest in this study.

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