Chemical and Sensory Characterization of Soybean Pulp Flour- Based Soft Cookies

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ABSTRACT
Soy milk pulp is the residue produced during the extraction process of soy juice to make soy milk. It contains a relatively high nutritional value, including fiber, protein, and several bioactive compounds. Research on soy milk pulp is relevant due to its potential for developing highly nutritious food products and its positive environmental impact through waste management. This study aims to assess the interaction between the proportions of wheat flour and soy milk pulp flour, along with the addition of GMS (glyceryl monostearate), on the chemical and organoleptic properties of soft cookies. The goal is to produce high-quality soft cookies that are widely acceptable based on taste, color, and texture, while also being rich in fiber and protein. These cookies promote health and increase public interest in local, nutritionally rich food products. Additionally, the study encourages the utilization of soy milk processing waste, which is often discarded in the environment. This research used a factorial Completely Randomized Design (CRD) experimental design involving two factors. The first factor was the proportion of wheat flour substituted with soy milk pulp flour at three levels: A1 (50% wheat flour, 50% soy milk pulp flour), A2 (40% wheat flour, 60% soy milk pulp flour), and A3 (30% wheat flour, 70% soy milk pulp flour). The second factor was the GMS concentration at two levels: B1 (2%) and B2 (3%). The research results showed that the best treatment was achieved by replacing 60% of soy milk dregs with flour and adding 2% GMS. This combination resulted in the following parameter values: water content = 12.0%, protein content = 8.94%, fiber content = 10.93%, fat content = 15.46%. The organoleptic evaluation showed high acceptance, with scores of 4 (like) for color, taste, aroma, and texture.

Keywords*: soft cookies; soy milk pulp; GMS*

INTRODUCTION

Cookies are sweet snacks made from a mixture of flour, sugar, butter, and other ingredients, such as chocolate, nuts, or dried fruit that are processed in the oven. Many people like cookies because they taste sweet and appetizing, as well as their texture which is crunchy on the outside and soft on the inside. As one of the popular snacks, cookies rely heavily on wheat flour as their main raw material. Wheat flour gives cookies a distinctive structure and texture, helping to create a crispy feel on the outside and soft on the inside. Although wheat flour provides many benefits, there are some drawbacks to its use. One of them is the high gluten content, which can cause some people who are sensitive or have gluten intolerance to experience digestive problems. The high gluten content in wheat flour may cause negative reactions in individuals suffering from celiac disease or non-celiac gluten sensitivity, which can result in symptoms such as abdominal pain, bloating, and fatigue. Wheat flour is generally low in fiber and nutrients, so excessive consumption can contribute to problems such as obesity and type 2 diabetes, as wheat-based foods often have a high glycemic index. To overcome this problem, it is necessary to think about how the healthier main ingredient of cookies is gluten-free flour, which offers better nutritional benefits for health.

Some of the studies reported related to the development of gluten-free food products include: Formulation of gluten-free cookies from corn-almond flour supplemented with mung bean flour (N Aini, et al. 2022), Nutritional improvement of gluten-free cookies with moringa leaf flour (I Anggita, et al. 2023), Innovation of gluten-free soft cookies products from mocaf flour and porang

ISSN 2622-1985 (print) | ISSN 2622-4127 (online)
DOI: http://dx.doi.org/10.25139/fst.vi.9192

flour (LD Rahmaris, et al. 2022), Ganyong flour and sorghum flour substitution in gluten- free chocolate cookies (DP Arum, et al. 2024). One alternative raw material that can be applied as a substitute for wheat flour in making cookies is soybean dregs. This soybean meal is a remnant of the soy milk making process (which has been a leftover of production and has not been utilized optimally. In addition to being a gluten-free raw material, soybean pulp has a high content of protein, fiber, vitamins, and minerals that are beneficial for health. The use of soybean pulp as a raw material for making cookies not only helps reduce waste in the food industry, but also provides a healthier option for anyone who is sensitive to gluten or is looking for a plant-based protein source.

The application of soybean pulp in the manufacture of cookies provides many benefits as an alternative to gluten-free flour, but it has its drawbacks. Cookies made from soybean dregs produce a brittle dough that makes the cookie forming process difficult. Cookies that use soybean meal tend to be more difficult to form and have less stability compared to those that use wheat flour. Therefore, additional ingredients such as Glycerol Monostearate (GMS) are needed. GMS additives act as emulsifiers and stabilizers while helping to improve the texture of the dough, providing better chewiness. The presence of GMS in the cookie dough will allow the cookies to be made according to the desired shape while maintaining their taste.

Although there have been several gluten-free cookies, the use of soybean pulp combined with GMS has not been found. This study aims to develop gluten-free cookie products and study the effect of the interaction between the combination of soy milk pulp substitution and the addition of GMS concentration on chemical properties (protein content, fat content, fiber content and moisture content) as well as organoleptic soft cookies. By creating delicious and nutritious gluten-free cookies, this research has the potential to open new opportunities in the food industry and provide a better solution for anyone who wants to enjoy a safe and healthy snack.

METHODS

Material

The main ingredients used in this study were soy milk pulp flour and glycerol monostearate. Soy milk pulp, a byproduct of soy milk production, was obtained from the food technology processing unit at the Faculty of Agriculture, Dr. Soetomo University. Glycerol monostearate was obtained from "Soghiemart". Supporting ingredients used in cookie production included blue triangle brand wheat flour, Marmila brand margarine/butter, brown sugar, granulated sugar, eggs, Cendrawasih brand baking powder, and Mercolade brand chocolate. These ingredients were purchased from the "Nico" cake ingredient store in Sukodono Supermarket, Sukodono District, Sidoarjo Regency.

The materials used for chemical analysis include 3.25% and 30% NaOH solutions, 96% ethanol, K_2SO_4, concentrated H_2SO_4 solutions, 4% H_3BO_3 solutions, and 0.01 N HCl solutions.

Equipment

The equipment used in making soy milk pulp flour included gauze, pots, basins, baking sheets, food dehydrators, blenders, sieves, and jars. While the equipment used for making cookies included basins, scales, spatulas, spoons, parchment paper, baking sheets, plastic boxes, and ovens.

Equipment for chemical analysis included scales, mortars, watch glasses, desiccants, ovens, clamps, flasks, distillation devices (heating mantles, condensers, pumps, hoses, buckets), analytical balances, beakers, measuring cups, drip pipettes, refrigerators, Erlenmeyer flasks, funnels, burettes, Buchner funnels, vacuum pumps, water baths, Soxhlet flasks, water flow and collection systems, filter paper, and wool threads

ISSN 2622-1985 (print) | ISSN 2622-4127 (online)
DOI: http://dx.doi.org/10.25139/fst.vi.9192

Making Soybean Dregs Flour

The manufacture of soybean pulp flour follows the method of Yustina (2012). Soybean pulp is squeezed to reduce moisture content, then steamed for 20 minutes at 100–120°C, unless the pulp has been boiled or steamed beforehand. After that, the pulp is dried at 60 ^{o}C for 4 hours using a food dehydrator, then mashed with a blender and sifted using an 80-mesh sieve. The process is as follows

The manufacture of soybean pulp flour begins by taking 1.017 g of wet soybean pulp that has been extracted, then washed clean 1-3 times with running water. After that, the dregs are filtered using gauze until the laundry water no longer drips. The cleaned pulp is then dried using a food dehydrator at 60ºC for 4 hours, resulting in 285 g of dry pulp. The dry pulp is then mashed with a blender at high speed, then sifted using an 80-mesh sieve until 200 g of soybean pulp flour is obtained.

Making Soft Cookies

The process of making soy milk pulp flour soft cookies begins by preparing and weighing all ingredients, including wheat flour, soy milk meal flour, sugar, butter or butter, eggs, baking powder, and dark chocolate. Sugar, butter, eggs, and baking powder are mixed and stirred using a spatula until evenly distributed. After that, soy milk pulp flour and wheat flour are gradually added to the dough until it is completely combined. Dark chocolate that has been roughly cut is then added to the dough and stirred until evenly distributed. The cookie dough is formed using two spoons and placed on a baking sheet lined with parchment paper. Then it is stored in the freezer for ±7 hours, then let it sit at room temperature for 10 minutes. After that, the cookies are baked at 160°C-200°C for 20-35 minutes.

Research Design

This study used a completely randomized design (CRD) with two treatment factors combined in a factorial design. The first factor (A) is the ratio of wheat flour to soybean dregs, with three levels: A1 (50%:50%), A2 (40%:60%), and A3 (30%:70%). The second factor (B) is the concentration of GMS, which has two levels: B1 (2%) and B2 (3%). In total, there were six combinations of treatments, each repeated three times, resulting in 18 experimental units.

Test Parameters

To assess the quality of soybean pulp flour soft cookies, tests were carried out on protein content (SNI method 01-2891-1992), crude fiber test (SNI 01-2891-1992 extraction method), moisture content test (SNI 01-2891-1992 gravimetry method), fat content test (SNI 01-2354.3-2006), and organoleptic test preferences of 25 trained panelists using preference tests which include color, taste, aroma, texture

Data Analysis

The data were analyzed using variance analysis (ANOVA), and if significant differences were found between the treatments, it was followed by the Duncan test (DMRT) at a significance level of 5%. Organoleptic analysis was conducted based on the preferences of 25 trained panelists to evaluate whether the treatment had a significant effect. The analysis was tested using the Kruskal-Wallis test.

ISSN 2622-1985 (print) | ISSN 2622-4127 (online)
DOI: http://dx.doi.org/10.25139/fst.vi.9192

RESULT AND DISCUSSIONS

Protein Content

The results of this research's analysis of variance show that flour ratio and GMS content have an interrelated and significant influence on the protein content in soft cookies. The results of the Duncan test are shown in Table 1.

Table 1. The results of the Duncan test for the interaction between flour proportion and GMS concentration factors on protein content (dry basis)

Flour Concentration (A) (Flour: Soybean dregs flour)	**GMS concentration**	
	B1 (2%)	**B1 (3%)**
A1 (50% : 50%)	8.54%±0.185[a]	8.20%±0.085[c]
A2 (40% : 60%)	8.94%±0.025[b]	6.65%±0.18[a]
A3 (30% : 70%)	9.36%±0.07[c]	7.48%±0.19[b]

Note: The letters following the numbers with identical notations in each column signify no significant differences based on the Duncan test at α = 5%. Lowercase letters denote horizontal comparisons, while uppercase letters indicate vertical comparisons.

The highest value of protein content was 9.36% with 70% soybean milk pulp substitution treatment and 2% GMS addition. The lowest value of protein content was 6.65% with 60% soy milk pulp substitution treatment and 3% GMS addition.

Based on the results of the study, there is a tendency for the protein content to increase as the proportion of soy milk pulp flour increases. This is because soy milk pulp flour has a higher protein content compared to wheat flour, and the protein content decreases as the concentration of GMS increases. Based on the Ministry of Health, Indonesian Food Composition Data (2017) shows that soybean pulp still has a protein content of 20% while wheat flour has a medium protein content of only 11%. The protein content is not affected by the addition of GMS. Mudjisihono et al (1993) stated that GMS mostly contains stearic acid instead of protein so that the addition of glycerol monostearate does not result in a change in the amount protein in the resulting product.

The increase in protein content with higher soybean milk pulp substitution highlights the potential of this ingredient as a functional alternative in flour-based products. Soybean milk pulp, a byproduct of soy milk production, not only boosts protein levels but also contributes to enhanced nutritional profiles and sustainability by reducing food waste. Its incorporation into various food formulations can address consumer demands for healthier, protein-rich options without significantly altering product texture or flavor when balanced with other ingredients.

Furthermore, the study emphasizes the importance of understanding ingredient interactions in product development. While glycerol monostearate (GMS) enhances the structural integrity and shelf stability of products, its non-protein nature underscores the need for careful formulation to achieve the desired nutritional and functional balance. This insight supports ongoing efforts to develop innovative food products that meet both health standards and consumer preferences, especially in regions where protein intake remains a nutritional challenge.

Fiber Content

The analysis of variance in this study revealed an interaction between the proportion of soybean dregs flour and the significant combination of GMS concentration, which affected the fiber content of the soft cookies. The results of the Duncan test are shown in Table 2.

ISSN 2622-1985 (print) | ISSN 2622-4127 (online)
DOI: http://dx.doi.org/10.25139/fst.vi.9192

Table 2. The Duncan test results for the effects of flour proportion and GMS concentration factors on fiber content (dry basis).

Flour Concentration (A) (Flour: Soybean dregs flour)	GMS concentration	
	B1 (2%)	**B1 (3%)**
A1 (50% : 50%)	9.44%±0.035[a]	9.35%±0.005[a]
A2 (40% : 60%)	10.93%±0.03[c]	10.17%±0.03[c]
A3 (30% : 70%)	10.05%±0.03[b]	10.02%±0.03[b]

Note: The letters following the numbers with identical notations in each column signify no significant differences based on the Duncan test at α = 5%. Lowercase letters denote horizontal comparisons, while uppercase letters indicate vertical comparisons.

The highest value of protein content of 10.93% was found in the substitution treatment of 60% soy milk pulp flour and the addition of 2% GMS. The lowest value of moisture content of 9.35% was found in the treatment of 50% soybean milk meal substitution and the addition of 3% GMS.

The study results show that increasing the amount of flour leads to higher fiber content. This is because soy milk pulp flour has a higher fiber content than wheat flour. Based on the Ministry of Health, Indonesian Food Composition Data (2017) shows that soybean pulp has a fiber content of 5% while wheat flour is only 0.3%. The fiber content is not affected by the addition of glycerol monostearate. Mudjisihono, e al.(1993) stated that GMS contains mostly stearic acid instead of fiber so the addition of GMS does not result in a change in the amount of fiber in the resulting product. Glycerol monostearate does not contain fiber because glycerol monostearate is not included in carbohydrate compounds.

Crude fiber differs from dietary fiber. Fiber is a substance that cannot be broken down by acids or alkalis. The fiber content in food can serve as an indicator of its dietary fiber content, as fiber contains 0.2 - 0.5 parts of dietary fiber (Korompot et al., 2019). Fiber is made up of cellulose, pentose, lignin, and other components (Rindengan, 2015).

The significant increase in fiber content from soybean milk pulp flour highlights its potential as a functional food ingredient. Dietary fiber not only supports digestive health but also plays a role in controlling blood sugar and cholesterol levels. Substituting wheat flour with soybean milk pulp flour can be an innovative solution to enhance the nutritional value of food products, especially in the bakery industry. This aligns with global trends encouraging the use of high-fiber ingredients to support healthier eating habits.

Moreover, this study underscores the importance of selecting appropriate food additives in product development. While glycerol monostearate (GMS) can improve the texture and stability of products, its lack of fiber content emphasizes the need for careful formulation to preserve the desired nutritional profile. These findings provide a foundation for further research aimed at optimizing functional ingredient combinations to meet consumer demands for healthy and high-quality products.

Fat Content

The analysis of variance in this study showed that the ratio of soybean pulp flour and the GMS concentration interact with each other, significantly influencing the fat content of soft cookies. Table 3 shows Duncan's test results.

FOODSCITECH, 7 No. 2 December 2024
ISSN 2622-1985 (print) | ISSN 2622-4127 (online)
DOI: http://dx.doi.org/10.25139/fst.vi.9192

Table 3. The Duncan test results for the influence of flour proportion and GMS concentration factors on fat content (dry basis).

Flour Concentration (A) (Flour: Soybean dregs flour)	GMS concentration	
	B1 (2%)	**B1 (3%)**
A1 (50% : 50%)	19.35%±0.36^{c}	17.76%±0.025^{b}
A2 (40% : 60%)	15.46%±0.07^{a}	17.67%±0.09^{b}
A3 (30% : 70%)	17.33%±0.045^{b}	17.20%±0.08^{a}

Note: The letters following the numbers with identical notations in each column signify no significant differences based on the Duncan test at α = 5%. Lowercase letters denote horizontal comparisons, while uppercase letters indicate vertical comparisons.

The highest value of fat content of 19.35% was found in the treatment of 50% soy milk pulp flour substitution and the addition of 2% GMS. The lowest value of fat content of 15.46% was found in the substitution treatment of 60% soy milk pulp flour and the addition of 2% GMS.

Based on the results of the study, it was shown that there was no difference in the fat content between the varying proportions of soy milk pulp flour and the addition of GMS, because the source of fat in soft cookies came from the composition of margarine. Since the proportion of soybean meal flour and the addition of GMS have no effect, the fat content of soft cookies comes from other ingredients, specifically margarine. Margarine is a food product in emulsion (w/o) form, which can be semi-solid or solid. Margarine is made from fats and/or vegetable oils, with or without chemical modifications such as hydrogenation and interesterification, and has gone through a refining process (SNI, 2002).

The consistent fat content observed across treatments emphasizes the role of margarine as the primary contributor to fat in soft cookies. Margarine contains a blend of saturated and unsaturated fats, which not only provide a rich texture and flavor but also play a crucial role in the structural integrity of baked goods. This aligns with previous findings that fat content in cookies remains relatively stable when other minor ingredients are adjusted, as long as the fat content in the base formulation is unchanged.

Furthermore, the use of margarine in the production of soft cookies highlights its functional benefits, such as enhancing the mouthfeel, extending shelf life, and improving overall sensory properties. The findings of this study suggest that while soy milk pulp flour and GMS contribute to other nutritional aspects of the product, they do not influence the fat content significantly. This insight can guide future formulations by allowing manufacturers to focus on balancing other nutritional components, such as protein and fiber, without compromising fat-related characteristics.

Moisture Content

The analysis of variance in this study revealed that there was no interaction between the proportion of soybean meal flour and the concentrations of GMS added concerning the moisture content of the soft cookies. Table 4 presents the results of the Duncan test.

Table 4. The Duncan test results on the effect of the flour proportion factor on moisture content (dry basis).

Flour Concentration (A) (Flour: Soybean dregs flour)	Average
A1 (50% : 50%)	11.0%±0.178^{a}
A2 (40% : 60%)	12.0%±0.126^{b}
A3 (30% : 70%)	14.2%±0.282^{b}

Note: The letters following the numbers with identical notations in each column indicate no significant differences in the Duncan test at α = 5%.

Table 5. The Duncan test results on the effect of the GMS concentration factor on moisture content.

GMS (B)	Average
B1	12.0%±0.215^{a}
B2	12.8%±0.25^{b}

Note: Letters following the numbers with the same notation in each column signify no significant difference according to the Duncan test at α = 5%.

The results showed that there was no interaction between the components tested. However, the proportion of soybean meal flour and the addition of GMS have a significant influence on the fiber content in soft cookies. The increase in fiber content was caused by the increasing amount of soybean meal added. Likewise, the addition of GMS also contributed to increasing the total fiber content in soft cookies. Soybean pulp functions as an alternative source of fiber (Adhimah et al., 2017).

The highest value of moisture content affected by the proportion of soybean pulp flour was 14.2% (A1), while the lowest value of moisture content was influenced by the proportion of soybean pulp flour was 11.0% (A3), while the effect of GMS concentration was 12.0% (B2).

Based on the results of the study, there is no interaction between the proportion of soy milk meal meal and GMS on moisture content, but it should also be noted that GMS has the ability to absorb water with its hydrophilic group (Latifah et al., 2017).

Organoleptic Characteristics of Wet Noodles

Color

The results of the Kruskal-Wallis test showed that the proportion of wheat flour and soybean meal, as well as the added concentration of GMS, had no effect on the color of the soft cookies. Table 6 displays the median hedonic color scale for soft cookies made with soybean meal flour.

Table 6. Median value of the color of soybean pulp soft cookies.

Treatment	Hedonic Scale
A1B1 (50%:50%:2%)	4±0.77^{a}
A1B2 (50%:50%:3%)	4±0.67^{b}
A2B1 (40%:60%:2%)	4±0.70^{b}
A2B2 (40%:60%:3%)	4±0.66^{a}
A3B1 (30%:70%:2%)	4±0.67^{a}
A3B2 (30%:70%:3%)	4±0.81^{a}

Note: The letters following the numbers with identical notations in each column indicate no significant difference based on the Duncan test at α = 5%.

The results of the color preference test for soy milk meal soft cookies (appendix 12) showed that the substitution of soy milk meal flour 60% (A2) and the addition of GMS 3% (B2) gave the highest color preference value of 155.43. Middle value (median) color soft cookies soybean pulp flour

The color of soft cookies is affected by the addition of sugar and chocolate composition and is not affected by the proportion of soybean meal flour and GMS. Soybean Meal Flour (TAK) is yellowish white with a neutral and smooth taste (Ahmed et al., 2018), and GMS is a powdered product and is white. So that soybean meal and GMS do not affect the color of soft cookies.

ISSN 2622-1985 (print) | ISSN 2622-4127 (online)
DOI: http://dx.doi.org/10.25139/fst.vi.9192

Taste

The Kruskal-Wallis test results indicated that the proportion of wheat flour to soybean meal had no significant effect, as well as the added concentration of GMS, had no effect on the taste of the soft cookies. Table 7 presents the median hedonic scale for the color of soybean meal flour soft cookies.

Table 7. Median value of the taste of soybean pulp soft cookies.

Ttreatment	Hedonic Scale
A1B1 (50%:50%:2%)	4±0.85^{b}
A1B2 (50%:50%:3%)	4±0.97^{b}
A2B1 (40%:60%:2%)	4±0.91^{b}
A2B2 (40%:60%:3%)	4±0.88^{a}
A3B1 (30%:70%:2%)	4±0.98^{a}
A3B2 (30%:70%:3%)	4±0.84^{a}

Note: The letters following the numbers with identical notations in each column indicate no significant difference based on the Duncan test at α = 5%.

The table above shows that the treatment proportion of soybean meal flour has the same median value in each treatment, which is 4 which means that the taste of these soft cookies is rated as liked by the panelists. The taste of soy milk pulp in the resulting soft cookies is not prominent, Soybean Meal Flour (TAK) has a neutral and smooth taste (Ahmed et al., 2018), while GMS does not affect the taste of soft cookies. Furthermore, sugar and chocolate, as primary ingredients in soft cookies, exert a significant influence on the flavor of the produced cookies, consistent with Sitepu's report (2019)

Aroma

The Kruskal-Wallis test results showed that the ratio of wheat flour and soybean meal, as well as the addition of GMS concentration, did not affect the aroma of the soft cookies. Table 8 displays the middle value of the aroma assessment scale for soft cookies using soybean meal flour.

Table 8. Median value of the aroma of soybean dregs wet noodles

Treatment	Hedonic Scale
A1B1 (50%:50%:2%)	4±0.76^{b}
A1B2 (50%:50%:3%)	4±0.73^{b}
A2B1 (40%:60%:2%)	4±0.70^{b}
A2B2 (40%:60%:3%)	4±0.71^{a}
A3B1 (30%:70%:2%)	4±0.71^{a}
A3B2 (30%:70%:3%)	4±0.84^{a}

Note The letters following the numbers with identical notations in each column indicate no significant difference based on the Duncan test at α = 5%.

The table 8 shows that treatments of the proportion of soybean meal flour has the same middle (median) value in each treatment, which is 4 which means that the taste of these soft cookies is rated as liked by the panelists. The aroma of soft cookies is obtained from the raw materials used in making soft cookies such as butter which is added which causes a fragrant smell. The addition of GMS has no impact on the aroma of soft cookies.

ISSN 2622-1985 (print) | ISSN 2622-4127 (online)
DOI: http://dx.doi.org/10.25139/fst.vi.9192

Texture

The results of the Kruskal Wallis test showed that the ratio of wheat flour and soybean meal, as well as the addition of GMS concentration, had no effect on the texture of the soft cookies. Table 9 displays the middle value of the color assessment scale for soft cookies using soybean meal flour.

Table 9. Median value of the texture of soybean dregs wet noodles.

Ttreatment	Hedonic Scale
A1B1 (50%:50%:2%)	4±0.76^{b}
A1B2 (50%:50%:3%)	4±0.83^{b}
A2B1 (40%:60%:2%)	4±0.78^{b}
A2B2 (40%:60%:3%)	4±0.78^{a}
A3B1 (30%:70%:2%)	4±0.81^{a}
A3B2 (30%:70%:3%)	4±0.83^{a}

Note: The letters following the numbers with identical notations in each column indicate no significant difference based on the Duncan test at α = 5%

The table 9 shows that treatments of the proportion of soybean meal flour has the same middle (median) value in each treatment, which is 4 which means that the texture of these soft cookies is considered liked by the panelists. The texture of soft cookies is influenced by the ingredients used, especially the high fiber content in soy milk pulp flour. The addition of GMS, an artificial emulsifier made up of stearic acid radicals as non-polar groups and two hydroxyl groups of glycerol as polar groups, can improve the texture of the soft cookies. Two hydroxyl groups of glycerol as polar groups, then one hydroxyl group (-OH) at the end of the glycerol monostearate chain reacts with the amylose molecules in a helical manner. As a result of this reaction, a bond is formed between amylose molecules so that it is able to combine and flatten the ingredients in the cookie dough. This can make the cookie making process easier and produce a more even texture. (Basuki, et al. 2013).

CONCLUSION

The findings of the study on the substitution of soy milk pulp flour and the addition of GMS to soft cookies can be summarized as follows. The interaction between soy milk pulp substitution and GMS addition significantly affected the water and fat content, while having a very significant impact on protein and fiber content. The results indicated that the optimal treatment, based on all parameters, was the substitution of 60% soy milk pulp flour and the addition of 2% GMS. This combination yielded the best values for the following parameters: moisture content = 12.0%, protein content = 8.94%, fiber content = 10.93%, fat content = 15.46%, color = 4 (like), taste = 4 (like), aroma = 4 (like), and texture = 4 (like).

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ISSN 2622-1985 (print) | ISSN 2622-4127 (online)
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