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The Effect of Soybean Extract Substitution on Physical and Sensory Quality Pukis Cake

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Abstract
This study aims to analyze the effect of substituting instant coconut milk with soy milk on the physical quality and sensory quality of pukis cakes in order to determine the optimum formula for producing a product with good quality. The research method used was an experiment with three levels of soy milk substitution, namely 80%, 90%, and 100%. Physical tests were conducted by measuring height for expansion power and measuring hardness levels with a texture profile analyzer. Meanwhile, sensory quality was tested through organoleptic tests by 45 semi-trained panelists from Culinary Education students. Physical quality data were analyzed using the One Way ANOVA test and followed by Duncan's Multiple Range Test (DMRT), while sensory quality data were analyzed using the Kruskal-Wallis test and followed by Tukey's test. The results of statistical analysis showed that soybean milk substitution had a significant effect on the expansion, hardness level, and sensory characteristics of soybean flavor in pukis cakes. An increase in the percentage of soybean milk and a decrease in the use of coconut milk tended to produce pukis cakes with higher expansion, lower hardness values, and stronger soybean flavor. The formula with 80% soybean milk substitution is recommended as the optimal formulation because it produces the best balance between the physical quality and sensory quality of pukis cakes.

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1. INTRODUCTION

Pukis cake is a popular Indonesian traditional cake consumed as a daily snack, breakfast alternative, or served at traditional events (Hakim, 2023). Its popularity continues to increase with the advent of various innovations, such as the addition of various flavors and toppings, modifications to raw materials, and marketing strategies. Although well-known to the public, innovations related to the use of liquid raw materials in pukis cake are still limited. In general, pukis cake uses coconut milk as the main liquid ingredient which plays a role in providing a savory taste, distinctive aroma, soft texture, and nutritional contribution (Faizah et al., 2020). According to TKPI (2017), coconut milk contains 122 kcal of energy, 2 g of protein, 10 g of fat, 7.5 g of carbohydrates, 1.4 g of fiber, and minerals such as calcium, phosphorus, and iron. However, most Indonesians use instant coconut milk as an alternative to natural coconut milk in making various coconut milk-based products, including pukis cake. This is supported by the increase in instant coconut milk consumption in Indonesia, which reached 57.1% from August to September 2023 (Indonesia-Data, 2023). Instant coconut milk tends to be high in fat and energy, but low in protein. According to Ariningsih et al. (2020), every 100 grams of instant coconut milk contains 208.8 kcal of energy, 23.2 g of fat, and 0 g of protein. These values indicate that the use of instant coconut milk does not contribute to increasing the protein content of pukis cakes, which are already relatively low in energy, dense in energy, and high in fat.

Protein is an essential macronutrient that acts as a building block and regulator in the body. Protein deficiency can affect the strength of bones, nails, and hair, as well as cognitive abilities, immunity, and growth and development in children (Khairina et al., 2025). The growing trend of healthy lifestyles and public awareness of functional food consumption have led to changes in food

needs and interests, including snack choices (Avila et al., 2023). In this regard, innovation in pukis cakes is needed to maintain their popularity and meet today's consumer preferences. One form of innovation is through substitution with alternative liquid ingredients that have similar characteristics and higher protein content, such as soy extract.

Soybeans are one of the main sources of protein in Indonesia with a protein content of 36–46% and a relatively complete essential amino acid profile except methionine (Khairina et al., 2025).Apart from being easy to obtain at an affordable price, soybeans also have high nutritional value so they have the potential to be developed into various food products.(Suryandari, 2021).The use of soybeans has so far been dominated by the form of tempeh and tofu., so that processing it into soybean extract can support product diversification(Susenas, 2023; in Suciati et al., 2023). Soybean extract is a yellowish-white liquid obtained through a soybean seed extraction process that includes soaking, boiling, grinding, filtering, and heating (Mudjajanto & Kusuma, 2005). Processing it into soybean extract offers advantages over dried soybeans in increasing protein digestibility and minimizing harmful compounds *off-flavor* causes of unpleasant odors that can reduce consumer acceptance, as well as eliminating anti-nutritional compounds (antitrypsin, hemagglutinin, phytic acid, and oligosaccharides) that can inhibit the absorption of nutrients in the body (Winarsih, 2019). In addition, processing it into soy milk is also more flexible to be developed in the diversification of food products because it can be used as a substitute for raw materials in various liquid-based products. Soy milk contains 41 kcal of energy, 3.5 g of protein, 2.5 g of fat, 5 g of carbohydrates, 0.2 g of fiber, 50 mg of calcium, 45 mg of phosphorus, 0.7 mg of iron, 287.9 mg of potassium, 0.08 mg of thiamin, 0.7 mg of niacin, and 2 mg of vitamin C (TKPI, 2017). Soy milk has advantages in the form of high protein content, low fat, cholesterol free, and contains isoflavones which act as antioxidants and phytoestrogens. According to research by Faizah et al. (2020), substituting 30% coconut milk with soybean extract is effective in increasing the protein content in baked cakes.

However, adding protein-rich ingredients in certain amounts to food composition can affect product characteristics. Adding high proportions of protein can result in a hard product texture. The carboxyl group in protein causes high water absorption (hydrophilic), so that during heating the water content in the dough will be more difficult to evaporate, resulting in a harder texture in the food. In addition, high protein content can also result in lower porosity or denser cavities. This indicates that the addition of protein can affect the rise power of the resulting product (Khairina et al., 2025). The replacement of liquids with different sensory characteristics (color, taste, aroma, and texture) also affects the resulting sensory quality. According to Erfanian & Rasti (2019), the best percentage of soy milk substitution based on sensory quality recommended as an alternative to milk in cake making is 50%.

Based on the background description above, this study was conducted to analyze the effect of soy milk substitution on the physical and sensory quality of pukis cakes. This study can be a form of innovation from previous research by creating an innovative pukis cake based on functional foods that are attractive and more nutritious. Furthermore, this study is also expected to determine the optimal proportion of soy milk used to produce sensory quality that is close to or even better than coconut milk-based pukis cakes.

2. MATERIALS AND METHODS

2.1. Materials and tools

The raw materials used to make soy milk substitute pukis cakes include wheat flour, granulated sugar, eggs, instant coconut milk, water, soy milk, margarine, instant yeast, salt, and vanilla powder. The soy milk used is produced by researchers from local yellow soybeans of the Grobogan variety obtained from *Attempt Healthy Food*. The tools used in this research include scales, *mixer, mixing bowl, spatula, measuring glass,* 100 mesh sieve, *food processor,*

sauce pan, pukis mold, digital caliper for expansion power analysis, and *Texture Profile Analyzer*(TPA) for testing the level of hardness (*hardness).*

2.2. Research methods

This study used an experimental method aimed at analyzing the effect of soy milk substitution on the physical and sensory quality of pukis cakes, as well as finding the optimal formulation to produce good quality pukis cakes. The experiment was conducted at three levels of soy milk substitution percentage treatment, namely 80%, 90% and 100%. Observation parameters included physical quality tests (expandability and hardness level) and sensory quality (inner color, outer color, sweetness, soybean flavor, soybean aroma, softness in the mouth, and inner fiber texture).

2.2.1. Making Soybean Juice

Soybean juice was made based on the method of Adawiyah et al. (2024) with modifications in the soaking, boiling, and heating stages. The process began with weighing 100 g of good quality soybeans, then soaking them in a 0.25% $NaHCO_3$ solution (1:3 ratio) for 8 hours, and rinsing them with running water. Next, the soybeans were boiled at 85 °C for 15 minutes, peeled, and then ground with the addition of water (1:6 ratio). The extraction results were filtered using two layers of 100 mesh sieves and reheated at 82 °C for 24 minutes to produce soybean juice.

2.2.2. Making Pukis Cake Using Soybean Extract Substitution

The process of making soy milk substitute pukis cake in this study refers to the Hakim (2023) method with several modifications, namely in the stages of mixing ingredients, weighing the dough, and baking. The manufacturing stage begins with weighing the ingredients according to the formula in the table. Next, eggs and granulated sugar are beaten using a hand mixer at speed 4 of 5 until the dough is white and has traces. The dough is then mixed with dry ingredients (wheat flour, instant yeast, salt, and vanilla powder) as well as sweetened condensed milk, coconut milk, and soy milk with varying ratios of coconut milk and soy milk (80:20, 90:10, and 100:0). After that, melted margarine is added until homogeneously mixed. The dough that has been formed is fermented for 60 minutes, then weighed as much as 45 g/pcs and baked using a pukis mold at a temperature of 210 °C for 5 minutes. The formulation of the ingredients in this study can be seen in table 2.1 below:

Table 2.1. Research Formula for Pukis Cake with Soybean Extract Substitution

Material Name	80%		90%		100%	
	Gram	%	Gram	%	Gram	%
Thick Coconut Milk	30	20	15	10	0	0
Soybean Extract	120	80	135	90	150	100
Total Fluid	**150***	**100***	**150***	**100***	**150***	**100***
Flour	100	66,7	100	66,7	100	66,7
Egg	80	53,3	80	53,3	80	53,3
Granulated Sugar	60	40	60	40	60	40
Margarine	50	33,3	50	33,3	50	33,3
Sweetened Condensed Milk	15	10	15	10	15	10
Instant Yeast	2	1,3	2	1,3	2	1,3
Vanilla Powder	1	0,67	1	0,67	1	0,67

Description: Calculation using the method of *Bakers Percentage*

2.3. Data Collection Techniques

2.3.1. Physical Quality Test of Development Aspect

The expansion analysis used Hakim's (2023) method, which involves measuring the dough height using a digital caliper. Each sample was measured three times before and after

baking. The results were then calculated using the following formula to determine the percentage increase in dough expansion.

Flowering power $=\frac{B-A}{A}\ x\ 100\%$

Information:
A: The height of the soy substitute pukis cake dough before baking
B: Height of the soy substitute pukis cake dough after baking

2.3.2. Physical Quality Test Aspect of Hardness Level

The analysis of the level of violence refers to the method proposed by Handayani*et al.*(2022). Testing was carried out using *Texture Profile Analyzer* (TPA) on a cube-shaped pukis cake sample measuring 25 × 25 × 25 mm. The hardness value (*hardness*) obtained from *peak load* produced during the pressing process. The test was carried out in three replicates using *flat cylindrical probe*35 mm in diameter, 10 mm/s pressing speed, and 70 mm pressing distance.

2.3.3. Sensory Quality Test

Sensory quality testing was conducted through organoleptic assessment of 45 semi-trained panelists (n = 45), namely students of the Culinary Arts Education Study Program, Jakarta State University who had taken the Organoleptic course. The testing procedure was carried out by giving 1 product sample to 15 different panelists, then the panelists were asked to provide responses to the organoleptic test instrument consisting of 5 organoleptic categories on various assessment aspects including inner color, outer color, sweetness, soybean flavor, soybean aroma, softness texture and fibrous texture.

2.4. Data analysis

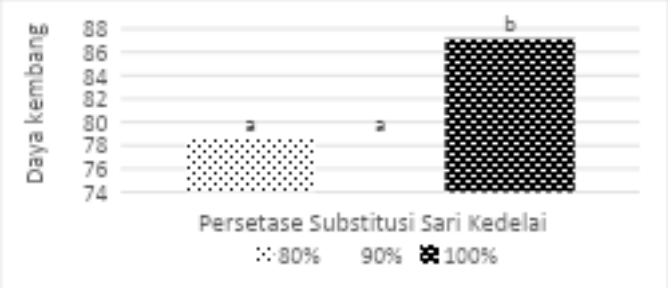
Analysis of physical quality data was carried out using *One Way ANOVA* (*Analysis of Variance*) and continued with testing of *Duncan's Multiple Range Test* (DMRT) at a 95% confidence level (α = 0.05) if it shows a significant difference. The sensory quality data were analyzed using the Kruskal-Wallis test with a significance level of 0.05 and continued with the *Tuckey's* at a 95% confidence level (α=0.05) if it shows a significant difference.

3. RESULTS

3.1. Physical Quality

3.1.1. Development Power

The results of the analysis of the expansion power of pukis cake using soy extract as a substitute can be seen in Figure 3.1 below:

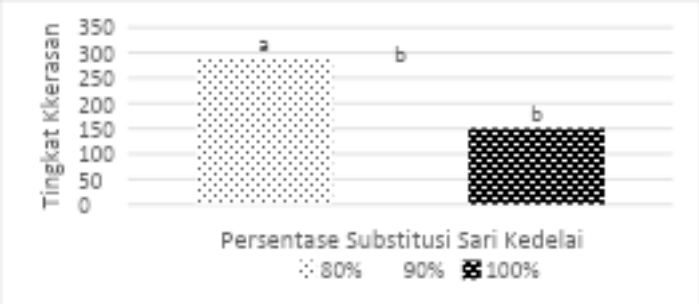


Note: Differences in letter notation indicate significant differences (p<0,05)
Figure 3.1. Diagram of the Results of the Swelling Power Test

Based on the results of the statistical analysis, there was a significant interaction between the percentage of soy milk substitution ($p<0.05$) on the expansion power of pukis cakes. Duncan's further test showed that the 80% and 90% soybean substitution treatments were significantly different compared to the 100% treatment, but there was no significant difference between the 80% and 90% treatments. Pukis cake with 80% soybean substitution had the lowest average rise rate of 78.64%, while 100% substitution produced the highest rise rate of 87.15%. This indicates that an increase in the percentage of soybean substitution is directly proportional to the increase in the rise rate of pukis cake. According to Handayani et al. (2022), soybeans contain lecithin which functions as an emulsifier, capable of maintaining foam stability in the dough by reducing the interphase tension between fat and water, thus producing a sponge cake with a greater volume and height. In addition, the increase in rise rate can also be caused by the presence of glycine and β-glycinin in soybean juice, which play a role in increasing dough volume through higher CO_2 production and the formation of a stable protein membrane (Nozawa et al., 2014).

3.1.2. Level of Violence *(Hardness)*

The data from the analysis of the level of hardness can be seen in the bar chart below:



Note: Differences in letter notation indicate significant differences ($p<0,05$)

Figure 3.2. Diagram of Hardness Level Test Results

In Figure 3.2, it is known that there is a tendency for the hardness value to decrease as the percentage of substitution increases, as shown by the lowest average hardness was found in the 100% soybean extract treatment and the highest value was found in the 80% substitution. The results of the ANOVA test showed that the percentage of substitution had a significant effect ($p<0.05$) on reducing the hardness of pukis cakes. Further DMRT testing indicated that the 80% treatment had the most significant effect with the highest hardness value compared to other treatments. The decrease in pukis cake hardness was influenced by the reduced use of instant coconut milk containing stabilizers, which are food additives that function to maintain emulsion stability by increasing viscosity. Stabilizers are hydrophilic hydrocolloids with high water absorption, so they can increase dough viscosity and inhibit water evaporation during heating (Estiasih et al., 2015). This condition caused the pukis cake hardness value to decrease as the instant coconut milk ratio decreased and the soybean extract content increased. These results are in line with research by Faizah et al. (2020) found that stabilizers in commercial coconut milk can increase product hardness, as evidenced by the lower hardness value of baked kuih products substituted with natural soybean extract (1315.41 gf) compared to those using commercial coconut milk (1396.30 gf).

3.2. Sensory Quality

A summary of the results of the statistical analysis of sensory quality using organoleptic assessment can be seen in the following table:

Table 3.2 Results of Organoleptic Testing of Pukis Cake with Soybean Extract Substitution

Organoleptic Assessment Category	Soybean Extract Substitution Treatment		
	80%	90%	100%
Inner Color	4,47[a]	4,27[a]	3,93[a]
Exterior Color	4,33[a]	4,67[a]	4,13[a]
Sweet Taste	4,067[a]	4,067[a]	4,067[a]
Soybean Flavor	3,87[a]	3,6[b]	3,0[c]
Soybean Aroma	3,733[a]	3,733[a]	3,467[a]
Softness in the Mouth Texture	4[a]	4[a]	4,2[a]
Inner Fiber Texture	4[a]	3,933[a]	4,133[a]

Note: Differences in letter notation indicate significant differences ($p<0,05$)

3.2.1. Inner Color

Based on the hypothesis analysis using the test of *Kruskall Wallis* shows that there is no significant effect ($p> 0,05$) on the inner color of pukis cakes. Table 3.2 shows that the highest average value in the organoleptic test results for the inner color was found in the 80% treatment, namely 4.47 with indicator criteria between light yellow and yellowish cream, while the lowest average value was found in the 100% treatment, namely 4.13 with indicator criteria approaching light yellow. Soybean extract has a characteristic yellowish-white color caused by the riboflavin (vitamin B2) content, which theoretically can affect the color of food products when used in high proportions (M. N. Handayani & Wulandari, 2016). However, in the results of the hypothesis analysis, this effect did not appear significant because the inner color was more influenced by other ingredients such as eggs and margarine. Strengthened by Kimara and Holinesti (2022), the quality of crumb color in *cake closely* related to the characteristics of the ingredients used. According to Mawarni (2024), the use of eggs can affect the brightness, redness, and yellowness values of the product of Margarine *cake* contains provitamin A (beta-carotene), **which** contributes to the yellow color of processed foods (Syafii, 2023). The dominant use of these two ingredients resulted in a uniform interior color for pukis cakes across all treatments. This finding aligns with research by Rahma and Syarif (2022), which found that increasing the percentage of soybean extract as an alternative to coconut milk had no significant effect on the yellow color of kue lumpur.

3.2.2. Exterior Color

The results of the hypothesis test determined that soy milk substitution did not have a significant effect ($p> 0,05$) on the change in the outer color of pukis cakes. Referring to the average results of the organoleptic test of the outer color in Table 3.2, it shows that the 80% and 90% treatments fall into the category between golden brown and light brown, while the 100% treatment falls into the golden-brown category. The brownish color of similar baked products of *cake* including pukis cakes are influenced by the non-enzymatic browning process, namely the reaction of *maillard* (J. Lee. ; in Sachriani & Mariani, 2024). Maillard reaction is an interaction between reducing sugars and amino groups (amino acids) that occurs during the heating process at high temperatures, resulting in the production of melanoidin pigments that cause brownish color in food ingredients (Syafii, 2023). The rate of this reaction can be influenced by several factors, such as the type of sugar and amino group that react, temperature, and water activity (Aw). According to Kusnandar (2011), the amino acid lysine is a type of amino acid that is more susceptible to the Maillard reaction compared to other amino acids because it has two functional amino groups. However, the lysine content in soybean extract is relatively low, namely 0.179 g/100 g (Suryandari, 2021). The low level of

lysine causes its contribution to the Maillard reaction to be greater. Maillard in the pukis cake dough is limited, so that differences in substitution levels do not cause significant differences in browning color. In addition, each treatment uses the same baking temperature (210 °C), so that the reaction intensity *maillard.* The results tended to be similar. These results align with research by Faizah et al. (2020), which found that the use of coconut milk and soybean extract in making Baked Cookies did not produce significant differences in browning color analysis.

3.2.3. Sweet Taste

In terms of sweetness, the organoleptic test results showed that the three soy extract substitution treatments had a uniform average value of 4, which is included in the sweet category. The results of the hypothesis test using the *Kruskal-Wallis* shows that the percentage of soy extract substitution in pukis cake has no effect ($p > 0,05$)on the resulting sweetness. This finding is in line with research by Ramadhan and Holinesti (2022), which stated that increasing the percentage of soy extract substitution did not affect the sweetness level of *chiffon cake.* According to (Hakim, 2023), the sweetness detected in pukis cakes is derived from the sweeteners used, such as granulated sugar. Sugar serves as the main source of sweetness in cake products (Ridhani et al., 2021). In addition, the soybean extract used in the study did not contain any additional sweeteners, as indicated by preliminary measurements of the total soluble solids value of the soybean extract before being added to the sample, which was 4° Brix, reflecting a characteristic taste that tends to be bland. Therefore, increasing the percentage of soybean extract substitution did not significantly affect the sweetness intensity of pukis cakes.

3.2.4. Soybean Flavor

Hypothesis analysis states that the three soy milk substitution treatments have a significant effect ($p<0.05$) on the quality of pukis cake in terms of soy flavor. The average value obtained from the organoleptic test results showed that the soy flavor was increasingly detected along with the increasing number of substitution percentages, as evidenced by the average value of the 80% treatment of 3.87, 90% of 3.6 and 100% of 3.0. This is in accordance with Qisthi's research (2017), where a higher substitution percentage can produce a stronger soy flavor in Malaysian layer cake products. The unpleasant taste of soybeans is influenced by the presence of enzyme activity.*lipoxygenase*on soybeans (Rosniatin et al., 2021).

3.2.5. Soybean Aroma

Table 3.2 above shows that increasing the percentage of soy extract substitution resulted in a decrease in the panelists' average organoleptic assessment of the soybean aroma aspect, resulting in an aroma intensity ranging from weak to somewhat strong. However, hypothesis testing showed no significant effect ($p > 0,05$)The substitution of soybean extract on the aroma of soybeans in the resulting pukis cake. This finding aligns with research by Rahma and Syarif (2022), which stated that substituting soybean extract as an alternative to coconut milk did not affect the fragrant aroma produced by the mud cake. This is due to the processing of soybean extract through soaking in sodium bicarbonate ($NaHCO_3$), grinding using hot water, and boiling, which contribute to inactivating compounds that cause unpleasant aromas.*(beany flavour),* such as anti-trypsin and enzyme lipoxygenase (Winarsih, 2019). Furthermore, the addition of vanilla powder to the pukis cake formulation helps reduce the distinctive aroma of soybeans. Vanilla is known as a flavor enhancer frequently used in the food industry (Puwastuti & Purtiningrum, 2015). According to Kusumastuti & Adriani (2017), the addition of vanilla to soy substitute ice cream products is effective in suppressing unpleasant aromas and increasing consumer acceptance of the product.

3.2.6. Softness in the Mouth Texture

Based on the results of organoleptic testing of the softness in the mouth texture of pukis cakes with 80%, 90%, and 100% soy extract substitution, the average value obtained was between 4.0-4.2, which indicates that the three treatments have a texture indicator criterion that tends to be uniform, namely soft. The results of the hypothesis analysis stated that soy extract substitution did not have a significant effect ($p > 0,05$)on the softness of the texture in the mouth. A similar study reported by Rahma and Syarif (2022), that the softness of the mud cake is not influenced by the proportion of coconut milk substitution with soy extract, but rather by the dominant fat content in egg yolks and margarine. The fat content in egg yolks and margarine is known to be able to maintain the softness of cake-like products (Hakimah et al., 2024). Another factor that affects the softness of the pukis cake is due to the denaturation of protein in the soy extract due to the processing process which results in the weakening of the protein network to bind free water in the dough, so that the water content can still maintain its ability to moisturize the dough and help maintain the softness of the pukis cake after going through the baking process (Khairina et al., 2025).

3.2.7. Inner Fiber Texture

Based on the hypothesis analysis, it states that there is no interaction between soy extract substitution ($p > 0,05$)on the inner fiber texture of pukis cakes. Table 3.2 shows that all three treatments had a relatively uniform fiber texture, namely fibrous. The fibrous texture is influenced by the fermentation process because it is related to the dough's ability to retain gas or expand (Riana et al., 2021). During the fermentation stage, gluten forms a thin layer that can retain gas, which is then pushed upward and forms vertical cavities (Sayekti et al.; in Hakim, 2023). However, ingredients with high protein and fiber content can inhibit the dough expansion process. Protein can interfere with starch gelatinization, while fiber can reduce the gluten network's ability to retain air, thereby reducing expansion and fiber formation in the dough (Winarno; in Azzari et al., 2024). Soybean extract contains 3.5 g of protein and 0.5 g of fiber (TKPI, 2017), while the commercial coconut milk used contains neither protein nor fiber. The lack of effect of soy milk substitution on the inner fiber texture of pukis cakes is due to the low protein and fiber content resulting from the soybean processing, such as soaking, milling, extraction, and heating, which can reduce these nutritional values. Therefore, even though the proportion of soy milk substitution is increased, there is no significant change in the formation of the inner fiber texture.

4. CONCLUSION

Based on the research results, it can be concluded that soybean substitution has an effect on both physical quality attributes, namely swelling power and hardness level, as well as sensory quality on soybean flavor attributes. The optimal formulation selected in this study was obtained at 80% soybean substitution treatment. The resulting pukis cake had a swelling power of 78.64%, a hardness level of 289.75, and an overall sensory assessment was acceptable to the panelists with a description of the inner color between light yellow and yellowish cream, the outer color between golden brown and light brown, sweet taste, taste and aroma of soybeans that were close to not strong, and a soft and fibrous texture.

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