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Formulation of Pecel Chili Sauce with the Proportion of Peanuts and Cashew Nuts, and the Use of Black Garlic

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A B S T R A C T

Pecel chilli sauce is a food made from peanuts combined with several ground spices, mixed into a paste, then served as a complementing sauce for vegetable pecel. The ingredients used affect the chemical and organoleptic properties of the pecel chili sauce. This study aims to determine the best formulation of pecel chili sauce to treat the proportion of peanuts : cashew nuts and the proportion of garlic : black garlic based on chemical and organoleptic parameters. This study uses a Completely Randomized Design (CRD) with a factorial pattern, two factors, and two repetitions. The first factor is the proportion of peanuts : cashew nuts (100%:0%, 75%:25%, 50%:50%), and the second factor is the proportion of garlic : black garlic (100%:0%, 0%:100%, 50%:50%). The data were analyzed using ANOVA and followed by the DMRT test at the 5% level. The pecel chili sauce with the proportion of peanuts : cashew nuts 75%:25% and garlic : black garlic 0%:100% was the best treatment, resulting in pecel chili sauce with a moisture content of 12.53%, protein content of 10.63%, fat content of 12.83%, and antioxidant activity of 60.97%, as well as organoleptic values of taste 3.68 (liked), smell 3.52 (liked), and color 3.72 (liked).

Contribution to Sustainable Development Goals (SDGs):
SDG 2: Zero Hunger
SDG 3: Good Health and Well-being
SDG 9: Industry, Innovation, and Infrastructure
SDG 12: Responsible Consumption and Production
SDG 15: Life on Land

1. INTRODUCTION

1.1. Research Background

Cashew nuts come from the cashew tree (Anacardium occidentale L.), which will produce 642,776 tons in Indonesia in 2023, mainly from Central Java and Sulawesi. Wonogiri Regency has 20,505 hectares of cashew orchards with a total production of 7,145 tons [1]. In addition to producing whole cashew nuts, the production process also generates crushed ones, which have a lower market value and can be enhanced through product diversification such as pecel chili sauce. Pecel chili sauce is a traditional Javanese condiment made from spices and ground nuts [2].

Crushed cashew nuts are suitable for making pecel chili sauce because they are small and easy to crush. Pecel chilli sauce with cashew nut substitution provides a sweeter, savory, and creamier taste due to the high fat content in cashew nuts, which are rich in monounsaturated and polyunsaturated fatty acids [3]. The frying process using oil in making pecel chili sauce can increase the fat content due to oil absorption. Therefore, this study uses the dry-roasting method (frying without oil) to reduce the fat content in the sauce and prevent fat oxidation.

The formula for making pecel chili sauce can be innovated by using black garlic to add functional value to the product. Black

garlic is fermented garlic at high temperature and humidity [4]. Black garlic is rich in antioxidants such as S-allyl-cysteine (SAC) and polyphenols, which help improve blood vessel health, reduce the risk of blood vessel narrowing, and provide other benefits such as antibacterial, blood pressure-lowering, and immune-boosting properties [5]. Research on the combination of black garlic and cashew nuts shows that it enhances the sweet and savory flavors in hoisin sauce due to a higher umami content compared to other ingredients [6]. Therefore, this research aims to examine the effects of the proportion of peanuts to cashew nuts and the proportion of garlic to black garlic on the chemical and organoleptic characteristics of pecel chili sauce.

1.2. Literature Review

1.2.1. Pecel Chili Sauce

Pecel chili sauce is a typical Javanese sauce made from bird's eye chili, peanuts, garlic, palm sugar, salt, kencur, kaffir lime leaves, and lime juice/tamarind. These ingredients are ground and mixed into a paste that is served as a complement to the vegetable pecel dish [7].

Pecel is a dish served with boiled vegetables like water spinach and bean sprouts, then topped with pecel chili sauce and served with side dishes, such as fried eggs and rempeyek. The sauce for pecel has a distinctive smell of kencur and kaffir lime leaves [8].

The formula and process for making pecel chili sauce starts with weighing 3 kg of peanuts and 1,5 kg of palm sugar. 300 g of garlic, 300 g of kencur, 150 g of bird's eye chili, and 150 g of red chili are fried after being cleaned. 45 kaffir lime leaves and 50 g of tamarind are sliced, and then all ingredients are ground together with salt. After that, the peanuts are fried, ground, and mixed with the spices and palm sugar until well blended. The pecel chili sauce is then weighed, packaged, and labeled [9].

1.2.2. Cashew Nuts

Cashew nuts come from the cashew apple (Anacardium occidentale), which consists of two parts: the false fruit resembling a water apple and the true fruit, which is kidney-shaped [8]. Cashew nuts are the main product of the cashew tree, having a kidney shape and varying colors from bottle green to brownish-gray (dried fruit) [10].

Consumers prefer cashew nuts over other types of nuts due to their sweet and savory taste. Cashew nuts are rich in fatty acids and micronutrients (calcium, magnesium, sodium) [11]. Cashew nuts contain 60% monounsaturated fats in the fat content found in cashew nuts [12]. Polyunsaturated fatty acids can reduce the risk of stroke and heart attacks. Monounsaturated fats can help with weight loss, and the protein content in cashew nuts can promote longer-lasting satiety [13].

1.2.3. Black Garlic

Black garlic is garlic that has been heated at specific temperatures and humidity, turning it black, soft, and slightly sour [14]. During the heating process, the antioxidant compound allicin is converted into a more stable bioactive component, S-allylcysteine (SAC). The SAC content, which is a sulfur compound, in black garlic is five to seven times higher compared to regular garlic [15]. Black garlic is rich in phenolic compounds and sulfur compounds. Due to the heating process, polyphenols increase six times compared to the polyphenol content in regular garlic, along with a significant increase in the amount of flavonoids [16].

1.3. Research Objective

This study aims to determine the effect of the proportion of peanuts : cashews and the proportion of garlic: black garlic on the chemical and organoleptic characteristics of pecel chili sauce.

2. MATERIALS AND METHODS

2.1. Materials and Tools

The ingredients used in making pecel chili sauce are peanuts, cashews, palm sugar, tamarind, kencur, kaffir lime leaves, large red chilies, bird's eye chilies, garlic, black garlic, and salt. The materials used for analysis are petroleum ether, Kjeldahl tablets, H_2SO_4, diphenyl-2-picrylhydrazyl (DPPH), and sterile aquades.

The equipment used to prepare pecel chili sauce includes a food chopper, stove, frying pan, spatula, and scale. The equipment used for analysis includes an incubator, Soxhlet apparatus, Kjeldahl flask, spectrophotometer, oven, vortex mixer, analytical balance, Erlenmeyer flask, 100 ml measuring glass, 20 ml test tubes and test tube rack, and test tube caps.

2.2. Research Design and Analysis

This study uses a Completely Randomized Design with a two-factor factorial pattern, nine treatments, and two replications, resulting in 18 samples. Factor 1 is the proportion of peanuts: cashews (100%:0%, 75%:25%, 50%:50%) and Factor 2 is the proportion of garlic: black garlic (100%:0%, 0%:100%, 50%:50%). The samples from the formulations are then subjected to chemical and organoleptic testing. The data from the tests are analyzed using Analysis of Variance (ANOVA) at a 5% significance level. If there are significant differences, further testing is performed using the DMRT test at a 5% significance level (α=0.05). The combinations of treatments studied are shown in Table 1.

Table 1. Treatment of research experiments

The use of Garlic	The proportion of Peanuts: Cashews		
	A1	A2	A3
B1	A1B1	A2B1	A3B1
B2	A1B2	A2B2	A3B2
B3	A2B3	A2B3	A3B3

2.3. Making Pecel Chili Sauce

Prepare the necessary tools and ingredients, then peel the garlic and kencur, and separate the chili peppers from their stems. Wash the garlic, kencur, kaffir lime leaves, large red chili peppers, and bird's eye chilies thoroughly. Weigh the peanuts: cashews according to the formula (100 grams), garlic: black garlic according to the formula (25 grams), palm sugar (50 grams), tamarind (5 grams), kencur (5 grams), kaffir lime leaves (2 leaves), large red chili peppers (10 grams), bird's eye chilies (10 grams), and salt (3 grams). Roast the peanuts, cashews, kencur, kaffir lime leaves, large red chili peppers, bird's eye chilies, and garlic for 15 minutes over low heat. Finally, grind all the ingredients using a food chopper until a smooth texture is achieved.

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2.4. Observation

The chemical analysis of pecel chili sauce includes moisture content, protein content, fat content, and antioxidant activity. The organoleptic analysis of pecel chili sauce is conducted by 25 panelists using the hedonic scale method. The sensory attributes analyzed in the organoleptic test include smell, taste, and color.

3. RESULT AND DISCUSSION

3.1. Chemical Analysis

3.1.1. Moisture Content

The analysis of variance results show a significant interaction ($p \leq 0.05$) between the treatments of the proportion of peanuts:cashews and the proportion of garlic:black garlic on the moisture content of pecel chili sauce. The moisture content of pecel chili sauce ranges from 10,61% to 13,06%. The treatment with a peanut:cashew ratio of (50:50) and a garlic:black garlic ratio of (0:100) produced the lowest moisture content (10.61%), while the treatment with a peanut:cashew ratio of (100:0) and a garlic:black garlic ratio of (100:0) produced the highest moisture content (13.06%).

Table 2. Average Moisture Content of Pecel Chili Sauce

Treatment	Average Moisture Content (%) ± $\overline{SD}$
A1B1	13.06g ± 0.13
A1B2	12.80f ± 0.02
A1B3	12.99fg ± 0.03
A2B1	12.53e ± 0.08
A2B2	11.95c ± 0.01
A2B3	12.26d ± 0.04
A3B1	11.98c ± 0.09
A3B2	10.61a ± 0.12
A3B3	11.55b ± 0.16

Note: The average values followed by different letters indicate significant differences ($p<0.05$).

Table 2 shows that the higher the proportion of peanuts and the lower the proportion of cashews, as well as the lower the proportion of black garlic, the higher the moisture content of the pecel chili sauce. The higher fiber content in peanuts affects the moisture content of the pecel chili sauce. Fiber can bind water that is difficult to release during the roasting process, thereby contributing to the moisture content of the final product. Fiber in food can absorb and bind water quickly in large amounts [17].

3.1.2. Protein Content

The analysis of variance shows that there is no interaction ($p \geq 0.05$) between the proportion of peanuts:cashews and the proportion of garlic:black garlic on the protein content of pecel chili sauce. The proportion of peanuts:cashews has a significant effect on the protein content, while the proportion of garlic:black garlic does not show a significant effect.

Table 3. Average protein content of pecel chili sauce with treatment of peanut:cashew proportion

Peanut : Cashew (%)	Average Protein Content (%) ± $\overline{SD}$
100:0	9.18^{a} ± 0.63
75:25	10.64^{b} ± 0.36
50:50	11.08^{c} ± 0.43

Note: The average values followed by different letters are significantly different ($p<0.05$).

Table 3 shows that as the proportion of peanuts decreases and the proportion of cashew nuts increases, the protein content of the pecel chili sauce significantly increases. This is due to the higher protein content in cashew nuts compared to peanuts. Cashew nuts contain 26 grams of protein per 100 grams, while peanuts contain only 18 grams of protein per 100 grams [13].

Table 4. The average protein content of pecel chili sauce with the treatment of garlic : black garlic ratio

Garlic : Black Garlic (%)	Average Protein Content (%) ± $\overline{SD}$
100:0	10.32^{a} ± 0.88
0:100	10.29^{a} ± 0.89
50:50	10.30^{a} ± 0.89

Note: The average values followed by different letters are significantly different ($p<0.05$).

Table 4 shows that the proportion of garlic: black garlic does not have a significant effect on the increase in the protein content of the pecel chili sauce. This is because the main component of garlic consists mostly of water, while other nutritional content, such as fats, carbohydrates, and proteins, are relatively low [18].

3.1.3. Fat Content

The analysis of variance shows that there is no interaction ($p \geq 0.05$) between the proportions of peanuts: cashews and garlic: black garlic proportions on the fat content of the pecel chili sauce. The proportion of peanuts: cashews has a significant effect on the fat content of the pecel chili sauce, while the proportion of garlic: black garlic does not significantly affect the fat content of the pecel chili sauce.

Table 5. Average Fat Content of Pecel Chili Sauce with the Proportions of Peanuts : Cashews

Peanut : Cashew (%)	Average Fat Content (%) ± $\overline{SD}$
100:0	6.29^{a} ± 0.24
75:25	12.80^{b} ± 0.14
50:50	15.67^{c} ± 0.11

Note: The average values followed by different letters are significantly different ($p<0.05$).

Table 5 shows that the lower the proportion of peanuts and the higher the proportion of cashews, the higher the fat content in the pecel chili sauce. This is due to the higher fat content in cashews compared to peanuts. Cashews contain 48,3% fat [19], while peanuts have a fat content of only 42,7% [20].

Table 6. Average fat content of pecel chili sauce with the treatment of garlic: black garlic ratio

Garlic: Black Garlic (%)	Average Fat Content (%) ± $\overline{SD}$
100:0	$11,48^{a}$ ± 4,35
0:100	$11,71^{a}$ ± 4,21

50:50	$11,56^{a} \pm 4,33$

Note: The average values followed by different letters indicate significant differences ($p<0.05$).

Table 6 shows that the proportion of garlic: black garlic did not significantly affect the increase in fat content in pecel chili sauce. This is because the nutritional content of garlic, such as fat, carbohydrates, and protein, is relatively low [18]. The fat content in garlic is only 0,1%, while black garlic contains 0,3% fat [21].

3.1.4. Antioxidant Activity

The analysis of variance shows that there is no significant interaction ($p\geq0.05$) between the proportions of peanuts: cashew nuts and garlic: black garlic on the antioxidant activity of the pecel chili sauce. The proportions of peanuts: cashew nuts did not have a significant effect on the antioxidant activity, while the proportions of garlic: black garlic significantly influenced the antioxidant activity of the pecel chili sauce.

Table 7. Average antioxidant activity values of pecel chili sauce with the treatment of peanut: cashew proportions

Peanut : Cashew (%)	Average Antioxidant Activity (%) ± $\overline{SD}$
100:0	$52.04^{a} \pm 7.53$
75:25	$54.26^{a} \pm 7.91$
50:50	$55.39^{a} \pm 7.99$

Table 7 shows that the proportion of peanuts to cashew nuts does not have a significant effect on the antioxidant activity of pecel chili sauce. This is due to the main composition of the nuts, which is dominated by fats, proteins, and carbohydrates [22], and they do not contain antioxidant compounds.

Table 8. Average antioxidant activity values of pecel chili sauce with the treatment of garlic: black garlic ratio

Garlic : Black Garlic (%)	Average Antioxidant Activity (%) ± $\overline{SD}$
100:0	$43.22^{a} \pm 0.31$
0:100	$62.64^{c} \pm 0.77$
50:50	$55.83^{b} \pm 0.36$

Table 8 shows that the lower the proportion of garlic and the higher the proportion of black garlic, the antioxidant activity of pecel chili sauce significantly increases. During the aging process of garlic into black garlic, the allicin compound is converted into other antioxidant compounds such as S-allylcysteine (SAC), tetrahydro-β-carbolines, alkaloids, and flavonoids [23]. The heating process during aging also increases the polyphenol content up to six times compared to the polyphenols in garlic, accompanied by a significant increase in flavonoid levels [16].

3.2. Organoleptic Analysis

The Friedman test on pecel chili sauce showed a significant interaction ($p\leq 0.05$) between the proportion of peanuts: cashews and the proportion of garlic: black garlic on the taste, smell, and color of the pecel chili sauce.

A 75% peanut, 25% cashew, and 100% black garlic combination had the highest average value (4,24) for the taste parameter, categorized as "liked." This is because the combination of cashews and black garlic enhances the umami flavor of the pecel chili sauce, making it more preferred by the panelists. The combination of black garlic and cashews boosts the sweet and savory taste of hoisin sauce due to its higher umami content compared to other ingredients [6].

Table 9. Average liking scores of pecel chili sauce

Treatment	Taste	Smell	Color
A1B1	3.52	3.32	3.32
A1B2	3.36	2.96	2.84
A1B3	2.92	3.08	3.08
A2B1	3.68	3.52	3.72
A2B2	4.24	3.60	3.96
A2B3	3.32	3.80	4.28
A3B1	3.48	3.76	4.08
A3B2	4.04	3.56	3.48
A3B3	3.56	3.96	3.92

Note: Scale 1 = Very Dislike; 2 = Dislike; 3 = Neutral; 4 = Like; 5 = Very Like

The treatment with a 50% proportion of peanuts and 50% cashews, along with a 50% proportion of garlic and 50% black garlic, achieved the highest average value (3.96) for the smell parameter, categorized as "liked." The 50% peanut and 50% cashew proportion was preferred by the panelists due to the sweeter and creamier smell of cashews compared to peanuts. This smell is often considered more pleasant and appetizing, giving a more positive impression to consumers [13].

The treatment with 75% peanuts, 25% cashews, and a 50% proportion of both garlic and black garlic achieved the highest average value (4,28) for the color parameter, categorized as "liked." The pecel chili sauce preferred by the panelists was generally reddish-brown in color [24]. Peanuts provide a characteristic brown color, while cashews give a lighter, creamier color. The combination of both results in a reddish-brown color that is favored by consumers.

4. CONCLUSION

The treatment with the proportion of peanuts: cashews and garlic: black garlic significantly affected the moisture content and organoleptic properties (taste, color, and smell) of pecel chili sauce, but did not significantly affect the protein content, fat content, and antioxidant activity of the sauce.

The pecel chili sauce with a 75%:25% proportion of peanuts: cashews and a 0%:100% proportion of garlic: black garlic was selected as the best formula. This formula had a moisture content of 12,53%, protein content of 10,63%, fat content of 12,83%, antioxidant activity of 60,97%, and organoleptic values of taste 3,68 (liked), smell 3,52 (liked), and color 3,72 (liked).

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