Industria: Jurnal Teknologi dan Manajemen Agroindustri
Volume 11 No 1: 31-39 (2022)

Industria: Jurnal Teknologi dan Manajemen Agroindustri
http://www.industria.ub.ac.id
ISSN 2252-7877 (Print) ISSN 2548-3582 (Online)
https://doi.org/10.21776/ub.industria.2022.011.01.4

# Sauce Product Development with Black Garlic Addition as a Flavour Enhancer and Antioxidant

## *Pengembangan Produk Saus dengan Penambahan* Black Garlic *sebagai Penambah Rasa dan Antioksidan*

Herlina[1]*, Riska Rahma Vionita[1], Sulistiyani[2], Nurhayati[1], Triana Lindriati[1]
[1]Department of Agricultural Product Technology, Faculty of Agricultural Technology, Universitas Jember
[2]Departement of Community Nutrition, Faculty of Public Health, Universitas Jember,
Jl. Kalimantan 37, Jember 68121, Indonesia
*lina.ftp@unej.ac.id
Received: 11th December, 2020; 1st Revision: 05th April, 2021; 2nd Revision: 02nd October, 2021; Accepted: 25th April, 2022

**Abstract**

This study aims to determine the variations effect of black garlic concentration on the sauce's physical, chemical, and organoleptic characteristics. The experimental design used was a Completely Randomized Design with a single factor, the ratio of black garlic concentration to sauce paste. The experiment was performed with five treatments and three replications. The ratio of black garlic concentration to the sauce paste in this experiment was 5:95 (A1), 10:90 (A2), 15:85 (A3), 20:80 (A4), and 25:75 (A5). The results showed that the black garlic concentration significantly affected the sauce's physical and chemical characteristics (Total Dissolved Solids (TDS), color intensity, viscosity, antioxidant activity, and total polyphenols). The organoleptic test showed that black garlic concentration significantly affected panelists' preference for color, taste, viscosity, and overall parameters and did not significantly affect aroma preference. The best treatment was the sauce with a 15:85 (A3) concentration ratio of black garlic to sauce paste. The best treatment sauce's physical characteristics were 34.23±0.17 °Brix TDS, 1.35±0.12 color intensity, and 0.41±0.05 Poise viscosity, while the chemical characteristics were 22.75±0.38% antioxidant activity and 1.07±0.21 mg GAE/g total polyphenols. The organoleptic test of the best treatment sauce's results was 5.97 color preference, 5.30 aroma, 5.57 taste, 5.43 viscosity, and 5.23 overall preference.
**Keywords:** antioxidant, black garlic, organoleptic, product diversification, sauce

***Abstrak***

*Penelitian ini bertujuan untuk mengetahui pengaruh variasi konsentrasi* black garlic *terhadap karakteristik fisik, kimia, dan organoleptik saus. Rancangan percobaan pada penelitian ini adalah rancangan acak lengkap dengan faktor tunggal, yaitu perbandingan konsentrasi* black garlic *terhadap bahan saus. Percobaan dilakukan dengan 5 perlakuan dan 3 kali ulangan. Perbandingan konsentrasi* black garlic *terhadap bahan saus pada percobaan ini adalah 5:95 (A1), 10:90 (A2), 15:85 (A3), 20:80 (A4), dan 25:75 (A5). Hasil penelitian menunjukkan bahwa konsentrasi* black garlic *berpengaruh nyata terhadap karakteristik fisik dan kimia saus, yaitu Total Padatan Terlarut (TPT), intensitas warna, viskositas, aktivitas antioksidan dan total polifenol. Uji organoleptik menunjukkan bahwa konsentrasi* black garlic *berpengaruh nyata terhadap kesukaan panelis pada parameter warna, rasa, viskositas, dan keseluruhan, serta berpengaruh tidak nyata terhadap kesukaan aroma. Perlakuan terbaik diperoleh pada saus dengan perbandingan konsentrasi* black garlic *terhadap bahan saus 15:85 (A3). Karakteristik fisik saus tersebut adalah TPT 34,23±0,17 °Brix, intensitas warna 1,35±0,12, dan viskositas 0,41±0,05 Poise, sedangkan karakteristik kimianya adalah aktivitas antioksidan 22,75±0,38% dan total polifenol 1,07±0,21 mg GAE/g. Hasil uji organoleptik terhadap saus dengan perlakuan terbaik adalah kesukaan warna 5,97, aroma 5,30, rasa 5,57, viskositas 5,43, dan keseluruhan 5,23.*
***Kata kunci:*** *antioksidan,* black garlic*, diversifikasi produk, organoleptik, saus*

## INTRODUCTION

Garlic (*Allium sativum* L) is a vegetable widely used as a culinary spice and medicinal herb. According to Zhang et al. (2016), the main components of garlic are cysteine-based sulfur-rich amino acid, called alliin (diallyl disulfide oxide), and a protein-based enzyme called alliinase, which acts as a catalyst. These two compounds form a third compound, diallyl thiosulfinate, commonly called allicin. Several studies have shown various pharmacological effects of garlic, for example, antibacterial, antifungal, antihypertensive, and anticancer, also showed protective effects related to its antioxidant properties (Lisiswanti & Haryanto, 2017). In vitro and in vivo studies have confirmed that garlic has many properties as antidiabetic, antihypertensive, anticholesterol, antiatherosclerosis, antioxidant, antiplatelet cell aggregation, fibrinolysis promoter, antiviral, antimicrobial, and anticancer (Lu et al., 2017; Gebreyohannes & Gebreyohannes, 2013).

Garlic often found in Indonesia is both imported and local varieties. The consumption level of local garlic variety in Indonesia is still low compared to the imported ones. This condition is because imported garlic generally has better quality and lower prices than local garlic. Local garlic has a sharper aroma and a higher price than imported garlic, making some people more comfortable consuming imported garlic (Adelia et al., 2016). Processing garlic into black garlic has increased local garlic consumption in recent years.

Black garlic is aged garlic heated at 60-80 °C with 70-80% humidity for 14-21 days (Bae et al., 2014). The aging process can remove strong odors, give a sweet taste, and increase the functional effect of garlic (Ryu & Kang, 2017). Many studies have shown that black garlic has several health benefits. Black garlic has stronger antioxidant activity than fresh garlic, so it can be used to prevent an increase in blood low-density lipoprotein (LDL) levels (Kimura et al., 2017; García-Villalón et al., 2016). The antioxidant activity of fresh garlic processed into black garlic increased from 34.60% to 78.70% (Herlina et al., 2019).

Indonesians use black garlic more as herbal medicine, even though it can be added as a cooking flavor enhancer. People in Korea and Thailand have used black garlic for a long time as a flavor enhancer in fish dishes, chicken dishes, soup, and risotto (Kimura et al., 2017). Several studies in Indonesia have also begun to diversify black garlic products to increase their consumption. Examples of black garlic diversification are jam, jelly, and crackers. Black garlic can also be diversified as a sauce, that is relatively easy to produce.

The sauce is food seasoning, usually in a thick porridge form. On the market today, sauces are generally made from tomatoes, chilies, fish, shrimp, and oysters. Adding black garlic to sauces can diversify black garlic products, sauce innovations with new flavors, and sources of antioxidants. The black garlic concentration added to the sauce affects the sauce's physical, chemical, and organoleptic characteristics. Research on added black garlic concentration to sauces is rarely performed. Therefore, this study aims to determine the effect of black garlic concentration on the sauce's physical, chemical, and organoleptic characteristics. This study also aims to determine the right concentration of black garlic to produce a sauce with optimal and preferred physical and chemical characteristics.

## METHODS

### Tools and Materials

The tools used in this study consisted of sauce production tools and analysis tools. The tools used for sauce production are knives, scales (Sigma type SM 6000), pans (stainless steel), spoons (doll), beaker glass (Duran), measuring cylinder (Shagufta), stove (Rinnai RI-522E), filter cloth, glass bottles, and paper labels. The tools used for analysis are a hand refractometer (Atago Master), UV-Vis spectrophotometer (Spectronic 200 Visible), a color reader (Minolta model CR-10), measuring flask, 500 ml measuring cylinder (Pyrex), and a kiln.

The raw materials used in this study consisted of ingredients for making sauces and materials for analysis. The ingredients used to produce the sauce are black garlic from single clove onions (local) obtained from the Agricultural Process Engineering Laboratory, Faculty of Agricultural Technology, Universitas Jember, coconut water, brown sugar, salt, galangal, lemongrass, bay leaves, deaf, *Pangium edule* seeds, candlenut, and sesame (obtained at Pasar Tanjung, Jember). The materials used for analysis were distilled water, $Na_2SO_4$(pa), concentrated $H_2SO_4$ (pa), 30% NaOH, 0.1 N NaOH standard solution, $CaCO_3$, Pb acetate (pa), DPPH, 95% ethanol (pa), and HCl 0.1 N.

### Sauce Production

Sauce production steps include preparing ingredients, filtering coconut water, mashing garlic, candlenut, and keluak (*Pangium edule* seeds), roasting and refining sesame and star anise, and slicing brown sugar to make it dissolve quickly. All these ingredients are then put into the cooked coconut water. Lemongrass, galangal, and salt are added during cooking. The cooking process is 1 hour, then filtering to separate the insoluble material (Haerani & Hamdana, 2017).

The peeled black garlic is then added to the sauce paste with the ratio of black garlic to sauce paste, as shown in Table 1. All these ingredients are mixed using a blender and then cooked at a temperature of ±80 °C for ±10 minutes. The sauce was filtered and cooled before physical, chemical, and organoleptic analysis.

**Experimental Design**

The experimental design in this study was a completely randomized design with a single factor; the ratio of black garlic concentration to sauce paste. The experiment was performed with five treatments and three replications. The comparison of the black garlic concentration to the sauce paste in this experiment is shown in Table 1.

Analysis of Variance (ANOVA) was then performed. Duncan's New Multiple Range Test (DNMRT) was performed at a 95% confidence level (α 0.05) if there were significant differences between treatments to show which treatments were different. Organoleptic data were analyzed using the chi-square test at the 95% confidence level (α 0.05). The data is processed by Statistical Product and Service Solutions (SPSS) 23. The results obtained are then displayed in tabular form. The best treatment was determined using an effectiveness test based on the test variables for physical properties (total dissolved solids, color intensity, and viscosity), chemical properties (antioxidant activity and total polyphenols), as well as organoleptic properties (color, aroma, taste, viscosity, and overall preference). The effectiveness test is determined by assigning a weighted score (WS) to each test parameter with a final number of 0-1, the normal weight depending on the importance of each test parameter whose results are obtained as a treatment result. The analyzed parameters were grouped into two groups. Group A consists of parameters that get better if the average score is getting high. Group B consists of parameters that get better if the average score is getting low. The effectiveness score (ES) of each variable is calculated by the formula (De Garmo et al., 1997):

**Table 1.** Treatment comparison of the black garlic to sauce paste concentration

| Treatment | Black Garlic (%) | Sauce Paste (%) |
|---|---|---|
| A1 | 5 | 95 |
| A2 | 10 | 90 |
| A3 | 15 | 85 |
| A4 | 20 | 80 |
| A5 | 25 | 75 |

$$\text{Effectiveness Score}=\frac{\text{Treatment Score - Lowest Score}}{\text{Highest Score- Lowest Score}} \quad (1)$$

In the group A parameters, the lowest score is the worst. On the other hand, the group B parameter has the highest score as the worst. Calculate the Result Value (RV) of all parameters with the equation:

$$\text{Result Score (RS)} = \text{Effectiveness Score} \times \text{Normal Weight Parameter} \quad (2)$$

The RS of all parameters was added up, and then the best treatment was selected based on the combination of treatment with the highest RS.

**Analysis Method**

The best treatment was determined using an effectiveness test (De Garmo et al., 1997) based on physical, chemical, and organoleptic characteristics tests. The physical characteristics tested were total dissolved solids (°Brix according to the refractometer manual), color intensity (Manual Color Reader Minolta Type CR-10), and viscosity (modified falling ball viscometer). The chemical characteristics tested were antioxidant activity (2,2-diphenyl-1-picrylhydrazyl/DPPH) and total polyphenols (Arteaga et al., 2012). The organoleptic tests performed were color, aroma, taste, viscosity, and overall preference (Rochmawati, 2019).

## RESULTS AND DISCUSSION

**Total Dissolved Solids (TDS)**

TDS sauce at various concentrations of black garlic was analyzed using ANOVA with a 95% confidence level (α≤0.05). The results showed that the black garlic concentration significantly affects the sauce's TDS value. The sauce TDS value at black garlic various concentrations can be seen in Table 2.

**Color Intensity**

The sauce color intensity at various black garlic concentrations was analyzed using ANOVA with a 95% confidence level (α≤0.05). The results show that the black garlic concentration significantly affects the sauce color intensity. The sauce color intensity value at various black garlic concentrations is shown in Table 3.

**Viscosity**

Sauce viscosity at various black garlic concentrations was analyzed using ANOVA with a 95% confidence level (α≤0.05). The results showed that the black garlic concentration significantly affected the sauce's viscosity. The sauce's viscosity at various black garlic concentrations is shown in Table 4, and the value is between 0.18±0.01 Poise to 2.15±0.11 Poise. The lowest viscosity value was found in treatment A1 with 5% black garlic concentration, while the highest was found in the A5 treatment with 25% black garlic concentration. The viscosity value is influenced by the concentration of black garlic and sauce paste variations. Black garlic has a chewy, jelly-like texture, so the sauce's viscosity increases as the black garlic concentration increases (Kamal, 2010).

**Antioxidant Activity**

The sauce antioxidant activity analysis results on various black garlic concentrations using the ANOVA test at the 95% confidence level (α≤0.05) showed that variations in the black garlic concentration significantly affected the sauce antioxidant activity value. The sauce antioxidant activity value at various black garlic concentrations is shown in Table 5.

Table 5 shows that the sauce antioxidant activity ranged from 15.93±0.58% to 35.94±0.31%. The lowest antioxidant activity was found in treatment A1 with 5% black garlic concentration, while the highest antioxidant activity was found in A5 treatment with 25% black garlic concentration. The sauce antioxidant activity value tends to increase along with the increase of black garlic concentration. Black garlic has higher antioxidant activity than garlic. According to research by Choi et al. (2014) and Kim et al. (2013), the active compound content of black garlic is more abundant than garlic. The heating process induced a six-fold increase in S-allylcysteine (SAC) than garlic. Research by García-Villalón et al. (2016) explained that the SAC in black garlic increased dramatically to 194.3 g/g. SAC is black garlic compounds that act as antioxidants. Therefore, the antioxidant activity value is higher if the black garlic concentration is also high.

**Table 2.** Sauce TDS value at various black garlic concentrations

| Treatment (Black Garlic:Sauce Paste) | TDS Value (°Brix) | Notation |
|---|---|---|
| A1 (5: 95) | 33.12±0.07 | a |
| A2 (10: 90) | 33.75±0.08 | b |
| A3 (15: 85) | 34.23±0.17 | c |
| A4 (20: 80) | 36.72±0.30 | d |
| A5 (25: 75) | 40.06±0.13 | e |

The same notation shows a significant difference at the 95% confidence level (α≤0.05)

**Table 3.** Sauce color intensity value at various black garlic concentrations

| Treatment (Black Garlic:Sauce Paste) | Color Intensity Value | Notation |
|---|---|---|
| A1 (5:95) | 0.58±0.01 | a |
| A2 (10:90) | 0.67±0.01 | b |
| A3 (15:85) | 1.35±0.12 | c |
| A4 (20:80) | 1.48±0.02 | d |
| A5 (25:75) | 1.90±0.02 | e |

The same notation shows a significant difference at the 95% confidence level (α≤0.05)

**Table 4.** Sauce viscosity values at various concentrations of black garlic

| Treatment (Black Garlic:Sauce Paste) | Viscosity Value (Poise) | Notation |
|---|---|---|
| A1 (5: 95) | 0.18±0.01 | a |
| A2 (10: 90) | 0.30±0.05 | ab |
| A3 (15: 85) | 0.41±0.05 | b |
| A4 (20: 80) | 0.89±0.07 | c |
| A5 (25: 75) | 2.15±0.11 | d |

The same notation shows a significant difference at the 95% confidence level (α≤0.05)

**Table 5.** The sauce antioxidant activity value at various black garlic concentrations

| Treatment (Black Garlic:Sauce Paste) | Antioxidant Activity Value (%) | Notation |
|---|---|---|
| A1 (5:95) | 15.93±0.58 | a |
| A2 (10:90) | 16.78±0.25 | b |
| A3 (15:85) | 22.75±0.38 | c |
| A4 (20:80) | 27.94±0.45 | d |
| A5 (25:75) | 35.94±0.31 | e |

The same notation shows a significant difference at the 95% confidence level (α≤0.05)

**Total Polyphenol**

The analysis of sauce total polyphenols on black garlic at various concentrations using the ANOVA test at a 95% confidence level (α≤0.05) showed that variations in black garlic concentration significantly affect the sauce polyphenols' total value. The sauce polyphenols' total value at various black garlic concentrations is shown in Table 6.

**Table 6.** The total value of sauce polyphenols at various concentrations of black garlic

| Treatment (Black Garlic:Sauce Paste) | Antioxidant Activity Value (%) | Notation |
|---|---|---|
| A1 (5:95) | 0.36±0.15 | a |
| A2 (10:90) | 0.65±0.24 | b |
| A3 (15:85) | 1.07±0.21 | b |
| A4 (20:80) | 1.24±0.15 | b |
| A5 (25:75) | 2.20±0.49 | c |

The same notation shows a significant difference at the 95% confidence level (α≤0.05)

Table 6 shows that the sauce's total polyphenols ranged from 0.36±0.15 mg GAE/g to 2.20±0.49 mg GAE/g. The lowest total polyphenol was found in treatment A1 with 5% black garlic concentration, while the highest total polyphenol value was found in A5 treatment with 25% black garlic concentration. The sauce's total polyphenols value increased with the black garlic concentration increase. This condition is because polyphenols are closely related to antioxidants. Most antioxidants in natural ingredients are polyphenol compounds. According to Arteaga et al. (2012), the total polyphenol test aims to determine the sample of total phenolic compounds contained. Antioxidant activity will be high if the sample phenolic compounds content is high too. Black garlic has a higher total polyphenol content than fresh garlic. The Maillard reaction caused the black garlic's total polyphenol to increase during the aging process. Heat can increase the phytochemical components released from the cell matrix, such as phenolic acids. The thermal process makes cell walls and cell membranes weaken, so the cells release dissolved phenolic components from ester and glycoside bonds to become phenolic acid free-fractions (Kim et al., 2012).

## The Organoleptic Properties of Black Garlic Sauce

### Color Preference

The average value of sauce color preference for various black garlic concentrations ranged from 4.03 to 6.50, as shown in Figure 1. The chi-square test results at the 95% confidence level showed that the sauce color in the treatment of various concentrations of black garlic and sauce paste significantly affects the preference of sauce color. This result is based on the chi-square value of color preference obtained at 78.55. This value is greater than the chi-square value with degree of freedom (df) = 28, which is 41.34.

Figure 1 showed that the average value of the panelists' highest preference for sauce color was found in treatment A5 with a 25% black garlic concentration and an average value of 6.50 (like). The lowest color preference value was found in A1 sauce, with a 5% black garlic concentration and an average value of 4.03 (neutral). The data showed that the panelists preferred the darkest color sauce. The black garlic addition affects the sauce product color. The higher the black garlic concentration, the sauce color gets darker. According to Setiani et al. (2013), the food product's color is influenced by the characteristics of the raw material. The sauce's dark brown color comes from the black garlic, coconut water, and brown sugar mixture. The Maillard reaction during sauce production also influences the sauce color. The ingredients for sauce production contain protein amino groups and carboxyl groups of reducing sugars so that the Maillard reaction occurs when the ingredients are heated. The Maillard reaction occurs due to the reaction between the protein amino group and the reducing sugar carboxyl group, which produces a brown compound called melanoidin. Therefore, the sauce color produced from treatments A1 to A5 is getting browner and darker.

### Aroma Preference

The average value of sauce aroma preference in various black garlic concentrations ranged from 4.33 to 5.53, as shown in Figure 2. The chi-square test results at the 95% confidence level indicate that the sauce aroma of various black garlic concentrations treatment did not significantly affect the preference level of aroma sauce. The chi-square value calculation shows 34.32, which is smaller than the chi-square value with df = 28, 41.34. The data showed that the panelists could not distinguish the sauce aroma. This result may be because the variations range of black garlic concentration used was too low, so the panelists experienced difficulty distinguishing the sauce aroma.

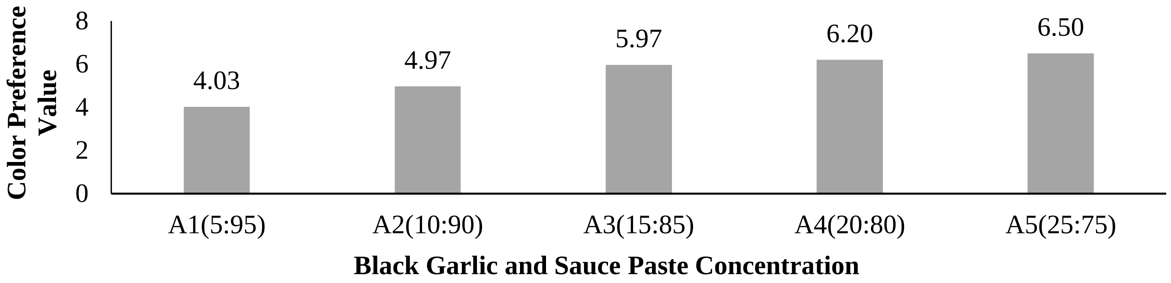


**Figure 1.** Color Preference Value of Black Gralic Sauce

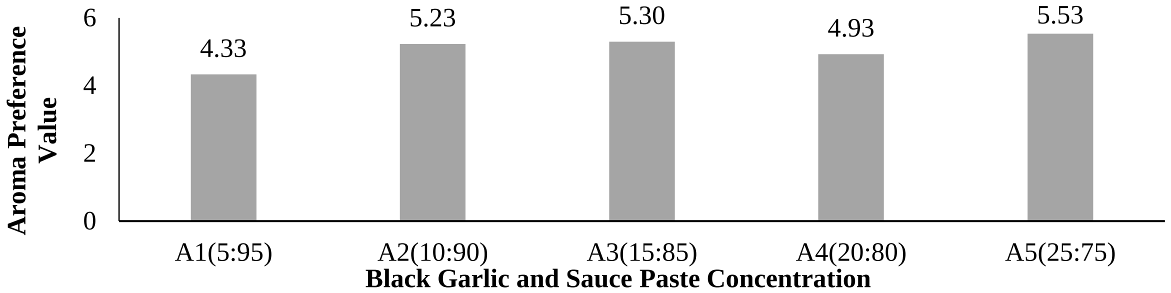


**Figure 2.** Aroma Preference Value of Black Gralic Sauce

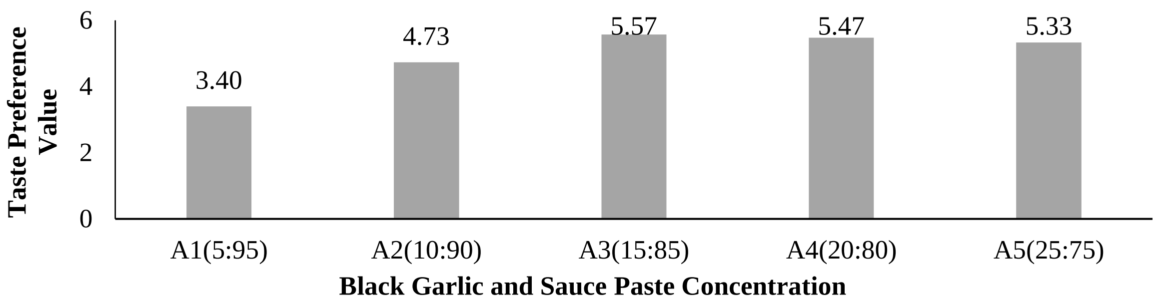


**Figure 3.** Taste Preference Value of Black Gralic Sauce

Taste Preference

The average value of sauce taste preference for various black garlic concentrations ranged from 3.40 to 5.33, as shown in Figure 3. The chi-square test results at a 95% confidence level indicate that the sauce taste in various black garlic concentrations treatment significantly affects the taste preference level. The chi-square value calculation shows 87.85, which is higher than the chi-square value with df = 32, which is 46.19.

Figure 3 shows the average value of the panelists' highest preference for sauce taste, found in treatment A3 with a 15% black garlic concentration and an average value of 5.57 (somewhat like). The lowest preference was found in A1 sauce, with a 5% black garlic concentration and an average value of 3.40 (not much like). The panelists prefer sauces with a less dominant black garlic taste, less sweet, sour, and saltier. Black garlic has a distinctive sweet and sour taste that affects the sauce taste. This sweet and sour taste is due to the aging process of black garlic, which can convert garlic carbohydrates into simple sugars. According to Choi et al. (2014), the decomposition of the water molecules ($H_2O$) bonding components occurs during the aging process of black garlic. Water molecules form hydrates with other molecules containing O and N atoms, such as carbohydrates, which eventually increase the carbohydrates content. The carbohydrates increase also affects the total dissolved solids increase. Sugar, as a component of carbohydrates, is more soluble with more extended heat, so the TDS increases. TDS is closely related to the product's sugar content. According to Yuan et al. (2016), a high TDS value indicates that the sugar content in food is also high. Therefore, a carbohydrates increase can make black garlic taste sweet. The increased black garlic concentration of treatment A1 to A5 makes the sauce taste sweet.

Viscosity Preference

The average value of sauce viscosity preference for various black garlic concentrations ranged from 3.63 to 5.37, as shown in Figure 4. The chi-square test results at the 95% confidence level indicate that the sauce's viscosity of various black garlic concentrations treatment significantly affects the sauce viscosity preference level. The chi-square value calculation shows a value of 86.76, which is higher than the chi-square value with df = 28, which is 41.34.

Figure 4 shows that the highest average value of the panelists' preference for sauce viscosity is 5.43 (somewhat like), found in treatment A3 with a 15% black garlic concentration. The panelists' lowest preference for sauce viscosity is 3.63 (not much like), found in treatment A1 with a 5% black garlic concentration. According to data, panelists prefer a sauce with not too thick or not too liquid viscosity. This result is because the sauce thickness will increase if the black garlic concentration increases and the sauce paste concentration decreases. Black garlic has a jelly-like texture, so the sauce's viscosity increases as the black garlic concentrations increase (Kamal, 2010).

Overall Preference

The overall preference average value of sauces at various black garlic concentrations ranged from 3.50 to 5.23, as shown in Figure 5. The chi-square test results at the 95% confidence level showed that the overall preference for sauces at various black garlic concentrations significantly affected the sauce's overall preference level. The chi-square value calculation shows a value of 92.65, which is higher than the chi-square value with df = 32, which is 46.19.

Figure 5 shows that the highest average value of the panelists' preference for the overall sauce preference is 5.23 (somewhat like), found in treatment A3 with a 15% black garlic concentration. The panelists' lowest average preference for the overall sauce preference was 3.50 (dislike), found in A1 sauce with a 5% black garlic concentration. The panelists' overall preference rating was influenced by sauce attributes of color, aroma, taste, and viscosity. This result follows Rochmawati (2019), which states that a person's preference for a product is influenced by several factors, including attractive color, taste and appearance, high nutritional value, and benefits for the consumer.

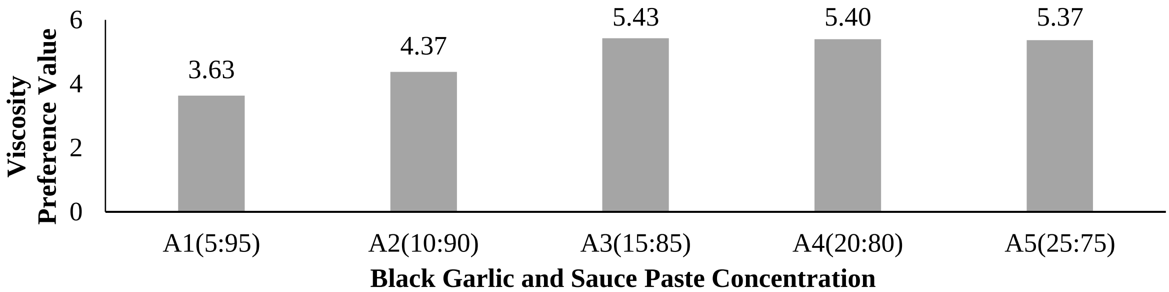


**Figure 4.** Viscosity Preference Value of  Black Gralic Sauce

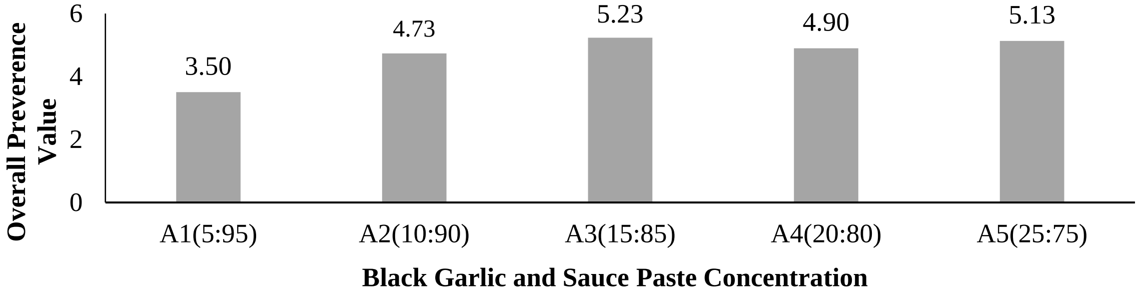


**Figure 5.** Sauce Overall Preference Value of  Black Gralic Sauce

### Effectiveness Score of Black Garlic Sauce

The effectiveness test results for each treatment ranged from 0.42 to 0.83. The effectiveness score of black garlic sauce is shown in Table 7. The highest effectiveness score was found in treatment A3 (15% black garlic concentration and 85% sauce paste) showed the best treatment of the overall black garlic sauce treatment. The lowest value indicating the worst treatment was found in treatment A2 (10% black garlic concentration and 90% sauce paste). The physical and chemical characteristics of black garlic sauce with the best treatment A3 (15% black garlic concentration and 85% sauce paste) were TDS 34.23±0.17 °Brix; color intensity 1.35±0.12; viscosity 0.41±0.05 Poise; antioxidant activity 22.75±0.38%; total polyphenols 1.07±0.21 mg GAE/g, with organoleptic values for color, aroma, taste, viscosity, and overall preference, respectively, of 5.97; 5.30; 5.57; 5,43, and 5,23 with the criteria somewhat like it.

**Table 7.** Sauce effectiveness score

| Treatment | Effectiveness Score |
|---|---|
| A1 | 0.42 |
| A2 | 0.32 |
| **A3** | **0.83** |
| A4 | 0.77 |
| A5 | 0.76 |

## CONCLUSIONS

Black garlic concentration variations in sauce production significantly affected Total Dissolved Solids (TPT), color intensity, viscosity, antioxidant activity, total polyphenols, and panelists' preference for color, taste viscosity, and overall. The variation of black garlic concentration in sauce production did not significantly affect aroma preference. The best treatment was a sauce with 15% black garlic concentration and 85% sauce paste (A3).

### References

Adelia, K. A. C., Pasangka, B., & Bukit, M. (2016). Penerapan radiasi multigamma untuk pengembangan bawang putih lokal Timor. *Jurnal Fisika : Fisika Sains Dan Aplikasinya*, *1*(1), 66–71.

Arteaga, J. F., Ruiz-Montoya, M., Palma, A., Alonso-Garrido, G., Pintado, S., & Rodríguez-Mellado, J. M. (2012). Comparison of the simple cyclic voltammetry (cv) and dpph assays for the determination of antioxidant capacity of active principles. *Molecules*, *17*(5), 5126–5138. https://doi.org/10.3390/molecules17055126

Bae, S. E., Cho, S. Y., Won, Y. D., Lee, S. H., & Park, H. J. (2014). Changes in S-allyl cysteine contents and physicochemical properties of black garlic during heat treatment. *LWT - Food Science and Technology*, *55*(1), 397–402. https://doi.org/10.1016/j.lwt.2013.05.006

Choi, I., Cha, H., & Lee, Y. (2014). Physicochemical and antioxidant properties of black garlic. *Molecules*, *19*(10), 16811–16823. https://doi.org/10.3390/molecules191016811

De Garmo, E. G., Sullivan, W. G., & Cerook., J. R. (1997). *Engineering Economy* (10th ed.). New York: MacMilland.

García-Villalón, A. L., Amor, S., Monge, L., Fernández, N., Prodanov, M., Muñoz, M., … Granado, M. (2016). In vitro studies of an aged black garlic extract enriched in S -allylcysteine and polyphenols with cardioprotective effects. *Journal of Functional Foods*, *27*, 189–200. https://doi.org/10.1016/j.jff.2016.08.062

Gebreyohannes, G., & Gebreyohannes, M. (2013). Medicinal values of garlic: A review. *International Journal of Medicine and Medical Sciences*, *5*(9), 401–408.

Haerani, & Hamdana. (2017). Pengembangan kecap dari air kelapa. *Prosiding Seminar Nasional Himpunan Sarjana Ilmu-Ilmu Sosial*, 335–348. Makassar: Fakultas Ilmu Sosial Universitas Negeri Makassar dan Himpunan Sarjana Pendidikan Ilmu-ilmu Sosial Indonesia.

Herlina, Lindriati, T., Sulistyani, Yunus, M., & Soekarno, S. (2019). Effect of duration and temperature of fermentation on black garlic properties. *Advance Journal of Food Science and Technology*, *17*(5), 86–93. https://doi.org/10.19026/ajfst.17.6033

Iskandar, A., & Handayani, M. N. (2016). Karakteristik saus paprika (*Capsicum annuum*) dengan penambahan rosella (*Hibiscus sabdariffa*) sebagai pewarna alami. *Edufortech*, *1*(1), 59–67.

Kamal, N. (2010). Pengaruh bahan aditif cmc (carboxyl methyl cellulose) terhadap beberapa parameter pada larutan sukrosa. *Jurnal Teknik: Majalah Ilmiah Fakultas Teknik Unpak*, *1*, 78–84.

Kim, J.-S., Kang, O.-J., & Gweon, O.-C. (2013). Changes in the content of fat- and water-soluble vitamins in black garlic at the different thermal processing steps. *Food Science and Biotechnology*, *22*(1), 283–287. https://doi.org/10.1007/s10068-013-0039-3

Kim, J. H., Nam, S. H., Rico, C. W., & Kang, M. Y. (2012). A comparative study on the antioxidative and anti-allergic activities of fresh and aged black garlic extracts. *International Journal of Food Science & Technology*, *47*(6), 1176–1182. https://doi.org/10.1111/j.1365-2621.2012.02957.x

Kimura, S., Tung, Y.-C., Pan, M.-H., Su, N.-W., Lai, Y.-J., & Cheng, K.-C. (2017). Black garlic: A critical review of its production, bioactivity, and application. *Journal of Food and Drug Analysis*, *25*(1), 62–70. https://doi.org/10.1016/j.jfda.2016.11.003

Lisiswanti, R., & Haryanto, F. P. (2017). Allicin pada bawang putih (*Allium sativum*) sebagai terapi alternatif diabetes melitus tipe 2. *Majority (Medical Journal of Lampung University)*, *6*(2), 31–36.

Lu, X., Li, N., Qiao, X., Qiu, Z., & Liu, P. (2017). Composition analysis and antioxidant properties of black garlic extract. *Journal of Food and Drug Analysis*, *25*(2), 340–349. https://doi.org/10.1016/j.jfda.2016.05.011

Rochmawati, N. (2019). *Food Science & Sensory Analysis*. Surabaya: OTTIMMO International Master Gourmet Academy.

Ryu, J. H., & Kang, D. (2017). Physicochemical properties, biological activity, health benefits, and general limitations of aged black garlic: A review. *Molecules*, *22*(6), 919. https://doi.org/10.3390/molecules22060919

Setiani, W., Sudiarti, T., & Rahmidar, L. (2013). Preparasi dan karakterisasi edible film dari poliblend pati sukun-kitosan. *Jurnal Kimia Valensi*, *3*(2), 100–109. https://doi.org/10.15408/jkv.v3i2.506

Yuan, H., Sun, L., Chen, M., & Wang, J. (2016). The comparison of the contents of sugar, amadori, and heyns compounds in fresh and black garlic. *Journal of Food Science*, *81*(7), C1662–C1668. https://doi.org/10.1111/1750-3841.13365

Zhang, X., Li, N., Lu, X., Liu, P., & Qiao, X. (2016). Effects of temperature on the quality of black garlic. *Journal of the Science of Food and Agriculture*, *96*(7), 2366–2372. https://doi.org/10.1002/jsfa.7351

Zhuang, Y., & Sun, L. (2011). Antioxidant activity of maillard reaction products from lysine-glucose model system as related to optical property and copper (II) binding ability. *African Journal of Biotechnology*, *10*(35), 6784–6793.