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# Study of Cracker Production with the Addition of Black Garlic and Sodium Tripolyphosphate

# *Kajian Pembuatan Kerupuk dengan Penambahan Bawang Hitam dan Sodium Tripolyphosphate*

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**Abstract**

This study examines how black garlic and sodium tripolyphosphate (STPP) concentrations effect cracker physical, chemical, and organoleptic characteristics, also determined the black garlic and STPP optimal concentration to produce cracker with desirable quality. A completely randomized design was used, with two factors: black garlic concentration (3%, 6%; 9%) and STPP concentration (0.1%; 0.3%; 0.5%). The test parameters were color (lightness), swelling power, hygroscopicity, water content, ash content, total polyphenols, antioxidant activity, and organoleptic tests (color, flavor, taste, crispiness, and overall). An effectiveness test was conducted to determine the black garlic and STPP right concentration in cracker production. The results showed that the black garlic concentration significantly effected the lightness, swelling power, hygroscopicity, water content, ash content, antioxidant activity, and total cracker polyphenols. STPP concentration significantly effected the cracker ash content. Garlic and STPP concentration had significant organoleptic effects on color preference, flavor, taste, and crispiness. The cracker with a concentration of 3% black garlic and 0.5% STPP were the best and preferred. The effectiveness score was 0.64, with physical characteristics of color lightness 23.39 ± 0.20, swelling power 82.51 ± 0.11%, hygroscopicity 5.07 ± 0.41%, and chemical characteristics of water content 5.83 ± 0.16%, ash content 2.77 ± 0.25%, total polyphenols 0.175 ± 0.001%, antioxidant activity 16.14 ± 0.20. The organoleptic test scores were color 6.00±0.12, flavor 5.60±0.43, taste 5.68±0.31, crispiness 6.92 ± 0.32, and overall 6.28 ± 0.42.
**Keywords**: antioxidant activity; black garlic; cracker, sodium tripolyphosphate

***Abstrak***

*Penelitian ini memeriksa pengaruh konsentrasi bawang hitam dan sodium tripolyphosphate (STPP) terhadap karakteristik fisik, kimia, dan organoleptik kerupuk serta mengetahui konsentrasi bawang hitam dan STPP yang tepat sehingga dihasilkan kerupuk dengan karakteristik yang baik dan disukai. Penelitian ini menggunakan metode Rancangan Acak Lengkap dua faktor: konsentrasi bawang hitam (3%; 6%; 9%) dan konsentrasi STPP (0,1%; 0,3%; 0,5%). Parameter pengujian yaitu warna (kecerahan), daya kembang, higroskopisitas, kadar air, kadar abu, total polifenol, aktivitas antioksidan, uji organoleptik (warna, flavor, rasa, kerenyahan, dan keseluruhan). Uji efektivitas untuk menentukan konsentrasi bawang hitam dan STPP yang tepat pada pembuatan kerupuk. Hasil penelitian menunjukkan bahwa konsentrasi bawang hitam berpengaruh nyata terhadap warna, daya kembang, higroskopisitas, kadar air, kadar abu, aktivitas antioksidan, dan total polifenol kerupuk. Konsentrasi STPP berpengaruh nyata terhadap kadar abu kerupuk. Konsentrasi bawang hitam dan konsentrasi STPP berpengaruh nyata secara organoleptik pada kesukaan warna, flavor, rasa, kerenyahan, dan keseluruhan. Kerupuk terbaik dan disukai adalah kerupuk dengan konsentrasi bawang hitam 3% dan STPP 0,5%. Nilai efektivitas kerupuk adalah 0,64, dengan karakteristik fisik kecerahan warna 23,39±0,20, daya kembang 82,51±0,11%, higroskopisitas 5,07±0,41%, karakteristik kimia kadar air 5,83±0,14%, kadar abu 2,77±0,25%, total polifenol 0,175±0,001%, aktivitas antioksidan 16,14±0,12. Nilai uji organoleptik kesukaan warna 6,00±0,12, flavor 5,60±0,43, rasa 5,68±0,31, kerenyahan 6,92±0,32, dan keseluruhan 6,28±0,42.*
***Kata kunci:*** *aktivitas antioksidan, bawang hitam, kerupuk, sodium tripolyphosphate*

## INTRODUCTION

Cracker is a snack with a crunchy texture and are often liked by people from various groups. Generally, the raw materials for cracker production are tapioca, wheat flour, and flavor enhancers such as onions, fish, shrimp paste, or other ingredients that characterize the cracker name produced (Zulfahmi et al., 2014). Cracker sold in the market generally do not have uniqueness or particular functional properties advantages. Cracker are often made using harmful food additives, such as high concentrations of food flavorings, synthetic dyes, and preservatives (borax) that harm human health. Continuously consuming foods containing borax can damage liver and kidney function and even trigger cancer (Berliana et al., 2021).

The development of cracker products through improving the quality, taste, and benefits for health is needed to meet consumer needs. One of the efforts to develop cracker products is adding black garlic. Black garlic is an aging product of garlic heated at 70 °C with 70-80% humidity for 14 days without additional treatment (García-Villalón et al., 2016). The aging process can remove the pungent odor, provide a sweet taste, and increase its functional effects (Ryu & Kang, 2017). Many studies have shown that black garlic has several health benefits; lowering cholesterol, stabilizing lipid profiles, anti-inflammation, and lowering blood sugar levels (Gebreyohannes & Gebreyohannes, 2013). Black garlic shows stronger antioxidant activity compared to raw garlic. According to Herlina et al. (2019), the antioxidant activity of fresh garlic processed into black garlic increased from 34.6% to 78.79%. Black garlic can be a natural black coloring in various food products. Korean and Thailand people have also used black garlic for a long time as a flavor enhancer in processed fish, chicken, soup, and risotto (Kimura et al., 2017).

In its development, the cracker production process also adds sodium tripolyphosphate (STPP). STPP is a food-grade additive used as a dough water-binding agent so the dough surface does not dry out and harden quickly because of water evaporation. STPP that reacts with starch will form bonds between starch and phosphate diester or cross-links between (OH) hydroxyl groups. This reaction causes the starch bonds to become stronger and resistant to heating and acid, increasing the dough's stability and reducing the granules' swelling degree. STPP, as a cracker dough stabilizer, can provide good physical properties to cracker regarding swelling and crispiness. Research conducted by Rosida et al. (2013) stated that STPP has the property of binding water, so adding STPP to the tempura batter would increase the tempura's water content. Retnaningtyas & Putri (2014) stated that starch reacting with STPP would produce hydrophilic phosphate groups. The more STPP concentration added the more phosphate groups bind water. If there is more bound water, swelling volume and the chance of forming cavities in the product will increase. In raw cracker, water occupies cracker cavities. During the frying process, the water will evaporate, leaving the cracker cavities. The water vapor then forces the starch gel so that the cracker swell. This statement follows Haryati et al. (2019) research on the production of milk and tapioca flour substitute cracker using the liquid method. Increasing the milk concentration by 15% in this crackers production process could increase the crackers water content by 1.9% and increase the crackers swelling power by 21.97%.

Using black garlic and STPP in cracker production will produce high-quality cracker, rich in antioxidants, have high levels of swelling, are crunchy, and have health benefits because black garlic can function as a flavor enhancer and natural coloring agent. The combination treatment of the correct black garlic and STPP concentration in the cracker production can produce good quality, preferred, and functionally healthy cracker. This study aims to determine the effect of the black garlic and STPP concentration on the crackers physical, chemical, and organoleptic characteristics and the right concentration of black onion and STPP so that cracker with good and favorable characteristics are produced.

## METHODS

The research was conducted at the Laboratory of Agricultural Product Processing Engineering, Entrepreneurship Laboratory, Integrated Analysis, and the Laboratory of Chemistry and Biochemistry of Agricultural Product Processing, Faculty of Agricultural Technology, Universitas Jember, East Java, Indonesia.

**Materials and Tools**

The ingredients used for cracker production were tapioca flour (Tani brand), wheat flour (Segitiga Biru brand produced by Bogasari), black garlic (production by the Agricultural Product Process Engineering Laboratory, Faculty of Agricultural Technology, Universitas Jember), STPP (food grade) salt, baking soda, palm oil (Bimoli brand) and distilled water. The materials used for analysis were distilled water, $Na_2SO_4$ (pa), concentrated $H_2SO_4$ (pa), 30% NaOH, standard solution of 0.1 N NaOH, $CaCO_3$, Pb acetate (pa), DPPH, 95% ethanol (pa), and HCl 0.1N.

The tools used in this study were divided into cracker production tools and analysis tools. The cracker production tools included knives, scales (Sigma type SM 6000), pots (stainless steel), spoons (Doll), beaker glass (Duran), measuring cylinder (Shagufta), stove (Rinnai RI-522E), filter cloth, glass bottles, aluminum boiler (local production without brand) and label paper. The tools used for analysis were a hand refractometer (Atago Master), a UV-Vis spectrophotometer (Spectronic 200 Visible), a color reader (Minolta model CR-10), a measuring flask, a 500 ml measuring cylinder (Pyrex), and a furnace.

**Experimental Design and Data Analysis**

The study used a Completely Randomized Design (CRD) with two factors (Harjosuwono et al., 2011). Factor A was the black garlic (BG) concentration (3%; 6%; and 9%), and factor B was the STPP concentration (0.1%; 0.3%; and 0.5%) with a combination of 3 (three) repeated treatments. Data from observations of physical and chemical properties were processed using the Analysis of Variance (ANOVA) test with a confidence interval of 95% ($\alpha \leq 0.05$). If there was a significant difference between treatments, then continue with the Duncan Multiple Range Test (DMRT) with a confidence interval of 95% ($\alpha \leq 0.05$). The organoleptic test results were analyzed using the chi-square test and discussed descriptively.

The best treatment was tested using an effectiveness test. The effectiveness test is a method for determining the best treatment by ranking the priority variables and contribution to the test results. Weight was given to each variable according to its contribution by a score of 0-1. The effectiveness score was calculated using the following equation (De Garmo et al., 1997):

$$\text{Effectiveness Score} = \frac{\text{Score} - \text{lowest score}}{\text{Higest score} - \text{lowest score}} \quad (1)$$

**Cracker Production**

The cracker production method Yuliani et al. (2018) used in the research was then developed. The raw materials were tapioca and wheat flour, added with black garlic and STPP. Black garlic was made based on the processing method used by Herlina et al. (2019). Cracker were made by preparing several ingredients: 100 grams of tapioca flour, 100 grams of wheat flour, and black garlic paste (4.98 grams, 9.96 grams, 14.94 grams). All the ingredients were mixed, then add 60 ml of water, 5 grams of baking soda, STPP (0.166 grams, 0.49 grams, 0.83 grams), and 1 gram of salt to make the dough. The dough was put into a plastic mold with a diameter of 5 cm and boiled at 100 °C for 3 hours. The boiled dough was sliced 2 mm thick and sun-dried for 6 hours. The dried crackers were fried using 500 ml of palm cooking oil at 150 °C for 7 seconds in a 30 cm diameter pan.

**Observation Parameters**

Observation parameters include physical, chemical, and organoleptic observations. Physical observations include tests for color lightness, swelling power (Mustofa & Suyanto, 2011), and hygroscopicity. Chemical observations included water content (Andarwulan et al., 2011), ash content (Andarwulan et al., 2011), total polyphenols and antioxidant activity (Chedea & Pop, 2019). Organoleptic preference/hedonic tests included a preference for color, flavor, taste, crispiness, and overall by hedonic scale scoring. The scale used was 1-7 (1=dislike very much; 2=dislike moderately, 3=dislike slightly; 4=neither like nor dislike; 5=like slightly; 6=like moderately, and 7=like very much). The panelists in this test were 25 students (Khairunnisa & Syukri, 2021) who had been trained in equating perceptions of the cracker characteristics before carrying out the hedonic test. Panelists comprised 15 women and 10 men in the 19-25 age range. Panelists were asked to determine the product preference value by giving a score in a predetermined range (Ayustaningwarno, 2014).

## RESULTS AND DISCUSSION

### Physical Characteristics

Color Lightness

Table 1 shows the results of cracker color lightness using ANOVA at the 95% confidence interval ($\alpha \leq 0.05$). The black garlic concentration significantly effected the cracker color lightness, so the DNMRT test was carried out. In contrast, the STPP concentration and their interaction had no significant effect. The crackers color gets darker (black) if the black garlic concentration added to the cracker dough increases, so the lightness value decreases. Cracker with 3% black garlic concentration and 0.1% STPP had the brightest color (color lightness value = 23.77±0.21), while cracker with 9% black garlic concentration and 0.5% STPP had the lowest lightness (color lightness value = 21.18±0.05).

The increase in black garlic concentrations caused the crackers color to become darker black. The Maillard reaction that occurred during garlic processing caused a blackish-brown color. The Maillard reaction is the main reaction between reducing sugars and amino components. The reaction speed increases with temperature increase, and water content decrease (Hustiany, 2017). The brown color due to the Maillard reaction will be more intense if the heating process is longer, causing the garlic to appear black.

**Table 1.** Crackers physical characteristics value with variations of black garlic and STPP concentration

| Concentrations (%) | Color (Lightness) | Swelling power (%) | Hygroscopicity (%) |
|---|---|---|---|
| BG 3 : STPP 0.1 | $23.77 \pm 0.21^{a}$ | $82.71 \pm 0.01^{a}$ | $5.11 \pm 0.15^{a}$ |
| BG 3 : STPP 0.3 | $23.55 \pm 0.11^{a}$ | $82.69 \pm 0.23^{a}$ | $5.10 \pm 0.06^{a}$ |
| BG 3 : STPP 0.5 | $23.39 \pm 0.20^{a}$ | $82.51 \pm 0.11^{a}$ | $5.07 \pm 0.41^{a}$ |
| BG 6 : STPP 0.1 | $22.77 \pm 0.31^{b}$ | $80.53 \pm 0.12^{b}$ | $4.62 \pm 0.32^{b}$ |
| BG 6 : STPP 0.3 | $22.46 \pm 0.01^{b}$ | $80.11 \pm 0.31^{b}$ | $4.62 \pm 0.21^{b}$ |
| BG 6 : STPP 0.5 | $22.21 \pm 0.12^{b}$ | $80.11 \pm 0.22^{b}$ | $4.61 \pm 0.25^{b}$ |
| BG 9 : STPP 0.1 | $21.97 \pm 0.32^{c}$ | $78.77 \pm 0.23^{c}$ | $4.11 \pm 0.31^{c}$ |
| BG 9 : STPP 0.3 | $21.59 \pm 0.04^{c}$ | $78.56 \pm 0.13^{c}$ | $4.09 \pm 0.24^{c}$ |
| BG 9 : STPP 0.5 | $21.18 \pm 0.05^{c}$ | $78.51 \pm 0.22^{c}$ | $3.90 \pm 0.20^{c}$ |

**Notes**: Numbers in the same column followed by the same letter show results that have no significant effect at the 95% confidence interval ($\alpha \leq 0.05$).

Swelling power

Table 1 shows the results of cracker swelling power using ANOVA at the 95% confidence interval ($\alpha \leq 0.05$). The black garlic concentration significantly effected the cracker swelling power, so the DNMRT test was carried out. The concentration of STPP and the interaction between the two had no significant effect on the crackers swelling power. Cracker with 3% black garlic concentrations and 0.1% STPP had a higher cracker swelling power (82.71±0.01%) than the other treatments. The crackers swelling power would decrease if the concentration of black garlic added to the cracker dough increased. The addition of black garlic would increase the crackers sugar level. High sugar levels cause the crackers swelling power to decrease. Sugar will inhibit the starch gelatinization process of tapioca and wheat flour, so the water transfer to the starch granules that form a gel will be hampered then causes the crackers swelling power to decrease (Rosiani et al., 2015).

Black garlic has a higher sugar content than fresh garlic, following research conducted by Choi et al. (2014), which stated that the sugar content (glucose, fructose, sucrose, and maltose) in black garlic increased compared to fresh garlic. These sugar levels increase related to the black garlic's sweet taste. The reducing sugars content in the black garlic production process is influenced by the hydrolysis reaction of polysaccharides into reducing sugars and the Maillard reaction. The hydrolysis reaction of polysaccharides into reducing sugars causes the reducing sugars levels to increase. The Maillard reaction causes reducing sugar levels to decrease. According to Zhang et al. (2016), reducing sugar levels decreased during the aging process of black garlic production until the 45th day. This result was caused by the hydrolysis reaction of polysaccharides which happens faster than the Maillard reaction.

Hygroscopicity

Table 1 shows the cracker hygroscopicity results using ANOVA at the 95% confidence interval ($\alpha \leq 0.05$). The black garlic concentration significantly effected the crackers hygroscopicity, so the DNMRT test was carried out. The STPP concentration and interactions between them did not significantly effect the crackers hygroscopicity. Cracker with 3% black garlic concentrations and 0.1% STPP had the highest hygroscopicity value (5.11 ± 0.15%), while cracker with 9% black garlic concentrations and 0.5% STPP had the lowest hygroscopicity value (3.90 ± 0.20%). The crackers hygroscopicity value decreased when the black garlic concentration added to the cracker dough increased. The cracker dough sugar content would increase if the added black garlic concentration increased, inhibiting the starch gelatinization process. This inhibition caused the dough cavities filled with water to decrease, so the cracker were not porous after the frying process (Koswara, 2009). This result follows research by Rosiani et al. (2015) on aloe vera cracker production, which showed that adding sugar would reduce the cracker swelling.

The greater the expansion volume, the larger the cracker surface area, so there will be more air voids. This increase in air void can increase the crackers water absorption, so the hygroscopicity value is high. Research on cracker conducted by Setyowati (2010) showed that their expansion volume was aligned with their hygroscopicity value. The crackers crispiness increases if the cracker have a higher hygroscopicity value (Wahyuningtyas et al., 2014).

## Chemical Characteristics

Water Content

Table 2 shows the cracker water content analysis using ANOVA at the 95% confidence interval ($\alpha \leq 0.05$). The black garlic concentration significantly effected the crackers water content, so the DNMRT test was carried out. The STPP concentration and the interaction between the two had no significant effect on the water content value. The crackers water content with different concentrations of black garlic and STPP ranged from 5.23±0.56% to 7.44±0.38%. The crackers water content would increase if the black garlic concentration added to the cracker increased. The water content of black garlic is 53.62% (Herlina et al., 2019). Increasing the black garlic concentration can increase the crackers water content because the other ingredients concentration used in production (except STPP) remains the same. According to Setyowati (2010), cracker made by adding STPP will increase the crackers water content from 0.7% to 0.9%, but it is not significantly different. The crackers water content based on SNI 0272-1990 is a maximum of 12%, so the cracker produced meet the SNI requirements.

**Table 2.** The crackers chemical characteristics value at variations concentrations of black garlic and STPP

| Treatment (%) | Water Content (%) | Ash Content (%) | Total Polyphenols (%) | Antioxidant Activity (%) |
|---|---|---|---|---|
| BG 3 : STPP 0.1 | 5.23±0.56$^{c}$ | 2.04±0.19$^{e}$ | 0.171±0.001$^{d}$ | 15.58±0.16$^{c}$ |
| BG 3 : STPP 0.3 | 5.57±0.91$^{c}$ | 2.44±0.43$^{de}$ | 0.174±0.001$^{cd}$ | 15.83±0.06$^{c}$ |
| BG 3 : STPP 0.5 | 5.83±0.14$^{c}$ | 2.77±0.25$^{d}$ | 0.175±0.001$^{c}$ | 16.14±0.12$^{c}$ |
| BG 6 : STPP 0.1 | 6.09±0.57$^{bc}$ | 2.27±0.22$^{cd}$ | 0.177±0.002$^{bc}$ | 19.10±0.47$^{b}$ |
| BG 6 : STPP 0.3 | 6.37±0.51$^{bc}$ | 2.73±0.78$^{c}$ | 0.179±0.002$^{b}$ | 19.59±0.03$^{b}$ |
| BG 6 : STPP 0.5 | 6.60±0.90$^{b}$ | 3.07±0.06$^{bc}$ | 0.180±0.003$^{b}$ | 19.75±0.25$^{b}$ |
| BG 9 : STPP 0.1 | 6.99±0.09$^{ab}$ | 2.53±0.07$^{b}$ | 0.181±0.003$^{ab}$ | 21.36±0.19$^{a}$ |
| BG 9 : STPP 0.3 | 7.02±0.52$^{ab}$ | 2.94±0.36$^{ab}$ | 0.184±0.005$^{a}$ | 22.16±0.50$^{a}$ |
| BG 9 : STPP 0.5 | 7.44±0.38$^{a}$ | 3.37±0.32$^{a}$ | 0.185±0.002$^{a}$ | 22.38±0.13$^{a}$ |

**Notes**: Numbers in the same column followed by the same letter show results that have no significant effect at the 95% confidence interval ($\alpha \leq 0.05$).

Ash Content

Table 2 shows the crackers ash content using ANOVA at the 95% confidence interval ($\alpha \leq 0.05$). The black garlic and STPP concentration significantly effected the cracker ash content, so the DNMRT test was carried out. The interaction between the two had no significant effect on the cracker ash content. The crackers ash content with different concentrations of black garlic and STPP ranged from 2.04±0.19% – 3.37±0.32%. The ash content increase if the concentration of black garlic and STPP increase. The black garlic ash content is 3.15% (Herlina et al., 2019). The black garlic concentration increases from 3% to 6% on average, increasing the crackers ash content by 0.28%. The crackers ash content based on SNI 0272-1990 is 2% maximum, so all the cracker produced did not meet SNI.

STPP is an inorganic salt, and inorganic material is the main component of ash. The ash content increases when the STPP concentration increases due to phosphorus penetration from STPP into the starch granules (Widhaswari & Putri, 2014). This penetration causes STPP to bind to the starch polymer chains and form phosphate bridges between starch molecules. Phosphorus can increase the crackers ash content because phosphorus is one of the mineral components that make up ash.

Total Polyphenols

Table 2 shows the crackers total polyphenol using ANOVA at the 95% confidence interval ($\alpha \leq 0.05$). The black garlic concentration significantly effected the crackers total polyphenol, so the DNMRT test was carried out. The STPP concentration and their interactions did not significantly affect the crackers total polyphenol. Total cracker polyphenols with different concentrations of black garlic and STPP ranged from 0.171±0.001% – 0.185±0.02%. If the added black garlic concentration increases, the crackers total polyphenols also increase. The highest total polyphenols were found at concentrations of 9% garlic and 0.5% STPP. According to Herlina et al. (2019), total black garlic polyphenols ranged from 0.93% to 1.19%.

Antioxidant Activity

Table 2 shows the crackers antioxidant activity using ANOVA at the 95% confidence interval ($\alpha \leq 0.05$). The black garlic concentration significantly effected the crackers antioxidant activity, so the DNMRT test was carried out. The STPP concentration and their interactions did not significantly affect the crackers antioxidant activity. The crackers antioxidant activity with different concentrations of black garlic and STPP ranged from 15.58±0.16% to 22.38±0.13%. The crackers antioxidant activity increased when the black garlic concentration increased.

The highest antioxidant activity was found in cracker with a 9% black garlic concentration. Table 2 shows that black garlic concentration increase from 3% to 9% in cracker production will increase its antioxidant activity by 6.12%. This increase is due to black garlic's antioxidant activity, 72.83% (Herlina et al., 2019). The crackers antioxidant activity was relatively small compared to the black garlic's antioxidant activity. This result was due to the cracker production's steaming, drying, and frying process. The heat generated during production can reduce the crackers antioxidant activity. Antioxidant activity decrease also occurred in a study of red cabbage antioxidant cracker conducted by Putri et al. (2018). This study's results indicated that red cabbage's antioxidant activity decreased from 86.98% to 23.93% when cooked into cabbage cracker. Temperature increases cause antioxidant activity to decrease. Antioxidants begin to break down or degrade from 60 °C to 70 °C (Miryanti et al., 2011).

**Organoleptic Test**

Color Preference

The chi-square test results at $\alpha \leq 0.05$ showed that black garlic and STPP concentration added to the cracker production significantly effected panelists' preference for cracker color. The color preference for various concentrations of black garlic and STPP ranged from 3.44±0.11 to 6.88±0.11 (Table 3). Panelists preferred cracker with 3% black garlic and 0.3% STPP. Panelists preferred the bright crackers color because it was more attractive and did not look burnt. The high concentration of black garlic caused the crackers color darker, and the panelist did not like it. The 3% black garlic concentration treatment cracker had a brighter color than the 9% one. High concentrations of STPP can also cause the product to be darker due to its ability to bind water, so the cracker color is much more intense. The high water content will increase the product's wetting properties. Water is easier to enter the product's pores, causing the product's color to become darker. Widhaswari & Putri (2014) stated that the presence of water in the cracker would trigger a Maillard reaction, causing the crackers color to be darker. At the Maillard reaction, carbohydrates in flour and carbohydrates in black garlic cause reducing sugars to react with the primary amine groups of proteins which produce melanoidin pigments so that the color of the cracker turns brown (Hustiany, 2017).

**Table 3.** The crackers preference score at variations concentrations of black garlic and STPP

| Treatment (%) | Color | Flavor | Taste | Crispiness | Overall |
|---|---|---|---|---|---|
| BG 3 : STPP 0.1 | $6.00{\pm}0.15^{a}$ | $5.56{\pm}0.33^{b}$ | $5.68{\pm}0.21^{b}$ | $6.16{\pm}0.27^{a}$ | $5.76{\pm}0.32^{b}$ |
| BG 3 : STPP 0.3 | $6.88{\pm}0.11^{a}$ | $6.12{\pm}0.23^{a}$ | $6.28{\pm}0.27^{a}$ | $6.28{\pm}0.43^{a}$ | $6.40{\pm}0.23^{a}$ |
| BG 3 : STPP 0.5 | $6.00{\pm}0.12^{a}$ | $5.60{\pm}0.43^{b}$ | $5.68{\pm}0.31^{b}$ | $6.92{\pm}0.32^{a}$ | $6.28{\pm}0.42^{a}$ |
| BG 6 : STPP 0.1 | $5.76{\pm}0.20^{b}$ | $5.48{\pm}0.21^{b}$ | $5.64{\pm}0.32^{b}$ | $5.24{\pm}0.23^{b}$ | $5.92{\pm}0.32^{b}$ |
| BG 6 : STPP 0.3 | $5.48{\pm}0.30^{b}$ | $5.84{\pm}0.22^{b}$ | $5.24{\pm}0.12^{b}$ | $5.40{\pm}0.33^{b}$ | $5.84{\pm}0.24^{b}$ |
| BG 6 : STPP 0.5 | $4.88{\pm}0.23^{b}$ | $5.56{\pm}0.34^{b}$ | $5.44{\pm}0.17^{b}$ | $5.56{\pm}0.32^{b}$ | $5.60{\pm}0.26^{b}$ |
| BG 9 : STPP 0.1 | $4.20{\pm}0.19^{bc}$ | $5.12{\pm}0.14^{c}$ | $3.56{\pm}0.32^{c}$ | $4.20{\pm}0.12^{c}$ | $4.44{\pm}0.11^{c}$ |
| BG 9 : STPP 0.3 | $3.44{\pm}0.11^{c}$ | $4.64{\pm}0.17^{c}$ | $3.48{\pm}0.44^{c}$ | $4.60{\pm}0.32^{c}$ | $4.56{\pm}0.26^{c}$ |
| BG 9 : STPP 0.5 | $3.80{\pm}0.24^{c}$ | 4.76±0.19c | $5.84{\pm}0.32^{c}$ | $4.80{\pm}0.33^{c}$ | $5.68{\pm}0.32^{c}$ |

**Notes**: Numbers in the same column followed by the same letter show results that have no significant effect at the 95% confidence interval ($\alpha \leq 0.05$).

Flavor Preference

The chi-square test results at $\alpha \leq 0.05$ showed that black garlic and STPP concentration significantly effected the panelists' preference for the flavor. The flavor preference for various concentrations of black garlic and STPP ranged from 4.64±0.17 to 6.12±0.23 (Table 3). Panelists preferred cracker with 3% black garlic and 0.3% STPP. Volatile substances caused the flavor of black garlic. According to Hustiany (2017), volatile substances are caused by reactions between carbohydrates, proteins, and fats or oil during high heating resulting in caramelization, Maillard, and oxidation reactions. The volatile substance in black garlic called allicin resulted in a pungent odor which the panelists did not like. Allicin is a transformation result from alliin compounds. According to Nelwida et al. (2019), high temperature causes the alliin compound to become unstable and turns into allicin which causes a sweet taste and flavor. The high concentration of black garlic causes the cracker flavor even stronger, and panelists did not like this.

Taste Preference

The chi-square test results at $\alpha \leq 0.05$ showed that black garlic and STPP concentration significantly effected the panelists' preference for the crackers taste. The taste preference for various concentrations of black garlic and STPP ranged from 3.48±0.44 to 6.28±0.27 (Table 3). Panelists preferred cracker with 3% black garlic and 0.3% STPP. Taste is an essential factor in food. The taste elicited in a food depends on the components of its constituent compounds. The combinations of various food ingredients and integrated flavors produce a complete food taste. The ingredient's consistency, concentration, and processing method will affect food taste. Panelists preferred cracker with low black garlic concentrations because black garlic had a slightly bitter taste from its azepine compounds. This compound was produced from the reaction between pyroline and pentenolone at the Maillard reaction when the black garlic production process (Hustiany, 2017).

Crispiness Preference

The chi-square test results at $\alpha \leq 0.05$ showed that black garlic and STPP concentration significantly effected the panelists' preference for the crackers crispiness. The crispiness preference for various concentrations of black garlic and STPP ranged from 4.20±0.12 to 6.92±0.32 (Table 3). The crispiness assessment used the senses of taste and hearing as parameters in the organoleptic assessment. The panelists preferred cracker with 3% black garlic concentration and 0.5% STPP. This result was because cracker with this treatment had the highest level of crispiness with a swelling power value of 82.51±0.11% and a hygroscopicity of 5.07±0.41%.

The 0.5% STPP in the cracker production can increase the cross-linking of the amylose/amylopectin chains with sodium/phosphate from STPP. Cross-linking will increase water holding capacity to reduce cracker shrinkage and increase cracker tenderness, elasticity, and crispiness (Stephen & Phillips, 2006).

Overall Preference

The chi-square test results at $\alpha \leq 0.05$ showed that black garlic and STPP concentration significantly effected the panelists' overall preference. The overall preference for various concentrations of black garlic and STPP ranged from 4.44±0.11 to 6.40±0.23 (Table 3). Panelists liked cracker with 3% black garlic concentration and 0.3% STPP concentration. The panelists' overall preference is a combination of color, flavor, taste, and crispiness preference. Panelists liked cracker with bright colors, not too overpowering black garlic flavor, savory flavors, and crispy.

**Effectiveness Test**

The effectiveness test is a method for determining the best treatment. Table 4 shows the crackers effectiveness score with various concentrations of black garlic and STPP based on the test parameters for swelling power, hygroscopicity, water content, ash content, total polyphenols, antioxidant activity, and preferences for color, flavor, taste, and crispiness. The highest effectiveness score was the cracker treatment with 3% black garlic concentration and 0.5% STPP with a value of 0.64.

**Table 4.** The crackers effectiveness score at various concentrations of black garlic and STPP

| No. | Treatments (%) | Effectiveness Score |
|---|---|---|
| 1 | BG 3 : STPP 0.1 | 0.58 |
| 2 | BG 3 : STPP 0.3 | 0.51 |
| 3 | BG 3 : STPP 0.5 | 0.64 |
| 4 | BG 6 : STPP 0.1 | 0.51 |
| 5 | BG 6 : STPP 0.3 | 0.52 |
| 6 | BG 6 : STPP 0.5 | 0.54 |
| 7 | BG 9 : STPP 0.1 | 0.53 |
| 8 | BG 9 : STPP 0.3 | 0.47 |
| 9 | BG 9 : STPP 0.5 | 0.57 |

**Notes**: The highest effectiveness score is the best treatment

## CONCLUSIONS

The concentration of black garlic significantly effected the crackers color, swelling power, hygroscopicity, water content, ash content, antioxidant activity, and total polyphenols. STPP concentration significantly effected the cracker ash content. The black garlic and STPP concentration have significant organoleptic effects on color, flavor, taste, crispiness, and overall preference. The best and preferred cracker were made with 3% black garlic and 0.5% STPP. The effectiveness score of these cracker was 0.64, with physical characteristics of color lightness 23.39±0.20, swelling power 82.51±0.11%, hygroscopicity 5.07±0.41%, chemical characteristics of water content 5.83±0.14%, ash content 2.77±0.25%, total polyphenols 0.175±0.001%, antioxidant activity 16.14±0.12. The organoleptic test values for the crackers preference for color were 6.00±0.12, flavor 5.60±0.43, taste 5.68±0.31, crispiness 6.92±0.32, and overall 6.28±0.42.

### References

Andarwulan, N., Kusnandar, F., & Herawati, D. (2011). *Analisis Pangan*. Jakarta: Dian Rakyat.

Ayustaningwarno, F. (2014). *Teknologi Pangan Teori Praktis dan Aplikasi*. Yogyakarta: Graha Ilmu.

Berliana, A., Abidin, J., Salsabila, N., Maulidia, N. S., Adiyaksa, R., & Siahaan, V. F. (2021). Penggunaan bahan tambahan makanan berbahaya boraks dan formalin dalam makanan jajanan: Studi literatur. *SALINK (Jurnal Sanitasi Lingkungan)*, *1*(2), 64–71.

Chedea, V. S., & Pop, R. M. (2019). Total Polyphenols Content and Antioxidant DPPH Assays on Biological Samples. In *Polyphenols in Plants* (pp. 169–183). Elsevier. https://doi.org/10.1016/B978-0-12-813768-0.00011-6

Choi, I. S., Cha, H. S., & Lee, Y. S. (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.

Harjosuwono, B. A., Arnata, I. W., & Puspawati, G. A. K. D. (2011). *Rancangan Percobaan Teori Palikasi SPSS dan Excel*. Malang: Lintas Kata Publishing.

Haryati, S., Sudjatina, & Sani, E. Y. (2019). Karakteristik fisikokimia dan organoleptik kerupuk subtitusi susu dan tepung tapioka dengan metode cair. *Jurnal Pengembangan Rekayasa Dan Teknologi*, *15*(1), 54–63. https://doi.org/10.26623/jprt.v15i1.1506

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

Hustiany, R. (2017). *Reaksi Maillard Pembentuk Citarasa dan Warna pada Produk Pangan*. Banjarmasin: Lambung Mangkurat University Press.

Khairunnisa, A., & Syukri, A. (2021). *Good Sensory Practices dan Bias Panelis*. Tangerang: Universitas Terbuka.

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

Koswara, S. (2009). *Pengolahan Aneka Kerupuk*. Semarang: eBookPangan.com. Retrieved from http://tekpan.unimus.ac.id/wp-content/uploads/2013/07/PENGOLAHAN-ANEKA-K-E-R-U-P-U-K.pdf

Miryanti, Y. I. P. A., Sapei, L., Budiono, K., & Indra, S. (2011). *Ekstraksi Antioksidan dari Kuit Buah Manggis* (Vol. 2). Bandung.

Mustofa, K. A., & Suyanto, A. (2011). Kadar kalsium, daya kembang, dan sifat organoleptic kerupuk onggok singkong dengan variasi penambahan tepung cangkang rajungan (Portunus pelagicus). *Jurnal Pangan Dan Gizi*, *2*(1), 1–14.

Nelwida, Berliana, & Nurhayati. (2019). Kandungan nutrisi black garlic hasil pemanasan dengan waktu berbeda. *Jurnal Ilmiah Ilmu-Ilmu Peternakan*, *22*(1), 53–64. https://doi.org/10.22437/jiiip.v22i1.6471

Putri, A. S., Kristiani, E. B., & Haryati, S. (2018). Kandungan antioksidan pada kubis merah (Brassica oleracea L.) dan aplikasinya pada pembuatan kerupuk. *Metana : Media Komunikasi Rekayasa Proses Dan Teknologi Tepat Guna*, *14*(1), 1–6. https://doi.org/10.14710/metana.v14i1.19162

Retnaningtyas, D. A., & Putri, W. D. R. (2014). Karakterisasi sifat fisikokimia pati ubi jalar oranye hasil modifikasi perlakuan STPP (lama perendaman dan konsentrasi). *Jurnal Pangan Dan Agroindustri*, *2*(4), 68–77.

Rosiani, N., Basito, B., & Widowati, E. (2015). Kajian karakteristik sensoris fisik dan kimia kerupuk fortifikasi daging lidah buaya (Aloe vera) dengan metode pemanggangan menggunakan microwave. *Jurnal Teknologi*

*Hasil Pertanian*, *8*(2), 84–98. https://doi.org/10.20961/jthp.v0i0.12896

Rosida, Yulistiani, R., & Awandhana, R. (2013). Kajian kualitas fisiko kimia dan mikrobiologi tempura ikan mujair menggunakan sodium tripolyphosphate. *Jurnal Teknologi Pangan*, *7*(1), 123–139.

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

Setyowati, A. (2010). Penambahan natrium tripolifosfat dan CMC (carboxy methyl cellulose) pada pembuatan karak. *Jurnal Agrisains*, *1*(1), 40–49.

Stephen, A. M., & Phillips, G. O. (2006). *Food Polysaccharides and Their Applications* (2nd ed.; A. M. Stephen & G. O. Phillips, eds.). CRC Press. https://doi.org/10.1201/9781420015164

Wahyuningtyas, N., Basito, & Atmaka, W. (2014). Kajian karakteristik fisikokimia dan sensoris kerupuk berbahan baku tepung terigu, tepung tapioka dan tepung pisang kepok kuning. *Jurnal Technosains Pangan*, *3*(2), 76–85.

Widhaswari, V. A., & Putri, W. D. R. (2014). Pengaruh modifikasi kimia dengan STPP terhadap karakteristik tepung ubi jalar ungu. *Jurnal Pangan Dan Agroindustri*, *2*(3), 121–128.

Yuliani, Marwati, Wardana, H., Emmawati, A., & Candra, K. P. (2018). Karakteristik kerupuk ikan dengan substitusi tepung tulang ikan gabus (Channa striata) sebagai fortifikan kalsium. *Jurnal Pengolahan Hasil Perikanan Indonesia*, *21*(2), 258–265. https://doi.org/10.17844/jphpi.v21i2.23042

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

Zulfahmi, A. N., Swastawati, F., & Romadhon. (2014). Pemanfaatan daging ikan tenggiri (Scomberomorus commersoni) dengan konsentrasi yang berbeda pada pembuatan kerupuk ikan. *Jurnal Pengolahan Dan Bioteknologi Hasil Perikanan*, *3*(4), 133–139.