Color and aroma changes in potato and chicken meat due to maillard reaction during roasting

Jaclyn Regina Anggara [1], Sharon Gisella Tambayong [2], Elbert Keene Wibowo [3], Fransisca Romana Titis Suniati [4*]

[1,2,3,4] *Universitas Ciputra Surabaya, Indonesia*

**Corresponding author: fransisca.titis@ciputra.ac.id*

JTCE

Journal of Tourism, Culinary, and Entrepreneurship

e-ISSN: 2776-0928

Publisher:
School of Tourism, Universitas Ciputra Surabaya, Indonesia

Keywords:
Maillard Reaction
Chicken Meat
Potatoes
Melanoidin
Color
Aroma

Received: *June 26, 2025*
Revised: *August 23, 2025*
Accepted: *September 1, 2025*

ABSTRACT

The Maillard reaction is a non-enzymatic browning process that occurs between reducing sugars and amino acids during heating, playing a key role in the development of color and aroma in food products. This study aims to evaluate the changes in color and aroma resulting from the Maillard reaction in food products subjected to different heating durations. Objective color analysis was performed using a colorimeter to measure browning index (BI), chroma, and °hue, as well as spectrophotometric analysis, while aroma was assessed subjectively. The results indicated that heating duration significantly influenced color changes and melanoidin formation in chicken, as evidenced by increased BI and chroma values, along with shifts in °hue. In contrast, although absorbance increased in potato samples, the color change was not significant, likely due to the low levels of reducing sugars, fat, and protein. Heating also enhanced the characteristic aroma of both chicken and potatoes, attributed to the formation of volatile compounds through the Maillard reaction.

1. INTRODUCTION

The Maillard reaction is a non-enzymatic browning process that occurs when reducing sugars present in carbohydrates react with amino acids containing primary amine groups under heat (Ridhani et al., 2021). This reaction involves interactions between reducing sugars, such as aldoses and ketoses, and primary amine groups from amino acids or other compounds containing amine groups (Safitri et al., 2023). Several factors influence the Maillard reaction, including temperature, moisture content, pH, and the concentrations of both amino acids and sugars (Fajri et al., 2023). High temperatures and prolonged storage typically promote the Maillard reaction (Rokana et al., 2022). The optimal Maillard reaction depends on appropriate heating duration. Longer exposure to heat and higher temperatures will lead to a greater extent of the Maillard reaction (Zhang et al., 2021). This reaction leads to changes in the color, aroma, and flavor of food products due to the formation of melanoidin compounds (Yuwana et al., 2022). Melanoidins are formed due to thermal processing of food material such as cooking, baking, roasting, and storage which are caused by reducing sugar and free amino groups. Consequently, temperature has the greatest impact on the development of melanoidin structures (Singh et al., 2021). The Maillard reaction starts to occur at a temperature of 140°C (Rokana et al., 2022). While Maillard reaction reaches its optimal rate at 180°C (El Hosry et al., 2025). The Maillard reaction plays a significant role during the processing and storage of various food products, including fruits, vegetables, cereals, dairy, and meats, affecting the overall quality of the final product. Additionally, it can influence the nutritional value of food and contribute to the development of specific flavor profiles. The formation of brown pigments, known as melanoidins, indicates the occurrence of Maillard reactions between proteins and carbohydrates in food. These changes may be perceived positively or negatively by consumers, depending on the product (Ramadhani et al., 2022). However, information regarding the effect of heating duration on food materials with different chemical compositions, such as protein- and fat-rich chicken meat and carbohydrate-dominant potatoes, remains limited. This gap poses challenges in controlling processing conditions to achieve optimal color, aroma, and quality without reducing nutritional value or triggering the formation of harmful compounds such as acrylamide. Therefore, this study aims to investigate the effect of oven duration on the Maillard reaction, using color, aroma, and absorbance values as parameters in chicken meat and potato samples. The comparison of these two materials is expected to provide a scientific basis for optimizing the roasting process to maintain sensory quality and product safety, while minimizing nutrient loss and the formation of undesirable compounds.

2. METHODOLOGY

This research was conducted in Surabaya, Indonesia, specifically in the Chemistry and Biochemistry Laboratory at Universitas Ciputra Surabaya. The research method used was a Completely Randomized Design (CRD).

Tools dan Materials

The equipment used in this research included a colorimeter, spectrophotometer, oven, centrifuge, test tube, mortar, pestle, glass funnel, and dropper pipette. The materials used were water, chicken meat, potatoes, aluminum foil, and toothpicks.

Roasting Procedure

Chicken meat and potatoes were sliced into uniform dimensions of 5 × 5 × 0.5 cm. Both samples were wrapped in aluminum foil and pierced with a toothpick. The samples were then placed in an oven and roasted at 180°C for 0, 15, and 30 minutes. Following the heat treatment, the samples were subjected to analysis for color and aroma changes.

Color Change Analysis Procedure

After undergoing thermal treatment, the samples were analyzed using a colorimeter. The browning index of each sample was calculated using equations (1) and (2). Subsequently, the chroma value was determined using equation (3), and the hue angle (°hue) was calculated based on equation (4).

$$x = \frac{(a* + 1{,}75L*)}{(5{,}645L* + a* - 0{,}3012b*)} \quad (1)$$

$$BI = \frac{[100(x - 0{,}31)]}{0{,}172} \quad (2)$$

$$chroma = \sqrt{a*^2 + b*^2} \quad (3)$$

$$°hue = arctan\ \frac{b*}{a*} \quad (4)$$

Aroma Analysis Procedure

The treated samples were evaluated for their aroma qualitatively by five untrained panelists. Each panelist smelled the treated samples, and the perceived aroma was rated using a scale as follows: 1 (slightly detectable), 2 (detectable), 3 (strongly detectable).

Spectrophotometric Analysis Procedure

Both unbaked and baked chicken meat and potatoes were weighed to obtain 1 gram of each sample. The samples were then ground using a mortar and pestle and mixed with 10 mL of water at 90°C. After thorough mixing, the samples were transferred into test tubes and centrifuged at 5000 rpm for 3 minutes. The resulting supernatant was extracted using a dropper pipette and placed into a cuvette. The cuvette containing the sample was then analyzed using a spectrophotometer at a wavelength of 400 nm.

Data Analysis Procedure

Browning index, chroma, and °hue were analyzed using one-way ANOVA (α = 0.05), followed by Tukey's HSD post hoc test for significance differences. Statistical analyses were performed using JASP 19.3.

3. RESULTS AND DISCUSSION

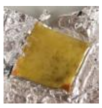
Maillard Reaction

The Maillard reaction occurs in three stages, beginning with the condensation of ketose or aldose sugars with an amine group to form a Schiff base, which then progresses to the formation of Amadori (aldose) or Heyns (ketose) intermediate compounds. Subsequently, the intermediate compounds involving the Amadori Rearrangement Product (ARP) undergo decomposition, resulting in volatile and non-volatile compounds. At this stage, dehydration occurs, forming furfural or reductones, along with a fission stage through aldolization, leading to Strecker degradation. Finally, carbonyl compounds, furfural, fission products, and Strecker aldehydes form melanoidins, which contribute to brown color formation, contain antioxidants, and can mask undesirable odors (Ridhani et al., 2021).

The samples were wrapped in aluminum foil to maintain moisture during the heating process. Aluminum foil serves to retain water vapor, gas, and air from the environment, as well as to reduce water loss in the samples (Pagiatun & Setiawan, 2023). The Maillard reaction occurs optimally at a water content of approximately 10–15% (Rokana et al., 2022). A water content that is too low limits molecular mobility, while excessive water content can dissolve reaction products, thereby reducing brown color formation (Dai et al., 2023). Additionally, the use of aluminum foil helps control heat transfer to prevent excessive heating and protects the samples from oxidation during the heating process (Duru & Duru, 2020).

Comparison of Color between Chicken Meat and Potatoes

Table 1. Observation Results of Color and Aroma in Chicken Meat and Potatoes

Parameter	Chicken Meat			Potatoes		
	0 Min	15 Min	30 Min	0 Min	15 Min	30 Min
Picture						
Browning Index	4.71± 0.45^{c}	27.4± 0.2^{a}	22.38± 0.16^{b}	6.64± 3.73	6.14± 0.41	4.08± 1.25
Chroma	-0.49± 0.22^{b}	0.56± 0.01^{a}	1.01± 0.00^{a}	1.29± 0.01	1.48± 0,04	1.01± 2.19
°hue	6.38± 0.16^{c}	42.99± 0.42^{b}	48.41± 0.57^{a}	30.84± 0.3	29.5± 1.97	31.85± 5.34
Aroma	1	3	3	1	2	3

*Description: 1 (slightly detectable), 2 (detectable), 3 (strongly detectable).
*Superscript letters that differ within the same row indicate that the corresponding values are significantly different from each other at a 95% confidence level (P < 0.05).

Based on the results presented in Table 1, the browning index (BI) of chicken meat samples increased significantly after 15 minutes of roasting at 180 °C. However, the BI significantly decreased when roasting was extended from 15 to 30 minutes. The chroma value of chicken meat showed a consistent increase at both 15 and 30 minutes of roasting. A significant difference was observed between 0 and 15 minutes as well as between 0 and 30 minutes, but not between 15 and 30 minutes. Meanwhile, the hue angle (°hue) of chicken meat increased progressively throughout the 30-minute roasting period, with significant differences found among all treatments. In contrast, potato samples showed a decreasing trend in browning index over the 30-minute roasting period at 180°C, although the differences among treatments were not statistically significant. The chroma values of potatoes tended to increase during the first 15 minutes and slightly decreased after 30 minutes of roasting, yet these changes were also not statistically significant. Lastly, the hue angle of potatoes decreased after 15 minutes of roasting and then increased after 30 minutes, with no significant differences observed among treatments.

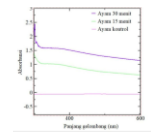
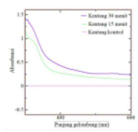
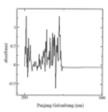
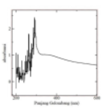
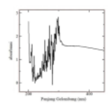
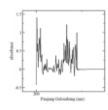
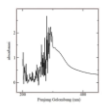
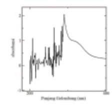
The browning index (BI) of chicken meat showed significant variation during the roasting process, with an increase observed at 0 and 15 minutes of roasting, followed by a decline at 15 to 30 minutes. This trend is attributed to the oxidation of fats and proteins that occurs during heating (Lv et al., 2023). However, the decrease in BI at 15 and 30 minutes may also be due to the fact that the raw chicken meat exhibits a darker brown color compared to partially or fully cooked meat. The amino acids and fats present in chicken meat act as precursors for the Maillard reaction to occur (Sholihah et al., 2024). An optimal Maillard reaction in chicken typically results in a BI value ranging from 30.86 to 33.75 (Taikerd & Leelawat, 2023). In contrast, the BI of potatoes did not show significant changes during the roasting process. The observed decrease in BI aligns with a reduction in redness, indicating that browning reactions were not proceeding effectively (Nascimento et al., 2021). Sterilized potatoes have been reported to show a BI value of 0.238 based on spectrophotometric absorbance (Nascimento & Canteri, 2020). In this study, BI values for both chicken and potatoes were calculated using lightness, redness, and yellowness parameters. Potatoes, which are low in protein and fat, exhibited no significant differences in Maillard reaction during roasting. BI values in protein-based samples did not differ significantly, whereas carbohydrate-based samples also showed no significant difference. This is because the Maillard reaction requires amino acids from proteins and reducing sugars. Protein-based samples contain sufficient amino acids to support a notable Maillard reaction during heating, whereas carbohydrate-based samples lack enough amino acids, resulting in a limited and insignificant reaction. Adequate sugar content and roasting conditions also influence BI outcomes (Kiranawati et al., 2021). BI serves as an indicator of the extent of the Maillard reaction in chicken meat. The optimum Maillard reaction is indicated by peak BI values, before melanoidin degradation begins. At this peak, melanoidins are fully formed, giving the product a deep brown color. However, prolonged heating beyond the optimal point can lead to the degradation of melanoidins (Alugwu et al., 2022). BI measurement helps assess the intensity of browning, which visually impacts the perceived quality of the product (Wulandari et al., 2023). The darker the color resulting from the Maillard reaction, the higher the BI value (Leelawat & Taikerd, 2024).

The chroma value of chicken meat showed no significant difference between the 15- and 30-minute treatments but did show a significant difference at the 0-minute treatment. The low chroma value in unroasted chicken is due to the suboptimal formation of melanoidins, which are brown pigments produced during the Maillard reaction (Chakraborty et al., 2022; Laurencia et al., 2023)Additionally, the fat content in chicken can influence chroma values. When fat is not directly exposed to heat, it tends to produce a pale yellow color (Martuscelli et al., 2021). Meanwhile, the chroma values of potatoes showed no significant differences across all treatment durations. This indicates that varying roasting times did not significantly affect the color intensity of the potatoes. The low content of reducing sugars in the potato variety used likely contributed to the lack of significant chroma changes, as the reducing sugars required for the Maillard reaction may have been depleted (Islam et al., 2022). The presence of amino acids such as histidine and lysine, which are relatively dominant, can accelerate the Maillard reaction in potatoes. However, as roasting time increases, changes in chroma become less pronounced (Sun et al., 2021). Chroma is used to measure the strength or saturation of a color—how dull or vivid it appears. In this study, chroma values indicated color intensity, where higher chroma values correspond to more vivid or saturated colors (Thamrin et al., 2022). An increase in chroma value also reflects greater color intensity changes resulting from the Maillard reaction (Hasanah et al., 2023).

The hue angle (°hue) of chicken meat showed a significant difference across treatments. The °hue value increased with longer roasting durations, indicating that the Maillard reaction became more prominent at the 15-minute mark, as shown by the sharp rise in hue angle. During the Maillard reaction, melanoidin compounds form, contributing to the brown coloration of the sample (Ridhani et al., 2021). This suggests that the color of the chicken meat shifted from red to reddish-yellow as reflected in the °hue values. The differences in °hue values across treatments were statistically significant, consistent with the stability of hue at temperatures between 180–200 °C during roasting times of 16–24 minutes (Savaş, 2025). In contrast, the °hue values of potato samples did not differ significantly across all treatments, as the potatoes already exhibited a reddish-yellow color even before the Maillard reaction occurred. Brightness (lightness) is not factored into the calculation of hue angle, so °hue cannot detect the brightness level of a sample (Misto et al., 2024). Instead, °hue is used to evaluate the base color or shade of a sample—red, yellow, green, blue, or purple. A °hue value of 0 indicates a red hue, and as the value increases, the color gradually shifts toward reddish-yellow, reaching a value of 54 (Iswanto & Afgani, 2025).

To complement the analysis of visual color changes observed through °hue, chroma, and BI, further examination was conducted using spectrophotometric measurements to quantify melanoidin formation. While BI, chroma, and °hue provide insights into the perceptible color shifts resulting from thermal processing, spectrophotometric analysis enables a more detailed evaluation of the chemical compounds, particularly melanoidins, that contribute to browning. The results of the spectrophotometric measurements are presented in Table 2.

Table 2. Observation Results of Spectrophotometer in Chicken Meat and Potatoes

Parameter	Chicken Meat			Potatoes		
	0'	15'	30'	0'	15'	30'
Graph of All Treatment						
Graph of Each Treatment						
Wavelength (nm)	203	291	299	200	279	290
Absorbance	1,302	2,435	2,835	1,414	2,678	2,055

Based on the results shown in Table 2, at the wavelength of 400 nm, the highest absorbance values for both samples were observed in the 30-minute treatment. This finding aligns with the study by Lestari et al. (2022), which reported that prolonged heating time leads to increased formation of melanoidin compounds, thereby resulting in higher absorbance values. In contrast, the control samples exhibited the lowest absorbance at 400 nm, likely due to the absence of a heating process, which prevents melanoidin formation at this wavelength (Rokana et al., 2022).

However, when considering absorbance values across the entire wavelength range, the highest absorbance for chicken was observed at 30 minutes, while the highest absorbance for potato was detected at 15 minutes. The elevated absorbance in the 15-minute potato treatment may be attributed to the presence of compounds other than melanoidins, particularly those absorbing at 279 nm. According to Saraiva (2020), the absorption in the 230–300 nm range is dominated by aromatic side chains of tryptophan, tyrosine, and phenylalanine residues. In the control samples, absorbance around 200 nm is presumed to result from non-melanoidin compounds, as this region typically corresponds to peptide bonds in proteins.

Absorption at this wavelength is due to π → π* transitions occurring within peptide bonds (Saraiva, 2020).

The comparison between absorbance values and BI, chroma, and °hue indicates a relationship between melanoidin formation and changes in visual characteristics. In chicken, the highest absorbance value was recorded in the 30-minute heating treatment, which also corresponded with increased BI and °hue values. This suggests that melanoidin formation during heating contributes to a browning effect (Ridhani et al., 2021; Sholihah et al., 2024). On the other hand, in potatoes, despite the highest absorbance at 400 nm also occurring at 30 minutes, no significant changes were observed in BI, chroma, or hue. This implies that although melanoidin-like compounds may be forming, visual changes in potatoes are minimal, likely due to their low content of proteins, fats, and reducing sugars that limit Maillard reactions, as well as their inherently yellowish-red color prior to heating (Alugwu et al., 2022); Islam et al., 2022).

Spectrophotometry operates on the principle of light absorption at specific wavelengths (Sulistyani et al., 2023). The choice of 400 nm was based on the characteristic absorption of melanoidin formed during thermal processing. Melanoidin absorbs light effectively in the range of 280–600 nm, with significant peaks around 300 ± 20 nm and 420 ± 20 nm (Gribkova et al., 2023). When melanoidin molecules absorb light from the spectrophotometer, they take in photon energy, causing electron excitation to higher energy levels. These electrons then return to their original states by releasing energy as heat or light. The amount of energy released is measured by the spectrophotometer as absorbance (Misto et al., 2024) According to the Lambert-Beer Law, absorbance is directly proportional to concentration, implying that higher absorbance values indicate higher concentrations of melanoidin in the sample (Fadhilah et al., 2022).

Comparison of Aroma between Chicken Meat and Potatoes

Based on Table 1, which presents results from a subjective aroma evaluation, the aroma of chicken meat was distinctly noticeable at the 15- and 30-minute roasting treatments. Meanwhile, the aroma of potatoes began to emerge at 15 minutes and became stronger at 30 minutes. According to Hustiany (2016), alkylpyrazines formed during the Maillard reaction in potatoes contribute to the characteristic aroma of potatoes. During this reaction, reducing sugars, formed from starch hydrolysis, react with free amino acids to release pyrazine compounds, which arise from the condensation of two amino ketone molecules. The amino acids and dicarbonyl compounds, derived from amino ketones, undergo Strecker degradation and aldol condensation, leading to the formation of 1-deoxyoson. After condensation, dehydration, and oxidation processes, alkylpyrazines form through interactions between glucose and asparagine. The Maillard reaction in potatoes produces several volatile compounds, including trans-β-ionone, which imparts a sweet aroma, and β-damascenone, formed from carotenoid degradation. Additionally, carbohydrates degrade into dark polymers that form 5-hydroxymethylfurfural, which gives a sweet aroma, furfural, with a roasted nut scent, 2-furanmethanol, which has a caramel-like (roasted) aroma, and maltol, with a caramel-like fragrance (Tsai et al., 2021).

In the case of chicken roasting, the Maillard reaction occurs when amino acids from chicken muscle proteins react with reducing sugars in the chicken tissue, producing aromatic compounds like pyrazine (which gives a nutty aroma) and thiazole (which provides a roasted meat scent). These aromatic compounds are formed through the degradation of cysteine and methionine. Pyrazine compounds are characteristic of roasted chicken due to the high temperature and low humidity required to form these compounds. Additionally, sulfur-containing compounds such as methanethiol, dimethyl trisulfide, and furanone contribute to the distinctive aroma of roasted chicken (Nie et al., 2024)

The oven temperature used in the study was 180°C, as the Maillard reaction typically begins at temperatures above 140°C. If temperatures above 180°C were used, the nutritional value of the sample could decrease due to the potential loss of amino acids and carbohydrates. Furthermore, toxic or carcinogenic substances may form because acrylamide, a potential toxic compound, is produced at temperatures above 180°C (Sen, 2017). At 180°C, amino acids in chicken react with reducing sugars to form pyrazine and thiazole compounds. In potatoes, starch breaks down into reducing sugars, which then react with asparagine to create aromas reminiscent of toasted bread and nuts (Mousavi et al., 2023). The temperature range of 140-180°C is suitable for the Maillard reaction in both chicken and potatoes. However, 180°C is optimal as the reaction occurs rapidly and produces the desired brown color and strong aroma. The aroma from the Maillard reaction in chicken is more intense than that in potatoes due to the higher amino acid content in chicken. The main components responsible for the Maillard reaction's distinctive volatile compounds, such as aldehydes, ketones, and sulfur, are derived from amino acids. Potatoes, being carbohydrate-based, contain fewer amino acids compared to chicken (Sandra et al., 2024).

4. CONCLUSION

This study demonstrates that heating duration influences color changes and melanoidin formation in chicken, as evidenced by increased BI, chroma, and shifts in °hue. In contrast, although absorbance increased in potatoes, color changes were not significant due to the low content of reducing sugars, fat, and protein. Heating also enhanced the characteristic aroma of both products, attributed to the formation of volatile compounds resulting from the Maillard reaction. However, this study was limited to potato and chicken meat samples, a single roasting temperature (180°C), and an untrained sensory panel, which may influence the research outcomes. Future studies should explore different sample types, as variations in chemical composition may lead to distinct Maillard reaction pathways. A wider range of temperature treatments is also necessary to capture more comprehensive thermal effects, while the involvement of trained panelists would provide reliable sensory validation. Together, these approaches would allow researchers to obtain more accurate and generalizable conclusions.

5. REFERENCES

Alugwu, S. U., Okonkwo, T. M., & Ngadi, M. O. (2022). Effect of cooking on physicochemical and microstructural properties of chicken breast meat. *European Journal of Nutrition & Food Safety*, *14*(11), 43–62. https://doi.org/10.9734/ejnfs/2022/v14i111264

Chakraborty, I., N, P., Mal, S. S., Paul, U. C., Rahman, M. H., & Mazumder, N. (2022). An insight into the gelatinization properties influencing the modified starches used in food industry: a review. In *Food and Bioprocess Technology* (Vol. 15, Issue 6, pp. 1195–1223). Springer. https://doi.org/10.1007/s11947-022-02761-z

Dai, Q., Hong, Q., Zhu, X., Hornung, P. S., Wang, H., Fang, W., Zhang, Y., & Beta, T. (2023). Formation of whey protein isolate–dextran conjugates by Maillard reaction with ethanol-water pretreatment. *LWT*, *185*. https://doi.org/10.1016/j.lwt.2023.115142

Duru, C. E., & Duru, I. A. (2020). Mobility of aluminum and mineral elements between aluminum foil and bean cake (Moimoi) mediated by pH and salinity during cooking. *SN Applied Sciences*, *2*(3). https://doi.org/10.1007/s42452-020-2170-0

El Hosry, L., Elias, V., Chamoun, V., Halawi, M., Cayot, P., Nehme, A., & Bou-Maroun, E. (2025). Maillard reaction: Mechanism, influencing parameters, advantages, disadvantages, and food industrial applications: A review. In *Foods* (Vol. 14, Issue 11). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/foods14111881

Fadhilah, R., Gatera, V. R., Saula, L. S., & Sakiran. (2022). Uji kadar formalin pada tahu yang di jual di Kabupaten Karawang dengan metode spektrofotometer visible. *Jurnal Ilmiah Wahana Pendidikan*, *8*(21), 357–369. https://doi.org/10.5281/zenodo.7275329

Fajri, P. Y., Astawan, M., & Wresdiyati, T. (2023). Evaluasi potensi rendang dan kalio minangkabau sebagai pangan fungsional. *Agroteknika*, *6*(1), 127–137. https://doi.org/10.55043/agroteknika.v6i1.208

Gribkova, I., Eliseev, M., Kosareva, O., Zakharov, M., & Zakharova, V. (2023). Evaluation of melanoidin contribution to colour characteristics of brewing products. *BIO Web of Conferences*, *57*, 1–5. https://doi.org/10.1051/bioconf/20235703001

Hasanah, C. T., Hidayat, L., Marniza, M., & Susanti, L. (2023). The physical, chemical and organoleptic characteristics of bay tat cake based on a mixture of wheat flour and potato flour (solanum tuberosum l.). *Edufortech*, *8*(2), 132–150. https://doi.org/10.17509/edufortech.v8i2

Hustiany, R. (2016). *Reaksi maillard pembentuk citarasa dan warna pada produk pangan*. Lambung Mangkurat University Press. https://www.researchgate.net/publication/342802067

Islam, M. M., Naznin, S., Naznin, A., Uddin, M. N., Amin, M. N., Rahman, M. M., Tipu, M. M. H., Alsuhaibani, A. M., Gaber, A., & Ahmed, S. (2022). Dry matter, starch content, reducing sugar, color and crispiness are key parameters of potatoes required for chip processing. *Horticulturae*, *8*(5), 1–12. https://doi.org/https://doi.org/10.3390/horticulturae8050362

Iswanto, F., & Afgani, C. A. (2025). Kajian penggunaan waktu yang tepat dalam proses penyangraian kopi biji asam khas sumbawa. *Jurnal Inovasi Teknologi Pangan*, *2*(1), 9–20.

Kiranawati, T. M., Rohajatien, U., & Rahma, S. J. (2021). Effect of long fermentation of dough on physical and chemical properties of crackers substitution of composite flour. *Jurnal Agroindustri*, *11*, 133–142. https://doi.org/10.31186/j.agroind.11.2.133-142

Laurencia, V. K., Mastuti, T. S., & Matita, I. C. (2023). Karakteristik cookies mocaf dengan substitusi ampas kacang hijau dan penambahan isolat soy protein. *FaST - Jurnal Sains Dan Teknologi*, *7*(1), 82–97. https://doi.org/https://doi.org/10.19166/jstfast.v7i1.6740

Leelawat, B., & Taikerd, T. (2024). Effect of drying methods and conditions on the physicochemical properties of young jackfruit-based chicken meat analogs. *ACS Food Science and Technology*, *4*(11), 2682–2689. https://doi.org/10.1021/acsfoodscitech.4c00561

Lestari, D., Hartanti, L., Sofiana, M. S. J., Yuliono, A., & Kurniadi, B. (2022). Proximate and essential macrominerals analysis of tembakul (mudskipper) fish flour as a food source for stunting prevention. *Berkala Saintek*, *10*(1), 45–50. https://doi.org/10.19184/bst.v10i1.31030

Lv, G., Wang, H., Wei, X., Lu, M., Yang, W., Aalim, H., Capanoglu, E., Zou, X., Battino, M., & Zhang, D. (2023). Cooking-induced oxidation and structural changes in chicken protein: their impact on in vitro gastrointestinal digestion and intestinal flora fermentation characteristics. *Foods*, *12*(23). https://doi.org/10.3390/foods12234322

Martuscelli, M., Esposito, L., & Mastrocola, D. (2021). The role of coffee silver skin against oxidative phenomena in newly formulated chicken meat burgers after cooking. *Foods*, *10*(8), 1–16. https://doi.org/10.3390/foods10081833

Misto, Indarti, S., Safitri, Y., Mutmainnah, Mulyono, T., & Alawiyah, D. D. (2024). Identification of chlorogenic acid, caffeine, melanoidin, sucrose, and protein content of local indonesia arabica coffee base on its cupping and variety variation. *BIO Web of Conferences*, *101*, 1–14. https://doi.org/10.1051/bioconf/202410101003

Mousavi, M. M., Mahmoudpourb, M., Yousefi, M., & Mortazavian, A. M. (2023). Strategies for reduction of acrylamide in fried potatoes and potato chips: a review. *Middle East Journal of Rehabilitation and Health Studies*, *11*(1), 1–8. https://doi.org/10.5812/mejrh-132710

Nascimento, R. F. do, Canteri, M. H. G., Rodrigues, S. Á., & Bittencourt, J. V. M. (2021). Optimization of processing parameters to control maillard browning in ready-to-eat processed potatoes. *Food Science and Technology International*, *27*(8), 764–775. https://doi.org/10.1177/1082013220984295

Nascimento, R. F., & Canteri, M. H. G. (2020). Use of sodium metabisulfite and ascorbic acid as anti-browning agents in processed potatoes. *British Food Journal*, *122*(2), 380–389. https://doi.org/10.1108/BFJ-05-2019-0322

Nie, R., Zhang, C., Liu, H., Wei, X., Gao, R., Shi, H., Zhang, D., & Wang, Z. (2024). Characterization of key aroma compounds in roasted chicken using SPME, SAFE, GC-O, GC–MS, AEDA, OAV, recombination-omission tests, and sensory evaluation. *Food Chemistry: X*, *21*, 1–11. https://doi.org/10.1016/j.fochx.2024.101167

Pagiatun, M. R. E., & Setiawan, A. W. (2023). Pengaruh jenis kemasan dan suhu penyimpanan terhadap pendugaan umur simpan beetroot leather dengan metode aslt (accelerated shelf life test). *AGRILAND Jurnal Ilmu Pertanian*, *11*(1), 22–33. https://doi.org/https://doi.org/10.30743/agr.v11i1.7472

Ramadhani, S. uriza, Agustini, T. W., & Suharti, S. (2022). Pengaruh penambahan jenis gula yang berbeda terhadap kualitas petis dari cairan pemindangan ikan tongkol (Euthynnus affinis). *Jurnal Ilmu Dan Teknologi Perikanan*, *4*(2), 77–84. https://doi.org/https://doi.org/10.14710/jekk.v%25vi%25i.13199

Ridhani, A. M., Prahastiwi Vidyaningrum, I., Nazzala Akmala, N., Fatihatunisa, R., Azzahro, S., & Aini, N. (2021). Potensi penambahan berbagai jenis gula terhadap sifat sensori dan fisikokimia roti manis: Review. *Pasundan Food Technology Journal (PFTJ)*, *8*(3), 61–68. https://doi.org/https://doi.org/10.23969/pftj.v8i3.4106

Rokana, E., Mubarak, A., & WK, D. A. (2022). Pengaruh lama waktu pemanasan terhadap kualitas organoleptik dan fisik biskuit biosuplemen. *Jurnal Buana Sains*, *22*(3), 1412–1638. https://doi.org/https://doi.org/10.33366/bs.v22i3.4499

Safitri, E., Dwi Anggo, A., & Rianingsih, L. (2023). Pengaruh penambahan tepung ikan nila (Oreochromis niloticus) terhadap kualitas dan daya terima fish flakes. *Jurnal Ilmu Dan Teknologi Perikanan*, *5*(1), 52–61. https://doi.org/https://doi.org/10.14710/jitpi.2023.15698

Sandra, S., Lutfi, M., & Choirunnisa, N. I. (2024). Pengaruh suhu dan frekuensi penggunaan minyak goreng kelapa (cocos nucifera l.) terhadap karakteristik fisikokimia kentang goreng. *Jurnal Ilmiah Rekayasa Pertanian Dan Biosistem*, *12*(2), 193–204. https://doi.org/10.29303/jrpb.v12i2.664

Saraiva, M. A. (2020). Interpretation of α-synuclein UV absorption spectra in the peptide bond and the aromatic regions. *Journal of Photochemistry and Photobiology B: Biology*, *212*, 1–14. https://doi.org/10.1016/j.jphotobiol.2020.112022

Savaş, A. (2025). Effects of different cooking parameters on various quality criteria, lipid oxidation, mineral composition, and free amino acid profile of chicken breast. *Processes*, *13*(5), 1–13. https://doi.org/10.3390/pr13051602

Sen, D. J. (2017). The maillard reaction of reducing sugars with amino acids in baking chemistry. *European Journal of Biomedical and Pharmaceutical Sciences*, *4*(1), 458–463. www.ejbps.com458

Sholihah, L. W., Handayani, I., Susila, U., & Jufrinaldi. (2024). Eksplorasi daging analog dari berbagai jenis protein nabati. *PESHUM: Jurnal Pendidikan, Sosial Dan Humaniora*, *4*(1), 1140–1148. https://doi.org/https://doi.org/10.56799/peshum.v4i1.7023

Singh, K., Tripathi, S., & Chandra, R. (2021). Maillard reaction product and its complexation with environmental pollutants: A comprehensive review of their synthesis and impact. *Bioresource Technology Reports*, *15*, 100779. https://doi.org/10.1016/j.biteb.2021.100779

Sulistyani, M., Huda, N., Prasetyo, R., & Alauhdin, M. (2023). Calibration of microplate uv-vis spectrophotometer for quality assurance testing of vitamin c using calibration curve method. *Indonesian Journal of Chemical Science*, *12*(2), 204–211. https://doi.org/10.15294/ijcs.v12i2.72451

Sun, Y., Lin, L., & Zhang, P. (2021). Color development kinetics of maillard reactions. *Industrial and Engineering Chemistry Research*, *60*(9), 3495–3501. https://doi.org/10.1021/acs.iecr.1c00026

Taikerd, T., & Leelawat, B. (2023). Effect of young jackfruit, wheat gluten and soy protein isolate on physicochemical properties of chicken meat analogs. *Agriculture and Natural Resources*, *57*(2), 201–210. https://doi.org/10.34044/j.anres.2023.57.2.01

Thamrin, E. S., Warsiki, E., Bindar, Y., & Amalia Kartika, I. (2022). Karakterisasi bahan pewarna tinta termokromik leuco dye system pada produk pempek ikan. *Itepa: Jurnal Ilmu Dan Teknologi Pangan*, *11*(4), 635–643. https://doi.org/https://doi.org/10.24843/itepa.2022.v11.i04.p05

Tsai, Y. J., Lin, L. Y., Yang, K. M., Chiang, Y. C., Chen, M. H., & Chiang, P. Y. (2021). Effects of roasting sweet potato (Ipomoea batatas l. lam.): Quality, volatile compound composition, and sensory evaluation. *Foods*, *10*(11), 1–3. https://doi.org/10.3390/foods10112602

Wulandari, P., Kusumasari, S., & Pamela, V. Y. (2023). Karakteristik fisikokimia food bar ubi ungu dengan penambahan tepung tulang ikan bandeng. *Jurnal Ilmu-Ilmu Pertanian*, *7*(2), 125–131. https://doi.org/https://doi.org/10.32585/ags.v7i2(is).4356

Yuwana, A. M. P., Putri, D. N., & Harini, N. (2022). Hubungan antara atribut sensori dan kualitas gula merah tebu: pengaruh ph dan kondisi karamelisasi. *Teknologi Pangan : Media Informasi Dan Komunikasi Ilmiah Teknologi Pertanian*, *13*(1), 54–66. https://doi.org/10.35891/tp.v13i1.2767

Zhang, Y., Yi, S., Lu, J., Pang, X., Xu, X., Lv, J., & Zhang, S. (2021). Effect of different heat treatments on the Maillard reaction products, volatile compounds and glycation level of milk. *International Dairy Journal*, *123*, 105182. https://doi.org/10.1016/j.idairyj.2021.105182