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Physical and Chemical Modification of Okara Flour and Its Effect on Chicken Nugget

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ABSTRACT: Okara is a by-product of soybean processing that remains underutilized. Okara flour requires physical and chemical modifications to improve its characteristics before it can be used in chicken nuggets. This study aims to determine the effect of physical and chemical modifications on the functional properties of okara flour and to determine the type and percentage of okara flour substitution on the characteristics of chicken nuggets. This research used okara flour treated with various modifications (autoclaving, cooling, acid hydrolysis, and a combination of acid hydrolysis and autoclaving-cooling) and applied it to a chicken nugget formulation at 5% and 10% flour substitution levels. Flour analysis results showed that autoclaving-cooling modification tended to improve emulsion stability and oil absorption. Acid hydrolysis modification and combination tended to increase flour emulsion stability but decreased oil absorption. The results of chicken nugget analysis showed that physical and chemical modification affected the proximate nutritional value. The type of flour modification tends to increase the emulsion stability of chicken nuggets but reduces water absorption. The best method, according to this study, is chicken nuggets, using a combination of methods, such as okara flour.

Keywords: autoclaving-cooling, chicken nugget, hydrolysis acid, modified, okara flour

INTRODUCTION

Soybean (*Glycine max* L.) is a legume that can be processed into products such as tofu, tempeh, soy milk, and more. Processed soybean products have a distinctive taste and texture and are high in nutritional value (Arisandi *et al.,* 2022). The processing of soybean products produces soybean pulp as a solid waste, that is not reused in Indonesia. Solid waste that is not reused can cause serious problems for the surrounding environment, such as unpleasant, pungent odors from the fermentation process (Jaya *et al.,* 2018). Okara is a by-product of the production of soybean-derived products with high nutritional value, namely protein, dietary fiber, fat, minerals, monosaccharides, and oligosaccharides (Adiari *et al.,* 2017).

Okara is a perishable product due to its highwater content; therefore, proper handling is required to prolong its shelf life. One way to extend okara's shelf life is to dry and grind it into okara flour. Wijaya *et al.* (2023) stated that the protein content of okara flour is higher than that of wheat flour, at around 24-35%. Okara flour also has a high crude fiber content of 0.4-0.5% (Fransiska & Deglas, 2017). The production of okara flour involves a drying process that can damage or alter its quality. Modifying okara flour is needed to optimize its functional properties. Physical and chemical modifications such as autoclaving-cooling, acid hydrolysis, and a combination of both can improve the functional characteristics of okara flour.

Based on research by Putri & Nita (2018), making chicken nuggets with increased okara flour will yield a softer, coarser texture compared to commercial chicken nuggets. The addition of 25% okara flour to snack bar products results in a rough, crumbly texture, making the product less preferred (Rachmayani *et al.,* 2017). Okara flour has a low starch content, so the amounts of amylose and amylopectin will decrease, which can affect the final product (Handarsari & Syamsianah, 2010). Research on okara flour modified by autoclaving-cooling and acid hydrolysis, or by a combination of both methods, has not been conducted extensively due to limitations in prior research. Chicken nuggets were produced using modified okara flour to evaluate the effects on the functional properties of okara flour and on the characteristics of the chicken nuggets. Chicken nuggets were chosen as a food model with a stable emulsion system. Modified okara flour is used as a binder to increase the stability of a chicken nugget emulsion. The purpose of this study was to determine the effect of modification type on the characteristics of functional properties of okara flour and to determine the effect of modification type and percentage of okara flour substitution on the characteristics of chicken nuggets produced.

MATERIALS AND METHODS

Materials

Fresh okara samples were obtained from Loso Tofu Factory, Semarang City. Ingredients for flour modification are 1.35% HCl, 1% HCl, 1 N NaOH, and distilled water. Ingredients for making chicken nuggets included modified okara flour, chicken thigh fillet, garlic, broth powder, salt, pepper, ice cubes, breadcrumbs, and cooking oil. Materials for analysis include corn oil, distilled water, H_2SO_4, boric acid (H_3BO_3), NaOH 45%, HCl 0.1 N, digestion solution, n-hexane solvent, and methyl red indicator. All chemicals used for analysis are pro-analysis (PA) chemicals.

Modification of autoclaving-cooling

Flour was suspended in 20% (w/v) distilled water, then packed in HDPE plastic and stored in a refrigerator at 4 °C for 12 hours. The flour was then heated in an autoclave at 121 °C for 15 minutes and cooled to room temperature for 1 hour. The flour was stored again in the refrigerator for 24 hours. Okara flour was dried in a cabinet dryer at 50 °C for 4 hours, ground in a blender, and sieved through a 60-mesh sieve (250 microns) (Lehmann *et al.,* 2003).

Modification of acid hydrolysis

Flour was suspended 10% (b/v) in 1.35% HCl solution, then heated on a hot plate at 80 °C for 35 minutes. The suspension was neutralized with 1 N NaOH to a neutral pH of 7. The suspension was then washed with distilled water several times, the solids were dried in a cabinet dryer at 50 ℃ for 12 hours, ground in a blender, and sieved through a 60-mesh sieve (Marta *et al.,* 2017).

Modified combination of acid hydrolysis and autoclaving-cooling

Flour was suspended at 1:4 (b/v) in 1% HCl solution and incubated in a waterbath at 45 °C for 24 hours. The suspension was neutralized with 1 M NaOH and stored at 4 °C for 24 hours. The suspension was then dried, ground, and sieved. The flour was then suspended 1:4 (b/v) in distilled water and heated in an autoclave at 121 °C for 30 minutes. The suspension was cooled to room temperature for 1 hour, dried in a cabinet dryer at 50 °C for 12 hours, ground, and sieved through a 60-mesh sieve (Ozturk et al., 2009).

Processing Chicken Nuggets

Chicken nuggets are made by weighing all raw materials and supporting ingredients according to a predetermined formulation. Then the chicken meat is ground together with garlic and ice water to facilitate pulverization in a chopper. The next step is to mix okara flour (5% or 10% of the weight of the chicken meat), salt, broth powder, and pepper until a dough forms. The dough is molded and steamed for 30 minutes, then cooled (Putri & Nita, 2018).

Sample Analysis

The analysis used on the modified okara flour samples included emulsion stability and oil absorption capacity. Emulsion stability analysis refers to the method of Coorey *et al.* (2014).

Calculations:

$$ES\ (\%) = \frac{\text{total volume of emulsion after heating (mL)}}{\text{total volume of heated suspension (mL)}} \times 100\%$$

Oil absorption capacity (OAC) analysis refers to the method Diniyah *et al.* (2018). Calculations:

$$OAC\ (\%) = \frac{(c - a) - b}{b} \times 100\%$$

Where:
a = weight of empty tube
b = weight of sample
c = weight of sediment + tube

The analysis of chicken nugget samples included proximate analysis and water-loss analysis. Proximate analysis includes water content using thermogravimetry, protein content using the Kjeldahl method, fat content using the Soxhlet method, ash content using the gravimetric method, and carbohydrate content by difference, which refers to the method of AOAC (2005). Water loss analysis refers to the method Jeong & Han (2019). This analysis uses a water bath at 80 ℃ for 30 minutes.

Data Analysis

Test data were analyzed using the Analysis of Variance (ANOVA) method. Data with differences between treatments were continued with the DMRT test at the 5% level. Data analysis using SPSS version 24.0.

RESULTS AND DISCUSSION

Emulsion Stability of Modified Okara Flour

Emulsion stability refers to the ability of an emulsion to maintain a uniform distribution of the dispersed phase over time (Adawiyah *et al.,* 2021).

Figure 1 shows that the three types of flour modification significantly increased the emulsion stability value. AH modified flour has the highest emulsion stability value because the use of acid will affect protein solubility. Adding acid lowers the flour pH to neutral or close to the

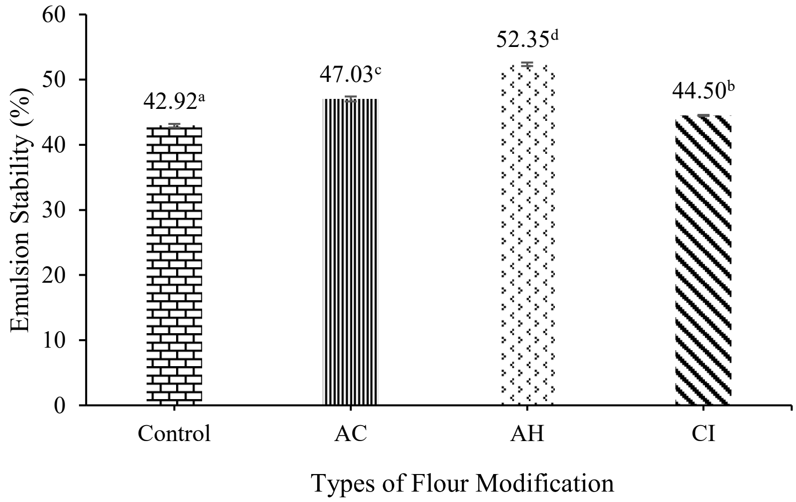

Figure 1. Emulsion stability of okara flour and modified okara flour

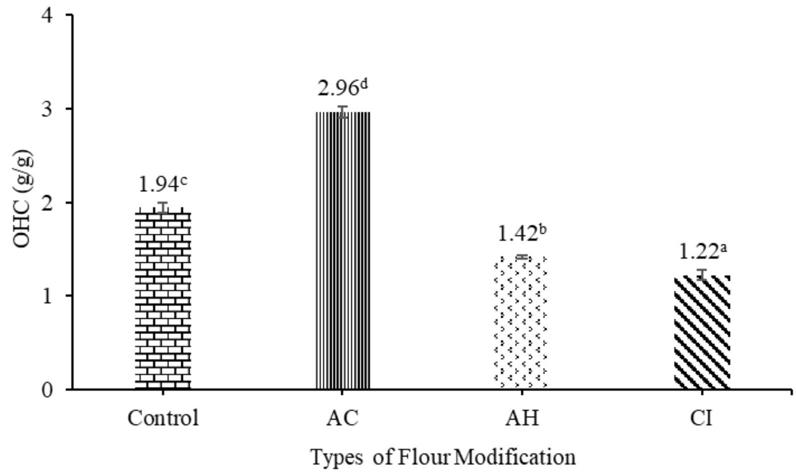

Figure 2. Oil Absorption Capacity of Okara Flour and Modified Okara Flour

Note: Control (without modification), AC (Modified autoclaving-cooling), AH (Modified acid hydrolysis), CI (Modified combination of acid hydrolysis and autoclaving-cooling). Different letter notations indicate significant differences at the significance level (*P*<0.05).

isoelectric point, thereby decreasing protein solubility. When the pH approaches acidic values or moves away from the isoelectric point, protein solubility increases (Bravo-Núñez *et al.,* 2019). Increasing protein solubility will improve flour emulsion stability. The emulsion stability of AC-modified flour is lower than that of AH flour. This is because the autoclave heating process denatures proteins, resulting in peptides with lower molecular weight (Li *et al.,* 2019). The modified combination is more stable than the control because this modification involves two processes. The processes involve lysis of cell membranes in okara flour, releasing the trapped proteins and thereby forming a more stable flour emulsion.

Oil Absorption Capacity (OAC) of modified okara flour

Oil Absorption Capacity (OAC) is the ability of food ingredients to absorb and retain oil or fat (Rahmaniar *et al.,* 2023). OAC depends on the protein structure of the material. The protein structure with nonpolar or lipophilic properties will more readily absorb oil from food ingredients.

Figure 2 shows that the three types of flour modification affected the oil absorption ability. The AC flour has the highest oil absorption value, presumably because the high-temperature heating process damages the cell tissue structure, allowing oil-containing deposits (small pores) to be released. According to Santoso (2008), heating

Table 1. Proximate Analysis of Chicken Nugget

Sample	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrates (%)
Control5	64.33 ± 0.14[d]	2.47 ± 0.11[d]	16.35 ± 0.20[c]	15.28 ± 0.34[e]	1.58 ± 0.23[a]
Control10	66.24 ± 0.23[e]	2.68 ± 0.10[e]	5.75 ± 0.35[a]	7.89 ± 0.09[b]	17.44 ± 0.52[g]
AC5	62.59 ± 0.12[b]	2.29 ± 0.05[c]	19.36 ± 0.36[d]	6.33 ± 0.30[b]	9.43 ± 0.64[e]
AC10	64.01 ± 0.22[d]	2.08 ± 0.03[b]	20.17 ± 0.36[e]	6.03 ± 0.18[a]	7.71 ± 0.30[d]
AH5	62.56 ± 0.17[b]	2.28 ± 0.08[c]	16.81 ± 0.55[c]	14.56 ± 0.31[d]	3.80 ± 0.50[b]
AH10	61.82 ± 0.15[a]	2.53 ± 0.04[d]	14.92 ± 0.47[b]	12.79 ± 0.40[c]	7.94 ± 0.78[d]
CI5	62.71 ± 0.17[b]	1.91 ± 0.10[a]	16.08 ± 0.36[c]	7.56 ± 0.17[b]	11.74 ± 0.29[f]
CI10	63.25 ± 0.23[c]	2.20 ± 0.08[bc]	16.51 ± 0.43[c]	12.68 ± 0.35[c]	5.36 ± 0.32[c]

Note: Control (without modification), AC (Modified autoclaving-cooling), AH (Modified acid hydrolysis), CI (Modified combination of acid hydrolysis and autoclaving-cooling), 5 is composition of okara flour (5%), 10 is the composition of okara flour (10%). Different letter notations in the same column indicate significant differences at the significance level (p<0.05) with Duncan's test.

coconut meat at high temperatures damages its cell walls, resulting in wide-open pores that allow trapped molecules to be released and evaporate. The AH flour has a reduced ability to absorb oil compared to the control because the addition of acid causes the breakdown of starch molecules, or hydrolysis of starch into simpler sugar molecules (Marta *et al.,* 2017). The hydrolysis of starch molecules into sugar molecules decreases the tendency to absorb oil, as sugar has a more hydrophilic structure than starch. The CI flour also showed a decrease in water absorption ability because the hydrolysis process ruptured the starch molecular structure and denatured proteins during heating, leading to a loss of its tendency to absorb oil.

Proximate Analysis of Chicken Nugget

Proximate analysis of chicken nugget samples includes moisture, ash, protein, fat, and carbohydrate content. The proximate analysis is performed on a wet basis. The results of the proximate analysis of chicken nuggets are shown in Table 1.

Moisture content is the water content contained in food ingredients, which is related to the quality of shelf life and product quality degradation (Apriliyanti *et al.,* 2020). Table 1 shows that the type of modification and the percentage of flour substitution significantly affect the moisture content of chicken nuggets. The AC sample has a lower moisture content than the control due to changes in flour components that dissolve under high pressure and temperature during the modification process (Rahmawati *et al.,* 2018). The percentage of flour substitution in the AC sample showed an increase in the moisture content value as the amount of flour increased. This is thought to be because the increasing amount of flour will make it easier to absorb water, and because it interacts with other ingredients, such as chicken meat, which has a high water content. The AH sample also showed a decrease in moisture content compared to the control due to changes in the molecular size of the chemical structure in flour due to the hydrolysis, which reduced the flour's water absorption ability (Raharja *et al.,* 2015). The percentage of flour substitution in the AH sample decreased the value of water content as the amount of flour increased. This is due to the breakdown of molecular size, resulting in low water absorption and a low moisture content in the sample. It is assumed that the decrease in water content in CI samples results from changes in the structure of flour components during acid hydrolysis and high-temperature, high-pressure heating.

Ash is a mixture of several inorganic substances and the residual combustion process of organic substances contained in a food ingredient. Ash content is expressed as the amount of mineral content produced from food ingredients (Kristiandi *et al.,* 2021). Table 1 shows that the type of flour modification has a significant effect, but the percentage of substitution does not affect the ash content of the samples. The AC sample had a lower ash content than the control because the high-temperature heating process volatilizes and decomposes the ash component (Gunorubon & Kekpugile, 2012). A higher percentage of AC flour substitution will decrease the ash content of the sample. This is presumably because AC modification is a physical modification that does not leave chemical residue, so the ash content decreases. The AH sample had lower ash content than the control, presumably because the acid solution dissolved mineral components. Increasing the AH flour substitution rate will increase the ash content. This is because the use of an acid solution will still leave mineral residues that persist during the precipitation and neutralization with NaOH, in the form of NaCl (Polnaya *et al.,* 2018). The CI sample also decreased compared to the control because the hydrolysis and heating process caused evaporation and dissolution of the ash component. Increasing the amount of flour will increase the ash content of the sample due to hydrolysis, which leaves mineral residues (Faridah *et al.,* 2010).

Protein content is determined by changing the nitrogen content contained in it. Protein content testing can be done using the Kjeldahl method. Based on Table 1, the results show that the type of modification and the percentage of flour substitution significantly affect the protein content of the sample. The protein content in the 10% control decreased as the flour substitution increased because okara flour contains less protein than chicken flour. This resulted in a lower protein content than with the 5% flour substitution. The increase in protein content in AC samples is due to damage to the matrix network structure in flour during heating, which allows trapped protein molecules to escape. According to Untailawam & Wijaya (2021), the heating process at high temperature and pressure can cause the erosion of proteins trapped in fish bones, leading to their release from the damaged tissue structure. The AH sample also showed an increase in protein content due to the use of an acid solution, which lysed cells in the flour, allowing trapped protein molecules to escape. The use of a strong acid, such as HCl, will cause cell wall degradation, releasing the molecules trapped within the cell as a result of the damaged cell wall (Rukmini & Santosa, 2019). The CI samples showed an increase in protein content due to the involvement of two modification processes that can release protein molecules trapped in the damaged tissue structure.

Fat is a source of energy and has an important role in influencing the characteristics of a food product. Fat content testing uses the Soxhlet method. Table 1 shows that both the type of modification and the percentage of flour substitution affect the fat content of the sample. The fat content in the nugget samples with 5% okara flour was higher than in the 10% control due to the lower okara flour proportion. As the proportion of okara flour added increases, the fat content of the nuggets decreases because the proportion of chicken meat used to contribute to the fat content in the nuggets decreases. The AC sample has the lowest fat content because lipid degradation during heating produces smaller components that dissolve more easily (Rosida *et al.,* 2016). The higher AC flour substitution rate also decreased the fat content. This is thought to be due to the heating process, which degrades lipids. The AH sample also decreased from both the control and the increasing percentage of substitution. This is because the use of strong acid HCl will hydrolyze fat. According to Rahmawati *et al.* (2019), the fat content in fermented sago flour decreased due to the presence of lipase enzymes that break down fat into fatty acids and glycerol. The hydrolysis process can also be broken down by hydrochloric acid. The use of strong acids hydrolyzes triglyceride bonds (fat bonds) into fatty acids and glycerol. The CI samples also showed a decrease in fat content, presumably because both modification processes can potentially break down fat, leading to lower fat content.

Carbohydrates are polysaccharide compounds that are the main source of calories and play a role in determining the physical characteristics of food ingredients (Putri *et al.,* 2023). Carbohydrate content can be determined using the by-difference method. Based on Table 1, the results show that the type of modification and the percentage of flour substitution significantly affect the carbohydrate content of the sample. Carbohydrate content is influenced by other nutrients, such as moisture, protein, ash, and fat. This is one of the causes of increases or decreases in carbohydrate content. The AC sample shows a decrease in carbohydrate content because the autoclaving process ruptures starch molecules, and amylose retrogrades during cooling. The rupture of starch molecules results in simpler carbohydrate molecules that are easier to digest, thereby decreasing carbohydrate levels (Mushollaeni *et al.,* 2021). The decrease in carbohydrate content in the AH sample is due to carbohydrate degradation, which can hydrolyze the protein matrix, releasing carbohydrate granules (Haryani *et al.,* 2021). Carbohydrate degradation changes carbohydrates into simpler molecules that are easily hydrolyzed, which decreases carbohydrate levels (Xu *et al.*, 2021). The CI sample also decreased because the two modification processes have an interrelated effect, as both degrade carbohydrates into simpler molecular components.

Water loss of chicken nugget

Emulsion stability is defined as the ability to maintain moisture content, fat content, and meat moisture during the cooking process (Jeong & Han, 2019). The water loss value indicates the amount of water that comes out of the nugget sample after the steam process.

Figure 3 shows that the type of modification and the percentage of flour substitution significantly affected the

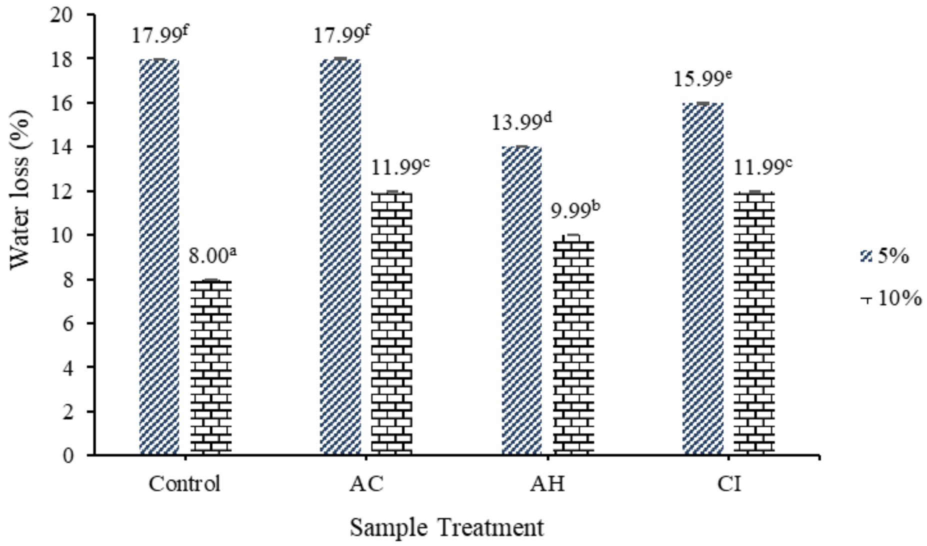

Figure 3. Analysis of water loss in chicken nugget treatment

Note: Control (without modification), AC (Modified autoclaving-cooling), AH (Modified acid hydrolysis), CI (Modified combination of acid hydrolysis and autoclaving-cooling). Different letter notations indicate significant differences at the significance level (P<0.05).

water loss of the samples. The AC sample showed an increase in water loss compared to the control, presumably due to the low water absorption ability of AC flour so that it is less able to hold water molecules during the cooking process. A higher percentage of AC flour can reduce water loss. The chicken nugget sample with 5% control had a higher water loss value because it had a lower flour proportion than the 10% control. The low flour proportion meant it was less able to retain water during cooking, even though the control flour had a high water absorption capacity. This is because the heating during nugget cooking causes the fat to melt and wrap the product, holding the water that comes out as the amount of flour increases (Ismanto *et al.,* 2014). The percentage of AH flour substitution also decreased the value of water loss due to depolymerization due to the addition of acid so that it changes the size and weight of the molecules and tends to make it easier for water to enter to help stabilize the emulsion that occurs (Dewi *et al.,* 2012). The CI samples also decreased as the flour substitution percentage increased. This is thought to be because CI flour has an emulsion stability that tends to increase, thereby reducing water loss. The involvement of two processes reduces water loss from the sample, so the emulsion formed tends to stabilize. According to the results, the modification and formulation that provides the best stability for chicken nuggets is acid hydrolysis modification at 10%. This result is due to reduced water loss resulting from improved emulsion stability. The addition of acid in the modification causes the hydrolysis of starch, and after hydrolysis, the starch undergoes depolymerization, which reduces its molecular weight. Reducing the molecular weight tends to make it easier for water to penetrate, thereby helping to stabilize the emulsion that occurs.

CONCLUSION

Physically and chemically modified okara flour significantly influenced functional properties and characteristics. Autoclaving-cooling modification tended to improve flour emulsion stability and oil absorption. Acid hydrolysis and combination modification tended to improve flour emulsion stability, but both decreased flour oil absorption. Physical and chemical modification of okara flour, along with the percentage of flour substitution, significantly affected the proximate nutritional value and improved the emulsion stability of chicken nuggets. Based on research, a combination method is considered a better sampling method because it provides results with increased proximate values and improved nugget texture without reducing the level of preference during organoleptic testing. Further research is needed on total dietary fiber and soluble protein content to determine the detailed effects on the composition of chicken nuggets.

REFERENCES

Adawiyah, D. R., Wefiani, F. P., & Patricia, K. (2022). Karakterisasi Serat Pangan, Kapasitas Pengikatan Air dan Kemampuan Emulsifikasi Biji Selasih dan Chia. *Jurnal*

Mutu Pangan: Indonesian Journal of Food Quality, 8(2), 63–69. https://doi.org/10.29244/jmpi.2021.8.2.63

Adiari, N. W. L., Yogeswara, I. B. A., & Putra, I. M. W. A. (2017). Pengembangan pangan fungsional berbasis tepung okara dan tepung beras hitam (Oryza sativa L. indica) sebagai makanan selingan bagi remaja obesitas. *Jurnal Gizi Indonesia (the Indonesian Journal of Nutrition)*, *6*(1), 51–57. https://doi.org/10.14710/jgi.6.1.51-57

AOAC. (2005). *Official Methods Of Analysis* (Issue 18th Edition). AOAC International.

Apriliyanti, M. W., Nurdihati, A., & Ardiyansyah, M. (2020). Pendugaan Umur Simpan Jelly Kelor Instan dengan Metode Accelerated Shelf Life Test (ASLT) Model Pendekatan Kadar Air Kritis. *Journal Of Food Technology and Agroindustry*, *2*(2), 54–63. https://doi.org/10.24929/Jfta.V2i2.967

Arisandi, F., Mahyudin, I., Suyanto, & Mahreda, E. S. (2022). Pemanfaatan Tepung Ampas Sari Kedelai (Okara) Sebagai Bahan Alternatif Pembuatan Kue Untuk Mengurangi Pencemaran Lingkungan di Kabupaten Tapin Provinsi Kalimantan Selatan. *Enviroscienteae*, *18*(1), 134–139. https://doi.org/10.20527/es.v18i1.13002

Aristyarini, R., Yasni, S., & Syamsir, E. (2022). Peningkatan Serat Pangan Larut dari Ampas Tahu dan Sifat Fungsionalnya dengan Perlakuan Fisik: Tinjauan Literatur. *Jurnal Teknologi Industri Pertanian*, *32*(1), 84–95. https://doi.org/10.24961/j.tek.ind.pert.2022.32.1.84

Bravo-Núñez, Á., Garzón, R., Rosell, C. M., & Gómez, M. (2019). Evaluation of Starch-Protein Interactions as a Function of pH. *Foods*, *8*(5), 2–11. https://doi.org/10.3390/Foods8050155

Coorey, R., Tjoe, A., & Jayasena, V. (2014). Gelling properties of chia seed and flour. *Journal of Food Science*, *79*(5), E859–E866. https://doi.org/10.1111/1750-3841.12444

Das, A. B., Singh, G., Singh, S., & Riar, C. S. (2009). Effect of acetylation and dual modification on physico-chemical, rheological, and morphological characteristics of sweet potato (Ipomoea batatas) starch. *Carbohydrate Polymers*, *80*(3), 725–732. https://doi.org/10.1016/j.carbpol.2009.12.018

Dewi, N. S., Parnanto, N. H. R., & Ridwan, A. (2012). Karakteristik Sifat Fisikokimia Tepung Bengkuang (*Pachyrhizus Erosus*) Dimodifikasi Secara Asetilasi dengan Variasi Konsentrasi Asam Asetat Selama Perendaman. *Jurnal Teknologi Hasil Pertanian*, *5*(2), 104–112. https://doi.org/10.20961/jthp.v0i0.13014

Diniyah, N., Subagio, A., Nur, R., Sari, L., & Yuwana, N. (2018). Sifat Fisikokimia dan Fungsional Pati dari Mocaf (Modified Cassava Flour) Varietas Kaspro dan Cimanggu. *Jurnal Penelitian Pascapanen Pertanian*, *15*(2), 80–90. https://doi.org/10.21082/jpasca.v15n2.2018.80-90

Faridah, D. N., Fardiaz, D., Andarwulan, N., & Sunarti, T. C. (2010). Perubahan Struktur Pati Garut (*Maranta arundinaceae*) Sebagai Akibat Modifikasi Hidrolisis Asam, Pemotongan Titik Percabangan dan Siklus Pemanasan-Pendinginan. *Jurnal Teknologi dan Industri Pangan*, *21*(2), 135–142. https://journal.ipb.ac.id/jtip/article/view/3410

Fransiska, & Deglas, W. (2017). Pengaruh Penggunaan Tepung Ampas Tahu Terhadap Karekteristik Kimia Jurnal Teknologi Pangan. *Teknologi Pangan*, *8*(2), 171–179. https://doi.org/10.35891/tp.v8i2.905

Gunorubon, J. A., & Kekpugile, K. D. (2012). Modification of Cassava Starch for Industrial Uses. *International Journal Of Engineering and Technology*, *2*(6), 913–919.

Gunorubon, J., Dagde, & Kekpugile, K. (2012). Modification of Cassava Starch for Industrial Uses.

Handarsari, E., & Syamsianah, A. (2010). Analisis Kadar Zat Gizi, Uji Cemaran Logam dan Organoleptik Pada Bakso dengan Substituen Ampas Tahu. *Prosiding Seminar Nasional Unimus*, 245–251.

Haryani, K., Lakzita, P. R., & Sari, P. P. (2021). Modifikasi Tepung Sorgum dengan Metode Fermentasi Menggunakan Bakteri Asam Laktat *Lactobacillus Bulgaricus*. *Jurnal Inovasi Teknik Kimia*, *6*(1), 11–16. https://doi.org/10.31942/Inteka.V6i1.4448

Indiarto, R., Nurhadi, B., & Subroto, E. (2014). Kajian Karakteristik Tekstur (Texture Profil Analysis) dan Organoleptik Daging Ayam Asap Berbasis Teknologi Asap Cair Tempurung Kelapa. *Jurnal Teknologi Hasil Pertanian*, *5*(2), 106–117. https://doi.org/10.20961/jthp.v0i0.13562

Ismanto, A., Arsanto, D., & Suhardi, S. (2014). Pengaruh Penambahan Ekstrak Bawang Tiwai (*Eleutherine Americana Merr*) Pada Komposisi Kimia, Kualitas Fisik, Organoleptik Dan Vitamin C Nugget Ayam Arab (*Gallus Turcicus*). *Sains Peternakan*, *12*(1), 31–38. https://doi.org/10.20961/Sainspet.V12i1.4776

Jaya, J. D., Lestari, E., & Wicaksono, R. Y. (2018). Karakterisasi dan Analisis Ekonomi Pemanfaatan Limbah Industri Tahu di UD. Usaha Berkah, Pelaihari. *Jurnal Teknologi Agro-Industri*, *5*(2), 120–131.https://doi.org/10.34128/jtai.v5i2.78

Jeong, Y., & Han, Y. (2019). Effect on the Emulsification Stability and Quality of Emulsified Sausages Added with Wanggasi-Chunnyuncho (*Opuntia humifusa* f. *jeollaensis*) Fruit Powders. *Food science of animal resources*, *39*(6), 953–965. https://doi.org/10.5851/kosfa.2019.e85

Kristiandi, K., Rozana, J., & Maryam, A. (2021). Analisis Kadar Air, Abu, Serat dan Lemak Pada Minuman Sirop Jeruk Siam (*Citrus Nobilis Var. Microcarpa*). *Jurnal Keteknikan Pertanian Tropis dan Biosistem*, *9*(2), 165–171. https://doi.org/10.21776/Ub.Jkptb.2021.009.02.07

Lehmann, U., Rössler, C., Schmiedl, D., & Jacobasch, G. (2003). Production and physicochemical characterization of resistant starch type III derived from pea starch. *Die Nahrung*, *47*(1), 60–63. https://doi.org/10.1002/

food.200390014

Li, B., Yang, W., Nie, Y., Kang, F., Goff, H. D., & Cui, S. W. (2019). Effect Of Steam Explosion on Dietary Fiber, Polysaccharide, Protein, and Physicochemical Properties Of Okara. *Food Hydrocolloids*, *94*, 48–56. https://doi.org/10.1016/J.Foodhyd.2019.02.042

Marta, H., Tensiska, T., & Riyanti, L. (2017). Karakterisasi Maltodekstrin dari Pati Jagung (*Zea Mays*) Menggunakan Metode Hidrolisis Asam Pada Berbagai Konsentrasi. *Chimica Et Natura Acta*, *5*(1), 13. https://doi.org/10.24198/cna.v5.n1.12816

Mushollaeni, W., Rahmawati, A., & Kurnia, E. (2021). Aplikasi Autoclaving-Cooling Dalam Karakterisasi Komponen Gizi Kacang Koro Benguk, Kacang Merah, dan Kacang Hitam. *Agrista*, *5*(1), 1024–1035.

Ozturk, S., Koksel, H., Kahraman, K., & Ng, P. K. W. (2009). Effect Of Debranching and Heat Treatments on Formation and Functional Properties of Resistant Starch From High-Amylose Corn Starches. *European Food Research And Technology*, *229*(1), 115–125. https://doi.org/10.1007/s00217-009-1032-1

Polnaya, F. J., Huwae, A. A., & Tetelepta, G. (2018). Karakteristik Sifat Fisiko-Kimia dan Fungsional Pati Sagu Ihur (*Metroxylon Sylvestre*) Dimodifikasi Dengan Hidrolisis Asam. *Agritech*, *38*(1), 7–15. https://doi.org/10.22146/agritech.16611

Putri, G. N. A., Aulia, N. N., Salsabila, N., Aisy, R., Indrawati, S., Madani, W. F., & Khastini, R. O. (2023). Pemanfaatan Ubi Jalar Sebagai Alternatif Karbohidrat yang Meningkatkan Ekonomi Warga Banten. *Semar (Jurnal Ilmu Pengetahuan, Teknologi, Dan Seni Bagi Masyarakat)*, *12*(1), 47–53. https://doi.org/10.20961/Semar.V12i1.62162

Putri, V. D., & Nita, Y. (2018). Uji Kualitas Kimia dan Organoleptik Pada Nugget Ayam Hasil Substitusi Ampas Tahu. *Jurnal Katalisator*, *3*(2), 135–144.

Rachmayani, N., Rahayu, W. P., Faridah, D. N., & Syamsir, E. (2017). Snack Bar Tinggi Serat Berbasis Tepung Ampas Tahu (Okara) dan Tepung Ubi Ungu. *Jurnal Teknologi dan Industri Pangan*, *28*(2), 139–149. https://doi.org/10.6066/jtip.2017.28.2.139

Raharja, S., Paryanto, I., & Yuliani, F. (2015). Ekstraksi dan Analisa Dietary Fiber dari Buah Mengkudu (*Morinda citrifolia*). *Jurnal Teknologi Industri Pertanian*, *14*(1), 30–39.

Rahmaniar, R., G. S., & Galung, F. S. (2023). Pengaruh Ukuran Partikel Terhadap Kandungan Fisikokimia Tepung Ikan Gabus (*Channa Striata*). *Perbal: Jurnal Pertanian Berkelanjutan*, *11*(1), 51–61. https://doi.org/10.30605/Perbal.V11i1.2257

Rahmawati, A., Murdiati, A., Marsono, Y., & Anggrahini, S. (2018). Changes Of Complex Carbohydrates On White Jack Bean (*Canavalia Ensiformis*) During Autoclaving-Cooling Cycles. *Current Research In Nutrition And Food Science*, *6*(2), 470–480. https://doi.org/10.12944/Crnfsj.6.2.21

Rahmawati, S., Wahyuni, S., & Khaeruni, A. (2019). Pengaruh Modifikasi Terhadap Karakteristik Kimia Tepung Sagu Termodifikasi : Studi Kepustakaan. *J. Sains Dan Teknologi Pangan*, *4*(2), 2096–2103.

Rosida, Harijono, Estiasih, T., & Sriwahyuni, E. (2016). Physicochemical Properties and Starch Digestibility of Autoclaved-Cooled Water Yam (*Dioscorea alata* L.) Flour. *International Journal of Food Properties*, *19*(8), 1659–1670. https://doi.org/10.1080/10942912.2015.1105818

Rukmini, P., & Santosa, I. (2019). Pemanfaatan Pati Gembili (Dioscorea Esculenta) Menjadi Glukosa Dengan Metode Hidrolisis Asam Menggunakan Katalis HCl. *Konversi*, *8*(1), 49–58. https://doi.org/10.20527/K.V8i1.6514

Santoso, H. (2008). Pengaruh Pemanasan dan Pengeringan Daging Buah Kelapa Terhadap Asam Lemak Bebas Pada Pembuatan Tepung Kelapa. *Jurnal Ilmu-Ilmu Pertanian*, *4*(2), 154–160.

Setiarto, R. H. B., Jenie, B. S. L., Faridah, D. N., & Saskiawan, I. (2015). Kajian Peningkatan Pati Resisten Yang Terkandung Dalam Bahan Pangan Sebagai Sumber Prebiotik. *Jurnal Ilmu Pertanian Indonesia*, *20*(3), 191–200. https://doi.org/10.18343/jipi.20.3.191

Untailawam, R., & Wijaya, J. (2021). Studi Kandungan Kalsium dalam Tepung Tulang Ikan. *Molluca Journal Of Chemistry Education (Mjoce)*, *11*(1), 55–60. https://doi.org/10.30598/Mjocevol11iss1pp55-60

Wijaya, J., Goretti, M., Purwanto, M., Bernard, J. E., Pantjajani, T., & Sukweenadhi, J. (2023). Pengaruh Penambahan Tepung Ampas Kedelai Terhadap Sifat Fisikokimia dan Sensori Kukis Kacang Rendah Gluten Tinggi Serat dan Protein. *Agrointek: Jurnal Teknologi Industri Pertanian*, *17*(2), 474–484. https://doi.org/10.21107/Agrointek.V17i2.14687

Winarti, C., Richana, N., Mangunwidjaja, D., & Sunarti, C. T. (2014). Pengaruh Lama Hidrolisis Asam Terhadap Karakteristik Fisiko-Kimia Pati Garut. *Jurnal Teknologi Industri Pertanian*, *24*(3), 218–225.

Xu, X., Waters, D., Blanchard, C., & Tan, S. H. (2021). A Study On Australian Sorghum Grain Fermentation Performance and The Changes In Zaopei Major Composition During Solid-State Fermentation. *Journal Of Cereal Science*, *98*(103160). https://doi.org/10.1016/J.Jcs.2021.103160

Yeni, G., Silfia, S., Hermianti, W., & Wahyuningsih, T. (2018). Pengaruh waktu hidrolisis dan konsentrasi HCl terhadap karakteristik pati termodifikasi dari bengkuang (*Pachyrrhizus erosus*). *Jurnal Litbang Industri*, *8*(2), 53. https://doi.org/10.24960/jli.v8i2.4334.53-60