e-ISSN 2808-2311
The 6th National Conference of Applied Animal Science 2025
Department of Animal Science
Politeknik Negeri Jember
Jember, September 25-26
doi: 10.25047/animpro.2025.889

Effect of green-synthesized nano-calcium fortification from broiler bones on the hedonic evaluation of broiler meatballs by child panelists

Pengaruh fortifikasi nano kalsium tulang broiler melalui sintesis hijau terhadap uji hedonik bakso daging broiler pada panelis anak-anak

Sya'ab Sam Abdil[1], Yoga Dwi Kurnia Putra[1], Lutfatul Mafazah[1], Ibnu Akbar May Naky [1], Agus Hadi Prayitno[1]*, Derico Setyabrata[2], and Rusna Meswari[3]

[1]Department of Animal Science, Politeknik Negeri Jember, Jl. Mastrip Po Box 164, Jember 68101 Indonesia
[2]Department of Animal Science, University of Arkansas, AFLS Building #B103G, 1120 West Maple Street, Fayetteville, Arkansas 72701 United States
[3]School of Health Sciences, Universiti Sains Malaysia, Kubang Kerian, 16150 Kota Bharu, Kelantan, Malaysia

*Corresponding Author's Email: agushp@polije.ac.id

Abstract. The green synthesis of nano-calcium from broiler bones is considered safer because it uses environmentally friendly solvents and has low toxicity. The objective of this research was to determine the effect of nano-calcium fortification derived from broiler bones using green synthesis on the hedonic evaluation of broiler meatballs by child panelists. The materials used in the research included broiler meat, tapioca flour, egg white, salt, shallots, garlic, monosodium glutamate, pepper, soy protein isolate, sodium tripolyphosphate, carrageenan, ice, lime juice, and distilled water. The nano-calcium fortification treatments were: P0 (0%), P1 (0.15%), P2 (0.3%), P3 (0.45%), and P4 (0.6%) based on the total weight of the meatball mixture. Sensory evaluation was conducted with 40 child panelists aged 6-12 years. The hedonic test parameters assessed included color, flavor, taste, texture, chewiness, and overall acceptability, using a 5-point Likert scale for scoring. The hedonic test data were analyzed using non-parametric statistical methods, specifically the Kruskal-Wallis test, followed by Duncan's New Multiple Range Test for post-hoc analysis when significant differences were found. The results showed that nano-calcium fortification from broiler bones significantly affected the taste and overall acceptability scores of the meatballs, while it had no significant effect on color, flavor, texture, or chewiness. It was concluded that fortification with 0.6% nano-calcium derived from broiler bones was the most effective treatment, yielding the highest scores for taste and overall acceptability at 4.88 and 4.98, respectively.

Keywords: meatball, broiler meat, nano-calcium, nanotechnology, bone.

Abstrak. Sintesis hijau nano kalsium dari tulang dianggap broiler lebih aman karena menggunakan pelarut ramah lingkungan dan rendah toksisitas. Tujuan penelitian ini untuk mengetahui pengaruh fortifikasi nano kalsium tulang broiler melalui sintesis hijau terhadap uji hedonik bakso daging broiler pada panelis anak-anak. Materi penelitian terdiri atas daging broiler, tepung tapioka, putih telur, garam, bawang merah, bawang putih, mononatrium glutamat, lada, isolat protein kedelai, natrium tripolifosfat, jeruk nipis, karagenan, es, dan juga akuades. Perlakuan fortifikasi nano kalsium yaitu P0 (0%), P1 (0,15%), P2 (0,3%), P3 (0,45%), dan P4 (0,6%) dari total adonan bakso. Uji

sensori dilakukan oleh 40 panelis anak-anak usia 6-12 tahun. Paramater yang diamati pada uji hedonik yaitu warna, aroma, rasa, tekstur, kekenyalan, dan daya terima. Skala hedonik menggunakan skala *likert* yaitu berkisar antara 1 sampai 5. Data hasil uji hedonik dianalisis dengan analisis non parametrik melalui uji *Hedonic Kruskal Wallis* dan apabila terdapat perbedaan diuji lanjut dengan uji *Duncan's New Multiple Range Test.* Hasil dari penelitian menunjukkan bahwa fortifikasi nano kalsium tulang broiler dapat mempengaruhi skor rasa dan daya terima bakso, tetapi tidak mempengaruhi skor warna, aroma, tekstur, dan kekenyalan bakso. Kesimpulan penelitian ini adalah fortifikasi nano kalsium tulang broiler sebanyak 0,6% dari total adonan sebagai perlakuan terbaik dengan skor rasa dan daya terima tertinggi secara berturut-turut yaitu 4,88 dan 4,98.

Kata kunci: bakso, daging broiler, nano kalsium, nanoteknologi, tulang.

INTRODUCTION

The process of growth and development in children is crucial. A balanced diet, particularly one rich in calcium, is essential for bone growth and strength (Fang et al., 2017). Calcium, as a vital mineral, not only supports optimal bone development but also contributes to dental health and muscle function. Children who do not get enough calcium are at risk of health problems such as impaired bone growth and low bone density, which can have long-term effects into adulthood (Harinarayan, Akhila, & Shanthisree, 2021). Furthermore, calcium deficiency in children may lead to rickets, osteopenia, and stunted growth. Therefore, it is extremely important for children to consume sufficient amounts of calcium through their daily diet.

Calcium deficiency remains a common health issue among children in many countries, including Indonesia. Wibowo & Dasuki (2020) reported that 98.6% of elementary school children in Sukoharjo had calcium intake levels below 70% of the Recommended Dietary Allowance (RDA). An unbalanced diet, especially inadequate calcium consumption, can lead to stunting, which subsequently causes growth disorders in children. Several factors may contribute to calcium deficiency, including a lack of dietary diversity, limited access to calcium-rich foods, and low awareness of the importance of calcium intake for children. In some cases, children may also experience problems with calcium absorption, which impair the body's ability to utilize the calcium present in their diet.

The development of functional foods represents a promising approach to addressing calcium deficiency among children in Indonesia. Functional foods not only supply essential nutrients but also provide additional health benefits (Suter, 2013). In this context, chicken meatballs are a potential product that can be developed as a calcium-rich functional food. Meatballs are widely available in Indonesia and are generally popular among children. By fortifying meatballs with calcium, their nutritional value can be enhanced while remaining enjoyable for children. It is important to note that daily calcium requirements vary by age and gender: children need about 600 mg per day, whereas adults require between 800 mg and 1,000 mg per day (Deborah dkk., 2016).

An innovative approach that can be applied is the use of nano-calcium derived from broiler bones through green synthesis. According to BP BPS (2023) broiler meat production reached 3,765,573.09 tons in 2022. However, the consumption of broiler meat generates bone waste, which has little economic value and is difficult to decompose. In fact, the main components of broiler bones are 57.35% calcium phosphate, 3.85% calcium carbonate, and 33.3% collagen (Jannah, Maunatin, Windayanti, Findianti, & Mufidah, 2013). Through nanotechnology, broiler bones can be processed into calcium particles at the nanometer scale. Due to its extremely small particle size and large surface area, nano-calcium allows for better absorption by the body. Green synthesis is the preferred method for producing nano-calcium from broiler bones because it supports environmental sustainability. This process uses natural, eco-friendly, and safe materials, producing not only a high-quality product but also one that is more sustainable for the environment (Khan, Ranjani, & Hemalatha, 2022).

The application of nano-calcium from broiler bones in chicken meatballs aims to create a functional food product that can enhance children's growth. Integrating nano-calcium from broiler bones into chicken meatballs is expected to produce a new food product that is not only appealing but also provides sufficient calcium for children's growth. The use of green synthesis is expected to contribute to the development of more environmentally friendly food products. This research is anticipated to offer an innovative solution to provide healthy foods that optimally support children's growth and health, while also raising awareness of the importance of regular calcium consumption. Therefore, this study needs to be conducted to determine the effect of adding nano-calcium from broiler bones on the hedonic test of chicken meatballs.

MATERIALS AND METHODS

Tools and Materials

The tools used in this research included a meat grinder, spoon, gas stove, pot, knife, plastic containers, cutting board, pH meter, scale, and tissue. The materials used in this study were broiler fillet meat, broiler bones, tapioca flour, eggs, salt, monosodium glutamate (MSG), pepper, garlic, shallots, isolated soy protein (ISP), lime, ethanol, ice, and water.

Research Method

The research method used was an experimental design with five levels of nano-calcium fortification. The fortification treatments were P0 (0%), P1 (0.15%), P2 (0.3%), P3 (0.45%), and P4 (0.6%) of the total meatball mixture.

Preparation of Broiler Bone Flour

Preparation of broiler bone flour as described by Prayitno, Umam, Ridho, Safitri, & Roihan (2025) Broiler bones were thoroughly washed and boiled for 1 hour. The bones were then mixed with water at a ratio of 1:6 (w/v) and cooked in a pressure cooker for 2 hours. Afterward, the bones were oven-dried at 105°C for 24 hours and ground into powder using a sample mill.

Preparation of Calcium Oxide from Broiler Bones

The broiler bone flour was converted into calcium oxide (CaO) following the modified method of Prayitno et al. (2021). The bone flour was calcined at 900°C for 4 hours to obtain CaO powder.

Preparation of Nano-Calcium from Broiler Bones

Nano-calcium was produced via green synthesis as described by Prayitno et al. (2025). CaO powder from broiler bones was mixed with distilled water. Lime juice extract and ethanol were added, and the mixture was stirred for 30 minutes using a magnetic stirrer at 75°C and 500 rpm. The sample was then dried under sunlight for 5 days, after which it was ground with a blender for 1 minute to produce nano-calcium powder.

Meatball Formulation

The meatball formulation was adapted from Prayitno et al. (2025). The formulation consisted of broiler meat (60%), tapioca (4%), egg white (12.5%), salt (1.4%), shallots (1%), garlic (2.5%), MSG (0.8%), pepper (0.5%), ISP (4%), sodium tripolyphosphate (STPP) (0.3%), carrageenan (0.5%), and ice (12.5%).

Meatball Preparation Process

The chicken meatball preparation followed the method of Prayitno et al. (2025). Chicken meat was cleaned with water, separated from fat, and cut into small pieces. The pieces were finely ground using a meat grinder. Spices were ground and mixed with salt, pepper, MSG, and the nano-calcium treatments, then processed in a meat processor. Tapioca, ISP, egg white, and ice were gradually

added to the meat processor and mixed until smooth. The dough was manually shaped into balls according to each treatment. The meatball dough was soaked in water at 60°C for 2 minutes, then boiled in boiling water for 10 minutes. The cooked meatballs were removed, drained, and cooled to room temperature.

Sensory Evaluation

The sensory evaluation of the chicken meatballs was evaluated using a hedonic test (Sujarwanta, Jamhari, Suryanto, Yuliatmo, & Prayitno, 2019). Sensory testing was conducted with 40 child panelists aged 6-12 years. The parameters evaluated in the hedonic test included color, flavor, taste, texture, chewiness, and overall acceptability. The hedonic scale used was a Likert scale ranging from 1 (extremely dislike) to 5 (extremely like).

Data Analysis

The hedonic test data were analyzed using a non-parametric approach through the Kruskal-Wallis test. If significant differences were detected, further analysis was conducted using Duncan's New Multiple Range Test (Zhang, He, Kang, & Li, 2018).

RESULTS AND DISCUSSION

The results of the hedonic test for broiler meatballs fortified with nano-calcium derived from broiler bones using green synthesis, as evaluated by children, are presented in Table 1.

Table 1. Hedonic test results of chicken meatballs among children

Variables	Treatments				
	0%	0.15%	0.30%	0.45%	0.60%
Color^{ns}	4.45	4.40	4.50	4.58	4.60
Flavor^{ns}	4.58	4.38	4.58	4.60	4.63
Taste	4.48^{a}	4.45^{a}	4.58^{ab}	4.55^{ab}	4.88^{b}
Texture^{ns}	4.43	4.48	4.55	4.63	4.73
Chewiness^{ns}	4.75	4.60	4.70	4.65	4.70
Overall acceptability	4.85^{ab}	4.68^{a}	4.75^{ab}	4.75^{ab}	4.98^{b}

^{ns}not significantly different (P>0.05)
^{ab}different superscripts indicate a significant difference (P<0.05)

Color

The results showed that fortification with different levels of nano-calcium from broiler bones had no significant effect (P>0.05) on the color scores of broiler meatballs in the hedonic test evaluated by child panelists aged 6-12 years. The color scores ranged from 4.40 to 4.60, indicating "like" to "extremely like." The insignificant effect of nano-calcium fortification on color scores may be due to the fact that the appearance of meatballs produced at different fortification levels did not present visually striking differences for the children's perception. Meatball color generally comes from a combination of main ingredients such as broiler meat, flour, and spices (Masyitah & Asyura, 2025), where the nano-calcium fortification levels used in this study did not produce extreme changes in color. Children aged 6-12 years usually have simple visual preferences, evaluating color based on general impressions such as brightness, cleanliness, and attractiveness without distinguishing detailed gradients (Adaval, Saluja, & Jiang, 2019). Thus, the hedonic test results for color suggest that the overall appearance of nano-calcium–fortified broiler meatballs remained appealing to children. This indicates that different fortification levels could maintain the familiar and acceptable visual appearance of broiler meatballs for the panelists.

Flavor

The results showed that fortification with different levels of nano-calcium from broiler bones had no significant effect (P>0.05) on the aroma scores of broiler meatballs in the hedonic test evaluated

by children aged 6-12 years. The aroma scores ranged from 4.38 to 4.63, meaning “like” to “extremely like.” This suggests that the fortification levels used were not strong enough to alter the characteristic aroma profile of broiler meatballs. Aroma results from volatile compounds formed during processing and cooking (Sohail et al., 2022), while the contribution of broiler bone–derived nano-calcium particles was likely minimal in influencing the aroma of meatballs. Children aged 6-12 typically have less sensitivity than adults in detecting complex aromas, distinguishing only between pleasant and unpleasant smells in a simple manner (Fry Vennerød, Nicklaus, Lien, & Almli, 2018). With flavor scores between 4.38-4.63, it can be concluded that no unpleasant, foreign, or off-odors were detected due to nano-calcium fortification. Overall, the flavor profile of broiler meatballs remained within the acceptable range for children, even with the addition of nano-calcium.

Taste

The results showed that fortification with different levels of nano-calcium from broiler bones had a significant effect ($P<0.05$) on taste scores in the hedonic test evaluated by child panelists aged 6-12 years. The taste scores ranged from 4.45 to 4.88, indicating “like” to “extremely like.” The significant influence suggests that nano-calcium addition at different levels could directly affect children’s taste perception of meatballs. Taste is a complex sensory attribute influenced by interactions among various chemical components in food (Liu, Deng, Sha, Abul Hashem, & Gai, 2017), including minerals such as calcium, which at certain concentrations may cause a bitter, metallic, or off-taste (Delompré, Guichard, Briand, & Salles, 2019). The results showed that the highest taste score was obtained at 0.60% fortification (4.88), while the lowest was at 0.15% fortification (4.45). This suggests that higher fortification levels actually produced a more preferred taste, possibly due to nano-calcium enhancing the savory or umami flavor of the broiler meatballs. The significant effect may be due to nano-calcium interacting with flavor compounds of the meat and spices, thus influencing children’s preferences more strongly.

Texture

The results indicated that fortification with different levels of nano-calcium from broiler bones had no significant effect ($P>0.05$) on texture scores in the hedonic test evaluated by children aged 6-12 years. The texture scores ranged from 4.43 to 4.73, meaning “like” to “extremely like.” This suggests that the physical structure and mouthfeel of the meatballs did not undergo significant changes based on children’s evaluation. Texture in meatball products is generally influenced by meat protein content, the addition of ice and starch, as well as mixing and heating techniques (Hajrawati et al., 2025). The amount of nano-calcium used in this study did not significantly affect protein gel binding or the structural matrix of broiler meatballs, and thus did not cause noticeable changes in texture as perceived by children. Additionally, children’s perception of texture is often more general, focusing on aspects like chewiness, softness, and ease of chewing without recognizing micro-level details. Overall, fortification with nano-calcium did not disrupt the sensory preference for texture among children.

Chewiness

The results showed that fortification with different levels of nano-calcium from broiler bones had no significant effect ($P>0.05$) on chewiness scores in the hedonic test evaluated by child panelists aged 6-12 years. The chewiness scores ranged from 4.60 to 4.75, indicating “like” to “extremely like.” This suggests that the elastic structure or springiness of the meatballs during chewing remained consistent across treatments. Chewiness in chicken meatballs is typically influenced by the formation of myofibrillar protein gels during heating and by binding agents such as starch or egg whites Nano-calcium particles likely did not significantly interact with protein gel structures, or

their effects were too minor to be perceived by children. Children often associate chewiness with a pleasant eating sensation and are less sensitive to small variations in elasticity, which may only be noticeable to adults or trained panelists (Chow, Skouw, Bech, Olsen, & Bredie, 2024). Generally, the chewiness of the meatballs in this study remained within the ideal range for children's preferences, without producing hardness, mushiness, or other undesirable textures.

Overall Acceptability

he results revealed that fortification with different levels of nano-calcium from broiler bones had a significant effect ($P<0.05$) on overall acceptability scores in the hedonic test evaluated by children aged 6-12 years. The overall acceptability scores ranged from 4.45 to 4.88, indicating "like" to "extremely like." The significant effect suggests that children's overall preference for chicken broiler meatballs was influenced by the combined interaction of sensory attributes such as taste, aroma, texture, and appearance. The highest overall acceptability score was obtained at 0.60% fortification (4.88), while the lowest was at 0.15% fortification (4.68). This indicates that children preferred meatballs with higher levels of nano-calcium fortification, possibly because these provided a better balance of taste, chewiness, and characteristic meatball aroma. Overall acceptability reflects the comprehensive impression of a product (Vivek, Subbarao, Routray, Kamini, & Dash, 2020), with taste often being the decisive factor for children, especially when supported by appealing appearance and enjoyable texture (Laureati, 2022). The addition of higher amounts of nano-calcium did not negatively affect other aspects such as color or aroma, thus contributing positively to the children's perception. This confirms that fortification with nano-calcium from broiler bones, when applied at appropriate levels, can enhance the acceptability of processed meat products such as meatballs without diminishing important sensory qualities for child consumers..

CONCLUSION

The results of the study showed that fortification with nano-calcium derived from broiler bones significantly affected the taste and overall acceptability scores of the meatballs but had no effect on their color, flavor, texture, or chewiness. The study concluded that the optimal treatment was the fortification with 0.6% nano-calcium from broiler bones, which achieved the highest taste and overall acceptability scores of 4.88 and 4.98, respectively.

ACKNOWLEDGEMENTS

The authors sincerely express their heartfelt appreciation to Politeknik Negeri Jember and the Directorate General of Vocational Education, Ministry of Education, Culture, Research, and Technology, for their generous support and funding provided through the Vocational Student Creativity Program (PKM Vokasi).

REFERENCES

Adaval, R., Saluja, G., & Jiang, Y. (2019). Seeing and thinking in pictures: A review of visual information processing. *Consumer Psychology Review*, *2*(1), 50–69. https://doi.org/10.1002/arcp.1049

BPS. (2023). *Produksi Daging Ayam Ras Pedaging menurut Provinsi (Ton), 2020-2022*. Jakarta: Badan Pusat Statistik Indonesia.

Chow, C. Y., Skouw, S., Bech, A. C., Olsen, A., & Bredie, W. L. P. (2024). A review on children's oral texture perception and preferences in foods. *Critical Reviews in Food Science and Nutrition*, *64*(12), 3861–3879. https://doi.org/10.1080/10408398.2022.2136619

Delompré, T., Guichard, E., Briand, L., & Salles, C. (2019). Taste Perception of Nutrients Found in Nutritional Supplements: A Review. *Nutrients*, *11*(9), 1–16. https://doi.org/10.3390/nu11092050

Fang, A., Li, K., Li, H., Guo, M., He, J., Shen, X., & Song, J. (2017). Low Habitual Dietary Calcium and Linear Growth from Adolescence to Young Adulthood: Results from the China Health and Nutrition Survey. *Scientific Reports*, *7*(1), 1–10.

Fry Vennerød, F. F., Nicklaus, S., Lien, N., & Almli, V. L. (2018). The development of basic taste sensitivity and preferences in children. *Appetite*, *127*, 130–137. https://doi.org/10.1016/j.appet.2018.04.027

Hajrawati, H., Maruddin, F., Hakim, M. R., Yulianti, Y., Rasak, A. N. M., & Suharyanto, S. (2025). Meatball properties as affected by substitution of tapioca with purple sweet potato. *Theory and Practice of Meat Processing*, *10*(1), 75–83. https://doi.org/10.21323/2414-438x-2025-10-1-75-83

Harinarayan, C. V., Akhila, H., & Shanthisree, E. (2021). Modern India and Dietary Calcium Deficiency—Half a Century Nutrition Data—Retrospect–Introspect and the Road Ahead. *Frontiers in Endocrinology*, *12*, 583654.

Jannah, A., Maunatin, A., Windayanti, A., Findianti, Y., & Mufidah, Z. (2013). Isolasi dan karakterisasi gelatin dari tulang ayam dengan metode asam. *Alchemy*, *2*(3), 184–189.

Khan, M. S., Ranjani, S., & Hemalatha, S. (2022). Synthesis and characterization of Kappaphycus alvarezii derived silver nanoparticles and determination of antibacterial activity. *Materials Chemistry and Physics*, *282*, 125985.

Laureati, M. (2022). Determinants of Preference and Consumption of Healthy Food in Children. *Foods*, *11*(2), 105. https://doi.org/10.3390/foods11020203

Liu, D., Deng, Y., Sha, L., Abul Hashem, M., & Gai, S. (2017). Impact of oral processing on texture attributes and taste perception. *Journal of Food Science and Technology*, *54*(8), 2585–2593. https://doi.org/10.1007/s13197-017-2661-1

Masyitah, & Asyura, S. (2025). Kualitas Fisik dan Organoleptik Bakso Ayam dengan Penambahan Tepung Talas (Colocasia Esculenta (L) Schoot) pada Konsentrasi yang Berbeda. *Zoologi : Jurnal Ilmu Peternakan, Ilmu Perikanan, Ilmu Kedokteran Hewan*, *3*(1), 101–109. https://doi.org/10.62951/zoologi.v3i1.122

Prayitno, A. H., Asrianto, N., Rahmasari, R., Handayani, H. T., Huda, C., Abdil, S. S., … Yogi, R. (2025). The effect of broiler bone nanocalcium citrate fortification on the color and sensory properties of Indonesian traditional beef meatballs 'bakso.' *IOP Conference Series: Earth and Environmental Science*, *1446*(1), 1–7. https://doi.org/10.1088/1755-1315/1446/1/012051

Prayitno, A. H., Siswoyo, T. A., Erwanto, Y., Lindriati, T., Hartatik, S., Aji, J. M. M., … Rusman. (2021). Characterisation of nano-calcium lactate from chicken eggshells synthesized by precipitation method as food supplement. *Jurnal Ilmu Ternak Dan Veteriner*, *26*(4), 139–144.

Prayitno, A. H., Umam, M. S., Ridho, M. R., Safitri, A. R., & Roihan, N. A. (2025). Characterisation of nano-calcium citrate from waste broiler chicken bones synthesized using lime as a novel food supplement. *Buletin Peternakan*, *49*(3), 187–193. https://doi.org/10.21059/buletinpeternak.v

Sohail, A., Al-Dalali, S., Wang, J., Xie, J., Shakoor, A., Asimi, S., … Patil, P. (2022). Aroma compounds identified in cooked meat: A review. *Food Research International*, *157*, 111385. https://doi.org/10.1016/j.foodres.2022.111385

Sujarwanta, R. O., Jamhari, Suryanto, E., Yuliatmo, R., & Prayitno, A. H. (2019). Physicochemical and sensory characteristics of chicken nugget with curcuma (Curcuma zanthorrhiza) flour fortification. *IOP Conference Series: Earth and Environmental Science*, *387*, 012091.

Suter, I. K. (2013). Pangan fungsional dan prospek pengembangannya. *Pentingnya Makanan Alamiah (Natural Food) Untuk Kesehatan Jangka Panjang*, 1–17. Denpasar: Jurusan Gizi Politeknik Kesehatan Denpasar.

Vivek, K., Subbarao, K. V., Routray, W., Kamini, N. R., & Dash, K. K. (2020). Application of Fuzzy Logic in Sensory Evaluation of Food Products: a Comprehensive Study. *Food and Bioprocess Technology*, *13*(1), 1–29. https://doi.org/10.1007/s11947-019-02337-4

Wibowo, H. K. A., & Dasuki, M. S. (2020). Hubungan Asupan Kalsium dan Pendidikan Ibu dengan Kejadian Stunting. *Proceeding Book Call for Papers Fakultas Kedokteran Universitas Muhammadiyah Surakarta*, 146–154. Surakarta: Fakultas Kedokteran Universitas Muhammadiyah Surakarta.

Zhang, H., He, P., Kang, H., & Li, X. (2018). Antioxidant and antimicrobial effects of edible coating based on chitosan and bamboo vinegar in ready to cook pork chops. *LWT - Food Science and Technology*, *93*, 470–476.