Journal of Food Health and Bioenvironmental Science
Journal homepage : http://jfhb.dusit.ac.th/

# Development of Sterilized Duck Meat in Coconut (*Cocos nucifera*) Sauce

Maria Petra O. Ebron[a], Nerisa N. Paladan[b]* & Percival O. Ebron[c]

[a] *College of Education, Partido State University, Goa, Camarines Sur, 4422 Philippines*
[b] *College of Accountancy and Economics, Partido State University, Goa, Camarines Sur, 4422 Philippines*
[c] *College of Integrated Arts and Humanities, Partido State University, Goa, Camarines Sur, 4422 Philippines*

**Article info**

*Article history:*
Received : 15 January 2024
Revised : 22 April 2024
Accepted : 29 April 2024

*Keywords:*
Duck product, Muscovy duck, Thermal process, Sensory characteristics

**Abstract**

This study developed a readily available food product and utilized the Muscovy duck in thermal processing with coconut sauce, ginger, and other ingredients. Ultimately, Muscovy duck in a bottle serves as a stand-in for other high-protein foods like cheese and meat. The study used experimental and developmental research methodologies to produce the final product. According to the sensory evaluation results, the formulation that was deemed acceptable was the Muscovy duck with coconut sauce and ginger (treatment code 654), which had the highest overall acceptance score of 8.37. With a general acceptability score of 8.23 for sensory qualities, the application of the 75-min thermal treatment was deemed appropriate. The application of high temperature and pressure at a certain time eliminates the microorganisms that cause spoilage and improves the quality. The addition of coconut sauce and ginger improves the flavor of the product. However, further studies on the effect of coconut sauce and ingredients added in the cooking of the Muscovy duck meat in its nutritional component are suggested. Furthermore, to demonstrate that the product is safe and has a longer shelf life, the shelf-life analysis of the bottled Muscovy duck meat with the designated ingredients must be taken into account.

## Introduction

Enhancing nutrition, achieving food security, promoting sustainable agriculture, and putting an end to hunger are some of the UN Sustainable Development Goals (SDGs). The goal is to guarantee that enough nutritious food is available to everyone on the planet so they can have healthy lives. Developing a readily available sterilized duck meat and utilizing the Muscovy duck using a thermal process with coconut sauce, ginger, and other ingredients added can contribute to achieving this UN SDG.

Utilizing Muscovy duck for sterilized duck meat can promote sustainable agriculture in the local areas. The total number of ducks in the inventory was 13.57 million as of June 30, 2022. This was 4.0% more than the 13.05 million birds recorded during the same period last year. Backyard farm stocks increased by 28.5%,



* Corresponding Author
e-mail: nerisa.paladan@parsu.edu.ph

whereas commercial farm stocks decreased by -43.8%. Eighty-seven percent of the duck population came from backyard farms, and the remaining eighteen percent came from commercial farms. With 77.9% of the overall duck population, mallards held the largest percentage, followed by muscovy and peking ducks with 20.8 and 1.3%, respectively (Philippine Statistics Authority, 2022). With the increase of Muscovy duck production, it is important to process this duck in order to add value to the product and offer the market an additional food and alternative processed meat product. Since Muscovy duck meat is considered red meat, it is healthier than other meat.

Studies consistently highlight the leanness of Muscovy duck meat, emphasizing lower fat content compared to conventional duck varieties. The meat is often lauded for its similarity to red meats such as beef or veal, contributing to its designation as a "red meat" alternative in culinary contexts (Kim & Je, 2018). The nutrient composition of Muscovy duck meat is explored in the literature, emphasizing its richness in essential nutrients. Researchers discuss the potential health benefits associated with consuming Muscovy duck, including its protein content, iron, zinc, and vitamin B (Lee et al., 1986). In the study of Fernandez et al. (2003), they compare Muscovy duck meat to other meats, drawing distinctions in terms of fat composition, calorie content, and nutritional value. Furthermore, the nourishment found in Muscovy ducks can strengthen the body's immunological system (Banaszak et al., 2020). These studies contribute to the understanding of how Muscovy duck fits into a balanced and healthy diet.

Ducks with less unsaturated fat are called muscovy ducks. In contrast to the wild duck, the muscovy duck is a tamed bird that cannot fly. More so than other fowl like broiler chicken, quail, turkey, and pigeon, Muscovy duck has a delicious flavor. This was supported in the study of McMillin et al. (2012), in which the unique flavor and texture of Muscovy duck meat were explored, and its sensory attributes set it apart from traditional poultry. This distinctiveness enhances its culinary appeal and positions it as a versatile ingredient in various dishes.

The development of readily processed products such as Muscovy duck meat holds significant importance in the contemporary food industry, responding to the dynamic lifestyles and preferences of consumers. Studies highlight the importance of readily processed products in meeting the culinary needs of individuals with busy schedules and diverse priorities (Kehoe et al., 2017). Also, the addition of supplementary ingredients to processed products like coconut sauce and ginger plays a pivotal role in enhancing their nutritional profile, flavor complexity, and overall consumer appeal. In the study of Ganorkar et al. (2018), they highlight the role of functional ingredients in processed foods in promoting health and well-being. Prior studies delve into the potential physiological effects of these ingredients on gut health, immune function, and disease prevention. According to Norman (2002), additional ingredients contribute to the overall sensory experience of processed products. Furthermore, advancements in food processing technologies have facilitated the creation of innovative and easily prepared products. This includes methods such as freeze-drying, vacuum packaging, and other techniques that enhance shelf life and preserve nutritional quality (Raju et al., 2003) like the thermal process that was used in this study.

One of the most popular and successful techniques of preservation is the canning or heat process (Aitken & Connell, 1979). Meat that has been precooked and then further thermally treated in hermetically sealed containers is free of germs, autolytic spoilage, and harmful microbes. This is especially crucial for the heat-resistant Clostridium botulinum, which can create a deadly toxin that can linger longer than two years at room temperature (Venugopal, 2012). Based on the background above, this study has the purpose of thermally processing the Muscovy duck meat in coconut (*Cocos nucifera* L.) sauce. Consumers of duck meat are generally unfazed by taboos related to culture or religion. Duck meat, therefore, offers a great opportunity for sustainable food security, but raising consumer awareness through sensory evaluation-a science of measurement that evaluates meat quality attributes like color, juiciness, and tenderness-is necessary (Lawless & Heymann 2010). These are the qualities that consumers find most important in meat. Consumers these days are worried about both the taste and safety of products. In addition to age, breed, and sex, other elements that impact these sensory qualities include post-mortem, cooking techniques, rearing systems, and the aging period. Customers around the world think that goods produced in ecological raising methods taste better and have superior nutritional quality (Andrée et al., 2010; Horsted et al., 2010).

The goal of this study is to improve the quality and productivity of agricultural and fishery products in

the nation, which supports the sustainable growth of these industries. Therefore, to assess the microbiological and sensory qualities as well as the viability of this new preserved product on the market, a scientific investigation was conducted into the use of Muscovy duck (*Cairina Moschata*) and other agricultural products like coconut, spices, and herbs in the bottling process.

The general objective of this study is to develop a thermally processed Muscovy duck meat with coconut sauce in a bottle. Specifically, it aims to answer the following objectives: to determine the most accepted treatment and the significant difference among treatments of Muscovy duck meat with coconut sauce in a bottle; to determine the most accepted thermally processed Muscovy duck meat with coconut sauce in a bottle and its significant differences; Lastly, to determine the microbiological count of accepted thermally processed Muscovy duck meat.

The hypothesis of the study is the following: (HO) The treatments do not significantly differ from one another in developing sterilized duck meat with coconut sauce in a bottle in terms of odor, texture, appearance, taste, and general acceptance. (HA) There is a significant difference between the treatments for developing sterilized duck meat with coconut sauce in a bottle in terms of odor, texture, appearance, taste, and general acceptance.

## Materials and methods

### 1. Study area and respondents of the study

The study was conducted at Mampirao, San Jose, Camarines Sur, Philippines in partnership with Rangas Agricultural Cooperative. The study area was chosen due to the availability of the Muscovy duck in the area where the members of the cooperative are Muscovy duck raisers.

### 2. Research procedures

Research methods used in the study included experimental, developmental, and descriptive-evaluative analysis. A new product was created with coconut milk in canned and bottled goods with Muscovy duck meat as the primary ingredient. This study employed an experimental research design that includes a series of protocols and methods designed to conduct scientific experimental research employing two variables. In this case, the first set of variables serves as a constant and is used to calculate the second set's differences. Two formulations of duck meat and coconut sauce concentration were tested to achieve the desired result.

Table 1 shows the proportion of ingredients for each treatment. The two treatments: treatment 1 with ginger additive with a code of 654; and treatment 2 without ginger with a code of 321 were subjected to sensory evaluation.

**Table 1** Filling media concentrations

| Ingredients | 654 (Trial 1) | 321 (Trial 2) |
|---|---|---|
| Lean duck meat | 500 g | 500 g |
| Coconut milk | 2 cups | 2 cups |
| Ginger | 50 g | |
| Garlic | 50 g | 50 g |
| Lack pepper | 5 g | 5 g |
| Lemon Grass | 100 g | 100 g |
| Vinegar | 1/4 cup | 1/4 cup |
| Fish sauce | 20 g | 20 g |
| Salt | 10 g | 10 g |

The following are the procedures for the development of sterilized Muscovy duck meat with coconut sauce in a bottle (Fig. 1):

2.1 Preparation of the filling media

Two Treatments (T) were created out of the filler media formulation. T1 had ginger, whereas T2 did not. In Table 1, the formulation is displayed. The formulation's concentrations were brought to a boil for fifteen min.

2.2 Pre-cooking the product

One (1) kg of duck meat was boiled in 1 L of water for 30 min. The ingredients were sautéed and added with coconut milk and boiled for 30 min until the meat became tender and oily. The finished product was subject to 30 panelists to determine the best formulation.

2.3 Filling the glass jars

Once more, the optimal mixture was precooked and packed into an 8-ounce container, glass jar, adding the same volume of filling material while maintaining an inch of headspace between the components and the jar's top.

2.4 Bottling/Canning process

The best formulation was used to thermally process the products. The treatments were at 15 psi and processed at 60, 75, and 90 min, respectively.

### 3. Sensory evaluation

There were two sensory evaluations conducted in this study. First, a sensory evaluation of the two (2) treatments: treatment 654 and treatment 321; and second the sensory evaluation of treatment 654 sterilized duck meat with coconut sauce and ginger at three thermal process temperatures: 60 min; 75 min; and 90 min. Both

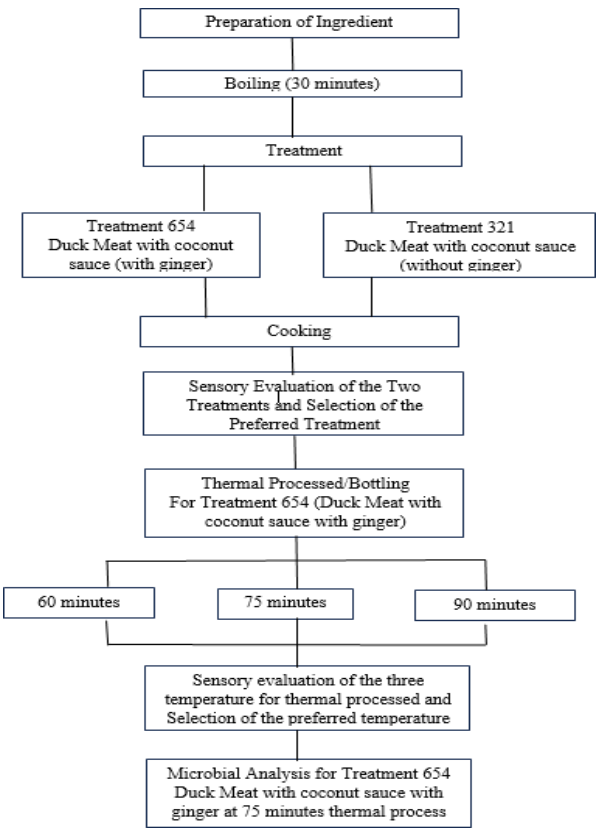


**Fig. 1** Process layout of sterilized duck meat with coconut sauce in the bottle

studies used a 9-point hedonic scale from 1 to 9, where 1 means "dislike extremely" and 9 means "like extremely" helping to capture a wide range of preferences. Both the odor, flavor, texture, color, coconut flavor, saltiness, and general acceptability for the thermal process as well as the appearance, taste, and general acceptability of the duck meat with coconut sauce were determined using the most preferred formulation.

**4. Microbiological analysis**

The sterilized duck meat with coconut sauce with ginger (treatment 654) with a 75-min thermal process was subjected to microbiological analysis. The method used for the coliform count, *E. coli* counts, and aerobic plate count was the TM-M-008 concerning AOAC 991.14, 21st Ed. Regular testing and monitoring are essential to maintain food safety standards. The analysis involved using specific techniques such as plating and incubation to determine the microbial count and type present in the samples at different time intervals during the thermal process.

**5. Statistical analysis**

ANOVA was used in this study to analyze the impact of different processing times on sensory test results. It compared the means of more than two groups to determine if there were significant differences between them. By using ANOVA, this study assesses how variations in processing time affect sensory perceptions such as taste, smell and texture. This study uses the Complete Random Design (CRD). The results provide valuable insights for optimizing processing methods to enhance the sensory qualities of products. The statistical package for social sciences (SPSS) version for experimental design was the program utilized for the analysis. It made use of the most recent version, which is created by the American company IBM.

## Results and discussion

**1. Sensory evaluation of two treatments of cooked Muscovy duck in coconut sauce**

When creating a new product, the sensory aspects play a crucial role in determining its quality criteria. These factors impact the product's position in the market and the willingness of people to purchase it. According to several studies, food technology, quality and safety analysis, or consumer testing can all be used to determine and regulate the sensory qualities of a product and assess its overall quality as well as the selected property that has been altered (Bahamonde et al., 2007; Grunert et al., 2008). This research aimed to develop a quality bottled Muscovy duck to match market needs and consumers' expectations.

Table 2 shows the result of the sensory evaluation of cooked Muscovy duck in coconut sauce. The result showed that the panelists extremely liked the odor, texture, appearance, and taste. This indicated that the cooked Muscovy duck in coconut sauce with ginger (Code 654) tasted better than the Code 321 version without ginger. According to Pathare & Roskilly's (2016) extensive analysis of the literature, cooking techniques significantly influence the eating quality characteristics of food products. Meat must be cooked so that the finished product has both desired sensory qualities and microbiological safety, according to Bisceglia et al. (2013). Nowadays, grilling-the cooking method that was used for the meat in this study-is a popular way to cook meat that is used in both the catering and industrial manufacturing of ready-to-serve meals. This study has demonstrated a substantial difference from Omojola

et al. (2014), who observed no significant difference between the treatments, with respect to the aspects of the cooked duck meat (see Table 2).

**Table 2** Sensory evaluation of two treatments for duck meat with coconut sauce

| Attributes | 654 Trial 1 (with ginger) | Interpretatio | 321 Trial 2 (without ginger) | Interpretatio | P-value |
|---|---|---|---|---|---|
| Odor | 8.30±1.09[a] | LVM | 7.90±0.92[b] | LVM | 0.049089906 |
| Texture[ns] | 8.07±0.95 | LVM | 7.70±1.11 | LVM | 0.083461129 |
| Appearance[ns] | 8.10±0.89 | LVM | 7.97±0.80 | LVM | 0.272521334 |
| Taste | 8.47±0.93[a] | LE | 7.97±0.86[b] | LVM | 0.022093357 |
| General acceptability[ns] | 8.37±0.73 | LVM | 8.13±1.07 | LVM | 0.199423496 |

**Remark:** Legend: LVM – Like Very Much; LE – Like Extremely; Means ± S.D. with different superscripts in the same row represent significantly different ($p \leq 0.05$) and ns represents not significantly different ($p > 0.05$)

## 2. Significant difference in the sensory attributes of cooked Muscovy duck in coconut sauce

Table 2 reflected the computed P value of each attribute of the sensory characteristics of each treatment to determine if there was a significant relationship. The null hypothesis (H0) which states that there is no significant difference between treatments was rejected. It was observed that the p-value is less than 0.05 which is typically considered to be statistically significant. Then the alternative hypothesis (HA) was accepted which states that there is a significant difference between treatments. Therefore, in this study, the null hypothesis (H0) was rejected, treatment code 654 (T2) duck meat with ginger had a significant difference from treatment code 321 duck meat without ginger in terms of odor and taste. Hence, treatment code 654 was the formulation used for the thermal process.

Furthermore, treatment code 654 duck meat cooked with coconut sauce and ginger had higher acceptability for the panelist. It was observed that the ginger on the meat makes it tender. Strong proteolytic enzyme found in ginger rhizome has been demonstrated to have antioxidant and tenderizing effects on tough meat (Lee et al., 1986; Mansour & Khalil, (2000). Compared to other tenderizing agents, the thiol proteinase known as "zingibain," which is derived from the natural spice ginger rhizome, has the benefit of having optimal proteolytic activity at a suitable temperature of 60ºC (Naveena & Mendiratta, 2001). According to Naveena et al. (2004), ginger rhizome, which is more affordable and readily available, can be used to tenderize tough meat.

## 3. Descriptive characteristics of bottled muscovy duck in coconut sauce at varied processing time

According to Tsutsumi's (1972) examination of commercial process time and temperature, F values that are suitable for commercially canned products are typically sufficient for retort pouch products. The pressure cooker utilized in this investigation is appropriate for thermally processing duck meat with coconut sauce in a glass container.

Table 3 reflects the summary and the average score of the bottled Muscovy duck in coconut sauce. General acceptability of the thermal product process at 60, 75 and 90 min at 121°C (Pressure 15 psi) was rated 8.1, 8.23 and 8.07, respectively. The data implied that the panelists liked the product at a very much rating. Hence the product is acceptable to the panelist and edible, this was regardless even if the product was processed at different times. This study showed that the high-pressure combined heating treatments at 15 psi and process for 60, 75 and 90 min have a positive impact on the duck meat, hence panelists liked it very much, especially the flavor of the products. According to some studies, the meat industry is making extensive use of high-pressure treatment, a non-thermal method, to enhance texture, speed up the product's processing, and encourage protein denaturation (Lou et al., 2018). In recent decades, the application of high pressure and heating in combination has become a widely used advanced technique in the processing of muscle food to expedite the changes that occur in myofibrillar proteins (Lou et al., 2018). In addition to causing the A- and I-filament to break and spread throughout the sarcomere, excessive pressure can also result in the removal of the M-line and the thickening of the Z-line (Zamri et al., 2006). According to reports, a rise in temperature caused myosin to denaturize (Raptopoulou et al., 2017).

Furthermore, the results demonstrated the long shelf life, safety and quality of the product. High-pressure (HP) processing, according to Raptopoulou et al. (2017), is a revolutionary approach used to extend food shelf life while retaining as much of the original sensory and nutritional qualities as feasible (Patras et al., 2009). Without heating, the HP procedure reduces the microbiological burdens at 100-1000 MPa and -20 to 60°C. Thus, the technique might help maintain food's antioxidant content as well as the potency of other nutritional substances impacted by heat (Tacon et al, 2013; Dyerberg, 1985).

## 4. Significant difference in the sensory attributes of bottled Muscovy duck in coconut sauce at varied processing time

Table 3 shows the result of the analysis of variance (ANOVA) on the effects of time at 121°C (Pressure 15 psi) using a pressure canner on the basic physiochemical properties of duck meat. The results showed no significant difference ($p > 0.05$) in the sensory attributes indicating that sterilization influenced the toughness of the meat. Since most of the panelists said the meat was tender. Furthermore, it implied that the quality of the product was not affected by the processing time at 121°C (Pressure 15 psi). The present findings are consistent with the research conducted by Khan et al. (2014), which reported that the heated and pressurized samples exhibited reduced hardness, gumminess, chewiness and increased tenderness. The study attributed these differences to variations in the heating medium and pressure during the exposure period.

Thermal sterilization and high pressure were used in the study. Since meat is a perishable protein food, the processing method used to preserve meat products has a significant impact on how long they may be stored. According to Wang et al. (2020), sterilization is essential to guaranteeing the security and longevity of meat products.

**Table 3** Sensory evaluation of thermally processed bottled Muscovy duck in coconut sauce at varied processing time

| Attributes | Thermal temperature | | | | | |
|---|---|---|---|---|---|---|
| | 60 min | | 75 min | | 90 min | |
| | WM | D | WM | D | WM | D |
| Odor$^{ns}$ | 7.63±1.45 | LVM7 | 53±1.61 | LVM | 7.73±1.55 | LVM |
| Flavor$^{ns}$ | 7.67±1.35 | LVM8 | 10±1.03 | LVM | 8.00±1.34 | LVM |
| Texture$^{ns}$ | 7.70±1.09 | LVM7 | 97±1.13 | LVM | 7.90±1.21 | LVM |
| Color$^{ns}$ | 7.53±1.53 | LVM8 | 23±0.90 | LVM | 8.03±1.43 | LVM |
| Coconut flavor$^{ns}$ | 7.57±1.22 | LVM7 | 63±1.81 | LVM | 7.80±1.58 | LVM |
| Saltiness$^{ns}$ | 7.93±1.36 | LVM7 | 27±1.87 | LM | 7.57±1.81 | LVM |
| General acceptability$^{ns}$ | 8.10±0.88 | LVM8 | 23±0.82 | LVM | 8.07±1.26 | LVM |

**Remarks**: WM= weighted mean; D= description of Interpretation; NS= not significant

## 5. Microbiological analysis of bottled Muscovy duck in coconut sauce at varied processing time

According to Kim et al. (2015), there have been concerns raised concerning food safety as a result of the rise in the consumption of duck meat and duck meat products in other countries (Korea Duck Association, 2014). Measuring duck meat or goods contaminated with other meats increases the danger of contracting foodborne illnesses, which is why microbiological examination is crucial. For example, Adzitey et al. (2012) found a correlation between outbreaks of salmonellosis and the intake of duck meat and duck meat derivatives. Therefore, in developing a product that involves duck meat it is necessary to undergo microbial analysis to check if it has the said bacteria. Salmonella spp. prevalence was reported by the Korea Centers for Disease Control and Prevention. throughout the food, particularly in the poultry meat (Bae et al., 2013). Hence, in this present study high temperature was applied to destroy and eliminate the spoilage microorganism. Due to its capacity to eliminate microorganisms without the need for preservatives or additives, high hydrostatic pressure (HHP) technology is both safe and user-friendly (Kruk et al., 2014), independent of the product's geometry (Zhang & Mittal, 2008). It is being used more and more in the meat industry, especially to extend the shelf life and safety of raw and sliced cooked product (Khan et al., 2014).

Table 4 shows the microbial load of the bottled Muscovy duck in coconut sauce. This test was conducted in a microbial laboratory facilitated by a licensed microbiologist. The microbiological analysis for the thermal process involved taking three samples of sterilized duck meat with coconut sauce and ginger (treatment code 654) with a 75-min thermal process. The results showed that Coliform count and *E. coli* counts were recorded as less than 10 CFU/g. On the other hand, Aerobic Plate Count was recorded at <300 CFU/g. The result is within recommended microbiological limits for meat food (ICMSF, 1986). However, the detection of *E. coli* does not assure the absence of enteric pathogens (Silliker & Gabis, 1976). Subjecting the duck meat to high pressure and temperature for at least 75 min eliminates harmful microorganisms, therefore the product is safe to eat and recommended that duck meat be thermally processed to improve the quality and to extend the shelf life. However, further studies on the nutritional and chemical components must be determined.

**Table 4** Microbiology of bottled Muscovy duck in coconut sauce

| Enterprise location (EL) | Coliform count (CFU*/g) | *E. coli* count (CFU*/g) | Aerobic plate count (CFU*/g) |
|---|---|---|---|
| Sardines SFE 1 | <10 | <10 | <300 |

**Remark**: *Colony-forming units (CFU) per gram

## Conclusion

In developing sterilized duck meat with coconut sauce in a bottle the application of high temperature and

pressure at a certain time eliminates the microorganisms that cause spoilage and improves the quality of the product. The addition of coconut sauce and ginger improves the flavor of the product. However, further studies on the effect of coconut sauce and ingredients added in the cooking of Muscovy duck meat in its nutritional component must be done. To further guarantee that this product is secure and has a longer shelf life, the shelf-life analysis needs to be taken into account.

## References


Adzitey, F., Huda, N., & Rahmat Ali, G. R. (2012). Prevalence and antibiotic resistance of Campylobacter, Salmonella, and *L. monocytogenes* in ducks: A review. *Foodborne Pathogens and Disease, 9*(6), 498-505.

Aitken, A., & Connel, J.J. (1979). Fish. In Priestly, R.J. (Ed.), *Effects of Heating on Food Stuffs* (pp. 219–253). London: Applied Science Publishers.

Andrée, S., Jira, W., Schwind, K.H., Wagner, H., & Schwägele, F. (2010). Chemical safety of meat and meat products. *Meat Science, 86*(1), 38-48.

AOAC. (2002). *Official methods of analysis* (21st ed.). Association of Official Analytical Chemists: Washington, DC, USA.

Bae, D.H., Dessie, H.K., Baek, H.J., Kim, S.G., Lee, H.S., & Lee, Y.J. (2013). Prevalence and characteristics of Salmonella spp. isolated from poultry slaughterhouses in Korea. *Journal of Veterinary Medical Science, 75*(9), 1193-120

Bahamonde, A., Díez, J., Quevedo, J.R., Luaces, O., & del Coz, J.J. (2007). How to learn consumer preferences from the analysis of sensory data by means of support vector machines (SVM). *Trends in Food Science and Technology, 18*(1), 20-28.

Banaszak, M., Kuźniacka, J., Biesek, J., Maiorano, G., & Adamski, M. (2020). Meat quality traits and fatty acid composition of breast muscles from ducks fed with yellow lupin. *Animal, 14*(9), 1969-1975.

Bisceglia, B., Brasiello, A., Pappacena, R., & Vietri, R. (2013). Food cooking process. Numerical simulation of the transport phenomena. In *Department of Industrial Engineering, University of Salerno, Via Giovanni Paolo II, COMSOL Conference in Rotterdam, Italy*.

Dyerberg, J. (1985). Coronary health aspects of fish food lipids. *Voeding, 46*(12), 388-391.

Fernandez, X., Auvergne, A., Renerre, M., Gatellier, P., Manse, H., & Babile, R. (2003). Preliminary observations on the colour variability of breast meat ('magrets') in force-fed ducks. *Animal Research, 52*(6), 567-574.

Ganorkar, A.B., Lakhe, R.R., & Agrawal, K.N. (2018). Time driven activity based costing (tdabc) model for cost estimation of assembly for a ssi. *International Journal of Productivity Management and Assessment Technologies (IJPMAT)*, 6(2), 56-69.

Grunert, K.G., Jensen, B.B., Sonne, A.M., Brunsø, K., Byrne, D.V., Clausen, C., ... Scholderer, J. (2008). User-oriented innovation in the food sector: relevant streams of research and an agenda for future work. *Trends in Food Science & Technology, 19*(11), 590-602.

Horsted, K., Allesen-Holm, B.H., & Hermansen, J.E. (2010). The effect of breed and feed-type on the sensory profile of breast meat in male broilers reared in an organic free-range system. *British Poultry Science, 51*(4), 515-524.

ICMSF. (1996). The international commission on microbiological specifications for foods. *Food Control, 7*(2), 99-101.

Kehoe, L., Romero-Muñoz, A., Polaina, E., Estes, L., Kreft, H., & Kuemmerle, T. (2017). Biodiversity at 817 risk under future cropland expansion and intensification. *Nature Ecology & Evolution, 1*(8), 1129-1135.

Khan, M.A., Ali, S., Abid, M., Ahmad, H., Zhang, L., Tume, R.K., & Zhou, G. (2014). Enhanced texture, yield and safety of a ready-to-eat salted duck meat product using a high pressure-heat process. *Innovative Food Science & Emerging Technologies, 21*, 50-57.

Kim, Y., & Je, Y. (2018). Meat consumption and risk of metabolic syndrome: Results from the Korean population and a meta-analysis of observational studies. *Nutrients, 10*(4), 390.

Kim, Y., Keogh, J., & Clifton, P. (2015). A review of potential metabolic etiologies of the observed association between red meat consumption and development of type 2 diabetes mellitus. *Metabolism, 64*(7), 768-779.

Korea Duck Association. (2014). *General statistics: Per capita duck meat consumption.* Retrieved from http://www.koreaduck.org/

Kruk, Z.A., Kim, H.J., Kim, Y.J., Rutley, D.L., Jung, S., Lee, S.K., … Jo, C. (2014). Combined effects of high pressure processing and addition of soy sauce and olive oil on safety and quality characteristics of chicken breast meat. *Asian-Australas J Anim Sci, 27*(2), 256-65.

Lawless, H.T., & Heymann, H. (2010). Sensory evaluation of food: Principles and practices (2nd ed.). Dordrecht Heidelberg London: Springer New York.

Lee, Y.B., Sehnert, D.J., & Ashmore, C.R. (1986). Tenderization of meat with ginger rhizome protease. *Journal of Food Science, 51*(6), 1558-1559.

Lou, X., Ye, Y., Wang, Y., Sun, Y., Pan, D., & Cao, J. (2018). Effect of high-pressure treatment on taste and metabolite profiles of ducks with two different vinasse-curing processes. *Food Research International, 105*, 703-712.

Mansour, E.H., & Khalil, A.H. (2000). Evaluation of antioxidant activity of some plant extracts and their application to ground beef patties. *Food Chemistry, 69*(2), 135-141.

McMillin, K., Lampila, L., & Marcy, J. (2012). Traceability in the meat, poultry and seafood industries. *Advances in Meat, Poultry and Seafood Packaging*, 565-595.

Naveena, B.M., Mendiratta, S.K., & Anjaneyulu, A.S.R. (2004). Tenderization of buffalo meat using plant proteases from *Cucumis trigonus* Roxb (Kachri) and *Zingiber officinale roscoe* (Ginger rhizome). *Meat Science, 68*(3), 363-369.

Naveena, B.M., & Mendiratta, S.K. (2001). Tenderisation of spent hen meat using ginger extract. *British Poultry Science, 42*(3), 344-349.

Norman, J. (2002). *Herbs and spices the cooks reference.* New York, NY: DK Publishing.

Omojola, A.B., Hammed, S., Attoh-Kotoku, V., Wogar, G.S.I., Iyanda, O.D., & Aremo, J.O. (2014). Physico chemical and organoleptic characteristics of Muscovy drake meat as influenced by cooking methods. *African Journal of Food Science, 8*(4), 184-189.

Pathare, P.B., & Roskilly, A.P. (2016). Quality and energy evaluation in meat cooking. *Food Engineering Reviews, 8*, 435-447.

Patras, A., Brunton, N., Da Pieve, S., Butler, F., & Downey, G. (2009). Effect of thermal and high pressure processing on antioxidant activity and instrumental colour of tomato and carrot purées. *Innovative Food Science & Emerging Technologies, 10*(1), 16-22.

Philippine Statistics Authority (2022). *Duck situation report, April-June 2022.* Retrieved form https://psa.gov.ph/content/duck-situation-report-april-june-2022

Raju, C.V., Shamasundar, B.A., & Udupa, K.S. (2003). The use of nisin as a preservative in fish sausage stored at ambient (28 ± 2°C) and refrigerated (6 ± 2°C) temperatures. *International Journal of Food Science & Technology, 38*(2), 171-185.

Raptopoulou, K.G., Pasias, I.N., Thomaidis, N.S., & Proestos, C. (2017). The effects of food processing and canning technologies on the nutritional value of foods. *Environmental and Agricultural Research Summaries, 10*, 78.

Silliker, J.H., & Gabis, D.A. (1976). ICMSF methods studies. VII. Indicator tests as substitutes for direct testing of dried foods and feeds for Salmonella. *Canadian journal of microbiology, 22*(7), 971-974.

Tacon, A.G.J., & Metian, M. (2013). Fish matters: Importance of aquatic foods in human nutrition and global food supply. *Reviews in Fisheries Science, 21*(1), 22-38.

Tsutsumi, Y. (1972). Retort Pouch. Its development and application to foodstuffs in Japan. *J. Plast, 6*, 24-30.

Venugopal, V. (2012). Heat treated fishery products. In *Second International Congress on Seafood Technology on Sustainable, Innovative and Healthy Seafood* (pp.67-84.). Rome, Italy: Food and Agriculture Organization.

Wang, W., Chen, H., Ke, D., Chen, W., Zhong, Q., Chen, W., & Yun, Y.H. (2020). Effect of sterilization and storage on volatile compounds, sensory properties and physicochemical properties of coconut milk. *Microchemical Journal, 153*, 104532.

Zamri, A.I., Ledward, D.A., & Frazier, R.A. (2006). Effect of combined heat and high-pressure treatments on the texture of chicken breast muscle (*Pectoralis fundus*). *Journal of Agricultural and Food Chemistry, 54*(8), 2992-2996.

Zhang, H., & Mittal, G.S. (2008). Effects of high-pressure processing (HPP) on bacterial spores: An overview. *Food Reviews International, 24*(3), 330-351.