Linking Socio-demographics of Meat Vendor-processors to Residual Nitrite in Skinless Native Sausage Sold in a Typical Public Market in the Philippines

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Nitrite plays a key preservative role in meat products. However, overapplication could increase the carcinogenicity risks while underapplication could shorten product shelf life. This study aimed to link the socio-demographic profile of the vendor-processors to the residual nitrite levels in skinless native sausage (skinless longganisa) in a typical public market in the Philippines. A total of 90 skinless longganisa packs were collected from the vendor-processors at three times. Skinless longganisa and commercial curing premix samples were analyzed for nitrite levels using the colorimetric method. Utilizing a random effects panel regression model, the impact of socio-demographic factors of the vendor-processors on the application of nitrite in their skinless longganisa products was assessed. The skinless longganisa samples had residual nitrite levels that ranged from 0.005–1.031 mg/kg with a mean value of 0.56 mg/kg of meat, which suggests the underapplication of nitrite at exceedingly low levels (only at most 2% of the recommended amount), compromising the microbial safety of the meat. The number of skinless longganisa vendor-processors with higher educational attainment (p < 0.01 for high school; p < 0.05 for college) was negatively associated with the nitrite content, whereas the frequency of married respondents (p < 0.01) and with more children (p < 0.05) was positively associated with the residual nitrite. Moreover, most of the vendor-processors had insufficient food safety knowledge despite having attended food safety seminars. With extremely low nitrite levels, monitoring and training programs should highlight the importance of applying the recommended levels of nitrite in skinless longganisa as an essential food safety measure.

Keywords: food safety, longganisa, nitrite, panel regression model, sausage, vendor-processors

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INTRODUCTION

Sausage comes in cultural varieties and is a popular value-added product (Nithin et al. 2015). Skinless native sausage (skinless *longganisa*) is a cured meat product common in the Filipino diet. It was introduced in the Philippines during the Spanish colonization from the 1500s to the 1800s. The Spanish traditional pork sausage called *longaniza* turned into skinless *longganisa* in the Philippines, where it grew to have many variations across the different ethnolinguistic groups. Skinless *longganisa* is usually made from pork but it can also be made from chicken, beef, or tuna, and can be encased in animal intestines or shaped in artificial casings (Ying 2016). Recently, marine fishes were also explored as an alternative filling for skinless *longganisa* (Flores et al. 2017). In this study, skinless *longganisa* refers to *longganisa* that is not encased in animal intestines or any artificial casing.

Nitrite has been employed in meat curing to impart distinct color and flavor, as well as to enhance the antioxidant activity in processed meat products. This food additive also functions to inhibit lipid oxidation that leads to rancidity and to control the growth of foodborne pathogens, especially *Clostridium botulinum*, the bacterium which causes botulism. However, due to the potential conversion of nitrite to carcinogens, safety concerns have been raised on its application throughout the years (Lee et al. 2018; Crowe et al. 2019; Cvetković et al. 2019). Several studies on the role of this additive in cancer development indicated that processed meat containing nitrite was correlated with a higher risk of colorectal cancer (Crowe et al. 2019). Moreover, the negative notion of the public concerning nitrite has been linked to the image projected by mass media (Hung et al. 2016).

According to the Discussion Paper on the Use of Nitrates (INS 251, 252) and Nitrites (249, 250) of the Codex Committee on Food Additives (2019), the maximum residual nitrite level in cured non-heat treated processed comminuted meat is 150 mg/kg. Meanwhile, 100–120 mg/kg is the standard maximum limit in other countries (Rezaei et al. 2013; Adam et al. 2017). Excessive usage of nitrite poses health risks, as recounted in several incidents. In 1992, children in Metro Manila were intoxicated from consuming sweet bacon (*tocino*), with nitrite levels reaching 1000 mg/kg of meat. Overapplication of nitrite also caused the death of a two-year-old child within 30 min of eating oriental pork sausage, with nitrite up to 9885 mg/kg of meat (Azanza and Rustia 2004). Another incident of nitrite poisoning involved a child who consumed *tocino* with a nitrite level of 1398 mg/kg of meat, which was more than ten-fold the allowable limit (Hartigan-Go et al. 1996). In a more recent report, high amounts of nitrite can cause methemoglobinemia, a fatal condition wherein the amount oxygen carried through the blood is reduced, as in the case of a 70-year-old man who died from nitrite intoxication after ingestion of homemade sausages with almost 30 times higher than the allowed nitrite levels (Cvetković et al. 2019). Furthermore, Wang et al. (2013) mentioned how weak regulations and monitoring resulted in three nitrite poisoning cases in China. Due to these reported nitrite-related illnesses, processors and consumers have manifested an increasing desire for low nitrite concentrations in processed meat products (Lee et al. 2018).

In a study by Azanza and Rustia (2004), the nitrite levels in *tocino* prepared by meat processors from Pampanga, Philippines, ranged from 0.76–144.42 mg/kg of meat, with most of the results deviating from the recommended values. As explained in the same study, the underapplication of nitrite may compromise the microbiological safety of cured meat. At least 50 mg/kg of meat is needed to inhibit the growth of *Clostridium botulinum* (CAC 2019). Thus, very low nitrite levels are not sufficient to suppress such pathogenic bacteria. A review by Lee et al. (2018) further stressed how decreased nitrite levels may enhance the risk of illness caused by foodborne pathogens.

Furthermore, socio-demographic profiles drive perceptions regarding food consumption and preparation. One study found that the number of children, gender, age, voting preferences, and income strongly determined the perceptions of food-related health risks (Dosman et al. 2001). Another study revealed that factors such as gender, age, college education, and income influence the food safety risk perceptions of consumers in Canada, the US, and Japan (Tonsor et al. 2009). In the perspective of food vendors, various socio-economic variables were explored such as sex, religion, worker status, marital status, ethnicity, and educational level of the vendor (Montcho et al. 2018), age, sex, marital status, family size, educational status, and average household income per month (Tesfaye and Tegene 2020); and gender, age, marital status, education, and vending places (Kabwang et al. 2019).

Thus, this study aimed to link the socio-demographic characteristics of the vendor-processors to the residual nitrite levels in skinless *longganisa* processed and sold in Bankerohan Public Market, a typical market in Davao City, Philippines. This study could provide helpful information for monitoring and establishing intervention programs to improve the safety of skinless *longganisa* and other cured meat products sold in public markets in the country.
MATERIALS AND METHODS

Skinless Longganisa Samples
Skinless longganisa samples were obtained from the meat vendor-processors in Bankerohan Public Market, Davao City, Philippines. Bankerohan Public Market is the largest public market in the city and it is where meat and other foods sold in smaller public markets are sourced. Practices in Bankerohan Public Market such as food handling, display, and marketing are typical in a public market in the Philippines (Digal et al. 2006; Briones 2013). A total of 90 cured skinless longganisa packs weighing 120–320 g per pack were collected from the 30 vendor-processors at three times. The samples were collected in the same period (i.e. 10:00 AM to 1:00 PM), which is the time of skinless longganisa processing. The basis for collecting samples three times is to capture the normal practice of processing skinless longganisa.

Samples for analysis were placed in chest coolers with ice for immediate transport. Analyses were carried out within 5–8 h of sampling. Sampling was done in triplicate and on different days. A total of six skinless longganisa curing premix samples – which include Prague powder, among other ingredients – were also obtained from three major sellers identified by the vendor-processors as their supplier. The samples were collected at two times and analyzed for nitrite content. However, in this research, other physicochemical characteristics such as temperature, storage, packaging, and pH were not considered.

Residual Nitrite Analysis
The skinless longganisa sample and curing premix were subjected to nitrite analysis using the colorimetric method described by the Association of Official Analytical Chemists 973.31 (1990). A scatter plot was used to illustrate the mean and standard deviation of the residual nitrite values across the three replicates.

Survey of Skinless Longganisa Vendor-processors
Data were collected through personal interviews using a structured questionnaire. The questionnaire had been pre-tested in a public market with settings similar to the major public market used in the present study, and formal consents were previously secured from the respondents. As for the validity and reliability, the questionnaire focused only on obtaining the socio-demographic information of the respondents (e.g. sex, age, marital status, number of children, household size, educational attainment, and years of skinless longganisa selling) and their attendance to training. Also, there were no questions regarding the use of ratings that were administered to the respondents. Pre-testing the survey questionnaires contributed to the increased accuracy of obtaining the information, which increases the reliability of the survey instrument.

The survey with prior informed consent was conducted among 30 skinless longganisa vendor-processors in Bankerohan Public Market, where 90 skinless longganisa samples were also collected. The number of respondents was based on complete enumeration as there were only more or less 30 skinless longganisa vendor-processors in the public market studied. Moreover, the central limit theorem states that as the sample size increases (i.e. at least 30), the sample’s distribution approaches normality and, therefore, the inferences regarding hypothesis testing become valid (Kwak and Kim 2017; Murao et al. 2019).

The survey consisted of vendor-processors’ socio-demographic background, which includes household size, age, gender, educational attainment, marital status, number of children in the household, number of years in skinless longganisa selling, attendance to meat processing training seminars, and attendance to annual food safety training seminars. Other questions included their knowledge of the functionalities of curing ingredients (salt, sugar, Prague powder, accord powder).

Estimation of a Panel Regression Model
A panel regression model was used in determining the linkage between the levels of residual nitrite in skinless longganisa and the household socio-demographic variables. More specifically, a panel regression random-effects model was utilized to estimate the effect of time-invariant regressors on the residual nitrite level (Alison 2009; Cameron and Trivedi 2009). Thus, an empirical model was specified, where time-invariant drivers such as sex, age, marital status, number of children household size, educational level, number of years in skinless longganisa selling, attendance to meat processing training and seminars, and attendance to annual food safety training and seminars affect the amount of nitrite in processed meats. The empirical model specification is denoted as:

\[
\text{Nitrite}_{it} = \beta_0 + \beta_1 \text{Sex}_{it} + \beta_2 \text{Age}_{it} + \beta_3 \text{Married}_{it} + \beta_4 \text{Number of Children}_{it} + \beta_5 \text{Household Size}_{it} + \beta_6 \text{High School}_{it} + \beta_7 \text{College}_{it} + \beta_8 \text{Technical Vocational}_{it} + \beta_9 \text{Experience}_{it} + \beta_{10} \text{MPST}_{it} + \beta_{11} \text{FST}_{it} + \epsilon_{it}
\]

where Nitrite_{it} is the residual nitrite of skinless longganisa from meat vendor-processor i at time t. The vector of individual and household socio-demographic variables at meat vendor-processor i at time t include the sex of the respondent (1 = male, 0 = female), age (yr), marital status whether married (1 = married, 0 = not married), number of children (number), household size (number), level of education (ordinal) relative to elementary level such as
high school (1 = high school, 0 = otherwise), college (1 = college, 0 = otherwise), technical and vocational school (1 = technical/vocational, 0 = otherwise), number of years of experience in selling skinless longganisa (yr), attendance to meat processing training and seminars (1 = yes, 0 = no), and attendance to annual food safety training and seminars (1 = yes, 0 = no). These variables were hypothesized as important drivers that impact the residual nitrite in their skinless longganisa products.

Furthermore, diagnostic tests in multicollinearity and normality of residuals were performed, and this study also applied the estimated robust standard error of the coefficients to address potential issues regarding heteroskedasticity (Studenmund 2011). The multicollinearity test indicated that the model did not exhibit degrading collinearity because the mean variance inflation factor (VIF) was less than 10 (minimum VIF = 1.48, mean VIF = 2.50, and maximum VIF = 3.18) (Kennedy 2008). Furthermore, results from the Shapiro-Wilk test indicated a failure to reject the null hypothesis, wherein the null hypothesis assumes normality of residuals (p-value = 0.65). The researchers implemented the regression estimation using Stata 15.1.

RESULTS AND DISCUSSION

Sanitary Practices and Level of Food Safety Knowledge

The Code on Sanitation of the Philippines requires food handlers to observe proper hygiene and sanitation (DOH-EHS 1995). Of the 30 skinless longganisa vendor-processors surveyed, 93% were reported wearing hairnets, 70% wore aprons, 40% wore face masks, and 13% wore gloves (data not shown). The respondents remarked that they normally do not wear gloves and masks because these aggravate the discomfort due to poor ventilation in the market. The absence of handwashing facilities and sources of potable water makes it difficult to apply sanitation and hygiene in processing the product. Moreover, all skinless longganisa vendor-processors prepare the products on-site as required by the market administrators for easy monitoring. This poses a major disadvantage of exposure to unsanitary areas and a consequently higher risk of microbial contamination. In a related study by Calumba et al. (2019), some habits of meat vendors in a similar public market in Davao City, Philippines, were observed to be non-compliant with recommended good manufacturing practices (GMP), which enhance possible transmission of foodborne pathogens. Thus, poor hygienic and sanitary practices of the vendor-processors increase the possibility of the presence of pathogenic microorganisms in skinless longganisa.

The knowledge of the vendor-processors on the function of curing ingredients in skinless longganisa is described in Table 1. Most of the vendor-processors were familiar with the functionality of each ingredient, although only 60% of the respondents declared that Prague powder is added as a preservative. Prague powder is a curing salt that contains 6.25% sodium nitrite (Quinton et al. 1997). This commercial form of nitrite is widely used not just to impart the typical pink color and develop a unique meat flavor of cured meat products but also as a preservative that combats pathogenic microorganisms (Zhang et al. 2018). Given that not all skinless longganisa vendor-processors were knowledgeable about the role of this ingredient, overapplication or underapplication of nitrite may have detrimental effects on the safety of the meat product. Even if the majority of the vendor-processors signified knowledge about the roles of the basic curing ingredients, this did not necessarily translate to practice (Rustia et al. 2017).

Table 1. Knowledge of vendor-processors on the functions of the curing ingredients in skinless longganisa (n = 30).

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Frequency</th>
<th>Purpose according to vendor-processors</th>
<th>Standard purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt</td>
<td>24 (80%)</td>
<td>Taste</td>
<td>Preservation and flavor</td>
</tr>
<tr>
<td>Sugar</td>
<td>23 (77%)</td>
<td>Taste</td>
<td>Preservation and flavor</td>
</tr>
<tr>
<td>Prague powder</td>
<td>18 (60%)</td>
<td>Preservation</td>
<td>Preservation, color, and flavor (sodium nitrite)</td>
</tr>
<tr>
<td>Accord powder</td>
<td>22 (73%)</td>
<td>Increasing the water-binding capacity of meat</td>
<td>Anticaking, color, flavor, firming, stabilizing, thickening (phosphates)</td>
</tr>
</tbody>
</table>
gaps in meat handling due to the absence of worker training, increasing the risks especially in people of developing countries (Langford et al. 2018). In the case of street food vendors in Iloilo City, Philippines, those who underwent training had more knowledge regarding hygienic practices (Calopez et al. 2017). In this study, attendance to training and years of experience were not shown to effectively ensure safe practices. Similar results were observed by Park et al. (2010), who mentioned that consistent food safety training is crucial to bringing about behavioral improvements in food safety management. Rustia et al. (2017) further stressed the need for regular and refresher training and support resources for better compliance with food safety requirements. Therefore, proper education and training of meat vendor-processors, especially in the public market, are key drivers for improving their practices in handling meat.

Residual Nitrite Levels

Residual nitrite refers to the amount of nitrite that has remained unreacted with meat constituents such as proteins, lipids, and pigments. It is also the nitrite that can be detected using analytical methods (Pegg and Shahidi 2000). The residual nitrite content of the 90 skinless longganisa samples ranged from 0.005–1.031 mg/kg of meat with a mean of 0.56 mg/kg across replicates (Figure 1). More specifically, the mean ± SD for the first, second, and third replicates are 0.5 ± 50.29 mg/kg, 0.5 ± 50.30 mg/kg, and 0.5 ± 70.28 mg/kg, respectively. The apparent consistency in these values may be attributed to the common stores where they obtain their curing premix. Residual nitrite concentrations in meat are also affected by the type of muscle cured, pH, and temperature of the food (Pegg and Shahidi 2000), although the interaction of these variables with residual nitrite in skinless longganisa needs to be explored. Based on the maximum limit of 150 mg/kg of cured meat product (CAC 2019), all samples had residual nitrite levels way below this value.

Similarly, the nitrite levels of the curing premix used were also way lower than that needed to inhibit C. botulinum. The nitrite levels ranged from 2–35 mg/kg (Table 2). Aside from nitrite, the curing premix contains other ingredients such as salt and sugar. It was observed that the nitrite values varied greatly between sampling times. Curing premix vendors are not required to attend food safety seminars and may not be aware of the importance of consistency during preparation. All of the obtained concentrations were lower than the minimum requirement to inhibit the growth of C. botulinum, which is 50 mg/kg expressed as sodium nitrite (CAC 2019), and this may compromise the microbiological safety of cured meat products (Feiner 2016). Nitrite levels in pre-mixed curing salts used by tocino processors in the Philippines only ranged from 1.2–3.0% (Azanza and Rustia 2004). Another similar study found that nitrite levels in processed meat products were below the maximum limits (Adam et al. 2017). Thus, in this study, the measured residual nitrite levels for skinless longganisa samples and nitrite levels in the curing premix were below the values needed to inhibit C. botulinum.

Table 2. Nitrite content of curing premix obtained from three different curing premix vendors (n = 6).

<table>
<thead>
<tr>
<th>Batch</th>
<th>Nitrite (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
</tr>
<tr>
<td>1</td>
<td>2.0–8.5</td>
</tr>
<tr>
<td>2</td>
<td>6.5–35.0</td>
</tr>
</tbody>
</table>

<sup>a</sup>Batch 1 and 2 samples were taken at different dates and different times.
<sup>b</sup>Values were computed as mean ± standard deviation.

Consumer and market feedback influence Filipino vendors to indiscriminately use food additives that are considered controversial. Misconceptions of the vendor-processors themselves also contribute to the misuse of the additives. It was noted that nitrite is primarily used by Filipino market vendors more for color, texture, and flavor function rather than as a preservative or antimicrobial agent (Azanza and Rustia 2004). As gathered from the survey, the skinless longganisa vendor-processors were aware of the negative health impacts of nitrite; conversely, they were not entirely vigilant of the antimicrobial effect of the additive. According to personal communication with members of the food safety team in the city, annual food safety seminars in the region emphasize the dangers of the overapplication of nitrite without equally highlighting the consequences of applying very little amounts of this food additive. As a result, the extreme precaution of the vendor-processors may have led to their underapplication of nitrite in skinless longganisa. In a study by Malakauskiene et al. (2016) on cured meat sausages, it was explained that meat producers need adequate knowledge to assure that products sold are safe and of good quality. Therefore, the
application of food additives such as nitrite should be based on the Codex General Standard for Food Additives and must be effectively conveyed to food processors in training and seminars.

**Linkage of Socio-demographic Characteristics to Residual Nitrite Levels**

A total of 30 skinless *longganisa* vendor-processors in Bankerohan Public Market were interviewed in this study. The respondents were mainly female (83%) and the average age was 51 yr old. The majority (63%) were married. On average, there was at least one child per household (1.33). There were at least approximately five members in the household (4.70). In terms of educational attainment, the majority of the respondents were at least high school level (2.27). Approximately, the length of experience of skinless *longganisa* selling was 14.23 yr. More than half of the respondents have attended a meat processing training and seminar (57%), and food safety training and seminar (83%). The summary statistics of the variables used in the panel regression model are reported in Table 3.

Using the random effects panel regression model, the significant variables affecting residual nitrite levels in skinless *longganisa* were educational attainment (*p* < 0.01 for high school and *p* < 0.05 for college), the marital status if married or not (*p* < 0.01), and the number of children in the household (*p* < 0.05) (Table 4). Educational attainment was negatively associated with nitrite content, whereas the number of married respondents and the number of children were positively associated with higher nitrite levels.

The educational attainment of the vendor-processors was among the strong determinants of nitrite application. The results showed that reaching both high school and college levels had a significant correlation with the residual nitrite in the skinless *longganisa* products. Skinless *longganisa* processed by the vendor-processors who reached high school had lower residual nitrite by about 0.2076 mg/kg compared to those who attained elementary education. Furthermore, skinless *longganisa* products from vendor-processors who finished tertiary education had lower residual nitrite by about 0.2415 mg/kg compared to those who attained elementary education. Thus, as educational attainment increased, residual nitrite levels decreased, with the values falling way below the allowable limit. A study by Bhattarai *et al.* (2017) found that education significantly affected meat hygienic practices while another study by Jores *et al.* (2018) found no significant association between the level of education and food safety and hygiene practices. In the current study, as educational attainment increased, the chemical hazard on the use of excessive nitrite may have been emphasized more compared to the consequences of its underapplication. Similarly, based on personal communication with the food safety team, food safety seminars in the region stress the risks of excess nitrite application with minimal or no discussion of the dangers of very little nitrite application. The vendor-processors who participated in the study could have been more exposed to information about the risk of using nitrates in meat.

Married respondents incorporated more nitrite into their products relative to unmarried respondents. The difference between married and unmarried respondents in terms of residual nitrite levels was 0.2544 mg/kg of meat. In a related study, married respondents were found to be more trusting that the food additives approved by the government are safe compared to single respondents, although this finding was significant at 10% only (Shim *et al.* 2011). Moreover, marital status was shown to correlate with vendor choices in sourcing raw materials (Montcho *et al.* 2018), suggesting that this factor could also be linked to nitrite application in the current study. Finally, in this context, the researchers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrite (mg/kg)</td>
<td>0.0022</td>
<td>1.0917</td>
<td>0.5563</td>
</tr>
<tr>
<td>Sex (dummy)</td>
<td>0.00</td>
<td>1.00</td>
<td>0.17</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>29.00</td>
<td>63.00</td>
<td>50.80</td>
</tr>
<tr>
<td>Marital status (dummy)</td>
<td>0.00</td>
<td>1.00</td>
<td>0.63</td>
</tr>
<tr>
<td>Number of children (number)</td>
<td>0.00</td>
<td>5.00</td>
<td>1.33</td>
</tr>
<tr>
<td>Household size (number)</td>
<td>1.00</td>
<td>12.00</td>
<td>4.70</td>
</tr>
<tr>
<td>Educational attainment (ordinal)</td>
<td>1.00</td>
<td>4.00</td>
<td>2.27</td>
</tr>
<tr>
<td>Experience (yr)</td>
<td>2.00</td>
<td>40.00</td>
<td>14.23</td>
</tr>
<tr>
<td>Meat processing training/seminar (dummy)</td>
<td>0.00</td>
<td>1.00</td>
<td>0.57</td>
</tr>
<tr>
<td>Food safety training/seminar (dummy)</td>
<td>0.00</td>
<td>1.00</td>
<td>0.83</td>
</tr>
</tbody>
</table>

aNumber of skinless *longganisa* vendor-processors (n = 30), number of skinless *longganisa* samples (N = 90), (1 = male, 0 = female), (1 = married, 0 = not married), (1 = elementary, 2 = high school, 3 = college, 4 = technical/vocational), (1 = yes, 0 = no).
acknowledge that literature is limited and, perhaps, the current study can provide new information linking marital status to nitrite application in meat processing. The presence of children in the household also significantly affected the residual nitrite levels. Those who have children in the household were more likely to have higher residual nitrite in their skinless longganisa products by about 0.0620 mg/kg of meat. Having children implies a bigger household, hence the need for a higher household budget. As most of the vendor-processors perceived nitrite as functioning primarily for color and flavor, increasing its amount makes skinless longganisa more appealing, similar to how flavor enhancers like monosodium glutamate may lead to larger profit (Pearson and Gillett 1996). The skinless longganisa processors with children in the household may tend to increase the application of nitrite to make the color and flavor more pleasing to the consumers, which then translates to increased profit to support the bigger household.

CONCLUSIONS AND IMPLICATIONS

This study looked into the application of nitrite in skinless longganisa processed and sold in Bankerohan Public Market, Davao City. The results demonstrated that all skinless longganisa samples had residual nitrite levels ranging from 0.005–1.031 mg/kg with a mean value of 0.56 mg/kg of cured meat, which was way below the minimum required amount of 50 mg/kg for the inhibition of C. botulinum. In addition, the measured nitrite levels of the sampled curing premix were also below the required amount. Poor sanitation and hygienic practices, as well as insufficient food safety knowledge, may contribute to the compromised microbiological safety of the skinless longganisa products. Moreover, using the random effects panel regression model, educational attainment was negatively associated with nitrite content, while the number of married respondents and the number of children were positively associated with nitrite levels. Thus, there is a need to improve the food safety knowledge and practices of the skinless longganisa vendor-processors, specifically on the application of appropriate nitrite levels to ensure the safety of the processed meat. Food safety seminars must be conducted regularly and emphasis should focus on the dangers of both low nitrite and high nitrite applications. Owing to the differences in the educational attainment of those attending the seminar, it is recommended that the content be presented in the vernacular to assure effective learning. Lastly, food safety seminar providers should have an assessment tool to evaluate participants prior to the issuance of certificates.

The output of this study can help food regulatory agencies such as the Department of Health, Department of Science and Technology, Food and Drug Administration, and National Meat Inspection Service regarding nitrate/nitrite monitoring in Philippine cured meat products. The results of this study could also aid in the improvement of modules in meat processing training and seminars, which need to focus on the importance of applying the recommended levels of nitrite in skinless longganisa production.

| Table 4. Panel regression model for residual nitrite (N = 90). |
|---------------------------------|-------------------------------|----------------------|------------------|
|                                | Coef.                         | Robust std. err.     | z                | P > z   |
| Sex (Base = Female)            | –0.0942                       | 0.0808               | –1.1700          | 0.2440  |
| Age                            | –0.0009                       | 0.0056               | –0.1700          | 0.8680  |
| Marital Status (Base = Single) | 0.2544                        | 0.0914               | 2.7800           | 0.0050  **
| Number of children             | 0.0620                        | 0.0293               | 2.1200           | 0.0340  *
| Household size                 | –0.0337                       | 0.0220               | –1.5300          | 0.1260  |
| Education (Base = Elementary)  |                               |                      |                  |         |
| High school                    | –0.2076                       | 0.0792               | –2.6200          | 0.0090  **
| College                        | –0.2415                       | 0.1098               | –2.2000          | 0.0280  *
| Technical/ vocational          | 0.0722                        | 0.1987               | 0.3600           | 0.7160  |
| Experience                     | 0.0063                        | 0.0046               | 1.3800           | 0.1690  |
| Meat processing training       | 0.0166                        | 0.1065               | 0.1600           | 0.8760  |
| Food safety training           | –0.0128                       | 0.1000               | –0.1300          | 0.8990  |
| Constant                       | 0.6105                        | 0.2795               | 2.1800           | 0.0290  *

*p < 0.05; **p < 0.01; Wald chi-squared (11) = 27.67; prob > chi-squared = 0.0036
ACKNOWLEDGMENTS

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