NITRITE CONCENTRATION ANALYSIS USING SPECTROPHOTOMETRY ON LOCALLY PROCESSED MEAT PRODUCTS IN A PROVINCE IN THE PHILIPPINES

ENGR. EVELYN JOY D. NERI [1], MARK E. PATALINGHUG[2]
https://orcid.org/0000-0002-5663-4876[1],https://orcid.org/0000-0002-5194-3207[2]
joydonggonneri@gmail.com, mark.patalinghug@jhcsc.edu.ph[2]
J.H. Cerilles State College-Dumingag Campus
Caridad, Dumingag, Zamboanga del Sur, Philippines

ABSTRACT

To examine the nitrite content of meat products is essential to protect consumers from potential health risks. This study evaluated the nitrite concentrations of chorizo and longaniza products as preservatives in cured chorizo and longaniza in Zamboanga del Sur, Philippines. The descriptive and comparative quantitative research methods were used to examine the nitrite concentration. A kilogram of each of the samples of chorizo and longaniza products were randomly taken from the public market of Dumingag, Molave, and Pagadian City. These samples were analyzed to determine the nitrite concentration spectrophotometrically. The tests showed that chorizo samples from A, B, C, D, E, F, G, and H have nitrite concentrations below the allowable or standard level. In contrast, the sample I result showed a high concentration of nitrite, very far above the Meat Inspection Regulations Standard (MRI) and Food and Drug Administration (FDA) level within a nitrite concentration of 13.4 mg Nitrite (NO_2) per 100.0 grams of cured meat. On the other hand, longaniza samples J, K, and L have nitrite concentrations below the standard level, while samples M and N have nitrite concentrations above the standard. These results indicate that chorizo and longaniza products sold in the said market have not met the FDA's standards and are unsafe for human consumption.

Keywords: Health Science, Food Safety, Spectrophotometry, Nitrite concentrations, Food Preservatives, Philippines

INTRODUCTION

The government encourages low and average-income Filipinos to engage in entrepreneurship, such as food processing, to improve their income and living. However, usually, the products produced from the local food manufacturers did not undergo quality control. The meat vendors' alternative practice to preserve their unsold meat is by curing and processing the leftovers into more attractive and delicious products, such as chorizo and longaniza, preventing microbial degradation.

The abundance of nutrients in meat and meat products allows yeast, molds, and bacteria to strive. Consequently, the product spoils quickly in the natural environment. Numerous techniques can be done to prevent microbial spoilage of meat and meat products, such as using preservatives, different processing technologies, and extending shelf life (Mills et al., 2014; Nychas et al., 2008; Ruiz-Capillas & Jimenez-Colmenero, 2008). The microbial degradation of meat and meat products eventually leads to protection and consistency concerns where the meat is not adequately treated and preserved. The degradation of meat and meat products by bacteria, autolytic enzymes, and lipid oxidation will result in significant economic and environmental consequences (Jayasena & Jo, 2013).

For this reason, the use of preservatives in meat increased food safety, storage life, and food technology. Its vital role is to prevent harmful microorganisms from developing in food products (Lou et al., 2017).

Curing meat, including salt and occasionally nitrate to fresh meat cuts, allows preservative effects by eliminating water and reducing moisture in the product (Alahakoon et al., 2015; Ichimura et al., 2017; NSW Food Authority, 2009). Food curing practice had been long used for thousands of years, even before food preservation safety standards and refrigeration. These days, food safety and manufacturing processes rely on safe and efficient curing and preservation methods to include meat products (Parthasarathy & Bryan, 2012).

Meat curing is a well-known technology that uses advanced techniques in the current meat processing industry using nitrite. (Gassara et al., 2016; Sindelar & Milkowski, 2011). Nitrite is primarily used to preserve its microbial consistency, taste, and color in various meat products and avoid lipid oxidation (Alahakoon et al., 2015), and it remains the most effective curing agent to prevent food spoilage and bacterial contamination (Parthasarathy & Bryan, 2012).

The curative process imparts many other distinguishing characteristics and protective measures against Clostridium botulinum, typical of all cured meat products due to sodium nitrite present in the curing mixture. These characteristics add distinctive color, flavor, texture and protect the meat for lipids oxidation (Sindelar & Milkowski, 2011).

Nevertheless, nitrogen oxide and secondary amines are released by-products during the curing process and fermentation, formed into N-nitrosamines compounds as a reaction to organic amines. N-nitrosamines are classified as carcinogens by International Agency for Research on Cancer (IARC) and the United States Environmental Protection Agency US EPA (Park et al., 2015). N-nitrosamines have to pose increasing health risks (Akyüz & Ata, 2013; Aragón et al., 2013; Ramírez et al., 2012).

At high levels, nitrates and nitrites were associated with increased cancer incidence in adults, combined with N-nitroso derivatives from secondary or tertiary amines, and potential increased incidence of brain tumors, leukemia, and nasopharyngeal problems (Gassara et al., 2016). Nitrite residual for cured (including salted) and dried non-heat treated processed meat and poultry products in whole pieces or cuts was at 134 mg/kg tolerable rate (Alimentarius Codex, n.d.). Food safety is essential to protecting people's health. Safer food leads to less disease and thereby improving livelihood (Vogt et al., 2012).

Clear evidence suggests that meat products cured using nitrite compounds or technologies may not be safe for a human to consume if it does not conform to the Food and Drug Administration (FDA).

With the evidence presented above, the researchers were concerned regarding consumers' exposure to contaminants derived from meat preservation and curing with nitrite compound that may pose health risks.

This concern has led researchers to seek ways to reduce the risk of ingesting nitrosamine from processed meat and alleviate potential human health concerns by determining the presence and level of nitrite in products such as chorizo and longaniza in selected areas in Zamboanga del Sur.

OBJECTIVES OF THE STUDY

This study was conducted to determine nitrites presence as a preservative in the locally manufactured cured meat such as chorizo and longaniza in selected areas in the province of Zamboanga del Sur, Philippines. Specifically, it sought to evaluate the following: 1) Determine trace level compounds of nitrite concentration in chorizo products from the public market of Dumingag, Molave, and Pagadian City; 2) Determine trace level compounds of nitrite concentration in longaniza from the public market of Molave and Pagadian City; and 3) Evaluate the significant difference of the nitrite level present in the locally processed food as to the

guidelines set by the Philippine Food and Drugs Administration.

METHODOLOGY

The study made use of quantitative descriptive and comparative methods of research. Descriptive in the sense that it sought to determine the amount of nitrite present in cured meats of chorizo and longaniza and comparative because it sought to compare every sample's nitrite concentration taken from the local markets to the Department of Health's standard nitrite concentration through the Food and Drug Administration (DOH – FDA) and the Meat Inspection Regulations (MIR). The samples were taken randomly from the selected local markets within Zamboanga del Sur. Random sampling was conducted from the public markets in Molave, Dumingag, and Pagadian City. Each sample consisted of a kilogram of chorizo and a kilogram of longaniza. The samples gathered were brought to Iligan City, Lanao del Norte, and analyzed at the Chemistry Laboratory of Mindanao State University – Iligan Institute of Technology (MSU-IIT) for nitrites analyses. In determining the significant difference in the nitrite contents of the meat products gathered and the standard nitrite concentration set by the Philippine Food and Drugs Administration (DFA), a t-test was applied.

RESULTS AND DISCUSSION

1. Nitrite Concentration of Chorizo Samples from Dumingag, Molave, and Pagadian Manufacturers.

1.1. Nitrite Concentration per 100 Grams of Chorizo from Dumingag Manufacturer

As shown in Table 1, the laboratory results of the chorizo products samples from Dumingag manufacturers contained nitrite concentrations very much lower than that of the standard Standard Nitrite Concentration of 13.40 mg nitrite (NO_2) per 100.0g of cured meat.

Table 1
Average Nitrite Concentration of Chorizo from Dumingag Manufacturer

Location	Mass Sample in Grams	Chorizo Samples	Milligrams Nitrite Per sample	Variance	V.I.
Standard Amount of Nitrite	100		13.4 ± 0.02		Safe
Dumingag	100	A	1.02 ± 0.04	(12.38) or (92.39%)	Safe
Dumingag	100	B	0.80 ± 0.03	(12.6) or (94.03%)	Safe
Dumingag	100	C	0.76 ± 0.02	(12.64) or (94.33%)	Safe

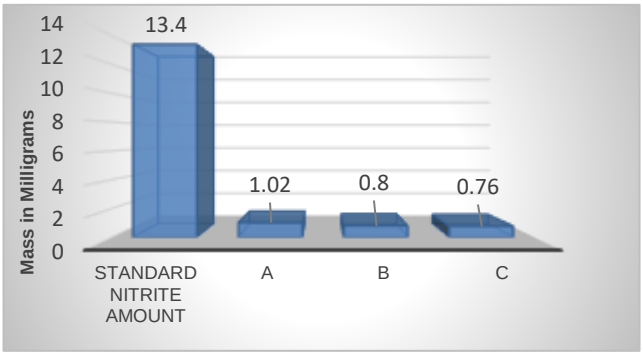

Figure 1. Nitrites Concentration per 100 Grams of Chorizo from Dumingag Manufacturers

The results showed that sample A has a nitrite concentration of 1.02 ± 0.04 milligram with a variance of 12.38 per 100 grams, which is interpreted as safe. Sample B has a nitrite concentration of 0.80 ± 0.03 with a variance of 12.6 and is interpreted as safe. Sample C has a nitrite concentration of 0.76 ± 0.02 with a variance of 12.6 and is interpreted as safe in terms of nitrosamine effects.

1.2. Nitrite Concentration per 100 Grams of Chorizo Samples from Molave Manufacturers

Table 2 shows that the chorizo samples D, E, and F from the Molave public market contained nitrite concentrations below the Food and Drug Administration's maximum level. Sample D, E, and F have a lower nitrites concentration of 13.4 mg nitrite (NO_2^-) per 100.0g of cured meat. These results depict that these chorizo products were safe regarding the

potential risks that the nitrites may pose to human health.

Table 2
Average Nitrite Concentration of Chorizo from Molave Manufacturers

Locations	Mass Sample in Grams	Chorizo Samples	Milligrams Nitrite Per sample	Variance	V.I.
Standard Amount of Nitrite	100		13.4 ± 0.02		Safe
Molave	100	D	1.73 ± 0.13	(11.67) or (87.09%)	Safe
Molave	100	E	0.15 ± 0.01	(13.25) or (98.88%)	Safe
Molave	100	F	0.28 ± 0.02	(13.12) or (97.91%)	Safe

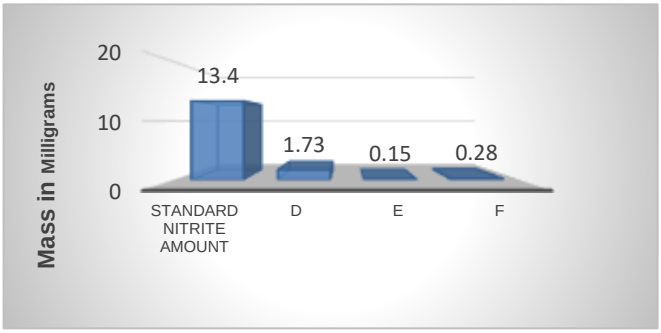

Figure 2. Nitrites Concentration per 100 Grams of Chorizo from Molave Manufacturers

1.3 Nitrite Concentration per 100 Grams of Samples from Pagadian City Manufacturers

As shown in Table 3, chorizo products from Pagadian City Public market, G and H, contained nitrite concentrations lesser than the maximum standard level of 13.40 mg nitrite (NO_2) per 100.0g of cured meat.

Table 3
Average Nitrite Concentrations of Chorizo in Pagadian City

Locations	Mass Sample in Grams	Chorizo Samples	Milligrams Nitrite Per sample	Variance	V.I.
Standard Amount of Nitrite	100		13.4 ± 0.02		Safe
Pagadian	100	G	4.73 ± 0.22	(8.67) or (64.70%)	Safe
Pagadian	100	H	4.59 ± 0.10	(8.81) or (65.75%)	Safe
Pagadian	100	I	39.07 ± 0.04	25.67 or 192%	Not Safe

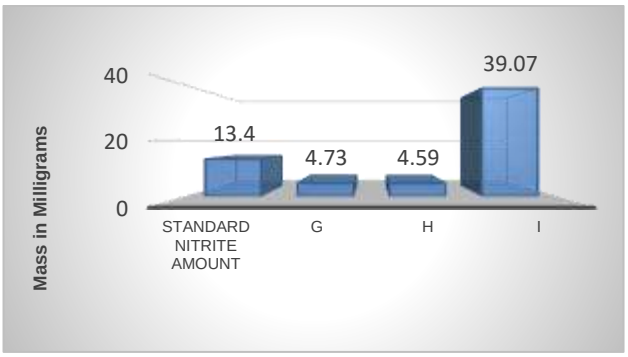

Figure 3. Nitrites Concentrations per 100 Grams of Chorizo from Pagadian City Manufacturers

The chorizo from sample I contained a very high nitrite concentration of 39.07 ± 0.04 milligrams of nitrite per 100.0 grams of chorizo sample, more than doubled from the standard level. This product was hazardous to health due to the possible effect caused by nitrite distraction.

2. Nitrite Concentrations of Longaniza from Manufacturers in Molave and Pagadian City

2.1 Nitrite Concentration per 100 Grams of Longaniza Samples from Molave Manufacturer

The results shown in Table 4 pointed that the longaniza products from Molave manufacturers J and K have nitrite concentrations less than the standard level of 13.40 mg nitrite (NO_2) per 100.0g of cured meat. This goes to show that the longaniza products from Molave manufacturers have less nitrite concentration.

Table 4.
Average Nitrite Concentration of Longaniza from Molave Manufacturer

Locations	Mass Sample in Grams	Longaniza Samples	Milligrams Nitrite Per sample	Variance	V.I.
Standard Amount of Nitrite	100		13.4 ± 0.02		Safe
Molave	100	J	2.54 ± 0.04	(10.86) or (81.04%)	Safe
Molave	100	K	0.55 ± 0.05	(12.85) or (95.90%)	Safe

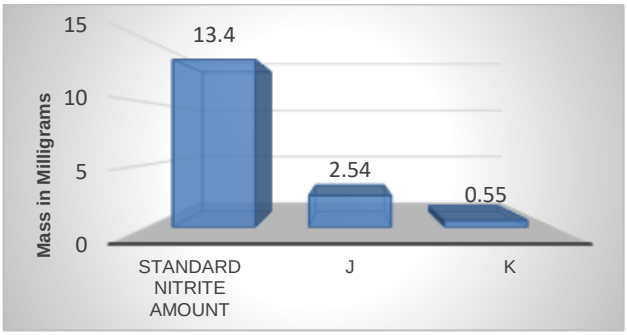

Figure 4. Nitrite Concentrations per 100 Grams of Longaniza from Molave Manufacturers

2.1. Nitrite Concentrations of Longaniza from Pagadian Manufacturers

As illustrated in Table 5, only the longaniza from manufacturer L had nitrite concentrations below the standard level. In contrast, the longaniza from manufacturers M and N had nitrite concentrations more than the standard level.

Table 5
Average Nitrite Concentrations of Longaniza from Pagadian Manufacturers

Locations	Mass Sample in Grams	Longaniza Samples	Milligrams Nitrite Per sample	Variance	V.I.
Standard Amount of Nitrite	100		13.4 ± 0.02		Safe
Pagadian	100	L	3.40 ± 0.32	(10.00) or (2.39%)	Safe
Pagadian	100	M	23.32 ± 2.03	9.92 or 74.03%	Not Safe
Pagadian	100	N	32.80 ± 0.01	19.40 or 144.8%	Not Safe

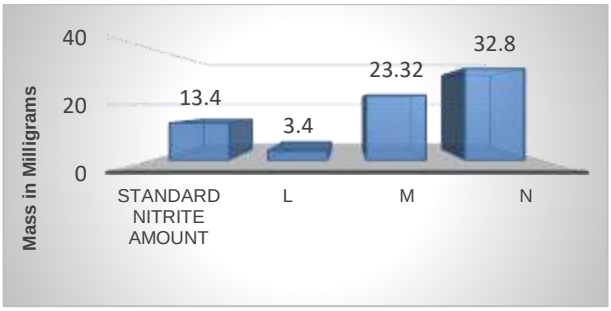

Figure 5. Nitrite Concentrations per 100 Grams of Longaniza from Pagadian Manufacturers

In contrast, the longaniza from manufacturers M and N had nitrite concentrations more than the standard level. The nitrite contained in longaniza from manufacturer M had reached 74.03% more than the standard level of nitrite concentration of 13.40 mg nitrite (NO_2) per 100.0g of cured meat. And the longaniza from manufacturer N had a very high, more than doubled nitrite concentration, 144.8% over the maximum allowable nitrite level of 13.40 mg nitrite (NO_2^-) per 100.0g of cured meat. Thus, the longaniza products from the two manufacturers M and N, were not safe for the health in terms of potential risks brought by nitrite.

3. Difference of the nitrite levels present in the locally processed food as to the guidelines set by the Philippine Food and Drugs Administration (FDA)

Table 6
T-test Results for Chorizo Samples

Sample	t critical	t-value
A	1.886	-631.33
B	1.886	-854.48
C	1.886	-1285.18
D	1.886	-184.80
E	1.886	-2676.02
F	1.886	-1326.75
G	1.886	-85.58
H	1.886	-190.70
I	1.886	1016.28

df = 2 and α = 0.10

The t-test results as shown in Table 6 for chorizo products from the three selected areas, indicated that only the chorizo from sample I was beyond the critical region, while the rest was not in the critical region. From the results, it can be deduced that only the chorizo from sample I posed a risk of getting nitrosamine, a potentially carcinogenic substance.

Table 7
T-test Results for Longaniza Samples

Sample	t-critical	t-value
J	1.886	-565.51
K	1.886	-521.35
L	1.886	-66.03
M	1.886	6.59
N	1.886	2979.13

df = 2 and α = 0.10

The results shown in Table 7 indicate that the longaniza samples J and K were taken from Molave Public Market contained nitrite concentrations below the critical level, hence safe from health hazards.

While the samples M and N were taken from the Public Market of Pagadian City had obtained a significant difference in the nitrite concentrations, which implied great potential risk to the consumers' health due to a carcinogenic chemical compound's possible production like nitrosamine that gives potential risk to the health. In contrast, sample L revealed nitrite concentration below the critical region, which meant safe from possible health risks.

CONCLUSIONS

In light of the findings, the following conclusions are drawn.

1. Among the chorizo and longaniza products from the manufacturers of the three selected areas of the First Congressional District of Zamboanga del Sur, only chorizos and longanizas from Dumingag and Molave are considered safe for human consumption because their nitrite concentrations are within the tolerable limit.
2. Not all chorizos and longanizas from Pagadian City manufacturers are safe for human consumption because some of the samples tested contained very high nitrite concentrations, which exceeded the tolerable limit.
3. Eating chorizo and longaniza from Dumingag manufacturers is not harmful to health in terms of nitrosamine effects. On the other hand, the chorizos and longanizas from Pagadian City manufacturers are not safe to health regarding the possible occurrence of nitrosamine effects.

RECOMMENDATIONS

Based on the findings and the conclusions made in this study, the researchers would like to recommend the following:

1. That random checking and monitoring be done regularly by the Meat Inspection Regulations (MIR) to the local manufacturers of cured and processed foods to ensure that the nitrite preservation level will not exceed the standard tolerable concentration.
2. That consumer's information drive and symposium be conducted to the community by the concerned agency to inform the consumers on the risks and beneficial effects of nitrite present in cured meat.
3. That seminar may be conducted with the processed food manufacturers to enhance their knowledge on food processing.
4. That the government agencies like DOST and DTI, and the like, provide financial assistance to conduct further study, analysis, and monitoring on all local meat processing entrepreneurs that will lead to policymaking.

REFERENCES

Akyüz, M., & Ata, Ş. (2013). Seasonal variations of particle-associated nitrosamines by gas chromatography-mass spectrometry in the atmospheric environment of Zonguldak, Turkey. *Environmental Science and Pollution Research*, *20*(10), 7398–7412. https://doi.org/10.1007/s11356-013-1758-y

Alahakoon, A. U., Jayasena, D. D., Ramachandra, S., & Jo, C. (2015). Alternatives to nitrite in processed meat: Up to date. *Trends in Food Science and Technology*, *45*(1), 37–49. https://doi.org/10.1016/j.tifs.2015.05.008

Alimentarius Codex. (n.d.). Codex General Standard for Food Additives. In *Photogrammetric Engineering and Remote Sensing*. http://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXS%2B192-1995%252FCXS_192e.pdf

Aragón, M., Marcé, R. M., & Borrull, F. (2013). Determination of N-nitrosamines and nicotine in air particulate matter samples by pressurised liquid extraction and gas chromatography-ion trap tandem mass spectrometry. *Talanta*, *115*, 896–901. https://doi.org/10.1016/j.talanta.2013.07.010

Gassara, F., Kouassi, A. P., Brar, S. K., & Belkacemi, K. (2016). Green Alternatives to Nitrates and Nitrites in Meat-based Products–A Review. *Critical Reviews in Food Science and Nutrition*, *56*(13), 2133–2148. https://doi.org/10.1080/10408398.2013.812610

Ichimura, S., Nakamura, Y., Yoshida, Y., & Hattori, A. (2017). Hypoxanthine enhances the cured meat taste. *Animal Science Journal*, *88*(2), 379–385. https://doi.org/10.1111/asj.12625

Jayasena, D. D., & Jo, C. (2013). Essential oils as potential antimicrobial agents in meat and meat products: A review. *Trends in Food Science and Technology*, *34*(2), 96–108. https://doi.org/10.1016/j.tifs.2013.09.002

Lou, Z., Rahman, R. T., Zhang, J., Xingran, K., Nkhata, G., Song, Z., & Al-hajj, N. Q. M. (2017). Determination of preservative residues and microbial contents of commercial Chinese duck neck meat Determination of preservative residues and microbial contents of commercial. *CyTA - Journal of Food*, *15*(3), 357–360. https://doi.org/10.1080/19476337.2016.1266390

Mills, J., Donnison, A., & Brightwell, G. (2014). Factors affecting microbial spoilage and shelf-life of chilled vacuum-packed lamb transported to distant markets: a review. *Meat Science*, *98*, 71–78. https://doi.org/doi:10.1016/j.meatsci.2014.05.002

NSW Food Authority. (2009). *Preservative use in processed meats* (Issue December). https://www.foodauthority.nsw.gov.au/sites/default/files/_Documents/industry/preservative_use_in_processed_meats.pdf

Nychas, G. J. E., Skandamis, P. N., Tassou, C. C., & Koutsoumanis, K. P. (2008). Meat spoilage during distribution. *Food Additives and Contaminants*, *78*(1–2), 77–89. https://doi.org/10.1016/j.meatsci.2007.06.020

Park, J. E., Seo, J. E., Lee, J. Y., & Kwon, H. (2015). Distribution of Seven N-Nitrosamines in Food. *Toxicological Research*, *31*(3), 279–288. https://doi.org/10.5487/TR.2015.31.3.279

Parthasarathy, D. K., & Bryan, N. S. (2012). Sodium nitrite: The “cure” for nitric oxide insufficiency. *Meat Science*, *92*(3), 274–279. https://doi.org/10.1016/j.meatsci.2012.03.001

Ramírez, N., Özel, M. Z., Lewis, A. C., Marcé, R. M., Borrull, F., & Hamilton, J. F. (2012). Determination of nicotine and N-nitrosamines in house dust by pressurized liquid extraction and comprehensive gas chromatography-Nitrogen chemiluminiscence detection. *Journal of Chromatography A*, *1219*, 180–187. https://doi.org/10.1016/j.chroma.2011.11.017

Ruiz-Capillas, C., & Jimenez-Colmenero, F. (2008). Determination of preservatives in meat products by flow injection analysis (FIA). *Food Additives and Contaminants*, *25*(10), 1167–1178. https://doi.org/doi:10.1080/ 02652030802036214

Sindelar, J. J., & Milkowski, A. L. (2011). Sodium nitrite in processed meat and poultry meats : a review of curing and examining the risk/benefit of its use. *American Meat Science Association*, *3*, 1–14.

Vogt, R., Bennett, D., Cassady, D., Frost, J., Ritz, B., & Hertz-Picciotto, I. (2012). Cancer and non-cancer health effects from food contaminant exposures for children and adults in California: A risk assessment. *Environmental Health: A Global Access Science Source*, *11*(1), 1–14. https://doi.org/10.1186/1476-069X-11-83

AUTHORS’ PROFILE

Engr. Evelyn Joy Donggon Neri is a Licensed Chemical Engineer. She is an Assistant Professor III of J.H. Cerilles State College of Zamboanga del Sur, Philippines. She finished her Bachelor’s Degree in Chemical Engineering at Mindanao State University – Main Campus at Marawi City as a scholar. She

graduated her Master's Degree in Science at La Salle University in Ozamiz City as a scholar. She had undergone trainings as a Specialist in Forensic Chemistry, and received an award as Best Prosecutor. Aside from being a faculty member, she had also been designated as Planning Director of the said institution. She has been teaching General and Organic Chemistry, Forensic Chemistry and Legal Medicine up to present.

Mark Erana Patalinghug is presently an Assistant Professor I of J.H. Cerilles State College-Dumingag Campus, Dumingag Zamboanga del Sur. Likewise, the designated Program In-charge of Bachelor of Science in Criminology and currently the Vice President of the Council of Deans for Criminal Justice Education ZAMBASULTA Region. He is a Registered Criminologist, Professional Teacher, NAPOLCOM Entrance Examination passer, and a Certified Security Management Specialist. He is a graduate of Master of Science in Criminal Justice with Specialization in Criminology from Jose Rizal Memorial State University, Dapitan City, and Doctor of Philosophy in Criminal Justice with Specialization in Criminology from the University of Cebu, Cebu City. He presented different researches at national and international conferences. He also serves as a facilitator in seminars and conferences, an external research