



The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

ENRICHED AND DEODORIZED FISH AMINO ACID AS SOURCE OF NUTRIENTS ON TOMATO PRODUCTION IN ZAMBOANGA CITY, PHILIPPINES

^{1*}Arlyn O. Rebuza and ²Elderico P. Tabal

¹Faculty, Agricultural Sciences Department, College of Agriculture, Western Mindanao State University, Zamboanga City, Philippines.

²Dean, College of Agriculture, Western Mindanao State University, Zamboanga City, Philippines.

DOI: <https://doi.org/10.51193/IJAER.2022.8309>

Received: 19 Jun. 2022 / Accepted: 26 Jun. 2022 / Published: 28 Jun. 2022

ABSTRACT

Strong fishy odor and limited available nutrients have been the common concerns among vegetable farmers which resulted to high refusal and low adoptability of Fish Amino Acid (FAA) in Zamboanga City, Philippines. The reason why the conventional FAA was enriched and deodorized or this is called the EDFAA. Three (3) plant-based materials such as guava (*Psidium guajava* L.), talisay (*Terminalia catappa*) and Acapulco (*Cassia alata*) leaves were selected and singly added in proportion to FAA and each were subjected for sensory evaluation by participating vegetable farmers to determine the level of acceptability. Fish waste for the making of FAA were collected from wet markets and canning factories. Scores were tabulated and analyzed using the Hedonic and descriptive method, where EDFAA with Acapulco leaves extract added with banana extract significantly emerged as the most acceptable EDFAA attributed to its reduced strong-fishy odor. As a final product, EDFAA was tested to determine the growth and yield performance of tomato crop applied in drench. This was carried out using the Randomized Complete Block Design (RCBD) with seven (7) treatments replicated three (3) times with six (6) subsamples per replication. Results showed, tomato crop was significantly improved by the periodic drenching of 40% EDFAA in terms of the yield as compared to other treatments. The application of EDFAA can be an alternative low-cost liquid fertilizer in drench application and a good source of nutrients to various vegetable crops in urban agriculture.

Keywords: Fish waste, conventional fish amino acid (FAA), enriched and deodorized FAA, sensory evaluation and acceptability, Acapulco extract

1. INTRODUCTION

The food canning industry has a negative influence on the environment in terms of water, air, and solid pollution. The stench during fish processing is the most major source of air pollution. Storage locations for processing waste, cooking by products during the creation of fish meal, and fish drying procedures are the primary sources of odor. Solid waste from the seafood preparation step often comprises of fish shells and heads. Only 25-50 percent of raw material is used for primary production, while the rest 50-75 percent is discarded. Zamboanga City is known as the “Sardines Capital of the Philippines” [1] due to its highest production of sardines. Improper utilization and disposal of fish waste from canning factories has been a remarkable problem. Many researches are now concentrating on transforming fish waste into important products like organic fertilizer such as Fish Amino Acid (FAA) which can be used in promoting crop yield. Organic fertilizer can be in a liquid form which is easily absorbed by plants and become more accepted nowadays.

According to [2] liquid fertilizer is made up of nutrients and good microorganisms. These fertilizers can be made in a short time and have good quality through the process of fermentation. This method has been used in Korean Natural Farming in the form of Fish Amino Acid (FAA). It is a liquid made from fish waste such as bones, head, internal organ mix with molasses. According to a research study by [3], fish waste biomass are locally available resources which contain nutrients. Fish processing industry and fish markets produce more than 60% by-products as waste, which includes skin, heart, viscera, trimmings, liver, frames, bones and roes. These by-products contain good amount of protein-rich nutrient materials among these is the *Sardinella longiceps*, commonly known as “tamban” used by various canning factories. This type of fish is found more in warm water of tropical countries including the Philippines. According to the study of [4], *Sardinella* is important source of protein and amino acids. As a component in FAA, this product is of a great value to plants and microorganisms in their growth because it contains various nutrients and amino acids.

FAA is one of the organic preparations which is used for improving crop growth and development [5]. There are researches related to enrichment of FAA [5-12] to name a few. Research on FAA combined with organic fertilizer has a positive result on the growth and yield of eggplant and this can be an alternative for commercial fertilizer [13]. Another study conducted by [5] is the combination of FAA and Egg Amino Acid (EAA) to improve the physiological parameters of rice, and [14] tested the efficacy of FAA as foliar spray on the growth and yield of *Amaranthus* plant. FAA enhanced the nitrogen availability in soils and improves crop yields while sustaining water quality [15].

Despite of several studies on FAA that showed a promising impact, the adoptability of this technology has been low due to its strong fishy odor and claims on limited nutrient availability among vegetable growers. To utilize the voluminous fish waste from supermarket and canning factories, this study focuses on the utilization of enriched and deodorized fish amino acid (EDFAA) as nutrient sources for tomato crop and provide farmers the alternative low-cost organic fertilizer other than the commercial ones that are widely available in agricultural stores. The study was conducted to develop and utilize the EDFAA and determine its effect to the yield performance of tomato crop in barangay Talisayan, Zamboanga City, Philippines.

2. MATERIALS AND METHODS

2.1 Location of the Study

The study was conducted in two (2) different areas: (1) the conduct of acceptability test through a sensory evaluation was done in Barangay La Paz, Zamboanga City, the largest local supplier of high valued vegetables; other Sitios include San Ramon and Talisayan; (2) the experimental set up was conducted in the experimental station of the College of Agriculture, San Ramon, Zamboanga City, Philippines.

2.2 Development of EDFAA

The deodorizer materials such as the Acapulco (*Cassia alata*), Talisay (*Terminalia catappa*), Guava (*Psidium guajava*) and banana trunk were separately prepared and processed for fermentation, while the fish waste was collected from different sources such as in fish markets and canning factories. The use of FAA has been used as foliar spray for plant growth and development although its effect is less compared than the commercial fertilizer, but the conventional FAA has a strong fishy odor which most farmers hesitate to utilize it despite various programs by the local government unit (LGU) of Zamboanga City and the Department of Agriculture (DA)-RFU IX, Western Mindanao, where free FAA is given to farmers.

This was the reason why the conventional FAA was enriched and deodorized using plant-based materials to meet plants and human requirements. The use of plant biomass is a natural renewable resource that can be converted into useful materials and energy [16] such as the Indian almond leaves, commonly known as the Talisay leaves, guava leaves and Acapulco leaves and singly added with banana pseudo-stem extract fermented for seven (7) days.

2.3 Sensory Evaluation

The individual sample of enriched and deodorized fish amino acid were subjected singly for

sensory evaluation by ten (10) farmers from different barangays: Talisayan, Lapaz and San Ramon, totalling to 30 respondents for each sample substrate. The procedure was conducted as described in the study of [17] and was modified to suit the requirement of the study.

The farmers were asked to rate the odor by assigning scores between 0 and 5: with 0 indicating no odor and 5 indicating an extremely strong odor. Data were tabulated and analyzed with the used of hedonic scales. The process in the development and application of EFAA is shown in Figure 1.

2.4 Application

The application of EDFAA starts one (1) week after transplanting. Drench application of diluted EDFAA solution is done once a week tested to tomato crop from February 15 to May 3, 2021.

2.5 Sampling and Statistic

The experimental area was laid out in a Randomized Completely Block Design (RCBD) composed of seven (7) treatments replicated three times with six (6) samples per replication. The treatments are as follows: T1 (*commercial FAA*), T2, T3, T4, T5, T6, and T7 applied as drench in 10, 20, 30, 40, 50 and 60 percent EDFAA, respectively.

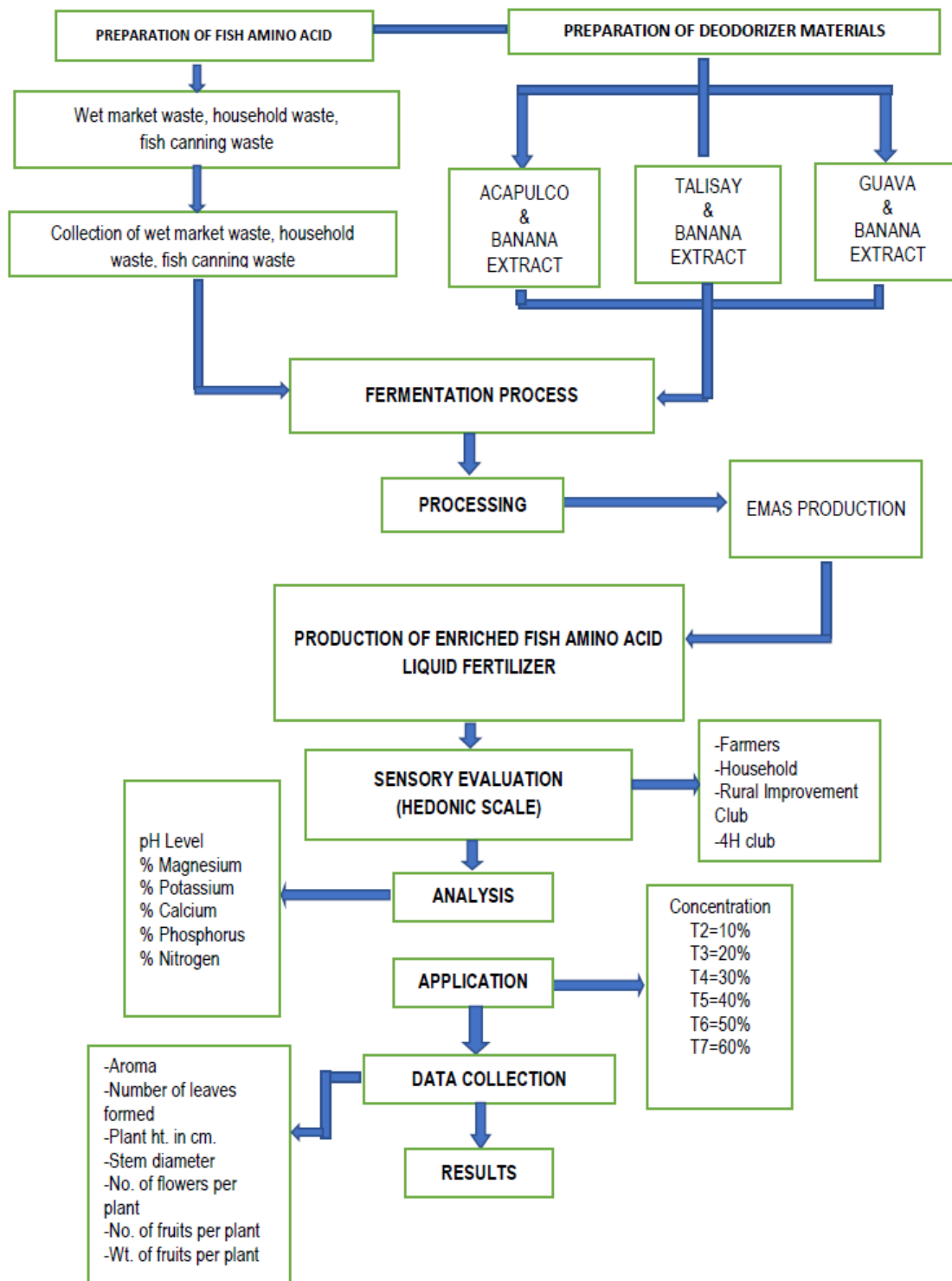


Figure 1: Process Flow of EDFAA

3. RESULTS AND DISCUSSION

Table 1 shows the Analysis of Variance (ANOVA) at 0.05 level of significance. Results showed no variations in the aroma of EDFAA with guava and Talisay extracts. On the other hand, a significant difference of EDFAA with Acapulco extract was observed in terms of aroma ($F_{val}=5.43 > F_t=3.55$). This means that there was a significant reduction of smell from ‘strong-fishy odor’ to ‘moderately fishy odor’. The acceptability of EDFAA with Acapulco extract was attributed to the general rating made by the majority of the vegetable growers (respondents) as ‘moderately fishy odor’ as compared to the conventional FAA.

Table 1: Mean score and descriptive rating of the aroma of EDFAA

Type of Extract	Concentrations			5% Level of Significance
	(A) 10.0 ml	(B) 20.0 ml	(C) 30.0 ml	
Guava	3.6	3.9	3.9	NS
Talisay	2.3	2.7	3.1	NS
Acapulco	2.9	3.2	3.6	S

NS, non-significant; S, significant

The conventional FAA has been used in organic and urban agriculture as organic concoction that promotes plant growth and development, however due to its characteristics of ‘strong fishy odor’ – farmers refused to use it either applied as foliar or drench. There were attempts in the past to deodorized FAA like the use of activated carbons commonly used in treating wastewater [19], but this commercially available activated carbon is too expensive on the part of the farmers. Part of the major objective of this study was to develop an alternative solution to the problem on high cost of commercially available activated carbon which can help our local farmers process and modify their own FAA. Geared toward at achieving this goal, a study was conducted where a common ‘FAA + Acapulco and banana extracts’ was processed and submitted for sensory evaluation. Result showed that the foul odor content in the common FAA was significantly reduced. Reduction of foul odor is attributed to Acapulco extract which is believed to have a deodorizing effect.

As a plant-based extract, *Cassia alata*, also called Acapulco or asunting in Zamboanga City, Philippines is known for its medicinal uses and widely distributed in tropical country including the Philippines. According to [20], Acapulco contains secondary metabolites like terpenes which is considered by [21] having a disinfectant effect. This suggest that terpenes found in Acapulco extract antagonized the microbial population that causes the foul odor in conventional FAA, hence minimized the ‘strong-fishy odor’ as described by the farmer respondents. Other findings

in various literatures suggested that Acapulco extracts contain anti-fungicidal and anti-bacterial properties [22-25]. These findings suggest that Acapulco as a primary plant extract used as deodorizer had contributed in the reduction of 'strong-fishy odor'. Another phytochemical component found in leaves is the tannins which has an aromatic property and used as primary materials to control industrial pollution in fish canning industry [26]. This also strongly suggests that Acapulco contributed to the 'sweet-aromatic odor of EDFAA' which favors acceptability among the vegetable growers. The acceptability of EDFAA with Acapulco extract by the majority of farmer respondents is a strong indicator of wide acceptance of farmers in the future. As the population continues to grow, there is a need to produce more to meet food demand at lesser cost unit⁻¹ area, low energy requirement, climate resilient and addresses soil erosion especially in the upland environments of Zamboanga City [29-31]. This is the ultimate goal of crop production which is to utilize alternative sources of nutrients and organic pesticides other than the indiscriminate usage of expensive inorganic fertilizers and other fossil fuel-based external inputs [29,30]. In contrary, the use of organic sources of nutrients like EDFAA and pesticides can fully support the call of the Department of Agriculture, Philippines to lessen the use of external inputs such as the use of inorganic fertilizers and pesticides which often attributed to various environmental issues [32].

Moreover, the EDFAA can help address challenges in urban agriculture because this type of organic concoction can be done at home, cheap and safe. The benefit of EDFAA may synergistically be achieved with the combined effect of various plant and fruit-based concoctions such as the fermented plant (FPJ) and fermented fruit (FFJ) juices. Achieving this goal can substantially contribute to urban and rural agricultural economy through the utilization of fish and fruit wastes by converting them into cheaper and usable organic inputs [33].

On the other hand, FAA alone contains high amount of N but low in P content based on the study of [18], however, Table 2 showed the comparative analysis results of nutrient contents of EDFAA analyzed by the Department of Science and Technology (DOST), Zamboanga City station, Philippines and the findings of [18] on FAA.

Table 2: Comparative analysis of EDFAA and FAA

PARAMETER	RESULT	
	DOST	[18]
pH	4.26	4.7
Magnesium (%)	0.119	-
Potassium (%)	0.992	0.01
Calcium (%)	0.375	-
Phosphorus (%)	0.131	0.39
Nitrogen (%)	0.868	1.17

Source: *Department of Science and Technology, 2021*

Shown in table 2, the EDFAA contains good amount of N and P believed to be attributed from the addition of banana extract. According to [27], P is the most important inorganic chemical that affects plant physiology. Leaves play an important role in the performance of the plant through the process of photosynthesis [28].

On the other hand, Table 3 showed that application of EDFAA has significantly affected the fruit weight. According to [34] potassium had significant effect in the yield of tomato and agreed by [35], which expressed that application of enough potassium increases fruit weight by increasing translocation of photosynthates to fruit and water use efficiency. Potassium also [36] increased the yield and improved the fruit quality of solanaceous crops. According to [37] nitrogen and potassium application in soil will increase tomato fruits. The incorporation of banana extract increases the amount of potassium content of EDFAA, which had significantly contributed to the yield performance of tomato as exhibited in T5 (40% EDFAA) and in the comparable results of T2, T3, T6 (10%, 20%, 50% EDFAA), and T4 & T5 (30%, 60% EDFAA), respectively.

Table 3: ANOVA on average weight of tomato fruits applied with different rates of EDFAA

TREATMENT	NUMBER OF SAMPLES	BLOCK			TOTAL	MEAN
		I	II	III		
1	1	1.45	0.95	1.40	25.86	1.44b
	2	1.59	1.27	1.56		
	3	1.00	1.95	1.82		
	4	1.59	1.00	2.23		
	5	1.18	1.73	1.64		
	6	0.68	1.27	1.55		

2	1	1.27	1.27	0.56	24.52	1.36b
	2	1.59	1.32	1.45		
	3	1.18	1.55	1.23		
	4	1.27	1.73	1.40		
	5	1.45	1.78	1.40		
	6	1.43	1.36	1.27		
3	1	1.64	1.77	1.32	26.70	1.48b
	2	1.86	1.82	1.18		
	3	1.95	1.64	1.36		
	4	1.05	1.68	0.88		
	5	1.64	1.59	1.18		
	6	1.10	1.41	1.64		
4	1	1.77	1.59	1.69	27.69	1.54ab
	2	1.41	1.68	1.82		
	3	1.77	1.64	2.05		
	4	1.14	0.97	1.86		
	5	1.18	1.72	1.82		
	6	1.32	1.02	1.25		
5	1	2.03	1.77	1.60	30.83	1.71a
	2	1.64	1.86	1.97		
	3	1.89	1.23	1.97		
	4	1.86	1.25	1.71		
	5	1.50	1.91	1.40		
	6	1.95	1.91	1.36		
6	1	1.05	1.40	1.36	24.51	1.36b
	2	1.18	1.59	1.73		
	3	0.91	1.36	1.38		
	4	2.06	1.25	1.38		
	5	1.77	1.45	1.27		
	6	1.05	1.09	1.23		
7	1	1.45	1.86	0.93	27.73	1.54ab
	2	1.32	2.05	1.61		
	3	1.86	1.91	0.96		
	4	1.82	1.97	0.97		
	5	1.59	1.22	1.23		
	6	1.68	1.36	1.94		

Pval = 0.0132

4. CONCLUSION

FAA has been used in organic and urban agriculture as organic liquid fertilizer that help promotes plant growth and development, however due to its characteristics of 'strong fishy odor' farmers refuse the use of common FAA. This was the reason why the common FAA was modified and deodorized so that acceptability level is achieved. In common practiced, activated carbons is used to remove foul odor, but this commercially available activated carbon is too expensive on the part of the farmers, hence, the need to modify and deodorized the common FAA using locally available plant extracts. FAA with Acapulco extract added with banana extract or call this the EDFAA obtained a significant difference in terms of scent and aroma. The use of Acapulco across all rates have significantly reduced the smell from 'strong fishy odor' to 'moderately fishy odor'.

Further, the application of EDFAA had significantly influenced the yield of tomato crop. Treatments with EDFAA have been found to be more effective on growth and development of tomato. This formulated liquid organic fertilizer is comparable to commercial FAA. The EDFAA is not only economically viable but will also benefit Zamboanga City in controlling air pollution from fish canning factories. The materials used for this type of liquid organic fertilizer is locally available.

Finally, the Acapulco extract had successfully minimized the foul odor present in conventional FAA. The addition of banana and Acapulco extracts not only reduced the strong fishy odor but also address the deficiency of potassium content in a conventional FAA. EDFAA is found to be high in nutrients and its potential to use as organic fertilizer applied as foliar or drenched can significantly help produce organic urban vegetable production of the city.

ACKNOWLEDGMENTS

Special thanks to Prof. Eriberto D. Salang, Ph.D (retired) and Dr. Elmer V. Galo, College of Agriculture, Graduate Program Coordinator, Western Mindanao State University.

REFERENCES

- [1] Philippine Statistics Authority (PSA, 2016). No. 2016, Series 141. Retrieved from <https://psa.gov.ph/tags/2016-philippines-figures-pif>
- [2] Phibunwatthanawong, T., & Riddech, N. (2019). Liquid organic fertilizer production for growing vegetables under hydroponic condition. *International Journal of Recycling of Organic Waste in Agriculture*, 8(4), 369-380.
- [3] Sahu, B.B., Barik, N.K., Mohapatra, B.C., Pillai, B.R. Sahu, H., Sahoo, P, Biswal N.C.,

- Mohanty, P.K., Mohanty, U.L., Mohanta, S.K. and Jayasankar, P. (2016 a): In vitro Assessment of plankton production using Fish hydrolysate in Aquatic Biology and Fisheries (IJSABF) 2(1): 14-24.
- [4] Chakraborty, K., Joseph, D., Chakkalakal, S. J., & Vijayan, K. K. (2013). Inter annual and seasonal dynamics in amino acid, vitamin and mineral composition of *Sardinella longiceps*. *Journal of Food and Nutrition Research*, 1(6), 145-155.
- [5] Priyanka, B., Anoob D., Gowsika, M., A., Sri, S. K., Kumar, R. V. K., ... & Theradimani, M. (2019). Effect of fish amino acid and egg amino acid as foliar application to increase the growth and yield of green gram. *The Pharma Innovation Journal*, 8, 684-686.
- [6] García-Santiago, J. C., Lozano Cavazos, C. J., González-Fuentes, J. A., Zermeño-González, A., Rascon Alvarado, E., Rojas Duarte, A., ... & Hernandez Maruri, J. A. (2021). Effects of fish- derived protein hydrolysate, animal-based organic fertilisers and irrigation method on the growth and quality of grape tomatoes. *Biological Agriculture & Horticulture*, 37(2), 107-124.
- [7] Bhaskoro, P. T., Tjahjaningsih, W., & Mubarak, A. S. (2020, FEBRUARY). The effect of addition of fish bone meal on the concentration of nitrogen (N), phosphorus (P), and potassium (K) in seaweed liquid organic fertilizer of *Gracilaria* sp. In *IOP Conference Series: Earth and Environmental Science* (Vol. 441, No. 1, p. 012144). IOP Publishing.
- [8] Hussein, W. A., & Ahmed, N. E. (2020). Growth and yield of potato in relation to application of Alphylax and fish oil as organic fertilizers. *EurAsian Journal of BioSciences*, 14(1), 371-375.
- [9] Sivasankar, S., IlakkiyA, P., Rameshkumar, S., Muruganandam, C., & Karthikeyan, P. K. (2021). Effect Of Organic Manures and Foliar Application of Fish Amino Acid on Vegetative Growth and Dry Matter Production of African Marigold (*Tagetes Erecta* L.). *Plant Archives*, 21(1), 2535-2537.
- [10] Krishnamoorthy, R., Alshatwi, A. A., Subbarayan, S., Vadivel, B., Periyasamy, V. S., Al-Shuniaber, M. A., & Athinarayanan, J. (2019). Impact of farm-made liquid organic nutrients jevamirtham and fish amino acid on growth and nutritional status in different season of *Abelmoschus esculentus*—a self-sustainable field trial. *Organic Agriculture*, 9(1), 65-79.
- [11] An, N. H., Cho, J. R., Gu, J. S., Kim, Y. K., & Han, E. J. (2017). Effect of fish meal liquid fertilizer application on soil characteristics and growth of cucumber (*Cucumis sativus* L.) for organic culture. *Journal of the Korea Organic Resources Recycling Association*, 25(3), 13-21.
- [12] Ekinci, M., Atamanalp, M., Turan, M., Alak, G., Kul, R., Kitir, N., & Yildirim, E. (2019). Integrated use of nitrogen fertilizer and fish manure: effects on the growth and chemical

- composition of spinach. *Communications in Soil Science and Plant Analysis*, 50(13), 1580-1590.
- [13] Lacaden, D. G. (1990). Organic fertilizer and different rates of Fish Amino Acid (FAA) on the growth and yield of eggplant (*Solanum melongena*).
- [14] Ramesh, T., Rathika, S., Murugan, A., Soniya, R. R., Mohanta, K. K., & Prabharani, B. (2020). Foliar spray of fish amino acid as liquid organic manure on the growth and yield of *Amaranthus*. *Chemical Science Review and Letters*, 9, 511-515.
- [15] Park, H. and M.W. DuPonte. 2008 (rev 2010). How to cultivate indigenous microorganisms. BIO-9. University of Hawai'i, College of Tropical Agriculture and Human Resources, Honolulu, HI
- [16] Klass, D. L. (2004). Biomass for renewable energy and fuels. *Encyclopedia of energy*, 1(1), 193-212.
- [17] Meilgaard, M. C., Civille, G. V., & Carr, B. T. (2006). Sensory evaluation techniques (4th ed.). Boca Raton: CRC Press.
- [18] Calub, B.M., Matienzo E.L. A and Tenorio, M.A. 2012. Mga Pamamaraan sa Organikong Gulayan (Mga Pamaagi sa Organikong Utanan) translated by JNM Garcia UPLB NEDA DA-BAR Organic Vegetable Project. Agricultural System Cluster, College Agriculture, University of the Philippines Los Banos, College Laguna. 24pp.
- [19] Hwang, Y., Matsuo, T., Hanaki, K., & Suzuki, N. (1994). Removal of odorous compounds in wastewater by using activated carbon, ozonation and aerated biofilter. *Water Research*, 28(11), 2309-2319.
- [20] Oladeji, O. S., Adelowo, F. E., Oluyori, A. P., & Bankole, D. T. (2020). Ethnobotanical description and biological activities of *Senna alata*. *Evidence-Based Complementary and Alternative Medicine*, 2020.
- [21] Elder, T. (2004). Non-wood products | Chemicals from Wood.
- [22] Carpio, J. L., & Ambida, P. K. P. (2005). Antibacterial activity of *Linn* (Acapulco) roots and barks crude extracts *Cassia alata*.
- [23] Apat, J. (2019). Synergistic Fungicidal Activity of Acapulco (*Cassia alata*) Leaf Extract and Calamansi (*Citrofortunella microcarpa*) Fruit Extract Against *Magnaporthe oryzae* on Rice (*Oryzae sativa*). Available at SSRN 3320517.
- [24] Palo, J. J. V., & Ramos, P. G. A. (2017). *Combined antifungal potential of Cassia alata L. (Acapulco) and Medicago sativa L. (Alfalfa) plant extracts on Candida albicans* (Doctoral dissertation, De La Salle University-Dasmariñas).
- [25] Legaspi, C. L. B., & Maramba-Lazarte, C. C. (2020). The Phytochemical Content and the In vitro Antifungal Properties of *Senna alata* (Linn.) Roxb.: A Review. *Acta Medica Philippina*, 54(1).
- [26] Singh, A. P., & Kumar, S. (2020). Applications of tannins in industry. *Tannins-structural*

- properties, biological properties and current knowledge.*
- [27] Marschner, H. (1995). Mineral Nutrition of High Plants (2nd ed.). London: Academic Press.
- [28] Hepsibha, B. T., & Geetha, A. (2021). Effect of Biofertilizer (Fermented fish waste–Gunapaselam) on structure and biochemical components of *Vigna radiata* leaves. *Research Journal of Chemistry and Environment Vol*, 25, 7.
- [29] Tabal, E. P., Mendoza, T. C., Paelmo, R. F., Garcia, J. N. M., & Visco, R. G. (2021). Energy Inputs of Selected Agroforestry Systems in Zamboanga City, Philippines. *American Journal of Agriculture and Forestry*, 9(3), 106.
- [30] Taib, A. P., Alamhali, J. A., & Tabal, E. E. Net Energy Use and Carbon Emission Equivalent of Tomato and Eggplant Production in Zamboanga City, Philippines.
- [31] Garan, M. A., Salang, E. D., Galo, E. V., & Tabal, E. P. Soil erosion rate estimate using USLE of corn producing areas in Barangay Vitali, Zambonga City, Philippines.
- [32] Tabal, E. P., Mendoza, T. C., Paelmo, R. F., Garcia, J. N. M., & Visco, R. G. 2022. Carbon emission equivalent of selected agroforestry systems in Zamboanga City, Philippines.
- [33] Tabal, E. P., Quijano, Q. T., & Garan, M. A. 2022. Unpublished. Organic vegetable production in raise-beds in selected urban barangays in Zamboanga City, Philippines. Joint DOST-PCAARRD-WMSU Project from February 2021-January 2022.
- [34] Woldemariam, S. H., Lal, S., Zelelew, D. Z., & Solomon, M. T. (2018). Effect of potassium levels on productivity and fruit quality of tomato (*Lycopersicon esculentum* L.). *Journal of Agricultural Studies*, 6(1), 104-117.
- [35] Ghourab, M.H.H., Wassel, O.M.M. and Raya, N.A.A. (2000). Response of cotton plant to foliar application of (Pottasin-P) TM under two levels of nitrogen fertilizer. *Egypt J. Agric. Res.*, 78, 781-793.
- [36] Wuzhong, N. (2002). Yield and quality of fruits of solanaceous crops as affected by potassium fertilization. *Better Crops International*, 16(1), 6-8.
- [37] Qi, H. Y., Li, T. T., Fu, H. D., & Zhou, X. (2006). Effects of Different Rates of Nitrogen and Potassium on Nutrient Levels in Tomato and Soil [J]. *Chinese Journal of Soil Science*, 2.