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Development of a Food Wrapper Using Water Spinach Leaves (*Ipomoea Aquatica*) as a Substitute Raw Material for Nori Seaweed Sheet

Jason C. Telan, Marc Raenel P. Barnedo, Luis Melchor P. Gonzalez, Leslie Ann C. Maranion, Em-Em C. Pascual, Camille Ponce, Christina T. Alfiler and Cristina B. Natividad

Cagayan State University, Tuguegarao City, Cagayan, Philippines

Corresponding Author: Jason C. Telan ✉ telan.jason25@gmail.com

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ABSTRACT

The present work aimed to develop a food wrapper using water spinach leaves as a substitute raw material for nori seaweed sheet. Water spinach (*Ipomoea Aquatica*) has been used in cooking variety of dishes and producing food products, it also has a high survival rate in different climates and environments making it a sustainable plant for different uses. Furthermore, nori seaweed sheets are not common product produced in the Philippines, reason why it's expensive in the market since due to importation. Therefore, the substitute for this product is using sustainable water spinach leaves abundant in Tuguegarao City. The production process of water spinach sheets involves soaking in saltwater, blanching, blending, drying, and pan frying for crispiness. The study applied an experimental research design consisting of four formulations and a control sample. A sensory evaluation was conducted with 50 respondents using a 9-hedonic scale to test the level of acceptability of the edible wrappers. Among the five formulations, Formulation 4 (100% water spinach) was the most acceptable and preferred by the evaluators based on sensory attributes. The results indicated that water spinach can serve as an effective substitute to nori seaweed for food wrapper production. It demonstrates good sensory qualities and high acceptability among consumers, suggesting strong potential for further development and possible commercial application. Moreover, the proximate composition indicates that the water spinach sheet is also nutritionally beneficial, using Block Digestion/Steam Distillation, the crude protein content was found to be 14.93 g/100g, confirming the product's high protein content. Crude fat content was measured at 3.62 g/100g using Soxhlet Extraction, suggesting the product is low in fat. The moisture content was 16.35 g/100g and the ash content, expressing mineral content, was fairly high at 12.56 g/100g, which suggests the availability of vital nutrients like calcium, magnesium, and potassium. These results confirm that the 100% water spinach Formulation 4 is not only the most acceptable based on sensory acceptability but also nutritionally better, a good and sustainable alternative to the more costly and imported nori seaweed widely utilized in food wrappers.

Keywords: *Food Wrapper, Water Spinach, Substitute, Nori Seaweed.*

INTRODUCTION

Nori seaweed sheet is an edible food wrapper used in making sushi rolls, onigiri, siomai or other fillings, and flavor soups originally from the East Asia but eventually adopted here in the Philippines because of the strong influence of other cultures. The Philippines exhibits a diverse culture shaped by its history of colonization. This history led to the adoption of various aspects of life, including religion, language, fashion, lifestyle, and cuisine. While colonization is in the past, cultural influences continue to shape the Philippines, particularly in the modern age dominated by technology. Filipinos drawn to Korean pop (K-Pop) culture and Japan where their animation is well-known, often imitates aspects of these cultures seen online. These influences extend to culinary habits, with portrayals of Korean and Japanese food inspiring Filipinos to incorporate these cuisines into their own lives which includes the use of nori (red algae) sheet. This trend is reflected in the increasing popularity and rapid growth of East Asian inspired restaurants throughout the country. Nori products in the market are imported mainly from Japan, China, and South Korea one factor why seaweed sheet products are expensive here in the Philippines. Porphyra a red algae that grows in cold shallow seawaters commonly known as Nori are produced in unprecedented quantities in Japan due to its successful artificial cultivation. However, the industry in the Philippines remains underdeveloped reason why the country relies mostly on importation. The seaweed is mainly gathered from rocky crevices by fisher folk who are exposed to hazards of the waves and the weather. The seasonality and the difficulty of collecting and processing using the traditional sun-drying method have made Porphyra a relatively high-priced food item (Castro et al., 2018).

Therefore, Water Spinach (*Ipomoea Aquatica*) widely known as Kangkong a green leafy vegetable thriving abundantly in the Philippines is assessed to investigate its potential as an alternative raw material of Nori Seaweed Sheet. Water Spinach is an herbaceous perennial plant that grows in dry and most specially wet land and could survive with low maintenance. Since Water Spinach can survive in a diverse soil condition, this makes it a more convenient option for food consumption. It is a crawling plant that has arrowhead shaped leaves with hollow vine and stems. Water spinach is rich in beta-carotene, protein, iron, magnesium and calcium. Other minerals that are present include phosphate, manganese, sulphate, nitrates and are relatively high in vitamins such as vitamin A, B1, C, and K (Igwenyi et al., 2011).

Water Spinach contains minerals and vitamins that provide a lot of health benefits including boosting the immune system, improved digestive system and eyesight, strong teeth and bones, and healthy skin. Known for the sustainability and health benefits it provides. Water Spinach has been used in cooking a variety of dishes and producing products such as chips and powder products. Water Spinach have a high survival rate in different climates and environment. It has no exception for thriving in Tuguegarao City making it a sustainable plant for different uses. Tuguegarao is a city located in the plains of Cagayan Valley far away from the seawaters making it more challenging for searching and harvesting seaweed and the production of Nori seaweed sheets is not a common product produced in this place. The reason why we import such products from other countries is the expensiveness of them in the market.

Given the nutrients and its potential as an alternative raw material, producing water spinach may also help the agricultural sector, especially the farmers of Tuguegarao City. Due to its capacity to grow fast, it does not need high expenses in planting so it can provide extra income for the local farmers. Strengthening local production of water spinach will not only reduce the dependence of importing nori seaweed sheet but also create more opportunities in agriculture, specifically in Cagayan province with vast water spinach plantation. Moreover, as a local crops vegetables, it will be more accessible in the market that can cause low prices rather than imported Nori (red algae) seaweed sheets.

Also, Filipinos always finds alternative vegetable food products to maintain a lifestyle with healthy diet. In line with this, the development of vegetable-based food continues to innovate, adhering to the changes and development of products in the market. By developing this alternative product, it will provide a range of nutritious food options that can be enjoyed by the individuals which at the same time address the issue of high-cost value of nori (red algae) seaweed sheet as a food wrapper.

Thus, the researcher became interested in assessing the potential of water spinach as a substitute for Nori (red algae) seaweed sheet, the evaluation will not only help in expanding the use of water spinach but also an affordable and healthy alternative food wrapper. The success of this research will open new opportunities for better and convenient options to the general market consumers and the food businesses in the city.

Objectives of the Study

Generally, the study was conducted to formulate and to evaluate nori sheet substitute made from water spinach. Specifically, it sought to: (1) Evaluate the sensory acceptability of the water spinach sheet in terms of: (1.1) Taste (1.2) Texture (1.3) Aroma (1.4) Appearance (1.5) General acceptability (2) Determine the best formulation of water spinach sheets based on their sensory profile. (3) Asses the Proximate Composition of the best formulation of Water Spinach sheet in terms of: (3.1) Crude Fat (3.2) Crude Protein (3.3) Moisture Content (3.4) Ash Content (4) Determine the significant difference among the formulations and controlled sample of the water spinach sheet in terms of each sensory attribute.

MATERIALS AND METHODS

Research Design

This study implemented an experimental design for the formulation of the water spinach sheets to evaluate the effectiveness of water spinach wrappers as a substitute for nori (red algae) seaweed sheets. Hassan (2024) stated that experimental design is a process of organizing study to test hypothesis, in which variables are changed to see how they affect results.

In this research, the preparation process involves two important ingredients, which is the water spinach leaves and seaweed. Different formulations of water spinach sheets were tested to evaluate their quality in terms of general sensory attributes as a sustainable food wrapper.

The researchers developed four different formulations of the product, with all ingredients kept in equal amounts except for the water spinach leaves and seaweed, which vary in each formulation. Formulation 1 contains 56 grams of water spinach leaves and 169 grams of seaweed, while Formulation 2 consists of 113 grams of water spinach leaves and 113 grams of seaweed. Formulation 3 includes 169 grams of water spinach leaves and 56 grams of seaweed, and Formulation 4 is made entirely of water spinach leaves with no seaweed. To clearly identify each formulation, specific codes were assigned: Code 123 for Formulation 1, Code 234 for Formulation 2, Code 345 for Formulation 3, and Code 456 for Formulation 4. A control sample was also prepared and labeled with Code 567.

Respondent and Sampling Technique

The respondents were the students at the College of Teacher Education Department at Cagayan State University at Andrews campus, Philippines who were enrolled during the academic year 2024-2025. The researchers used convenient sampling techniques. The students who were available during the conducting of sensory evaluation are the chosen respondents to assess the sensory attributes of water spinach sheet. Exclusion criteria were used to select the taste panel members. Only students who do not have colds and other illnesses, non-smokers, and respondents who aren't full or hungry during the food tasting that could possibly affect their sense of taste and smells during the sensory evaluation are considered.

Locale of the study

The study was conducted at Cagayan State University-Andrews Campus located in Caritan Highway,

Tuguegarao City, Cagayan. Specifically, the study focused on the College of Teacher Education Department during the second semester of academic year 2024-2025 which spanned from September 2024 to June 2025.

For food testing to assess the sensory satisfaction the researcher selected this locale as the settings provide a valuable research opportunity to assess the products and ensure a controlled and convenient environment for the participants.

Materials and Equipment

Shown below the exact measurements of raw materials and ingredients used in each formulation of the product.

Table 1. Exact Measurements of Raw Materials

Ingredients	Formulation 1	Formulation 2	Formulation 3	Formulation 4
Water Spinach Leaves	56g	113g	169g	250g
Nori Seaweed	169g	113g	56g	-
Gelatin	15g	15g	15g	15g
Salt	5g	5g	5g	5g
Sesame Oil	15g	15g	15g	15g

Tools and Equipment:

Parchment paper
Spatula
Sifter
Food processor
Dehydrator
Mixing Bowl
Measuring spoon and cup

Product Development Process

General Procedure:

1. The first step is the collection of raw materials for making water spinach sheets.
2. To make sure that it is clean, rinse the water spinach thoroughly to remove any dirt or impurities. To remove the bitterness of water spinach, it is soaked in water with salt for 30 minutes.
3. Blanch it for about 5 minutes. This helps to soften the leaves and retain their vibrant color. After blanching, let the water spinach cool.
4. Blend and add the gelatin until you achieve a smooth, paste-like consistency. After blending, strain the pureed spinach.
5. Line a baking sheet with parchment paper then brush it with small amount of sesame oil and pour the spinach mixture onto the parchment paper and spread it out evenly to form a thin layer and the seasoning on the spinach mixture.
6. Place the spinach mixture sheet in the food dehydrator for about 5-6 hours.
7. Once dried, remove the spinach sheet from the parchment paper and pan fry to achieve the crispiness like nori seaweed sheet.
8. Keep the homemade water spinach sheets in an airtight container to maintain their crispiness.

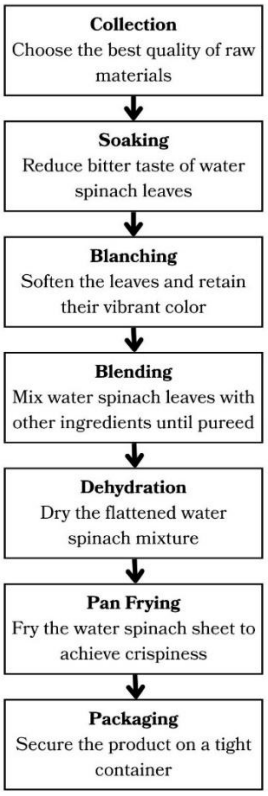


Figure 1: Flow chart process in making Water spinach sheets.

Research Instrument

Data was collected using a survey sheet with 9-point hedonic scale to measure the acceptability of the food wrappers. According to Johnson (2021), the 9-point hedonic scale is the most widely used scale for measuring

food acceptability. The questionnaire reviewed and validated to ensure clarity, relevance and alignment to the research objectives.

Data Gathering Procedure

The approach on collecting data was conveniently gathered to the respondents. The researchers seek approval from the college dean to conduct the study. After the approval of the letter, they selected 43 total students based on the established qualification. Researchers provided informed consent to the respondents before conducting the sensory evaluation and answering the evaluation forms. 7 experts also evaluated from the Food Innovation Center in Cagayan State University Campus Carig.

Analysis of the Data/ Statistical treatment

To analyze the data, SPSS software was used to statistically prove that the data collected was reliable and accurate. To interpret the data gathered, descriptive statistic (mean) was used for summarizing the acceptability of the water spinach sheet in terms of aroma, appearance, taste, texture and general acceptability ensuring that each rating was accurately represented in the overall assessment. The following arbitrary scale was used.

Scale	Interpretation
8.13-9.00	Like Extremely
7.24-8.12	Like Very Much
6.35-7.23	Like Moderately
5.46-6.34	Like Slightly
4.57-5.45	Neither Like or Dislike
3.68-4.56	Dislike Slightly
2.79-3.67	Dislike Moderately
1.90-2.78	Dislike Very Much
1.00-1.89	Dislike Extremely

To assess whether there was a significant difference among the formulations and controlled, a one-way analysis of variance (ANOVA) will be used. This is the best inferential statistical tool in experimental research comparing controlled against multiple treatments of the study.

After the analysis of variance (ANOVA) results showed a significant difference, a Tukey Honestly Significant Difference (HSD) post hoc test was conducted to identify which specific formulations of water spinach sheet differed from each other in each sensory attribute.

RESULTS AND DISCUSSION

Table 2. Summary Table of Sensory Acceptability across the different formulation of Water Spinach Sheet

Sensory Qualities	Formulation 1	Formulation 2	Formulation 3	Formulation 4	Control
Appearance	5.76	5.80	6.04	6.78	6.88
Aroma	6.08	6.10	6.54	7.12	6.22
Taste	5.76	5.98	6.36	6.98	6.26
Texture	5.80	5.84	6.32	6.92	6.38
General Acceptability	6.08	6.18	6.50	7.32	6.46
Total Mean	5.90	5.99	6.35	7.02	6.44

Table 2 presents the summary mean scores for appearance, aroma, taste, texture and general acceptability of various water spinach sheet formulations and the control sample. Out of the five formulations, Formulation 4 with 100% water spinach raw materials had the highest mean values for all sensory attributes, with an overall acceptability score of 7.02 categorized as Like Moderately, meaning that it was accepted by the panelists.

For appearance, control samples garnered a higher mean score of 6.88 compared to the other formulation, However, the score of Formulation 4 at 6.78 categorized as like moderately showed only a minimal difference, suggesting that its appearance is comparably acceptable. In terms of aroma, Formulation 4 received a high score of 7.12 categorized as like moderately described as having a "mildly earthy and fresh aroma" that enhanced the product's overall appeal. When it comes to taste, Formulation 4 obtained a mean score of 6.98 categorized as like moderately and characterized as "somewhat pleasant, Mild leafy taste with light salty finish" indicating a generally favorable response from the evaluators and contributed positively to the overall eating experience. For texture, the formulation 4 got the highest score rated 6.92 categorized as like moderately and characterized as "slightly pleasant with acceptable crispness or flexibility but not outstanding" indicates that the texture was acceptable and palatable. The highest score was recorded under the general acceptability

category, where Formulation 4 received a mean of 7.32 or "like very much".

In contrast, The Control with 100% nori seaweed showed moderate scores, with a mean score of 6.46, which was lower than Formulation 4 but slightly higher than Formulations 1 and 2. This suggests that the experimental formulation using 100% water spinach can compete with, and even outperform, the traditional nori in terms of sensory appeal. In comparison to other formulation, Formulations 1, 2, and 3, which were blends of water spinach and nori seaweed, recorded lower scores in all attributes, with total mean scores of 5.90 or "like slightly", 5.99 or "like slightly', and 6.35 or "like moderately" respectively.

This trend implies that increasing the proportion of water spinach in the formulation positively influenced the sensory characteristics of the product. These findings suggest that when increasing the water spinach mixture improves the acceptability of the food wrapper, even without any mixture of nori seaweed it can serve as an excellent raw material for developing edible food wrappers that are both nutritious and well-received by evaluators.

These findings are in accord with the earlier studies that noted the sensory and nutritional benefits of leafy green vegetables as a prime ingredient for food wrappers. Water spinach (*Ipomoea aquatica*), in particular, is recognized for its mild flavor, vibrant color, and nutritional benefits, making it a promising candidate for innovative food products Sreelatha & Padma (2009). Research has indicated that leafy vegetable wrappers produced solely from leafy vegetables tend to yield higher scores on sensory compared to films that are blended with other ingredients. For instance, Kumar et al. (2017) established that increased levels of leafy vegetable puree in edible films enhance color, flavor, and acceptability, while blends with seaweed or other additives may dilute these positive attributes. The lower ratings of formulations mixed with nori seaweed here are in line with these results, possibly due to the masking of the natural flavor and aroma of water spinach.

Table 3. Summary Analysis of Variance for Each Sensory Properties of Water Spinach Sheet

Sensory Qualities	Total Mean	F Value	P Value	Decision
Appearance	6.25	10.843	<.001	Reject the Ho
Aroma	6.41	6.369	<.001	Reject the Ho
Taste	6.27	6.242	<.001	Reject the Ho
Texture	6.25	6.178	<.001	Reject the Ho
General Acceptability	6.51	7.699	<.001	Reject the Ho

The table 3 presents the results of the Analysis of Variance (ANOVA) which examines whether there are significant differences in the sensory evaluation scores across five formulations of water spinach sheet, based on five sensory attributes: Appearance, Aroma, Taste, Texture, and General Acceptability. According to Jane Smith (2024) When the p-value is lower than the predetermined level of significance (usually 0.05), the null hypothesis is rejected. This suggests that the differences observed between the group means are statistically significant.

For Appearance, the ANOVA yielded a result of $F=10.843$, $p < 0.001$, indicating a statistically significant difference in appearance ratings among the different formulations. Since the p-value is less than 0.05, the null hypothesis was rejected which suggests that at least one formulation differs significantly in appearance compared to the others.

For Aroma, the result was $F=6.369$, $p < 0.001$. As the p-value is also below 0.05, this indicates that there are significant differences in how participants rated the aroma of the different formulations. Thus, the null hypothesis was rejected, implying that at least one formulation is significantly different in aroma.

For Taste, the ANOVA result was $F= 6.242$, $p < 0.001$, which again indicates a significant difference in taste ratings among the five groups. The null hypothesis is therefore rejected, and this suggests that taste perception varies across formulations.

Regarding Texture, the ANOVA yielded F= 6.178, p < 0.001, which means that there are statistically significant differences in texture ratings. Since the p-value is well below the 0.05 threshold, the null hypothesis was rejected and concluded that participants perceived texture differently among the samples.

Lastly, for General Acceptability, the result was F= 7.699, p < 0.001. This demonstrates a statistically significant difference in the overall acceptability scores across the formulations. Therefore, the null hypothesis is rejected once again, indicating that the general acceptability of the food wrapper formulations was not rated equally.

The ANOVA results indicate that all five sensory attributes showed statistically significant differences in scores among the different formulations of water spinach sheet (p < 0.001 in all cases). This suggests that at least one formulation was rated differently from the others in terms of appearance, aroma, taste, texture, and general acceptability. Further post-hoc analysis (Tukey HSD) is used to determine which specific formulations differ significantly from one another.

Table 4. Tukey HSD Post Hoc Test in terms of Appearance

Formulation	F1	F2	F3	F4	Control
F1	--	1.000	.747	.001	.001
F2	1.00	--	.839	.001	.001
F3	.747	.839	--	.014	.003
F4	.001	.001	.014	--	.993
Control	.001	.001	.003	.993	--

Formulation 1 and Formulation 2 did not show a significant difference in appearance (p = 1.000), indicating that panelists rated them similarly. Likewise, Formulation 2 and Formulation 3 (p = 0.839) and Formulation 2 and Formulation 3 (p = 0.747) also showed no statistically significant difference, suggesting these three formulations shared comparable visual qualities. However, significant differences were observed when these formulations were compared with Formulation 4 and the Control. Formulation 1 vs. F4ormulation 4(p = 0.001), Formulation 1 vs. Control (p = 0.001), Formulation 2 vs. Formulation 4 (p = 0.001), and Formulation 2 vs. Control (p = 0.001) all yielded highly significant differences, indicating that Formulation 4 and the Control had distinctly different appearance characteristics from F1 and F2. In addition, the comparison between Formulation 3 and Formulation 4 (p = 0.014) and Formulation 3 and Control (p = 0.003) also showed significant differences, although the magnitude of difference was less compared to other pairs. Meanwhile, Formulation 4 and the Control (p = 0.993) were not significantly different from each other, implying a high degree of visual similarity between these two samples.

These results suggest that while Formulation 1, Formulation 2, and Formulation 3 appear similar to one another, Formulation 4 and the Control stand out as visually distinct, with Formulation 4 closely resembling the appearance of the Control. This may be attributed to the higher proportion of water spinach in Formulation 4, potentially mimicking the natural color and texture of the seaweed-based Control formulation.

Table 5. Tukey HSD Post Hoc Test in terms of Aroma

Formulation	F1	F2	F3	F4	Control
F1	--	1.000	.331	.001	.979
F2	1.000	--	.377	.001	.988
F3	.331	.377	--	.127	.686
F4	.001	.001	.127	--	.003
Control	.979	.988	.686	.003	--

Formulation 1 and Formulation 2 (p = 1.000), Formulation 1 and Control (p = 0.979), and Formulation 2 and Control (p = 0.988) showed no significant difference, indicating that these three formulations shared similar aromatic characteristics. Additionally, Formulation 3 vs. Formulation 1 (p = 0.331) and Formulation 3 vs. Formulation 2 (p = 0.377) also did not exhibit significant differences, suggesting that the aroma of F3 was still comparable to F1 and F2. However, statistically significant differences were observed in comparisons involving Formulation 4. Specifically, Formulation 4 vs. Formulation 1 and Formulation 4 vs. Formulation 2 both had p-values of 0.001, showing highly significant differences in aroma. Formulation 4 also significantly differed from the Control (p = 0.003), suggesting that its aroma was perceived very differently from the other samples, particularly those with lower water spinach

content or 100% seaweed composition. Interestingly, Formulation 3 vs. Formulation 4 (p = 0.127) and Formulation 3 vs. Control (p = 0.686) did not show significant differences, implying that Formulation 3 holds a transitional aromatic profile, somewhat similar to both Formulation 4 and the Control, potentially due to its balanced 75%-25% water spinach-to-seaweed ratio.

In summary, the aroma of Formulation 4 stands out as distinctly different from the rest, possibly due to its 100% water spinach content, which may have contributed to a more earthy or vegetal scent. Meanwhile, Formulation 1, Formulation 2, Formulation 3, and the Control exhibit no significant differences, indicating a shared aromatic profile that may be more familiar or acceptable to consumers.

Table 6. Tukey HSD Post Hoc Test in terms of Texture

Formulation	F1	F2	F3	F4	Control
F1	--	.918	.151	.001	.315
F2	.918	--	.595	.002	.822
F3	.151	.595	--	.128	.995
F4	.001	.002	.128	--	.050
Control	.315	.822	.995	.050	--

The results show that Formulation1, Formulation 2, Formulation 3, and the Control were not significantly different from each other in terms of taste. Specifically, comparisons such as Formulation 1 vs. Formulation 2 (p = 0.918), Formulation 1 vs. Control (p = 0.315), Formulation 2 vs. Control (p = 0.822), and Formulation 3 vs. Control (p = 0.995) all yielded high p-values, indicating similar taste profiles among these formulations. Likewise, Formulation 2 vs. Formulation 3 (p = 0.595) and Formulation 1 vs. Formulation 3 (p = 0.151) also revealed no significant difference, suggesting that formulations with partial substitutions of water spinach still retained a taste similar to the Control. In contrast, Formulation 4, which contains 100% water spinach, showed statistically significant differences in taste when compared with Formulation 1 (p = 0.001) and Formulation 2 (p = 0.002). These results imply that the complete replacement of seaweed with water spinach in Formulation 4 produced a taste that was perceptibly different and possibly less acceptable to panelists who were accustomed to traditional nori-based products. Interestingly, Formulation 4 vs. Formulation 3 (p = 0.128) and Formulation 4 vs. Control (p = 0.050) approached the threshold of significance, with the latter exactly at the 0.05 level. This may indicate a marginal difference that warrants further investigation or suggests a borderline acceptability among respondents.

In summary, the taste of Formulation 4, being purely water spinach based, was perceived as significantly different from the other partially substituted formulations, while Formulation 1, Formulation 2, Formulation 3, and the Control maintained relatively similar taste profiles, highlighting the effectiveness of partial substitution in preserving acceptable flavor.

Table 7. Tukey HSD Post Hoc Test in terms of Texture

Formulation	F1	F2	F3	F4	Control
F1	--	1.000	.273	.001	.175
F2	1.000	--	.353	.001	.237
F3	.273	.353	--	.149	.999
F4	.001	.001	.149	--	.237
Control	.175	.237	.999	.237	--

Formulation 1 and Formulation 2 had no significant difference in texture (p = 1.000), indicating that panelists perceived their mouthfeel and consistency similarly. Likewise, Formulation 1 vs. Formulation 3 (p = 0.273) and Formulation 2 vs. Formulation 3 (p = 0.353) also yielded non-significant results, suggesting that the texture of the formulations with partial water spinach substitution (F1 to F3) remained fairly consistent. The Control also showed no significant differences when compared to Formulation 1 (p = 0.175), Formulation 2 (p = 0.237), and Formulation 3 (p = 0.999), indicating that the texture of the partially substituted formulations was comparable to that of the 100% seaweed sample. Notably, Formulation 3 and the Control shared an almost identical textural profile (p = 0.999). In contrast, Formulation F4, which used 100% kangkong, demonstrated statistically significant differences in texture when compared to Formulation 1 (p = 0.001) and Formulation 2 (p = 0.001). These findings suggest that the complete replacement of seaweed with

water spinach significantly altered the texture of the sheet, potentially making it less similar to traditional nori in terms of structure, flexibility, or mouthfeel. However, Formulation 4 vs. Formulation 3 (p = 0.149) and Formulation 4 vs. Control (p = 0.237) did not show significant differences, implying that as the water spinach ratio increases (especially in F3), its textural properties begin to resemble those of Formulation 4.

In summary, formulation 1 to Formulation 3 and the Control exhibited similar and acceptable textures, whereas Formulation 4 stood out as texturally different, likely due to the absence of seaweed. This suggests that partial substitution maintains the structural integrity of the product, while full substitution with water spinach may alter its desirable textural properties.

Table 8. Tukey HSD Post Hoc Test in terms of General Acceptability

Formulation	F1	F2	F3	F4	Control
F1	--	.994	.443	.001	.545
F2	.994	--	.700	.001	.793
F3	.443	.700	--	.010	1.000
F4	.001	.001	.010	--	.006
Control	.545	.793	1.000	.006	--

Based on the table 5.5, there were no statistically significant differences observed among Formulations Formulation 1, Formulation 2, Formulation 3, and the Control, as shown by their high p-values: Formulation 1 vs. Formulation 2 (p = 0.994), Formulation 1 vs. Control (p = 0.545), Formulation 2 vs. Control (p = 0.793), Formulation 2 vs. Formulation 3 (p = 0.700), and Formulation 3 vs. Control (p = 1.000). This indicates that these formulations were rated similarly by the panelists in terms of overall preference. On the other hand, Formulation 4, which was made with 100% water spinach, showed statistically significant differences when compared with all the other formulations: Formulation 4 vs. Formulation 1 (p = 0.001), Formulation 4 vs. Formulation 2 (p = 0.001), Formulation 4 vs. Formulation 3 (p = 0.010), and Formulation 4 vs. Control (p = 0.006). These results suggest that the complete substitution of seaweed with water spinach in Formulation 4 negatively impacted its overall acceptability. Interestingly, Formulation F3, which contained 75% water spinach and 25% seaweed, showed no significant difference from the Control (p = 1.000), indicating that a high level of water spinach incorporation is still acceptable as long as some seaweed remains in the formulation.

In summary, the findings imply that partial substitution of seaweed with water spinach maintains general acceptability among consumers, whereas full substitution significantly reduces it. Therefore, maintaining a balance between water spinach and seaweed is essential in preserving favorable consumer perception.

Table 9. Proximate Analysis of Water Spinach Sheet

Sample Code	Sample Description	Parameter	Result	Method used
CHE-0596	Water Spinach Sheet	Crude Fat (g/100)	3.62	Soxhlet Extracrion
		Crude Protein (g/100)	14.93	Block Digestion/ Steam Distillation
		Moisture (g/100)	16.35	Air Oven
		Ash (g/100)	12.56	Gravimetric Method

Source: Department of Science and Technology - Regional office 02

The crude protein content of the water spinach sheet, measured using the Block Digestion and Steam Distillation method, was found to be 14.93%. This figure represents the nitrogen content converted into protein, which is a common method for estimating protein in food samples. Water spinach is rich in essential amino acids, which are important for human health. They support growth, tissue repair, and maintenance according to Adelakun et al., (2016). The protein content found in this study matches earlier results showing that dried water spinach leaves had protein levels between 20% and 31% on a dry matter basis. These amounts depend on factors like the maturity of the plant and the methods used for processing (Adelakun, 2016).

Using Soxhlet extraction, the crude fat content of the water spinach sheet was determined to be 3.62%. This finding suggests that the product is healthier than other food wrappers with a higher fat content because it contains comparatively little fat.

The moisture content, determined by the air oven method, was recorded at 16.35%. This result shows that the product keeps a moderate level of moisture. Fresh water spinach usually contains over 90% moisture, so drying significantly concentrates the nutrients and improves the product's stability (Adelakun et al., 2016).

The ash content of the water spinach sheet, measured by the Gravimetric Method, was 12.56%. This indicates a rich presence of minerals, which may include essential nutrients like calcium, potassium, magnesium, iron, and phosphorus. Rudrappa (2009) emphasized that water spinach provides many health benefits due to its low calorie and fat content and is especially rich in vital nutrients. These include vitamin A, B-complex vitamins, as well as a range of antioxidants and essential minerals. This mineral richness improves the nutritional profile of the water spinach sheet, making it a valuable source of micronutrients in the diet.

The proximate composition of the water spinach sheet shows high protein and mineral content, moderate moisture, and low fat. This confirms its suitability as a nutrient-dense food ingredient.

CONCLUSION

This study was conducted with the primary objective of developing and evaluating water spinach (*Ipomoea aquatica*) sheets as a potential alternative to commercial nori seaweed. The research aimed to assess the sensory acceptability and nutritional quality of formulations using different ratios of water spinach and nori seaweed, ultimately identifying a sustainable, cost-effective, and locally sourced substitute.

The findings revealed that among the four formulations and a control sample tested, Formulation 4 (100% water spinach) consistently obtained the highest sensory scores across all attributes: appearance, aroma, texture, taste, and general acceptability. Statistical analysis using Analysis of Variance (ANOVA) and Tukey Honestly Significant Difference (HSD) post hoc tests indicated that Formulation 4 was significantly more acceptable compared to most other treatments, including the control. Furthermore, the proximate analysis showed that water spinach sheets contain considerable amounts of moisture, ash, protein and fat highlighting their nutritional potential.

Based on these findings, the study infers that water spinach, a readily available and underutilized leafy vegetable in the Philippines, can be effectively transformed into a sheet product that meets consumer standards in both quality and taste. The success of Formulation 4 underscores the feasibility of using 100% water spinach without compromising sensory attributes, offering a viable plant-based innovation in the food industry.

RECOMMENDATIONS

Based on the findings and conclusions of the study, the following recommendations are hereby proposed:

1. Promote the utilization of 100% water spinach formulation as a viable alternative to commercial nori seaweed wrappers, especially in communities with abundant Water Spinach supply. Local entrepreneurs and food processors may adopt this innovation to create sustainable and affordable edible wrappers.
2. Conduct microbial analysis of the developed water spinach wrapper to ensure that it meets food safety standards and is free from harmful bacteria or contaminants, especially if produced on a larger scale.
3. Study the shelf-life stability under different packaging materials and storage conditions to determine how long the product can maintain its quality, particularly crispness and aroma.
4. Explore natural preservatives or antioxidants that can be added to prolong the wrapper's shelf life without compromising its edibility and safety.
5. Assess consumer acceptance across different age groups and regions to support market expansion and refine product design based on target preferences.

Appendices

Appendix A. Research Instruments

Republic of the Philippines
Cagayan State University
Andrews Campus Caritan Sur,
Tuguegarao City 3500, Cagayan

Research Title: DEVELOPING A FOOD WRAPPER WITH WATER SPINACH LEAVES (*IPOMOEA AQUATICA*) AS A SUBSTITUTE RAW MATERIAL FOR NORI SEAWEED SHEET

Name: (Optional)_____ Age:_____

Instructions:

- Please evaluate the sample based on the following sensory attributes: Aroma, Appearance, Taste, Texture, and Overall Acceptability.
- Use the 9-point Hedonic Scale to indicate your level of liking or disliking for each attribute.
- Shade the appropriate score that best describes your evaluation of each attribute for the sample.
- Kindly provide honest and objective responses.

Appearance (Dark green, uniform, flat)

9- Dark green, uniform, perfectly flat with consistent thickness
8- Faint difference in color and minor waviness but still appealing
7- Good color with slight variation, surface mostly flat with slight wrinkles, and few tiny holes
6- Moderate variation in color, slight dullness with some surface unevenness and minor holes or rough patches
5- Noticeable variation in color, dull appearance, uneven surface, and small tears or several visible holes
4- Mixed color, surface irregularities, visible roughness, and moderate number of holes and flaws
3- Pale, uneven color, rough, crinkled surface with larger or multiple holes
2- Light patchy color, very rough surface, with many holes and weak structure
1- Highly discolored, broken, with extensive holes and unacceptable appearance and quality

Texture (Firm, crispy)

9- Texture is pleasant, perfectly crisp or flexible, smooth and easy to chew
8- Slightly unsatisfying either mostly crispy or well-balanced in flexibility, with minimal roughness
7- Fairly smooth and crisp or soft with minor flaws
6- Slightly pleasant with acceptable crispness or flexibility but not outstanding
5- Neither good nor bad. No strong positive or negative impression.
4- Somewhat unpleasant, slightly too rough.
3- Noticeably unpleasant, rough, chewy, and soggy.
2- Very poor, very rough, rubbery, or crumbly.
1- Unacceptable, extremely rough, overly chewy or soggy with unpleasant feel in the mouth

Aroma (Earthy, leafy vegetable scent, reminiscent)

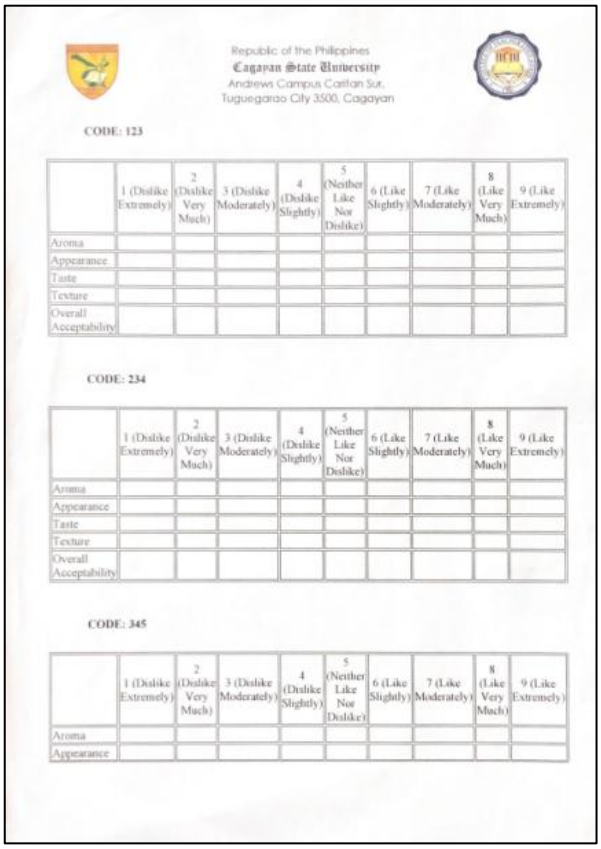
9- Very appealing earthy and pleasant vegetable scent that strongly resembles high-quality dried greens.
8- Distinctly natural and clean, with a noticeable fresh fresh-leaf scent and slightly earthy scent
7- Mildly earthy and fresh aroma.
6- Slightly pleasant aroma. Faint green scent, with minimal off-notes.
5- Neutral. Aroma is weak or not distinctive.
4- Slightly off or stale smell.
3- Noticeable unpleasant aroma, dull, musty, or too earthy.
2- Strong off-odor. May smell moldy, sour, or overly bitter-green. Significantly unpleasant.
1- Extremely unappealing odor. Sharp rotten, or sour smell. ?

Taste (Mild saltiness and water spinach taste, earthy)

9- Outstanding natural flavor, perfect blend of mild saltiness and earth with water spinach taste.
8- Enjoyable. Leafy flavor with a pleasant, slightly salty finish.
7- Tastes good, noticeable water spinach flavor with balanced seasoning
6- Somewhat pleasant. Mild leafy taste with light saltiness
5- Neutral. Taste is flat or lacks distinction. Neither good nor bad.
4- Slightly unpleasant. Water spinach flavor is weak or too earthy, with small minimal seasoning
3- Noticeably bitter or overly earthy, lacks appeal in taste.
2- Strong off-taste, bitter or stale flavor dominates, hard to appreciate.
1- Extremely unpleasant. Overpowering bitterness or grassy taste, not edible.

Overall Acceptability (From unacceptable to highly acceptable)

9- Highly acceptable, excellent overall quality
8- Very acceptable, minor imperfections needed
7- Acceptable, generally good
6- Slightly acceptable, some flaws
5- Neutral, neither good nor bad
4- Slightly unacceptable
3- Unacceptable
2- very unacceptable
1- Not acceptable at all



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CODE: 123

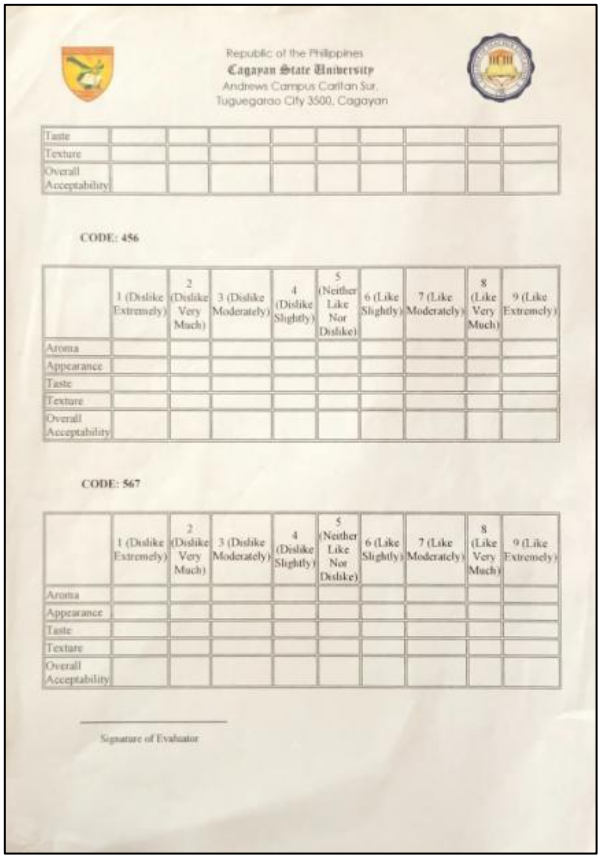
	1 (Dislike Extremely)	2 (Dislike Very Much)	3 (Dislike Moderately)	4 (Dislike Slightly)	5 (Neither Like Nor Dislike)	6 (Like Slightly)	7 (Like Moderately)	8 (Like Very Much)	9 (Like Extremely)
Aroma									
Appearance									
Taste									
Texture									
Overall Acceptability									

CODE: 234

	1 (Dislike Extremely)	2 (Dislike Very Much)	3 (Dislike Moderately)	4 (Dislike Slightly)	5 (Neither Like Nor Dislike)	6 (Like Slightly)	7 (Like Moderately)	8 (Like Very Much)	9 (Like Extremely)
Aroma									
Appearance									
Taste									
Texture									
Overall Acceptability									

CODE: 345

	1 (Dislike Extremely)	2 (Dislike Very Much)	3 (Dislike Moderately)	4 (Dislike Slightly)	5 (Neither Like Nor Dislike)	6 (Like Slightly)	7 (Like Moderately)	8 (Like Very Much)	9 (Like Extremely)
Aroma									
Appearance									



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Taste									
Texture									
Overall Acceptability									

CODE: 456

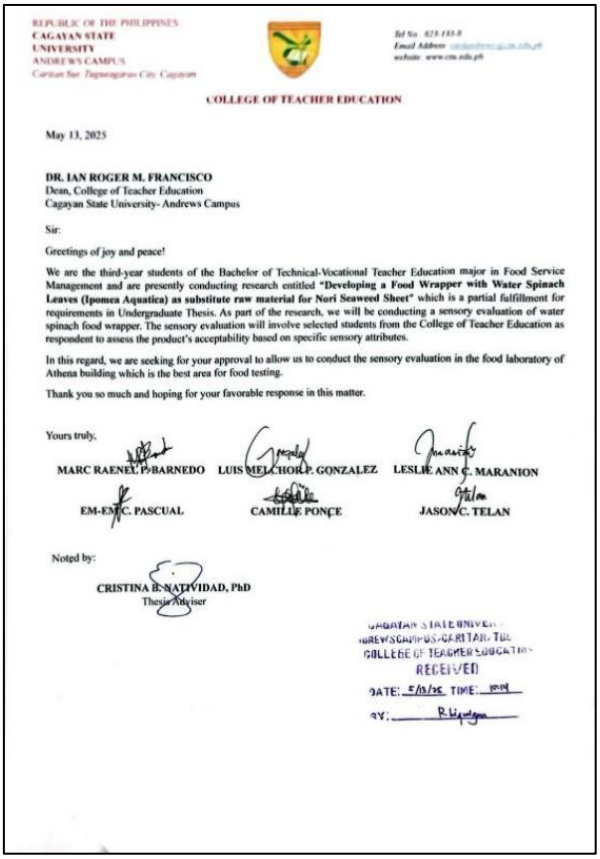
	1 (Dislike Extremely)	2 (Dislike Very Much)	3 (Dislike Moderately)	4 (Dislike Slightly)	5 (Neither Like Nor Dislike)	6 (Like Slightly)	7 (Like Moderately)	8 (Like Very Much)	9 (Like Extremely)
Aroma									
Appearance									
Taste									
Texture									
Overall Acceptability									

CODE: 567

	1 (Dislike Extremely)	2 (Dislike Very Much)	3 (Dislike Moderately)	4 (Dislike Slightly)	5 (Neither Like Nor Dislike)	6 (Like Slightly)	7 (Like Moderately)	8 (Like Very Much)	9 (Like Extremely)
Aroma									
Appearance									
Taste									
Texture									
Overall Acceptability									

_____
Signature of Evaluator

Appendix B. Letter to the Dean



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CAGAYAN STATE UNIVERSITY
ANDREWS CAMPUS
Caritan Sur, Tuguegarao City, Cagayan

Tel No. 823-133-8
Email Address: [redacted]
website: www.csu.edu.ph

COLLEGE OF TEACHER EDUCATION

May 13, 2025

DR. IAN ROGER M. FRANCISCO
Dean, College of Teacher Education
Cagayan State University- Andrews Campus

Sir:

Greetings of joy and peace!

We are the third-year students of the Bachelor of Technical-Vocational Teacher Education major in Food Service Management and are presently conducting research entitled **"Developing a Food Wrapper with Water Spinach Leaves (Ipomea Aquatica) as substitute raw material for Nori Seaweed Sheet"** which is a partial fulfillment for requirements in Undergraduate Thesis. As part of the research, we will be conducting a sensory evaluation of water spinach food wrapper. The sensory evaluation will involve selected students from the College of Teacher Education as respondent to assess the product's acceptability based on specific sensory attributes.

In this regard, we are seeking for your approval to allow us to conduct the sensory evaluation in the food laboratory of Athena building which is the best area for food testing.

Thank you so much and hoping for your favorable response in this matter.

Yours truly,

MARC RAENEL P. BARNEDO — LUIS MELCHOR P. GONZALEZ — LESLIE ANN C. MARANION

EM-EM C. PASCUAL — CAMILLE PONCE — JASON C. TELAN

Noted by:

CRISTINA B. NATIVIDAD, PhD
Thesis Adviser

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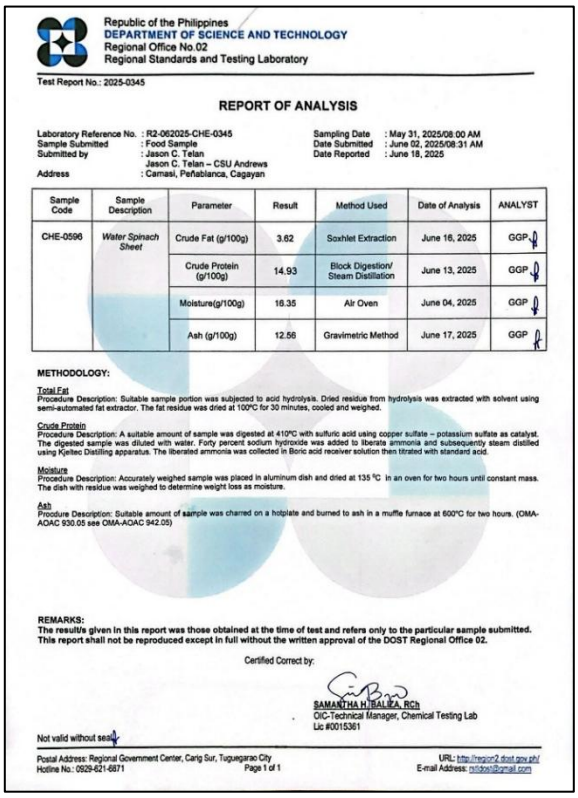
COLLEGE OF TEACHER EDUCATION
RECEIVED
DATE: 5/13/25 TIME: 10:14
BY: R. Lapuyan

Appendix B. Laboratory Test Result



Republic of the Philippines
DEPARTMENT OF SCIENCE AND TECHNOLOGY
Regional Office No.02
Regional Standards and Testing Laboratory

Test Report No.: 2025-0345

REPORT OF ANALYSIS

Laboratory Reference No. : R2-062025-CHE-0345
Sample Submitted : Food Sample
Submitted by : Jason C. Telan
Jason C. Telan – CSU Andrews
Address : Camasi, Peñablanca, Cagayan
Sampling Date : May 31, 2025/08:00 AM
Date Submitted : June 02, 2025/08:31 AM
Date Reported : June 18, 2025

Sample Code	Sample Description	Parameter	Result	Method Used	Date of Analysis	ANALYST
CHE-0596	*Water Spinach Sheet*	Crude Fat (g/100g)	3.62	Soxhlet Extraction	June 16, 2025	GGP
		Crude Protein (g/100g)	14.93	Block Digestion/ Steam Distillation	June 13, 2025	GGP
		Moisture(g/100g)	16.35	Air Oven	June 04, 2025	GGP
		Ash (g/100g)	12.56	Gravimetric Method	June 17, 2025	GGP

METHODOLOGY:

Total Fat
Procedure Description: Suitable sample portion was subjected to acid hydrolysis. Dried residue from hydrolysis was extracted with solvent using semi-automated fat extractor. The fat residue was dried at 100°C for 30 minutes, cooled and weighed.

Crude Protein
Procedure Description: A suitable amount of sample was digested at 410°C with sulfuric acid using copper sulfate – potassium sulfate as catalyst. The digested sample was diluted with water. Forty percent sodium hydroxide was added to liberate ammonia and subsequently steam distilled using Kjeltec Distilling apparatus. The liberated ammonia was collected in Boric acid receiver solution then titrated with standard acid.

Moisture
Procedure Description: Accurately weighed sample was placed in aluminum dish and dried at 135 °C in an oven for two hours until constant mass. The dish with residue was weighed to determine weight loss as moisture.

Ash
Procedure Description: Suitable amount of sample was charred on a hotplate and burned to ash in a muffle furnace at 600°C for two hours. (OMA-AOAC 930.05 see OMA-AOAC 942.05)

REMARKS:
The result/s given in this report was those obtained at the time of test and refers only to the particular sample submitted. This report shall not be reproduced except in full without the written approval of the DOST Regional Office 02.

Certified Correct by:

SAMANTHA H. BALIZA, RCh
OIC-Technical Manager, Chemical Testing Lab
Lic #0015361

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Hotline No.: 0929-621-6871
Page 1 of 1
URL: http://region2.dost.gov.ph/
E-mail Address: rstdost@gmail.com

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To the Research Adviser **Cristina B. Natividad, PhD**., for her guidance, mentorship, and support throughout the entire research process.

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To the faculty, staff, and students of the College of Teacher Education, for offering the environment and resources required for academic development.

The researchers' cherished family, for their unfailing support, love, and tolerance, especially in the most trying times. Your support has been our greatest motivation.

- *Researchers*

Note from the author: The accuracy and integrity of the content in this article are the sole responsibility of the author(s).