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Research Article

Fermented Golden Apple Snail (*Pomacea canaliculata* L.) as Nutrient Solution on the Growth of Batavia Lettuce (*Lactuca sativa* L.) under Kratky Hydroponic Method

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ABSTRACT

Golden apple snail (*Pomacea canaliculata* L.) is considered as a notorious pest in the rice fields along with different agricultural countries including the Philippines. This study was conducted to develop a fermented golden apple snail (FGAS) nutrient solution and investigate its effects on the growth of green loose-leaf Batavia lettuce (*Lactuca sativa* L.) under a Kratky hydroponic method. Green-loose leaf in grand rapid variety were used as the test plant to assess the effectiveness of the five treatments in the study: T1-SNAP solution, T2-FGAS, T3-double strength FGAS, T4-molasses, and T5-water. Due to its better suitability for trials carried out inside a screenhouse system, complete randomized design was used in the study. Moreover, the pH, electric conductivity (EC) and temperature of the treatments were measured as well as relative humidity and temperature within the screenhouse as indicators of its physicochemical characteristics. The developed FGAS has a 1:1:1 ratio composed of the meat of the *P. canaliculata*, food-grade molasses, and water. The result indicated that the lettuces which grew on T2-FGAS are comparable with the lettuces on the positive control. T1-SNAP solution in terms of plant height, number of leaves, length and width of the biggest leaf, fresh weight, and root length. However, lettuces on T2-FGAS displayed better leaf coloration, dry weight, and width of the biggest lettuce leaf than T1-SNAP. Additionally, *L. sativa* plants cultivated in T3-double strength FGAS produced results that were comparable to those obtained with negative treatments T4-molasses and T5-water. The study further revealed that the developed FGAS can probably be used as hydroponic nutrient solution by plant growers. The researchers recommend microbiological water analysis and lettuce contents analysis for further study.

Keywords: *Fermented Golden Apple Snail, Lactuca sativa L., Kratky Hydroponics, Nutrient Solution*

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Introduction

Agricultural pests are one of the major causes of the decline in several important agricultural products. Based on the data of IRRI (2018), the major pests in agricultural lands are golden apple snails, rice bugs, ladybird beetle, stem borer, blast, and brown planthoppers. Pomacea *canaliculata* L., locally known as "golden kuhol" or golden apple snail. A freshwater snail that is native to South America was introduced to the farmers in the Philippines in the 1980s from Argentina via Taiwan and other Asian countries to increase the income of farmers and enrich their protein diet (Joshi, 2003).

Moreover, according to Global Invasive Species Database (2013), *P. canaliculata* is also considered one of the top 100 worst invasive alien species. Based on Horgan et al. (2014), golden apple snails damage rice seedlings by feasting on them soon after sowing or transplanting. They can cause losses of 30 to 100 percent on seedlings at moderate concentrations without effective cultural management procedures. In the Philippines, several government sectors were tasked to mitigate the proliferation of *P. canaliculata* to aid farmers. Such as the Philippine Rice Research Institute (PhilRice) where they had focused on two things regarding *P. canaliculata*, which includes understanding and identifying the ecology as well as the life cycle of the golden apple snail, and the knowledge acquired will be utilized in managing the golden apple snail in an ecologically sustainable, socially acceptable and economically viable ways (Joshi, 2007).

As agriculture plays a crucial role in the Philippines' economy, it is very alarming that several farming problems, such as natural calamities, loss of agricultural land, and pests, may contribute to the country's drop in Gross Domestic Product (GDP) and food security (Brown et al., 2018; Bacani & Farin, 2018). Hence, according to the Journal of the House of Representatives (2016), to secure food security in the Philippines due to agricultural land loss, industrialization, low crop production, and soil degradation, the hydroponic planting system was proposed and introduced to farmers as an alternative to the traditional way of farming.

In that way, this scientific study will help mitigate the invasiveness of golden apple snails, promoting innovation and food security in the country. Due to the high level of macro and micro minerals in its meat, eggs, and shells (Siregar et al., 2017; Wang et al., 2020), researchers aim to formulate a nutrient solution using the meat of *P. canaliculata* to mitigate the disruptive effects of golden apple snail on crops and to encourage farmers to try hydroponics farming.

The general objective of the study is to determine the effectiveness of the developed hydroponic nutrient solution made from golden apple snail on the growth performances of the lettuce plant grown in a Kratky hydroponic method. Specifically, the research aims to: (1) develop a hydroponic nutrient solution from the meat of *Pomacea canaliculata* L.; and (2) evaluate the growth performance of the crop (*Lactuca sativa* L.) in terms of plant height, root length, length of the biggest leaf, the width of the biggest leaf, fresh weight, dry weight, leaf coloration and number of leaves.

Thus, this study aims to develop a hydroponic nutrient solution made from *P. canaliculata* and to test its effectiveness on the growth of the Green loose-leaf lettuce plant. The findings of the study would be a great help to the community, particularly to the following; local farmers, hydroponic growers, the local community, and future researchers.

Methods

A. Preparation and Fermentation of Golden Apple Snail

Golden apple snails were obtained from the rice fields in San Felipe, Zambales, and were left in the groundwater for a day in order for the golden apple snail to defecate or discharge waste. Samples of the collected golden apple snails were taken to an expert from Provincial Agricultural Office (PAO) for identification and certification that the collected samples were indeed *Pomacea canaliculata* L. species.

The meat of GAS was fermented with food-grade molasses and water in a 1:1:1 ratio in a sterilized container and covered with cloth and rubber bands (Uy et al., 2021). Furthermore, the GAS concentration was fermented for 7 to 14 days (Agricultural Training Institute, 2006). After fermentation, the developed fermented GAS samples were submitted to the CRL

Environmental Corporation in Clark Freeport Zone (CFZ), Pampanga, to determine its total nutrient composition in terms of Nitrogen, Phosphorus, Potassium, Magnesium, and Iron using Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES).

B. Kratky Hydroponic Set up Preparation

The Kratky method is a deep-water culture hydroponics. It is considered a non-circulating method for growing lettuce that does not require wicks, pumps, or even electricity—considering the simplest hydroponic system developed by Bernard A. Kratky of the University of Hawaii (Atkinson, 2018).

In preparing the Kratky hydroponic method, the study was conducted in a screenhouse of 17 feet by length, 10 feet by width, and 8 feet by the height of metal pipes and wood. The researchers used wood boxes as a reservoir comprising 205cm in length, 61cm in width, and 10cm in height that holds the water and styrofoam cups with holes as a seedling plug. About 4 to 6 slits, 2 inches long on the side and half an inch at the bottom were applied to the styrofoam cups. Polyethylene plastic bags were placed inside the container to hold the nutrient solution, prevent the growth of algae and bacterial contamination, and protect it from intense heat. Cocopeat served as the growing medium in the study and was placed on a cup about one inch thick where seeds were sown. The researchers sterilized the coco coir by boiling it in water for 30 minutes to eliminate the microorganisms (Ilahi & Ahmad, 2017).

Figure 1. Kratky hydroponic set-up of the study
(A) Kratky hydroponic set-up. (B) Growing beds is covered with polyethylene plastic sheets.

C. Evaluation and Application of Formulated FGAS and the Treatments

The different treatment solutions were tested on the green loose-leaf, grand rapid variety lettuce under the Kratky hydroponic method. On the seventh day, the seedlings were treated with half the strength of the solution of each treatment in 12.5ml SNAP solution-T1, 12.5ml FGAS-T2, 25ml double-strength FGAS-T3, 12.5ml molasses-T4, and water-T5 diluted into 10L of water. During the head development of lettuce, the researchers transplanted the lettuce seedlings on the Kratky hydroponic setup. On its 14th day, they treated them with the full-strength solution, 25ml SNAP solution-T1, 25ml FGAS-T2, 50ml double-strength FGAS-T3, 25ml molasses-T4, and water-T5 diluted into 10L of water. However, upon measuring the electrical conductivity (EC) of the nutrient solution, the researchers observed that the electrical conductivity of the treatments-25ml SNAP solution-T1, 25ml FGAS-T2, molasses-T4 reached the standard limit of EC for hydroponics which is 1.0 to 2.0 mS/cm as stated by the study of Henry et al. (2018).

To maintain the level of electrical conductivity, according to Brechner et al. (2013), adding pure water can decrease the EC, or adding a small amount and concentrated nutrient stock solution can raise it back. Thus, the researchers adjusted the concentration of the solution for T1-SNAP, T2-FGAS, and T3-double strength FGAS to meet the required standard EC for growing lettuce in a hydroponic system following Brechner et al. (2013) study by adding the specific solution to the setup as needed.

D. Cultivation of Crops

The 12 samples of green loose-leaf lettuce were used and planted in triplicates which have a total of 36 samples for each treatment-SNAP solution (T1), FGAS solution (T2), double strength FGAS solution (T3), molasses (T4), and water (T5) diluted into 80 liters of water in the Kratky hydroponics system setup. Furthermore, extra ten samples were allotted for each treatment to replace those plants that will die on a Kratky hydroponic method.

The plant seeds undergo germination using the ragdoll method for the first to the third day, then transplanted in seedling trays with a medium cocopeat. On the seventh day after sowing (DAS), half the strength of nutrient solutions was given to the plant samples. Another important factor in the germination stage and the development of plants is sunlight, which provides energy for photosynthesis. According to Mattson (2018), poor-quality lettuce seedlings grown under insufficient light exhibit excessive stem length and poor leaf and shoot development.

E. Assessment of Lettuce Growth and Its Environment

The following statistical treatments were utilized in the gathered data of the study. Weighted average or mean was used to determine the mean growth performance of *L. sativa* from each treatment for plant height, root length, length and width of the biggest leaf, fresh and dry weight, and the number of leaves. One-Sample Kolmogorov-Smirnov Test was used to determine if the collected data was normal distribution for all parameters observed and measured except for leaf coloration.

Analysis of variance (ANOVA) was used to determine the significant differences between the growth performances of the *L. sativa* grown on the different solution treatments. The researchers used the SPSS statistical software program version 24 to process data. Post-Hoc Scheffe was used in the study for multiple comparisons of the growth of each *L. sativa* for plant growth parameters whenever there was a significant difference among the five treatments. This can be divided into subsections if several methods are described.

Results and Discussion

A. Physicochemical Characterization of Nutrient Solution and its Environment

Table 1 shows the pH level in different treatments where T1-SNAP solution, T2-FGAS, and T4-molasses follow the optimum value of the Department of Agriculture (2021), ranging from 5.5 to 6.0 pH level. The pH range of 5.5 to 6.0 in a hydroponic setup will ensure that the nutrients will be readily available to the plants for their uptake (Singh & Dunn, 2016). On the other hand, T3-double strength FGAS and T5-water did not meet the standard value for pH in hydroponics resulting in the plant exhibiting low growth parameters in the study.

Table 1. Physicochemical characteristics of the treatments

Treatments	Mean pH	Mean EC (mS/cm)	Mean Temperature (ºC)
T1-SNAP	5.8	1.25	27
T2-FGAS	5.8	1.31	26.83
T3-Double Strength FGAS	6.08	2.36	26.83
T4-Molasses	5.98	1.4	26.67
T5-Water	7.36	0.19	27
Standard limit	5.5 - 6.0[a]	1.0- 2.0[b]	18-27[a]

Legend. [a]based from Department of Agriculture, Ministry of Agriculture and Forests Royal Government of Bhutan of 2021
[b]based from Henry et al. (2018). Electronic Grower Resources Online Nutritional Monitoring 2018

The relative humidity inside the screenhouse ranges from 57.64% to 65.02%, while the temperature ranges from 29.38°C to 25.04°C, as seen in Table 2, both of which are in accordance with the standard limit of daily temperature in the polyethylene greenhouse ranging from 18°C to 30°C and relative humidity of 45% to 85% (Nurhidayati et al., 2019).

Table 2. Physicochemical characteristics of the screenhouse

	Mean Relative Humidity (%)		Mean Temperature (°C)	
	AM	PM	AM	PM
Screenhouse	57.64	65.02	29.38	25.04
Standard limit	45 – 85[a]		18 -30[a]	

Legend. [a]based from Nurhidayati et al. (2021) Agriculture and Agricultural Science Procedia

B. Nutrient Analysis of Fermented Golden Apple Snail

The fermented golden apple snail was analyzed using Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) by CRL Environmental Corporation. CRL Environmental Corporation is DENR recognized company 023/2021; DOH accredited 03-001-20-LW-2, and ISO/IEC 17025:2005 certified company. Based on the result of the CRL analysis, the developed nutrient solution contains high amounts of potassium, followed by nitrogen, magnesium, and phosphorus, with the least amount of iron, as seen in Table 3.

Table 3. Nutrient analysis of fermented golden apple snail

	Nutrient Analysis (ppm)				
	N	P	K	Mg	Fe
FGAS	1,830	315	9,470	1,290	162
Standard limit	156[a] -210[b]	31[a]	210[b] -234[a]	24-34[b]	2.5[b]

Legend. [a]based from Department of Agriculture, Ministry of Agriculture and Forests Royal Government of Bhutan of 2021
[b]based from Henry et al. (2018). Electronic Grower Resources Online Nutritional Monitoring 2018

Table 3 shows that the fermented golden apple snail of the study contains some of the required elements according to the standard nutrient solutions of the Department of Agriculture (2021) and Meselmani (2022). It shows that the developed nutrient solution from the fermented golden apple snail has N, P, K, Mg, and Fe higher than the standard limit required for good quality and lettuce yields (Table 3). The developed FGAS nutrient solution contains magnesium which is vital for plants' photosynthesis and root development, as well as micronutrients such as iron that improve chlorophyll synthesis and other metabolic processes of the plant life cycle (Department of Agriculture, 2021). Among the minerals N, P, and K are the enormous elements in plants that cannot substitute for the effect of other minerals. Based on the Department of Agriculture (2021) indicates that nitrogen is vital for vegetative growth and improves the quality of leafy vegetables. Phosphorus promotes growth and early root formation. Potassium is necessary for disease resistance, enhances crop quality, and regulates plant water transportation and minerals.

In addition, the study of Salas and Salas (2019) justifies that fermented golden apple snail also contains nutrients such as Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, and Sulfur that contribute to the greater leaf size, highest chlorophyll b, and horticultural characteristics which is similar to the analysis of the current study. In contrast with the results of the analysis, the fermented golden apple snail of this study contains a higher amount of nitrogen, potassium, and magnesium than the study by Salas and Salas (2019). In the other study, the iron and phosphorus of the fermented GAS of Uy et al. (2021) have a greater concentration than the fermented GAS of the study, yet the concentration is still in accordance with the standard nutrient solution for hydroponics.

However, due to financial limitations and COVID-19 restrictions, researchers were not able to test the total amount of five specific nutrients, Nitrogen, Phosphorus, Potassium, Magnesium, and Iron, that are present in the FGAS after harvesting the grown lettuce plants. Moreover, however, other macronutrients and micronutrients present in the developed FGAS nutrient solution for hydroponics were not analyzed. Hence, the study initially focused on observing the effects of the nutrient solution on the growth of lettuce in a Kratky hydroponic system with N, P, K, Mg, and Fe.

C. Measurement of Plant Height and Root Length

Lactuca sativa L. was evaluated in terms of plant height (mm) and root length (mm). Plant height was assessed weekly, while root length was determined upon the maturity and harvest of the crops (Figure 2).

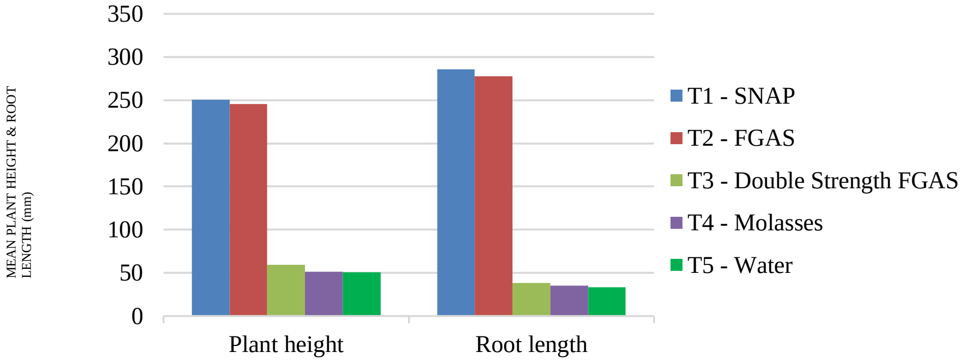

Figure 2. Mean plant height and root length of the Lactuca sativa L.

Figure 2 shows the comparative plant height of the *L. sativa* in their sixth week of plant cultivation as well as the root length. The Figure 2 and Analysis of Variance (ANOVA) showed a significant difference in the plant height of the five treatments used in the study as indicated by the significant value of 0.000, which is lower than the $\alpha = 0.05$.

Furthermore, the Post-Hoc Scheffe analysis showed that T1-SNAP and T2-FGAS are not significantly different, as shown in the significant value of 0.876, higher than the $\alpha = 0.05$ significance. In that case, the plant height of *L. sativa* in the SNAP solution is not different from that in the developed FGAS nutrient solution in T2. Furthermore, Post-Hoc analysis showed that T1-SNAP and T2- FGAS are both significantly different from T3-double strength FGAS, T4-molasses, and T5-water with significant values of 0.000 which are all lower than $\alpha = 0.05$. Moreover, the Post-Hoc analysis revealed that the plant height of the lettuce plants on the T3-double strength FGAS is not different from the lettuces in T4-molasses and T5-water. Hence, the plant height in T1-SNAP and T2-FGAS are comparable with each other since statistical analysis showed that there is no significant difference between the two.

This could be justified due to the high amounts of Nitrogen in the analysis of fermented gas compared to the standard limit in which, according to Ansari et al. (2020), high nitrogen application results in plants with marketable height. Furthermore, T3-double strength FGAS, T4-molasses, and T5-water may have stunted growth since the specific conductivity of the solution does not meet the standard EC for hydroponically grown lettuce.

On the other hand, the same results on ANOVA were seen on the mean root lengths of *L. sativa*; that is, there is a significant difference among the five treatments used in the study as indicated by the significant value of 0.000, which is lower than the $\alpha = 0.05$. Post-Hoc Scheffe analysis showed that the T1-SNAP solution and T2-FGAS are not significantly different, as shown by the significant value of 0.943, which is higher than $\alpha = 0.05$ of significance. Hence, the root length of *L. sativa* in SNAP solution is not different from the root length in the developed FGAS nutrient solution in T2 but is significantly different from T3-double strength FGAS, T4-molasses, and T5-water.

Hence, the root lengths of the lettuce plants in T1-SNAP and T2-FGAS are comparable since statistical analysis showed no significant difference between the two. Furthermore, as shown in the study of Neumann et al. (2014), Phosphorus, Nitrogen, and Iron have frequently stimulated the growth of the roots of plants. On the other hand, T3-double strength FGAS, T4-molasses, and T5-water experienced root rot and wilting due to a high concentration of T3-FGAS and lack of nutrients for T4-molasses and T5-water, which is similar to the study Meselmani (2022), which stated that inadequate or excessive concentration of nutrients nor ionic imbalanced in nutrient solution may inhibit plant development and causes plant deficiencies such as retarded root growth.

D. Measurement of Width and Length of the Biggest Leaf

Lactuca sativa L. were measured by length and width of the biggest leaf using a ruler in millimeters and were measured on their 6th week (Figure 3).

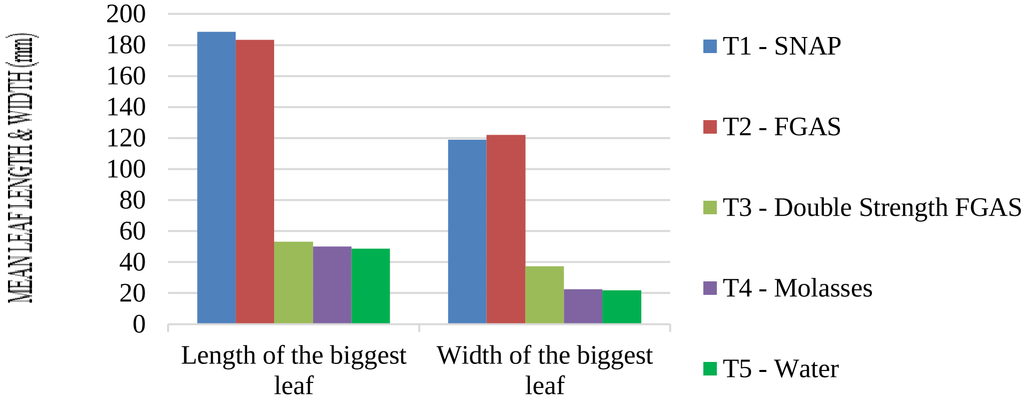

Figure 3. The mean length and width of the biggest leaves

Based on Figure 3 and ANOVA, results showed a significant difference in the mean length of the biggest leaf harvested from the five treatments used in the study, as indicated by the significant value of 0.000, which is lower than the α = 0.05. Hence, the researchers further analyzed the result of the ANOVA using Post-hoc Scheffe analysis and showed that T1-SNAP and T2-FGAS are not significantly different, as shown with the significant value of 0.174 higher than the α = 0.05 of significance. That is, the length of the biggest leaf of *L. sativa* in the SNAP solution is not different from the length of the biggest leaf in the developed FGAS nutrient solution in T2-FGAS. Furthermore, the analysis showed that T1-SNAP and T2-FGAS significantly differ from double strength T3-double strength FGAS, T4-molasses, and T5-water with significant values of 0.000 which are all lower than α = 0.05.

Furthermore, ANOVA with Post-hoc Scheffe analysis showed that there is a significant difference in the mean width of the biggest leaf harvested from the five treatments used in the study and further showed that T1-SNAP solution and T2-FGAS are not significantly different from each other as shown with the significant value of 0.534 for Scheffe but are significantly different from those in T3-double strength FGAS, T4-molasses and T5-water.

The good growth of plants on T1-SNAP solution and T2-FGAS, as observed on the length of the lettuce leaves, may be attributed to the minerals needed by plants. Furthermore, the leaves in T3-double strength FGAS, T4-molasses, and T5-water did not grow enough due to excessive amount of nutrients for double strength of FGAS and lack of nutrients in molasses and water.

Similar to the study by Salas and Salas (2019), the lettuce grown on fermented golden apple snails had a noticeably bigger leaf size and produced more yield. In addition, there is a significant difference between positive control and FGAS solution. Meanwhile, nutrient analysis of fermented golden apple snails comprises a great amount of Nitrogen which contributes to the leaf area of the lettuce. Hence, as observed on T4-molasses and T5-water, which have the smallest leaf length, may be due to the lack of nutrients which was justified in the study of Hossain and Ryu (2018), where Nitrogen's insufficient dynamics are directly related to the reduced leaf area of the lettuce.

E. Measurement of Fresh and Dry weight

The fresh weight of the vegetable crops Batavia lettuce (*Lactuca sativa* L.) was measured and evaluated after being harvested (Figure 4). In contrast, the dry weight was air-dried and measured in milligrams (mg) with OHAUS® top-loading balance.

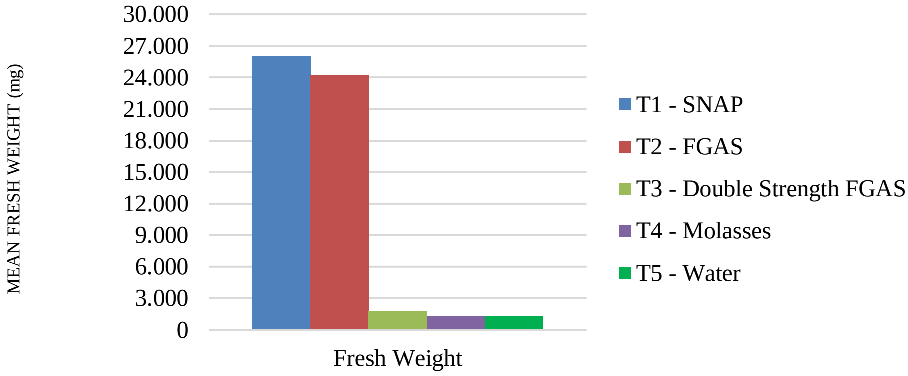

Figure 4. Mean fresh weight of the L. sativa

Analysis of Variance showed that there is a significant difference in the fresh weight of the *L. sativa* of the five treatments used in the study. Furthermore, Post-Hoc Scheffe analysis revealed that T1-SNAP and T2-FGAS are not significantly different (Sig. value = 0.108 < α = 0.05), indicating that the fresh weight of *L. sativa* grown in the developed T2-FGAS nutrient solution is comparable with the positive control T1-SNAP. Furthermore, the analysis showed that T1-SNAP and T2-FGAS solutions are both significantly different from T3-double strength FGAS solution, T4-molasses, and T5-water (Sig. values = 0.000 < α = 0.05).

The data further showed that the T1-SNAP solution showed the heaviest fresh weight among the five treatments; the same result was observed in the study of Santiago (2019), wherein the plants cultivated SNAP solution consistently grew the tallest, most leaves, longest roots, and had the greater fresh weight per plant. It was also revealed in the study of Uy et al. (2021) that plants grown in SNAP solution consistently increased their fresh weight per lettuce plant.

However, the FGAS weighed more than the other treatments, T1-SNAP, T3-double strength FGAS, T4-molasses, and T5-water in terms of *L. sativa* dry weight, as seen in Figure 5.

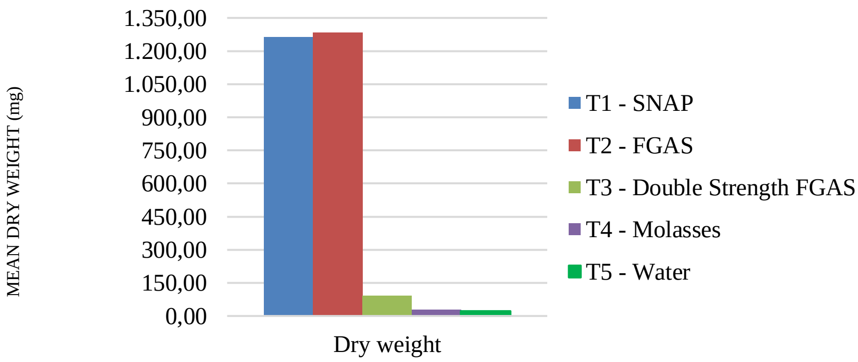

Figure 5. Mean dry weight of the Lactuca sativa

Significant differences in the dry weight of the plant of the five treatments used in the study were observed from ANOVA (Sig. value of 0.000 < α = 0.05), which is further revealed in the Post-Hoc Scheffe analysis that T1-SNAP and T2-FGAS solutions are not significantly different (Sig. value = 0.293 > α = 0.05 of significance). Furthermore, the analysis showed that T1-SNAP and T2-FGAS significantly differ from T3-double strength FGAS, T4-molasses, and T5-water in terms of dry weight. Hence, the dry weight of the plant in T1-SNAP and T2-FGAS are comparable since statistical analysis showed no significant difference between the two. However, the dry weight of the *L. sativa* in T1-SNAP and T2-FGAS differs from the plant's dry weight in T3-double strength FGAS, T4-molasses, and T5-water.

The study results align with the study of Posalak and Junkasiraporn (2017), where treating golden apple snail bio-extract with the ratio of 1:100 produced a higher total dry weight of the Chinese cabbage.

F. Assessment of the Number of Leaves and Leaf Coloration

Based on Table 4, *L. sativa* grown in T2-FGAS has dark green leaves, which was comparatively different from those lettuces grown using T1-SNAP solution, T3-double strength FGAS, T4-molasses, and T5-water, which acquires light to pale green, indicating general chlorosis (Figure 6). It was shown that the lettuce grown in T2-FGAS is better than the lettuce grown in the T1-SNAP solution, which is the control.

Table 4. Leaf coloration and mean number of leaves of L. sativa.

Treatments	Leaf color	Mean number of leaves
T1-SNAP	Green	8.3
T2-FGAS	Dark Green	8.3
T3-Double strength FGAS	Light Green	5.02
T4-Molasses	Pale Green	5.22
T5-Water	Pale Green	4.61

The result is shown in Table 4 that the T1-SNAP solution and T2-FGAS have an equal number of leaves and gained comparatively different among T3-double strength FGAS, T4-molasses, and T5-water. The result of the study is similar to the study of Borres et al. (2022), where applying SNAP solution to lettuce leaves had no significant influence on the length and width of lettuce leaves but rather had major effects on the height, the number of leaves, and yield (Borres et al., 2022).

Meanwhile, the study by Alexopoulos et al. (2021) showed that having a 5.5 level of pH of commercial nutrient solution in indoor hydroponics performed better than the too-acidic and basic solution on the growth of *Taraxacum officinale* and *Reichardia picroides*. Thus, it justifies the present study where double strength T3-double strength FGAS and T5-water have the least number of leaves because they exceeded the optimum pH level of 5.5-6.0 (Department of Agriculture, 2021). On the other hand, T3-double strength FGAS, T4-molasses, and T5-water also acquire the least number of leaves because of too high and low concentrations of the nutrient solution, respectively.

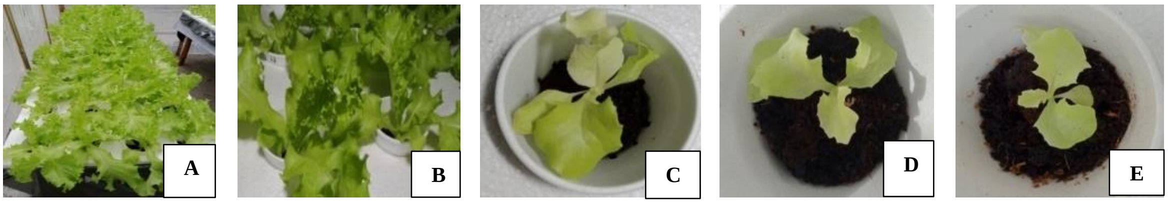

Figure 6. Leaf coloration of Batavia lettuce

(A*) L. sativa* in SNAP Solution. (B*) L. sativa* in FGAS. (C) *L. sativa* in double strength FGAS (D). *L. sativa* in Molasses. (E) *L. sativa* in water.

Furthermore, ANOVA showed a significant difference regarding the mean leaf number of *L. sativa* planted on the five treatments used in the study. Based on the Post-Hoc analysis Scheffe, it showed that T1-SNAP and T2-FGAS solutions are not significantly different from each other (Sig. value = 1.000 > α = 0.05 of significance), indicating that the number of leaves of *L. sativa* grown in the developed T2-FGAS nutrient solution is comparable with the positive control T1-SNAP. Furthermore, the analysis showed that T1-SNAP and T2-FGAS solution are both significantly different from T3-double strength FGAS solution, T4-molasses, and T5-water with significant values of 0.000 which are all lower than α = 0.05. The Results and Discussion may be combined into a single section or presented separately. They may also be broken into subsections with short, informative headings.

Conclusion and Recommendations

Determining the effectiveness of formulated fermented golden apple snails as a nutrient solution to the growth of *Lactuca sativa* is another way of mitigating the invasiveness of golden apple snails and helping reduce agricultural problems and manage food security. The results of the study reflect that the fermented golden apple snail can be used as a potential nutrient solution for hydroponically grown lettuce, for it exhibited comparable and no significant difference in the results when it comes to the growth performance of the *L. sativa* in a Kratky hydroponics system when compared to the commercially known SNAP solution given an optimum physicochemical characteristic in terms of pH (5.0-6.0), electrical conductivity (1.0 -2.0mS/cm), and temperature (18ºC-27ºC) and a significant difference to the double strength fermented golden apple snail solution, food-grade molasses, and water.

Furthermore, regulation of nutrient solution and nutrient analysis may be beneficial to the quality and yield of plants, as it contains the required elements of Nitrogen, Phosphorus, Potassium, Magnesium, and Iron, all according to the standard nutrient solutions in Kratky hydroponic system.

The researchers further recommend conducting microbial load analysis, plant tissue analysis, and future studies on the sensory organoleptic test for palatability and feedback on *L. sativa*.

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