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FORMULATION OF ORGANIC HIGHLIGHTER PEN INK USING BLUE TERNATE *(Clitoria ternatea)* FLOWER EXTRACTS

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ABSTRACT
This study formulated an organic highlighter pen ink using Blue Ternate (*Clitoria ternatea*) through a quantitative method, particularly true experimental design. This was done by adopting but modifying protocol from Zaidan (2017) and Zoe (2020). The procedures of product formulation were done at the Chemistry Laboratory of Colon National High School and the Nutraceutical Laboratory of Mindanao State University of General Santos City in the academic year *2022-2023*. Further, the researchers subjected the formulated organic highlighter pen ink and the commercial highlighter pen as the control of this study to an evaluation test to determine its quality. The results showed that when applied to bond paper, cream paper, and index paper, neither the treatment nor the control exhibited smudging. Contrary to bond paper, which bled when the treatment was applied, the treatment did not bleed or show through on the reverse side of the cream and index paper. In contrast, the control exhibited bleeding/show-through on all three *(3)* distinct types of paper used for testing. In terms of font color fading, the control did not transition through the three font colors utilized, whereas the treatment did. Additionally, the results indicated by the p-value of *0.07*, suggest there is no significant difference between the treatment and control groups in the smearing test. Concerning bleeding/show-through and font color fading, however, both the treatment and control groups demonstrated a significant difference, as supported by a p-value of *0.00*. Hence, it is recommended that verification of the ink's durability and archival qualities, the environmental effects, and other uses of Blue Ternate be done and explored.

Keywords: *Product Development, Organic Highlighter Pen, Blue Ternate, Smearing, Bleeding/Show-Through, Font Color Fading*

INTRODUCTION

Highlighters are water-based inks composed of fluorescein and polyethylene or polyester beads. They are constructed to ensure that the ink is thick and wet. Text-highlighting highlighters are a type of felt-tip pen with water-based ink that highlights words without concealing them. They are used by students to highlight essential sections of text for enhanced comprehension. Further, the ink used in highlighters consists of a number of compounds, including glycol solvent and water. The majority of the mixture consists of these two components, with a minor amount of the dye and fluorescent pigment. These solvents are extremely hazardous to both the health of their users and the environment. Moreover, the vast majority of products are distributed commercially today, and their production can be detrimental to the natural environment. Hence, this research aimed to develop more natural, safe, simple, and affordable products.

Blue Ternate (*Clitoria ternatea*) belongs to the family Fabaceae and is also known as Bluebell Vine, Butterfly Pea, Cordofan Pea, Darwin Pea, and Asian Pigeon Wings. Blue ternate (*Clitoria ternatea*) is a perennial leguminous herb that is used in agriculture and medicine. It is rich in antioxidants and protects against free radicals. Flowers are blue due to the presence of anthocyanin, which is a common source of natural food coloring. It can be used in agriculture, medicine, traditional medicine, and as an environmentally friendly insecticide source. Also, using this plant makes it possible to smear highlighted ink with any ink-based highlighter, but less likely with an alcohol-based liquid ink.

Thus, the present researchers expressed their interest to develop a highlighter pen using organic plants from Blue Ternate (*Clitoria ternatea*) as an alternative. Part of this study's objectives is also to demonstrate the great potential of the plant as an alternative highlighter pen considering the fact there have numerous health dangers and economic issues resulting from the use of commercial highlighter ink. To ensure its effectiveness as an alternative highlighter, the developed products were subjected to evaluation through testing such as smearing, bleeding or show-through, and font color testing.

In sum, the output of this study may provide the students and teachers with new and alternative choices to utilize organic highlighter pens whenever they highlight important words or texts during their reading to improve their comprehension and study habits techniques.

Objectives of the Study

To attain the main objective of formulating an organic highlighter pen ink, the following objectives were accomplished.

1.) Adopted but modified the protocol from Zaidan (2017) and Zoe (2020) in formulating an organic highlighter pen ink using the Blue Ternate (Clitoria ternatea) flower extracts.
2.) Evaluated the quality of the formulated organic highlighter pen ink using Blue Ternate (Clitoria ternatea) flower extracts and the commercial highlighter pen through these tests:
   2.1 Smearing;
   2.2 Bleeding/Show-through; and
   2.3 Font Color Fading.
3.) Compared the results of the evaluation tests between the formulated organic highlighter pen ink using Blue Ternate (Clitoria ternatea) flower extracts and the commercial highlighter pen.

Research Questions

Guided by the objectives of the study, the researchers sought answers to these subsequent scientific questions.

1.) How was an organic highlighter pen ink using Blue Ternate (*Clitoria ternatea*) flower extracts formulated using the adopted but modified protocol?
2.) What are the evaluation results on the quality of the formulated organic highlighter pen ink using Blue Ternate (*Clitoria ternatea*) flower extracts and the commercial highlighter pen through these tests:
   2.1 Smearing;
   2.2 Bleeding/Show-through; and
   2.3 Font Color Fading?
3.) Is there a significant difference in the evaluation tests between the formulated an organic highlighter pen ink using Blue Ternate (*Clitoria ternatea*) flower extracts and the commercial highlighter pen in terms of smearing, bleeding/show-through, and font color fading?

Hypothesis of the Study

Ho[1] There is no significant difference in the evaluation tests between the formulated organic highlighter pen ink using Blue Ternate *(Clitoria ternatea)* flower extracts and the commercial highlighter pen in terms of smearing, bleeding/show-though, and font color fading.

Scope and Delimitation of the Study

This study mainly focused on formulating an organic highlighter pen ink using Blue Ternate (*Clitoria ternatea*) flower extracts. This was effectively accomplished by adopting but modifying the protocol from Zaidan (2017) and Zoe (2020). First, the researchers gathered these materials, i.e., Blue Ternate *(18 ml)*, Vegetable Glycerine *(1 ml)*, Denatured Alcohol *(3 ml)*, and Cetyl Alcohol *(3 pcs.)*. Second, they heated the Cetyl Alcohol to *50* degrees Celsius on a hot plate while maintaining its temperature. Third, after heating the Cetyl Alcohol, the Denatured Alcohol and Vegetable Glycerine were added, followed by the Blue Ternate flower extracts. Fourth, the mixture was then removed from the hot plate after continuously stirring for a while. Fifth, the liquid was then transferred to a highlighter container once it cooled down.

After the product formulation, the researchers subjected it to evaluation tests such as smearing, bleeding/show-through, and font color fading to determine its quality along with the commercial highlighter pen used for comparative analysis. Thereafter, the results were interpreted using the One-way Analysis of Variance (ANOVA). This study was completed in the academic year *2022-2023* at the Nutraceutical Laboratory of Mindanao State University, General Santos City, and at the Chemistry Laboratory of Colon National High School, Brgy. Colon, Maasim, Sarangani Province.

Limitation of the Study

In the context of this academic research, one factor or constraint that has affected the interpretation, generalizability, or validity of the research findings that was beyond the researchers' control was the color fading of the formulated organic highlighter pen using Blue Ternate (Clitoria ternatea) flower extracts. Hence, the researchers believe that systematic studies may be conducted to understand the underlying mechanisms and identify strategies for improving color stability. This may involve optimizing formulation parameters, implementing protective measures to minimize light exposure, and exploring techniques to enhance pigment stability through encapsulation or chemical modification. Additionally, proper packaging and storage conditions may help mitigate color fading by protecting the highlighter pens from environmental factors that contribute to pigment degradation.

Significance of the Study

To Environmental Science, developing an organic highlighter using Blue ternate (*Clitoria ternatea*) flower extracts as an alternative reduces harm to the users and the environment since detrimental substances are carefully excluded from the formulation and production.

To Policy Implementation, this research supports the Green Policy which emphasizes the commitment to sustainability and environmental management through practicing environmental-friendly actions. Using organic materials like Blue Ternate (*Clitoria ternatea*) helps reduce the risks of using highlighters with chemicals that may be dangerous when the ink is ingested by a user.

To the Community, an organic highlighter made from Blue Ternate (*Clitoria ternatea*) poses an avenue of opportunities for the community to explore other potentials of this plant apart from being capable of being used as an organic highlighter pen. Also, this study means an innovation of product development from detrimental products to organic products.

To Teachers, who are among the most frequent highlighter users, will benefit greatly from this study. Teachers typically use highlighters to highlight key lessons. Additionally, alternative ink appears to have a significant impact on educators, as it provides them with low-cost, all-natural ink options.

To the STEM Students, this research will benefit and hones STEM students since it provides them the opportunity to apply their theories learned from research class in the actual setting of doing laboratory experiments. Their inventive and problem-solving skills are greatly enhanced in accomplishing this academic endeavor. Also, developing an organic highlighter pen posits successful research output and project helpful to the community.

To Future Researchers, the study will be helpful to them because it relates to assisting them in experimenting in the same field.

Reserch Gap

A research gap is, simply, a topic or area for which missing or insufficient information limits the ability to conclude a question. Identifying research gaps is an essential step in conducting research, as it helps researchers refine their research questions and focus their research efforts on areas where there is a need for more knowledge or understanding (Enago Academy, 2023). In this present study, the researchers found in the literature and studies that there may be a lack of comprehensive studies optimizing the formulation parameters of highlighter pens containing Blue Ternate flower extracts. Research could focus on determining the ideal concentration of Blue Ternate flower extracts, the compatibility of different ink components with the extract, and the influence of formulation variables on ink properties such as smearing, bleeding/show-through, and font color fading.

Thus, the present researchers conducted a study by formulating an organic highlighter pen ink using Blue Ternate flower extracts. By doing this study addresses the research gaps that provide valuable insights into the formulation, performance, safety, and environmental impact of highlighter pens incorporating Blue Ternate flower extracts, ultimately contributing to the development of innovative and sustainable writing instruments.

Conceptual Framework of the Study

In the context of formulating an organic highlighter pen ink using Blue Ternate *(Clitoria ternatea)* flower extracts, the conceptual framework is explained using the input, process, and output methods. The input stage involves gathering the necessary resources and information to initiate the formulation process. In this case, the inputs include the adoption and modification of the protocol from Zaidan (2017) and Zoe (2020) for developing an organic highlighter pen ink using Blue Ternate *(Clitoria ternatea)* flower extracts. Blue Ternate *(Clitoria ternatea)* flower extracts serve as the primary organic ingredient for the highlighter pen.

The process stage outlines the steps taken to transform the inputs into the desired outputs. This includes the adoption and modification of the protocol from previous studies to suit the specific requirements of formulating an organic highlighter pen ink using Blue Ternate flower extracts. This involved experimenting with different formulations, concentrations, and manufacturing techniques. Evaluation of the quality of the formulated organic highlighter pen ink and comparison with a commercial highlighter pen through various testing methods, including the Smearing test: Assessing the resistance of the highlighter ink to smudging when applied on paper, Bleeding/Show-through test: Examining whether the ink penetrates through the paper or causes bleed-through to the other side, and the Font Color Fading test: Evaluating the vibrancy and consistency of the color produced by the highlighter pen.

Finally, the output stage represents the final product or outcome of the process. In this case, the output is formulated organic highlighter pen ink using Blue Ternate *(Clitoria ternatea)* flower extracts: The culmination of the formulation process, resulting in a functional organic highlighter pen ink made with Blue Ternate flower extracts. This output should meet certain quality standards based on the evaluation tests conducted during the process.

In summary, the conceptual framework for formulating an organic highlighter pen ink using Blue Ternate flower extracts involves gathering inputs, following a defined process of adoption, modification, and evaluation, and ultimately producing the desired output of a formulated organic highlighter pen. Figure *1* below shows the conceptual framework of the study.

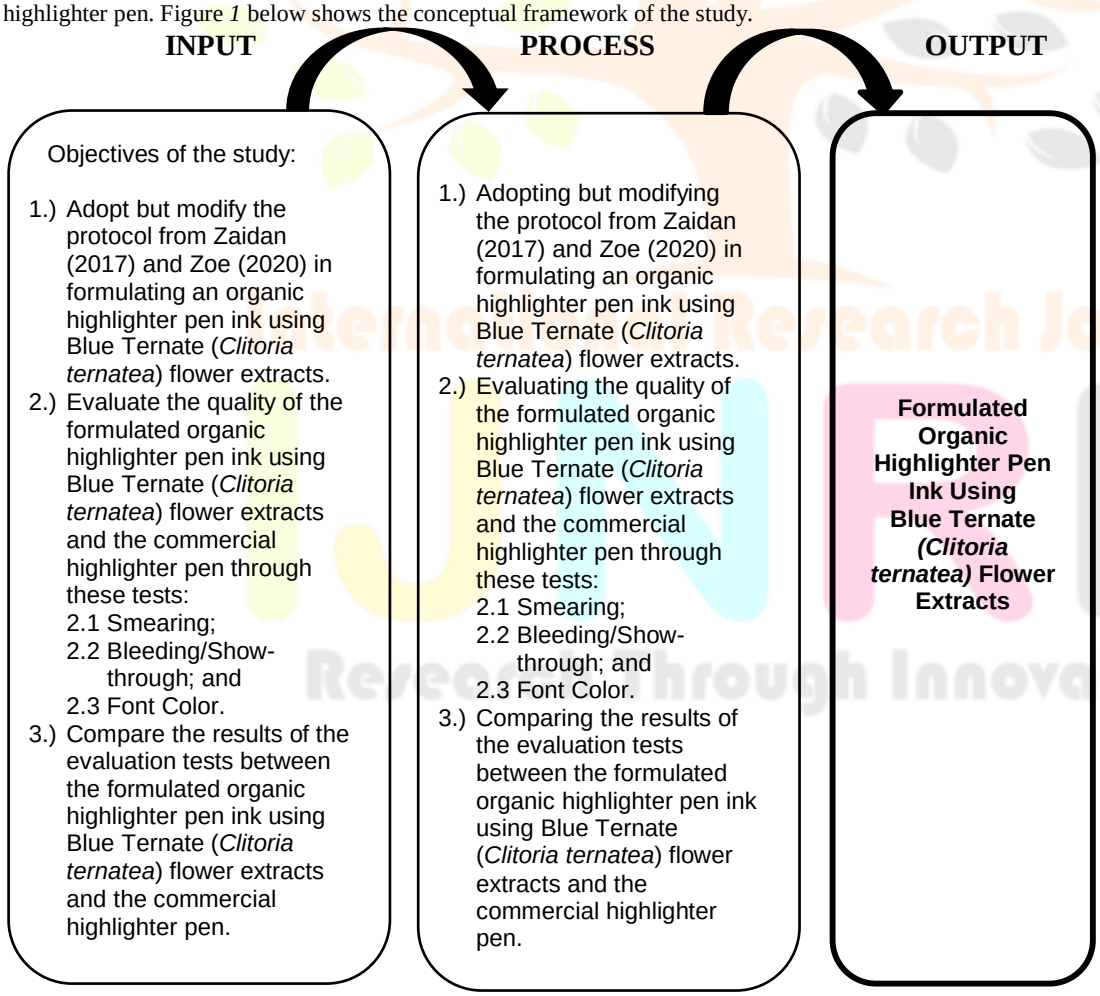

Figure 1. The Conceptual Framework of the Study

METHODOLOGY

The researchers' study used the quantitative method, specifically a true experimental design. The study focused on scientific experimentation and employed statistical analysis in its execution (Pubrica-Academy, 2020).

Procedures

A. Preparations of the Materials

The researchers collected their main materials from different locations in Maasim, and Kiamba, Sarangani Province. Along with the main materials, they also purchased other ingredients needed during the formulation of the organic highlighter pen ink such as Vegetable Glycerine, Acetone, Ethyl Alcohol, Cetyl Alcohol, and Distilled Water. Moreover, the main materials were collected at dawn to maintain their freshness, carefully washed with distilled water, and sealed in a ziplock. When these steps were done, the materials were transported to the Nutraceutical Laboratory of Mindanao State University for the commencement of the formulation.

B. Formulation of Organic Highlighter Pen Ink

The organic Blue Ternate highlighter pen ink was formulated by following the specified procedure. Beginning with the measuring of each material, i.e., Blue ternate (*18*mL), Vegetable Glycerine (*1*mL), Denatured Alcohol (*3*mL), and Cetyl Alcohol (*3* pcs.). After heating the Cetyl Alcohol to *50* degrees Celsius on a hot plate while maintaining its temperature, the denatured alcohol and vegetable glycerine were added, followed by the Blue Ternate flower extracts. The mixture was then removed from the hot plate after continuously stirring for a while. The liquid was then transferred to a highlighter container once it had cooled down.

C. Testing the Smearing of the Formulated Organic Highlighter Pen Ink

In this study, smearing testing was performed with different colors of pens: black, blue, and red. The researchers wrote on the paper using black, blue, and red pens, then highlighted it using the formulated highlighter pen, and commercial highlighter pen, and then they compared the formulated highlighter pen and commercial highlighter pen.

D. Testing the Bleeding/Show-through of the Formulated Organic Highlighter Pen ink

In testing the bleeding/show-through of the formulated highlighter pen ink, the researchers used different kinds of paper: bond paper, cream paper, and index paper. The researchers compared the formulated highlighter pen and commercial highlighter pen then researchers checked at the back of the paper if there was bleeding/showing through.

E. Testing the Font Color Fading of the Formulated Organic Highlighter Pen Ink

In testing the font color fading of the formulated organic highlighter pen, the researchers compared the color fading ability between the formulated organic highlighter pen ink and the commercial highlighter pen for five days of observation. After the duration, the researchers recorded which between the ink did not fade.

Variables of the Study

The independent variable of the study was the formulated organic highlighter pen ink using the Blue ternate *(Clitoria ternatea)* flower extracts, while the dependent variables of the study were the smearing, bleeding/show-through, and font color fading tests. On the other hand, the control variable of the study was the commercial highlighter pen *(Purple Stabilo Boss)*.

Data Gathering Techniques

To determine if there was smearing, bleeding/show-through, and font color fading manifested by the formulated organic highlighter pen using the Blue Ternate flower extracts, the researchers employed the *1-0* indicators, where *1* signifies YES, meaning there was an evident manifestation of the test while *0* indicates NO evident manifestation.

Statistical Analysis

To determine the significant difference in the evaluation tests between the formulated organic highlighter pen using Blue Ternate *(Clitoria ternatea)* flower extracts and the commercial highlighter pen in terms of smearing, bleeding/show-though, and font color fading testing, Analysis of Variance (ANOVA) -Two Factors with Replication was used.

RESULTS AND DISCUSSIONS

Formulation of Organic Highlighter Pen Ink

As the pivotal objective of this study was to formulate an organic highlighter pen ink using Blue Ternate (*Clitoria ternatea*), the researchers adopted but modified the protocol from Zaidan (2017) and Zoe (2020). First, the researchers gathered these materials, i.e., Blue Ternate flower extracts (18ml), Vegetable Glycerine (1ml), Denatured Alcohol (3ml), and Cetyl Alcohol (3 pcs.). Second, they heated the Cetyl Alcohol to 50 degrees Celsius on a hot plate while maintaining its temperature. Third, after heating the Cetyl Alcohol, the Denatured Alcohol and Vegetable Glycerine were added, followed by the Blue Ternate flower extracts. Fourth, the mixture was then removed from the hot plate after continuously stirring for a while. Fifth, the liquid was then transferred to a highlighter container once it cooled down.

Evaluation Testing

To test the quality of the developed organic highlighter pen using Blue Ternate (*Clitoria ternatea*) and the commercial highlighter pen as the control of this study, the researchers subjected the two samples of highlighters to smearing, bleeding/show-through, and font color fading test using three *(3)* different font colors, i.e., black, blue and red. Also, different types of paper such as bond paper, cream paper, and index paper were used in this testing. Table *1* shows the comparative results

Table 1. Evaluation Testing of Smearing, Bleeding/Show-Through, and Font Color Fading

TYPE OF PAPER USED	TESTING					
	Developed Organic Highlighter Using Blue Ternate (*Clitoria ternatea*) (Treatment)			Commercial Highlighter Using Purple Stabilo Boss (Control)		
	Smearing	Bleeding/ Show-Through	Font Color Fading	Smearing	Bleeding/ Show-Through	Font Color Fading
Bond Paper	0	1	1	0	1	0
Cream Paper	0	0	1	0	1	0
Index Paper	0	0	1	0	1	0

Legend: (0) means NO while (1) YES

It could be construed from the data on the table that in the smearing test, both the treatment (developed organic highlighter using Blue Ternate (*Clitoria ternatea*)) and the control (commercial highlighter, i.e., purple Stabilo Boss) did not smear when applied to bond paper, cream paper, and index paper. Moreover, with respect to bleeding/show-through testing, the treatment bled only when applied to bond paper, but showed no bleeding/show-through when used in both cream and index papers. On the other hand, the control demonstrated a bleeding/show-through ability, meaning it smudged and showed through the back of the papers used, i.e., bond paper, cream paper, and index paper. Furthermore, in terms of font color fading, after five *(5)* days of observation, when the treatment was applied to three *(3)* different font colors, i.e., black, blue, and red, it faded throughout the testing unlike the control when it was applied to the font colors, it did not fade.

In sum, with respect to smearing, both the treatment and control showed the same result of being unable to smear when applied to bond paper, cream paper, and index paper. Whereas, in terms of bleeding/show-through, it was remarkably noticeable that the treatment did not bleed or show through the back of the cream paper and index paper, opposite to bond paper since it bled when the treatment was applied. Conversely, in all three *(3)* different types of paper used in testing, the control exhibited bleeding/show-through. Lastly, with respect to font color fading, the control did not fade through the three *(3)* font colors used while the treatment did.

Highlighters and markers that are adjustable and simple to use and do not bleed or smear are the best options because they are adaptable and easy to use (Lexie, 2023). Color utilizes both its symbolic and cognitive properties to assist learning, memory, and concept recognition (Myers, 2014). Also, highlighters tend to bleed or smear depending on paper quality, usage, and ink type (Cosby, 2023). Color also influences how we see and interpret information. It can boost your memory for both words and images (Myers, 2014).

Significant Difference in the Evaluation Tests

This study determined the significant difference in the evaluation tests between the developed organic highlighter pen using Blue Ternate (*Clitoria ternatea*) and the commercial highlighter pen using purple Stabilo Boss in terms of smearing, bleeding/show-though, and font color testing. Using the Analysis of Variance (ANOVA) -Two Factors with Replication, Table *2* shows the results yielded.

Table 2. Significant Difference in the Evaluation Tests

TYPE OF PAPER USED IN TESTING	TESTING								
	Smearing			Bleeding/Show-through			Font Color Fading		
	P-value	F-crit	Interpre-tation	P-value	F-crit	Interpre-tation	P-value	F-crit	Interpre-tation
Bond Paper	0.07	3.55	There is no significant difference.	0.00	3.55	There is a significant difference.	0.00	3.55	There is a significant difference.
Cream Paper	0.07	3.55		0.00	3.55		0.00	3.55	
Index Paper	0.07	3.55		0.00	3.55		0.00	3.55	

The table shows that with respect to the smearing test, both the treatment (developed organic highlighter using Blue Ternate (*Clitoria ternatea*)) and the control (commercial highlighter, i.e., purple Stabilo Boss) showed no significant difference as evidenced by the p-value of *0.07* which is higher/greater than alpha=*0.05*; thus, the researchers failed to reject the null hypothesis. Therefore, there is enough evidence to say that there is no significant difference in the smearing test results between the treatment and the control. On the other hand, with respect to bleeding/show-through and font color fading, both the treatment and control demonstrated a significant difference as supported by the p-value of *0.00* which is lesser than alpha=*0.05*; thus, the researchers rejected the null hypothesis. Therefore, there is enough evidence to say that there is a significant difference in the bleeding/show-through and font color fading test results between the treatment and the control.

Summary of Findings

As the pivotal objective of this study was to formulate an organic highlighter pen ink using Blue Ternate *(Clitoria ternatea)*, the researchers adopted but modified the protocol from Zaidan (2017) and Zoe (2020). First, the researchers gathered these materials, i.e., Blue Ternate flower extracts (*18*ml), Vegetable Glycerine (*1*ml), Denatured Alcohol (*3*ml), and Cetyl Alcohol (*3* pcs.). Second, they heated the Cetyl Alcohol to *50* degrees Celsius on a hot plate while maintaining its temperature. Third, after heating the Cetyl Alcohol, the Denatured Alcohol and Vegetable Glycerine were added,

followed by the Blue Ternate flower extracts. Fourth, the mixture was then removed from the hot plate after continuously stirring for a while. Fifth, the liquid was then transferred to a highlighter container once it cooled down.

After the organic highlighter was developed, the researchers subjected the developed organic highlighter pen using Blue Ternate (*Clitoria ternatea*) and the commercial highlighter pen as the control of this study to evaluation test to determine its quality. The two samples of highlighters were subjected to smearing, bleeding/show-through, and font color fading tests using three *(3)* different font colors, i.e., black, blue, and red. Also, different types of paper such as bond paper, cream paper, and index paper were used in this testing. The results showed that when applied to bond paper, cream paper, and index paper, neither the treatment nor the control exhibited smudging. Contrary to bond paper, which bled when the treatment was applied, the treatment did not bleed or show through on the reverse side of the cream and index paper. In contrast, the control exhibited bleeding/show-through on all three *(3)* distinct types of paper used for testing. In terms of font color fading, the control did not transition through the three font colors utilized, whereas the treatment did.

Furthermore, regarding the significant difference between both treatment and control in terms of evaluation tests, i.e., smearing, bleeding/show-through, and font color fading, the results showed that in the smearing test, neither the treatment (organic highlighter containing Blue Ternate *(Clitoria ternatea)*) nor the control (commercial highlighter, i.e., purple Stabilo Boss) demonstrated a significant difference, as indicated by the p-value of *0.07*, which is greater than alpha=*0.05*; thus, the researchers did not reject the null hypothesis. Therefore, there is sufficient evidence to conclude that there is no significant difference between the treatment and control groups in the smearing test results. Regarding bleeding/show-through and font color fading, however, both the treatment and control groups demonstrated a significant difference, as supported by a p-value of *0.00* which is less than alpha=*0.05*; thus, the researchers rejected the null hypothesis. There is sufficient evidence to conclude that there is a significant difference between the treatment and the control in the bleeding/show-through and font color fading test results.

Conclusions

Based on the findings of the study, it is concluded that the development of organic highlighter using Blue Ternate (*Clitoria ternatea*) was done by adopting but modifying protocol from Zaidan (2017) and Zoe (2020). After the organic highlighter was developed, the researchers subjected the developed organic highlighter pen using Blue Ternate (*Clitoria ternatea*) and the commercial highlighter pen as the control of this study to evaluation test to determine its quality. The results showed that when applied to bond paper, cream paper, and index paper, neither the treatment nor the control exhibited smudging. Contrary to bond paper, which bled when the treatment was applied, the treatment did not bleed or show through on the reverse side of the cream and index paper. In contrast, the control exhibited bleeding/show-through on all three *(3)* distinct types of paper used for testing. In terms of font color fading, the control did not transition through the three font colors utilized, whereas the treatment did.

Furthermore, regarding the significant difference between both treatment and control in terms of evaluation tests, i.e., smearing, bleeding/show-through, and font color fading, the results showed that there is no significant difference between the treatment and control groups in the smearing test results, while there is a significant difference between the treatment and the control in the bleeding/show-through and font color fading test results.

Recommendations

In view of the summary of findings and conclusions, the researchers recommend the following:

1. Future researchers may verify the ink's durability and archival qualities.
2. The environmental effects of using it as the ink may be taken as one aspect to further investigate the present study.
3. Future researchers may dwell on studies relative to other uses of Blue Ternate apart from making it an organic highlighter.

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