



(RESEARCH ARTICLE)



Viability of organic sources as a sustainable highlighter pen ink

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Abstract

Highlighter pens have been essential tools for students, instructors, and office employees for many years. They are used to emphasize specific information in written texts, making it easier to recognize, remember, and retrieve later. This study proposed the use of organic sources to create solvent-based highlighter pen ink. Specifically, it aimed to determine the viability of using organic sources such as Annatto seeds and blue butterfly pea as sustainable highlighter pen ink and to assess if there was a significant difference between the physical properties of commercial and organic highlighters. An experimental research design was applied, wherein the researchers produced two concentrations of ink and observed which concentration was suitable as highlighter pen ink. The study involved forty (40) students from the College of Education at Laguna University who tested the organic highlighters in one day and answered a validated questionnaire. The results revealed that Annatto seed highlighter pen ink exhibited a more intense color, while blue butterfly pea highlighter pen ink had a mild odor. As a result, respondents strongly agreed on the physical properties of the two organic sources as highlighter pen ink. However, both organic sources resulted in show-through, meaning that the ink could be seen through to the other side, usually due to thin paper or bold ink. Additionally, the study showed that both Annatto seed and blue butterfly pea highlighters were acceptable. However, Annatto seed highlighter was preferred due to its better ink qualities. The research also indicated that there was no significant difference between the physical properties of commercial and organic highlighters, suggesting that highlighter pens made from organic sources can be used as sustainable alternatives. The researchers encouraged further investigation into the advantages of using natural inks derived from organic sources in ecologically friendly and sustainable production methods. This study opens possibilities for utilizing organic materials as alternatives to traditional highlighter pen inks, contributing to environmentally conscious practices in the stationery industry.

Keywords: Annatto seeds; Blue butterfly pea; Natural inks; Solvent-based highlighter pen; Sustainability

1. Introduction

For decades, highlighter pens have been an essential tool for students, teachers, and office workers. The primary function of highlighters is to highlight specific information in written texts, making it easier to recognize, remember, and retrieve later. The design and features of highlighter pens have evolved over time, with manufacturers creating pens with different ink colors, shapes, sizes, and ink compositions. (Diao et al., 2019) The pigment used in a highlighter pen has a significant impact on the reading experience, comprehension, and visual impact of the written message for the reader. As a result, highlighter pens have become an integral part of academic and non-academic reading and writing processes. However, most commercial highlighter pens are made of synthetic materials that can take hundreds of years to decompose, causing environmental concerns. In accordance with this, the researchers proposed to develop an organic highlighter pen containing extracts of Annatto seeds and blue butterfly peas.

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Organic highlighter pens have the potential to offer a sustainable and biodegradable alternative to commercial highlighters without compromising functionality or usability. In addition, it is necessary to investigate the possibility of scaling up the production of organic sources as sustainable highlighter pen ink and to compare its performance to that of commercial highlighter pens about color intensity, odor, text smearing, and show-through. This study aims to produce solvent-based ink using a simple aqueous process and extract from Annatto seeds and blue butterfly pea. Depending on the concentration and other variables, the characteristics of these organic sources as organic highlighter ink can vary. In addition, the researchers intended to use organic sources to reduce the use of chemical components present in commercial highlighter pens, as well as to evaluate the viability of organic sources as sustainable highlighter pen ink.

1.1. Statement of the Problem

This study focused on the viability of organic sources as sustainable highlighter pen ink.

Specifically, it sought to answer the following questions:

- What are the physical properties of commercial highlighter pens, Annatto seeds highlighter pen ink, and blue butterfly pea highlighter pen ink in terms of:
 - Intensity of color
 - Odor
 - Text smearing
 - Show-through
- What is the level of acceptability of organic sources as highlighter pen ink in terms of:
 - Annatto seeds
 - Blue butterfly pea
- Is there a significant difference between the physical properties of commercial highlighter pens and organic highlighter pens?

1.2. Theoretical Framework

This study is built upon the research of Biswas et al. (2020), which demonstrates that the process of extracting natural ink from organic sources involves several stages influenced by various factors. The first stage involves identifying suitable organic sources, which may include fruits, vegetables, flowers, and other pigment-containing natural materials. The selection of organic sources depends on the availability of materials and the desired ink color. Next, the pigments are extracted from organic sources, which can be achieved through methods like boiling, grinding, or maceration. The choice of extraction method depends on the characteristics of the organic source and the specific pigment to be extracted. Once the pigments have been extracted, they undergo purification to eliminate any impurities or unwanted substances. This purification process can involve filtration, centrifugation, or other techniques. After the purification, the pigments are ready to be used in formulating ink. The ink is formulated by combining the purified pigments with a solvent, such as water or alcohol. The choice of solvent is determined by the properties of the pigments and the desired qualities of the ink.

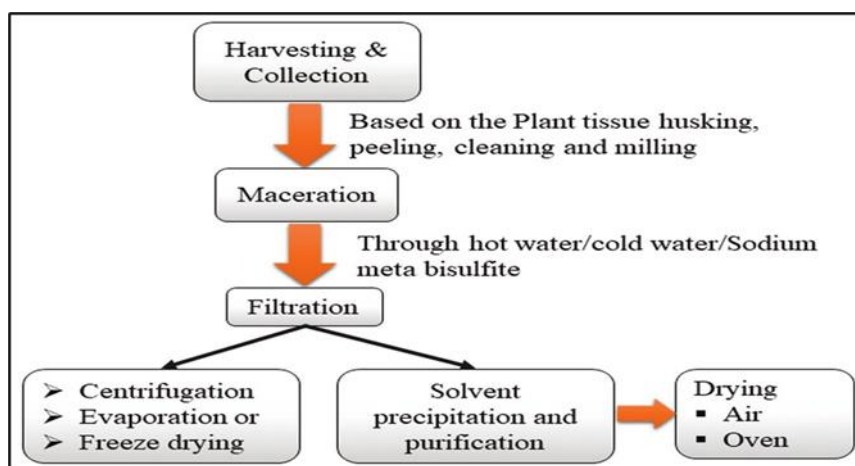


Figure 1 Theoretical paradigm

(Adapted from the study of Biswas et al, 2020 on the process of extraction of natural polymers)

1.3. Conceptual Framework

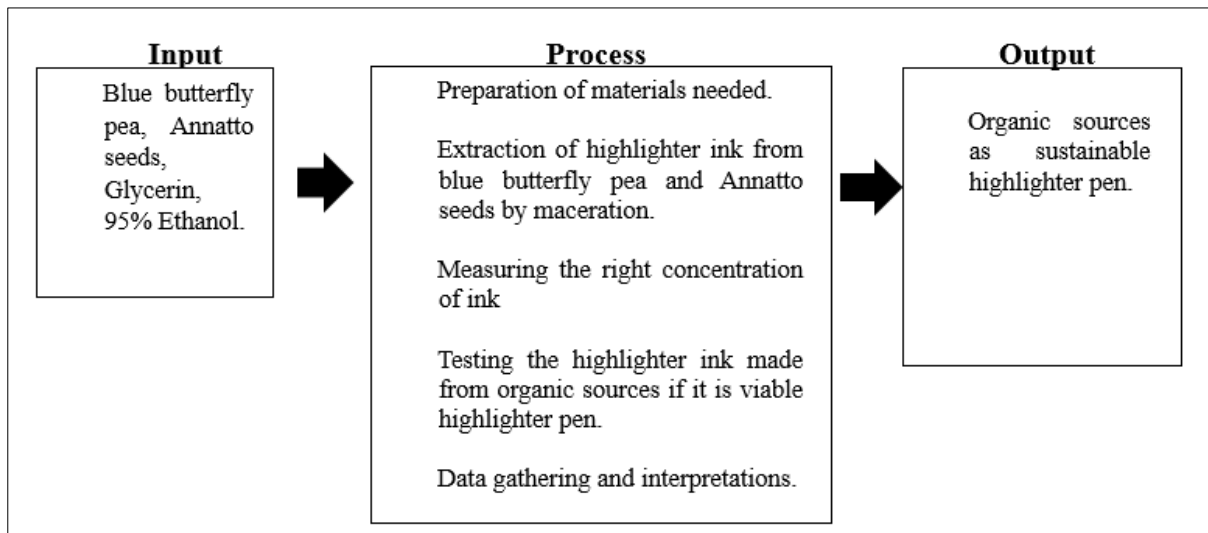


Figure 2 Conceptual framework

The figure above illustrates the IPO (Input, Process, Output) method used by the researchers to conduct their study. It showcases the process of creating highlighter pen ink from blue butterfly pea and Annatto seeds. Through this analysis, the researchers evaluated the feasibility of organic sources as a sustainable highlighter pen ink. The study has numerous advantages, such as reduced ink production expenses and its positive impact on the environment.

1.4. Significance of the Study

The researchers believed that the findings of this study helped to determine the viability of organic sources as a sustainable highlighter pen. Furthermore, the data gathered were useful to the following:

- **Teachers:** Teachers can incorporate highlighter pens made from organic sources to have a fun and eco-friendly way of teaching with a rustic appearance and a distinct aesthetic.
- **Students:** This study can be used as a basis for further research, and it will also provide new information on the production of highlighter pens made from organic sources.
- **Economy:** This study will also serve as an additional income for the community since the demand for highlighter pen production and consumption is increasing.
- **Environment:** This study will be beneficial to the environment as it lessens the use of commercial highlighter pens that contain harmful components that may contaminate the environment.
- **Future Researchers:** This research will assist future researchers in gathering data for their studies. It also teaches them about the benefits and drawbacks of using organic sources as highlighter pens.

1.5. Scope and Limitation of the Study

The researchers focused on evaluating the viability of organic sources, such as annatto seeds and blue butterfly pea, as materials for highlighter pens. For this investigation, forty (40) selected students from the College of Education at Laguna University participated, as they frequently use highlighter pens during their review activities. Validated survey questionnaires, designed in accordance with standard quality control measures for highlighter pens, were used to gather data during the second semester of the academic year 2022-2023.

2. Material and methods

The researchers employed an experimental research design to measure the viability of organic sources as a sustainable highlighter pen ink. According to S. Bell (2009), experimental design is the process of conducting research in an objective and controlled manner to maximize precision and draw precise conclusions regarding a hypothesis statement. In addition, experimental research is a research design that bases its method on a scientific activity known as experimentation, which involves testing or examining a thing in a manipulated or controlled environment to determine its validity or truthfulness. Using an experimental approach allowed the researchers to control for external variables that could influence the results and to test the hypothesis that organic sources can be a sustainable highlighter pen ink.

The researchers compared the performance of organic highlighter pen ink to that of a commercial highlighter pen and analyzed the results to determine if organic sources are a viable alternative. Overall, the experimental methodology permits systematic investigation into the viability of organic sources as a sustainable highlighter pen ink and the interpretation of its possible application based on empirical evidence.

2.1. Population of the Study

The researchers employed a purposive and convenience sampling technique to select the population of the study. These participants possess certain characteristics necessary for the researchers to evaluate their research question effectively. Therefore, the respondents in this research were students from the College of Education who met the inclusion criteria for the study. The researchers randomly selected forty (40) students from the college to take part in the study, and these students tested the highlighters made from organic sources in terms of their physical properties. Additionally, convenience sampling was used as the simplest method of sampling, where participants were chosen based on their availability and willingness to participate in the study.

2.2. Research Instruments

The researchers collected the data using a validated survey questionnaire, which was divided into four parts. In the first part, the respondents rated the physical properties of a commercial highlighter pen, including color, odor, text-smearing, and show-through. In the second and third parts, the respondents rated the physical properties of organic highlighter pen ink in terms of color, odor, text-smearing, and show-through. Lastly, the fourth part, which is divided into two sections, assessed the respondents' level of acceptability for the two organic sources as highlighter pen ink. The questionnaire employed a five-point Likert scale to rate the mentioned variables.

Table 1 Five-Point Likert Scale

Range	Verbal Interpretation	Scale
4.50 – 5.00	Strongly agree	5
3.50 – 4.49	Agree	4
2.50 – 3.49	Neutral	3
1.50 – 2.49	Disagree	2
1 – 1.49	Strongly Disagree	1

2.3. Data gathering

The pre-experimental and experimental phases of the study were conducted to determine the viability of organic sources as environmentally friendly highlighter pen ink.

2.3.1. Pre – experimental phase

Phase 1: Preparation of materials

The materials used for this study included Annatto seeds, blue butterfly pea, 95% ethanol, glycerin, and coffee filter.

Phase 2: Extraction by maceration

Two concentrations were prepared for each organic source. The Annatto seeds and blue butterfly pea were extracted by macerating or soaking them in ethanol for 30 minutes. After 30 minutes, the extracted pigments from Annatto seeds and blue butterfly pea were filtered using a coffee filter.

Table 2 Concentration for Annatto Seeds

	Annatto seeds	Ethanol	Glycerin
Concentration 1	½ cup of seeds	100 ml	½ tbsp
Concentration 2	¼ cup of seeds	50 ml	1 tbsp

Table 3 Concentration for blue butterfly pea

	Blue butterfly pea	Ethanol	Glycerin
Concentration 1	1 cup flowers	50 ml	1 tbsp
Concentration 2	½ cup flowers	100 ml	½ tbsp

2.3.2. *Experimental phase*

Phase 3: Conducting the experiment.

In this phase, the researchers tested different concentrations of ink made from the two organic sources to determine the most suitable concentration for use as a highlighter pen. After experimentation, Concentration 2 of Annatto seeds and Concentration 1 of blue butterfly pea were selected as the optimal concentrations for the highlighter pen ink.

Phase 4: Preliminary Survey

To identify potential respondents who met the inclusion criteria, the researchers conducted a pre-survey. They sought students who regularly used a highlighter pen while studying.

Phase 5: Testing the organic highlighter pen ink

In this phase, the researchers distributed the two organic highlighter pens to the forty (40) selected students from the College of Education. Each program (BEED, BSED English, Math, and Science) evaluated the organic highlighter pen ink for one day. After the evaluation period, the researchers distributed the survey questionnaire to the forty students selected for the study.

2.4. Treatment of Data

The following statistical procedures were used to interpret the data gathered from the respondents of the study.

Table 4 Statistical Treatment

No.	Research Question	Statistical tools
1	What are the physical properties of commercial highlighter pen, Annatto seeds highlighter pen ink, and blue butterfly pea highlighter pen ink in terms of: Intensity of color Odor Text smearing Show-through	Simple statistics such as mean, weighted mean, and standard deviation. $\bar{x} = \sum f * xi / n$ $Weighted\ mean = \sum wx / \sum w$ $\sigma = \sqrt{\sum (x - u)^2 / N} / 2$
2	What is the level of acceptability of organic sources as highlighter pen in terms of Annatto seeds and blue butterfly pea?	Simple statistics such as mean, weighted mean, and standard deviation. $\bar{x} = \sum f * xi / n$ $Weighted\ mean = \sum wx / \sum w$ $\sigma = \sqrt{\sum (x - u)^2 / N} / 2$
3	Is there a significant difference between the physical properties of commercial highlighter pens and organic highlighter pens made from Annatto seeds and blue butterfly pea?	One- way Analysis of Variance (ANOVA) $F = MSB / MSW$

3. Results

Table 5 presents the physical properties of the commercial highlighter pen. The intensity of color received the highest mean of 4.68 and a standard deviation of 0.57, indicating a "strongly agree" interpretation. On the other hand, the text-smearing received the lowest mean of 4.15 and a standard deviation of 0.92, indicating an "agree" interpretation.

Table 5 Physical properties of commercial highlighter pen ink

Physical Properties	Mean	SD	Interpretation
Intensity of color	4.68	0.57	Strongly agree
Odor	4.25	1.03	Agree
Text Smearing	4.15	0.92	Agree
Show-Through	4.35	0.83	Agree
Overall	4.36	0.84	Agree

Legend: 4.50 – 5.00 - Strongly agree; 3.50 – 4.49 - Strongly agree; 2.50 – 3.49 - Neutral; 1.50 – 2.49 – Disagree; 1.00 – 1.49 – Strongly disagree

When considering the overall physical properties of the commercial highlighter pen, including intensity of color, odor, text-smearing, and show-through, the overall weighted mean was 4.36 with a standard deviation of 0.84, indicating an "agree" interpretation. These findings suggest that the respondents agreed with the physical properties of the commercial highlighter pen ink.

Table 6 Physical properties of Annatto seeds as highlighter pen ink

Physical Properties	Mean	SD	Interpretation
Intensity of color	4.72	0.45	Strongly agree
Odor	4.70	0.56	Strongly agree
Text Smearing	4.50	0.64	Strongly agree
Show-Through	4.43	0.81	Agree
Overall	4.56	0.62	Strongly agree

Legend: 4.50 – 5.00 - Strongly agree; 3.50 – 4.49 - Strongly agree; 2.50 – 3.49 - Neutral; 1.50 – 2.49 – Disagree; 1.00 – 1.49 – Strongly disagree

Table 6 presents the physical properties of Annatto Seeds as a highlighter pen ink. The intensity of color received the highest mean of 4.72 and a standard deviation of 0.45, indicating a "strongly agree" interpretation. This suggests that the color of Annatto seeds highlighter pen was more intense compared to the commercial highlighter pen. On the other hand, the show-through property received the lowest mean of 4.43 and a standard deviation of 0.81, indicating an "agree" interpretation. This means that using Annatto seeds highlighter pen ink may result in show-through, where the ink can be seen through to the other side of the paper due to bold ink or thin paper.

The overall physical property of Annatto seeds as a highlighter pen ink, including color, odor, text-smearing, and show-through, received an overall weighted mean of 4.56 with a standard deviation of 0.62, which is interpreted as "strongly agree." These findings suggest that respondents strongly agreed with the physical properties of Annatto seeds as a highlighter pen ink.

These findings are consistent with a study by Diao et al. (2020), which stated that the ink made from Annatto seeds produced a color comparable to that of commercial highlighter markers in terms of saturation and intensity. Although the organic highlighter ink had slightly less refined characteristics than its commercial counterpart, it was just as effective at highlighting text and other materials.

Table 7 presents the physical properties of blue butterfly pea as a highlighter pen ink. The odor obtained the highest mean of 4.70 with a standard deviation of 0.56, indicating a "strongly agree" interpretation. This suggests that the smell of the blue butterfly pea highlighter pen was not strong and did not cause discomfort, unlike the commercial highlighter pen that has a strong smell. On the other hand, show-through received the lowest mean of 4.45 with a standard deviation

of 0.78, indicating an "agree" interpretation. This means that using blue butterfly pea highlighter pen ink may result in show-through, meaning the ink can be seen through to the other side of the paper due to bold ink or thin paper.

The overall physical property of blue butterfly pea as a highlighter pen ink, including color, odor, text-smearing, and show-through, received an overall weighted mean of 4.53 with a standard deviation of 0.68, interpreting a "strongly agree" response. These findings indicate that respondents strongly agreed with the physical properties of blue butterfly pea as a highlighter pen ink. Overall, these findings were supported by the study conducted by Kim (2020), which discussed the prospective benefits of the eco-friendly and sustainable highlighter pen made from blue butterfly pea.

Table 7 Physical properties of blue butterfly pea as highlighter pen

Physical Properties	Mean	SD	Interpretation
Intensity of color	4.48	0.72	Agree
Odor	4.70	0.56	Strongly agree
Text Smearing	4.50	0.64	Strongly agree
Show-Through	4.45	0.78	Agree
Overall	4.53	0.68	Strongly agree

Legend: 4.50 – 5.00 - Strongly agree; 3.50 – 4.49 - Strongly agree; 2.50 – 3.49 - Neutral; 1.50 – 2.49 – Disagree; 1.00 – 1.49 – Strongly disagree

Table 8 Acceptability of Annatto seeds as highlighter pen ink

Statement	Mean	SD	Interpretation
I believe that using highlighter pen made from Annatto seed is a sustainable option.	4.75	0.44	Highly acceptable
I may recommend highlighter pen made from Annatto seed as a viable alternative to commercial highlighter pen.	4.70	0.52	Highly acceptable
I believe that a highlighter pen made from Annatto seed is versatile because it can be used on different types of paper.	4.60	0.60	Highly acceptable
I am satisfied with the overall performance of Annatto seeds as an organic highlighter pen.	4.75	0.44	Highly acceptable
Overall	4.70	0.51	Highly acceptable

Legend: 4.50 – 5.00 - Strongly agree; 3.50 – 4.49 - Strongly agree; 2.50 – 3.49 - Neutral; 1.50 – 2.49 – Disagree; 1.00 – 1.49 – Strongly disagree

Table 8 presents the level of acceptability of Annatto seeds as a highlighter pen ink. Statements 1 and 4 received the highest mean of 4.75 and a standard deviation of 0.44, with an interpretation of "highly acceptable." This indicates that using a highlighter pen made from Annatto seeds was considered a sustainable option, and the respondents were satisfied with the overall performance of Annatto seeds as an organic highlighter pen ink. On the other hand, statement 3 obtained the lowest mean of 4.60 with a standard deviation of 0.60, which suggests that Annatto seeds may not be as versatile, as they may not be suitable for use on different types of paper.

The overall level of acceptability of Annatto seeds as a highlighter pen ink received an overall weighted mean of 4.70, which corresponds to an interpretation of "highly acceptable." This indicates that using Annatto seeds as a sustainable highlighter pen was highly acceptable among the respondents.

Table 9 presents the level of acceptability of blue butterfly pea as a highlighter pen ink. Statement 1 received the highest mean of 4.75 with a standard deviation of 0.49, indicating a high level of acceptability and a sustainable option for using blue butterfly pea highlighter pen ink. On the other hand, statement 3 obtained the lowest mean of 4.53 with a standard deviation of 0.64, suggesting that blue butterfly pea may not be as versatile and may not be suitable for use on different types of paper.

The overall level of acceptability of blue butterfly pea as a highlighter pen ink received an overall weighted mean of 4.66 with a standard deviation of 0.59, indicating that using blue butterfly pea as a sustainable highlighter pen was highly acceptable among the respondents.

Table 9 Acceptability of blue butterfly pea as highlighter pen ink

Statement	Mean	SD	Interpretation
I believe that using highlighter pen made from blue butterfly pea is a sustainable option.	4.75	0.49	Highly acceptable
I may recommend highlighter pen made from blue butterfly pea as a viable alternative to commercial highlighter pen.	4.65	0.58	Highly acceptable
I believe that a highlighter pen made from blue butterfly pea is versatile because it can be used on different types of paper.	4.53	0.64	Highly acceptable
I am satisfied with the overall performance of blue butterfly pea as an organic highlighter pen.	4.70	0.65	Highly acceptable
Overall	4.66	0.59	Highly acceptable

Legend: 4.50 – 5.00 - Strongly agree; 3.50 – 4.49 - Strongly agree; 2.50 – 3.49 - Neutral; 1.50 – 2.49 – Disagree; 1.00 – 1.49 – Strongly disagree

Table 10 One-way ANOVA for the physical property of commercial highlighter pen ink and organic highlighter pen ink

Source of Variation	SS	df	MS	F	F-crit	Conclusion
Between Groups	1.19	2	0.60	1.33	3.24	H ₀ =Accepted
Within Groups	30.50	38	0.80			
Total	31.69	40				

Note: MS=mean of squares; f-value < f-crit value of 3.24; SS=sum of squares; df=degree of freedom; α=0.05

Table 10 presented the statistical summary of the One-way Analysis of Variance for the physical properties of commercial highlighter pen ink and organic highlighter pen ink made from Annatto seeds and blue butterfly pea. The total sum of squares was 31.69, and the computed f-value was 1.33. Since the computed f-value was less than the 3.24 f-critical value with degrees of freedom (2, 38) at a 0.05 level of significance, the null hypothesis was accepted, indicating that there is no significant difference between the physical properties of commercial highlighter pen ink and organic highlighter pen ink. These findings suggest that, in terms of physical properties, commercial and organic highlighter pen inks were the same. Therefore, organic highlighter pen ink made from Annatto seeds and blue butterfly pea was a viable option as a sustainable highlighter pen ink.

In general, these findings were supported by a study conducted by Lagman et al. (2022), which revealed that highlighter pen ink made from organic sources has the potential to be a more sustainable alternative to commercial highlighter pens. Additionally, another study supports these findings, discussing that organic pen ink could reduce the environmental impact of commercial highlighter pens, making it a more sustainable option for schools and offices (Kim, 2020).

4. Discussion

According to Ghosh & Malik (2019), natural inks are considered environmentally friendly because they are made from natural resources such as plant leaves, roots, fruits, and minerals. This study further revealed that organic sources such as Annatto seeds and blue butterfly pea were potential options for sustainable highlighter pen ink. The Likert-scale interpretation showed that both Annatto seeds and blue butterfly pea were acceptable highlighter pen inks. However, based on the overall weighted mean of the two organic sources, Annatto seeds obtained the higher mean, implying that

it has better highlighter ink properties and hence was preferable to blue butterfly pea. These findings were supported by Diao et al. (2020), which proved that ink made from Annatto seeds provided a color comparable to commercial highlighter markers in terms of saturation and intensity. The study also indicated that one of the significant advantages of using Annatto seeds as a natural pigment for highlighters was their affordability, making them a potential alternative to synthetic pigments in traditional highlighter inks. The related literature also demonstrated that highlighter pen ink produced from Annatto seeds was a viable alternative to commercial highlighter pen ink due to its superior ink qualities. Additionally, as for blue butterfly pea, this study found that highlighter pen ink made from blue butterfly pea was also acceptable. The study revealed that the odor of blue butterfly pea highlighter pen ink is not strong and does not cause discomfort, unlike commercial highlighter pens that have a strong scent. However, blue butterfly pea highlighter pen ink does not possess better ink properties compared to the highlighter pen ink made from Annatto seeds.

Furthermore, regarding the summary of the statistical treatment, the null hypothesis of this study was accepted, indicating that there is no significant difference between the physical properties of commercial and organic highlighter pen ink. A study by Nagrale et al. (2022) supported these findings, showing that the physical properties of synthesized natural inks were free-flowing and non-clogging. It also demonstrated that natural inks derived from organic sources share common properties with commercial inks and that ink derived from organic sources can be used commercially. The natural inks were also environmentally friendly, chemical-free, and biodegradable. These results further support the viability of organic highlighter pen inks as a sustainable and eco-friendly alternative to commercial highlighter pens.

5. Conclusion

Based on the study's findings, the researchers concluded that there was no significant difference in the physical properties of commercial and organic highlighter pens, which accepted the null hypothesis of this study. This indicates that in terms of physical properties, the commercial highlighter pen and organic highlighter pen ink made from Annatto seeds and blue butterfly pea were comparable. As a result, organic highlighter pens were a viable substitute for commercial highlighter pens.

Recommendations

The researchers recommend that further studies should be conducted to investigate other concentration mixtures of organic sources to produce better quality inks. It is also recommended to conduct further study about the comparative advantage of organic highlighter to commercial highlighter pen. The researchers recommend gathering more relevant studies to support their claims and gain a deeper understanding of the prospective use of organic sources as sustainable highlighter pen ink. It is also recommended to utilize alternative extraction methods other than maceration, as well as different solvents and organic binders. During the testing, the researchers recommend expanding the number of trials in the laboratory and the number of respondents to assess the physical qualities of organic highlighter pen inks efficiently and precisely. A longer study period is recommended because the researchers were not experts in the ink-making process, and laboratory testing is recommended to fully comprehend the chemical structure of the pigments responsible for its color, how long this marker lasts, as well as how these pigments may interact with various solvents, substrates, and ink formulations. Moreover, the researchers also recommend investigating the marketability of these organic highlighter pens based on the cost price given by the researchers.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflicts of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

- [1] Diao, A., Ilagan, J., & Riman, M. (2019). Bixa orellana (Annatto Seeds) as an Alternative Highlighter Ink <https://ojs.aaresearchindex.com/index.php/AAJMRA/article/view/4392>
- [2] Biswas, Dipjyoti & Das, Sudip & Mohanto, Sourav & Mantry, Shubhrajit. (2020). Extraction, modification, and characterization of natural polymers used in transdermal drug delivery system: an updated review. *Asian Journal of Pharmaceutical and Clinical Research*. 13. 10-20. 10.22159/ajpcr.2020.v13i7.37756.
- [3] Kim, J. H. (2022). Development of a sustainable and eco-friendly highlighter pen using blue butterfly pea extract. *Journal of Industrial and Engineering Chemistry*, 48, 106084.
- [4] Lagman, C. P., De Guzman, J. S., & Dela Cruz, E. C. (2022). Production of eco-friendly highlighter pen using blue butterfly pea extract and guar gum. *International Journal of Innovative Science and Research Technology*, 7(2), 442-447.
- [5] Ghosh, M. & Malik, S. (2019). Synthesising natural ink from indian berries. [https://www.worldwidejournals.com/indian-journal-of-applied-research-\(IJAR\)/fileview/synthesising-natural-ink-from-indian-berries_October_2019_1571897665_3013879.pdf](https://www.worldwidejournals.com/indian-journal-of-applied-research-(IJAR)/fileview/synthesising-natural-ink-from-indian-berries_October_2019_1571897665_3013879.pdf)
- [6] Nagrale, P.M., Kamble, R.K., & Patil, P.V. (2022). Natural ink synthesis from flowers of flame of forest (*Butea monosperma*), common lantana (*Lantana camara*), and berries of malabar spinach (*Basella alba*). *Ethiopian Journal of Environmental Studies & Management* 15(4): 443 - 449, 2022. <https://ejesm.org/wpcontent/uploads/2022/08/ejesm.v15i4.3.pdf>
- [7] S. Bell. (2009). Experimental Design. *International Encyclopedia of Human Geography*, Pages 672-675, ISBN 9780080449104. <https://doi.org/10.1016/B978-008044910-4.00431-4>.