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Butterfly Pea Flower (Clitoria Ternatea) Extract and Okra Mucilage as an Alternative Gel Ink for Pens

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***Abstract*—** This study was conducted to develop an alternative gel ink for pens using Butterfly Pea flower extract and Okra mucilage in various formulations: Sample 1 comprised 90% Butterfly Pea flower extract and 10% Okra mucilage, Sample 2 contained 75% Butterfly Pea flower extract and 25% Okra mucilage, and Sample 3 consisted of 50% Butterfly Pea flower extract and 50% Okra mucilage. The study aimed to determine if there were significant differences between Butterfly Pea flower extract and Okra mucilage as alternative gel ink components across various formulations, concerning pH level, viscosity, drying time (on bond paper), surface area covered by dropped ink on the bond paper, and color. This natural ink could potentially be used to refill empty pen ink cartridges, thereby reducing plastic waste and the harmful effects of synthetic dyes. The researchers employed an experimental design and the F-test to ascertain significant differences among the three samples. Results revealed that the three samples showed no significant differences in terms of pH level, surface area covered by dropped ink on the bond paper, and color. However, significant differences were observed among the various formulations of the alternative gel ink in terms of viscosity and drying time on bond paper. Among the samples, Sample 1 exhibited the highest pH level, lowest viscosity, fastest drying time, broadest surface area coverage, and color-changing properties. Sample 2, with a pH level identical to that of Sample 3, ranked as the second most viscous, second fastest-drying, with the smallest surface area coverage, and also displayed color-changing properties. Sample 3, mirroring the pH level of Sample 2, was the most viscous, slowest to dry, with the second largest surface area coverage, and likewise exhibited color-changing properties.

***Keywords*—** Butterfly Pea, Flower Extract, Okra Mucilage, Alternative, Gel Ink, Pen

I. INTRODUCTION

These days, ink-filled pens are available for writing. With its development, people could communicate more easily. This can be oil-based, gel-based, or water-based. However, most often employed pigments and dyes in this modern -day inks are synthetic to produce a long-lasting coloring effect. These synthetic dyes are harmful to the environment and the people. According to Routoula et al., (2020), as cited in Ardila-Leal et al., (2021) the textile, paper, and leather industries are responsible for discharging a large volume of colored wastewater into water bodies. According to Lellis et al., (2019) as cited in Ardila-Leal et al., (2021), it increases biochemical (BOD) and chemical (COD) oxygen demand, prevents photosynthesis, and inhibits plant growth. Synthetic dyes are recalcitrant, bio-accumulative, toxic, mutagenic, and carcinogenic. Other than that, students buy a lot of pens and throw them away as the ink runs out and it increases the plastic waste in the country.

According to the Science History Institute (2023), one of the largest challenges to the environment today is plastic garbage. Plastic can remain in the environment for a very long time and have long-term effects since it does not biodegrade.

In light of these pressing concerns, this study will endeavor to investigate the possibility and efficacy of environmentally friendly and economically sustainable ink formulations as a way to lessen plastic waste and lessen the negative impact on the environment brought by synthetic dyes. The researchers came up with the idea of creating natural ink that can be used to refill the pens' ink cartridges to reduce plastic waste and the harmful effects of synthetic dyes. In this study, the Butterfly Pea flower also known as “Blue Ternate” and Okra Pods was used to create an alternative gel ink for pens. The Butterfly Pea flower was used as the colorant and the Okra pod was used to extract mucilage to thicken the ink and prevent it from being too watery since the goal is to make an alternative gel ink for pens that glides smoothly in the paper.

Citoria Ternatea commonly known as butterfly pea, is a perennial herbaceous plant from the Fabaceae family. It

is widely used in Indonesia, Malaysia, the Philippines, and Thailand. It produces an extremely valuable blue food coloring and it is one of the very few sources of edible blue color. The pharmaceutical industry also makes use of the blue color that is extracted from the flowers (Sandoval, 2016). According to Gamage et al. (2021), the flower has blue extracts because of its high abundance of polyacylated anthocyanins known as ternatins. Hot water or cold water extraction and pounding through mortar and pestle of dried or fresh petals of blue pea flowers could be employed successfully to extract anthocyanins. The extract's blue color also changes as it is exposed to an acidic environment and substance (Torres, 2018). As Clitoria Ternatea extracted a blue color Siti Azima et al., (2017) as cited in Nagrale et al. (2022) suggested that the extract of the flowers of the butterfly pea (Clitoria Ternatea) can serve as a natural blue colorant, tends to be convenient to use, and possess a longer shelf life than comparable plant-based colorants.

Several studies proved that it is possible to make an alternative ink using natural colorant. Camais flower extract was used to make a paper marker ink in the study of Lumata and Saladain. The ink was tested in terms of intensity of color, resistance to fading, stability of color, and overall acceptability. It was revealed that the writings of the ink were permanent, did not fade and the intensity of the color was acceptable. The ink also contains a color-changing property. Flowers of Flame of Forest and Common Lantana were used to make natural inks in the study of Nagrale et al. (2022), it was discovered that these plant materials have the prerequisite properties that can be used for the synthesis of natural inks. Their study revealed that the different inks were effective on writing on the paper, were resistant to rubbings, and did not wear off. Clitoria Ternatea (Blue Ternate) and Basella Alba (Alugbati) was used in the study of Estrope et al. (2020) as an Alternative Ink for Pens in various formulations. The ink was tested in terms of color, consistency, and odor. It was revealed that treatment A (90% pigmented extract and 10% water) has a color of Dark Blue while treatment B (75% pigmented extract and 25% water) has a color of Blue, lastly, treatment C (50% pigmented extract and 50% water) has a color of Light Blue. In terms of the qualities of stick consistency and color of the ink, it is revealed that treatment A showed the greatest efficacy as an alternative ink for pens. However, in quality of odor, treatment C showed the greatest efficacy. Furthermore, turmeric, blueberries, onion skin, red cabbage, and other plants that produce natural pigment can be used as ink in arts and crafts projects.

The studies mentioned above were only limited to making a water-based ink, thus, in this study, the researchers will create an alternative gel ink that is thicker than the water-based ink. Gel ink is primarily composed of a water-based gel and powdered pigments. The gel is a colloid that often consists of common biopolymers such as xanthan gum. This creates a thick, viscous ink that is simultaneously very smooth flowing (What Are Gel Pens and How Do They Work?, n.d.). On the other hand, Okra is the seed pod of the Abelmoschus esculentus plant, has a sweet, grassy flavor, and contains seeds and mucilage, a thick, gel-like substance that makes okra a good thickening agent (Lthompso, 2023). Xanthan gum and Okra mucilage are both thickening agents, they contain hydrophilic molecules that can combine with water to form viscous or gel-like solutions (Amiri et al, 2021). Thus, in this study, okra mucilage was used as a substitute for xanthum gum. This helps the Butterfly Pea flower extract a little bit sticky and thick. There are also studies that it is being used to create an alternative glue, gel, and hair gel, and as an emulsifying agent.

Furthermore, the American and Asian markets also have excessive utilization of mucilage in the ink, glue, and adhesive industries (Tosif et al., 2021). Thus, the researchers investigated the Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens that intends to provide important insights into encouraging a more ecologically responsible approach to ink production and consumption by exploring the creation, characteristics, and possible uses of sustainable ink substitutes.

Statement of the Problem:

The study aims to determine if there is a significant difference of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of:

a) pH Level
b) Viscosity
c) Drying Time (on bond paper)
d) Surface area of dropped ink on the bond paper
e) Color

Hypothesis:

For problem 1, the hypothesis was tested at 0.05 and 0.01 levels of significance.

H0: There is no significant difference of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of:

a) pH Level
b) Viscosity
c) Drying Time (on bond paper)
d) Surface area of dropped ink on the bond paper
e) Color

II. METHODS

Research Design:

This study used an experimental design. The study employs an experimental method to introduce a procedure on purpose and record the outcomes observed (The Office of Research Integrity, n.d.). This design was relevant to the study, for this study aims to create an alternative gel ink for pens using the Butterfly Pea flower extract and Okra mucilage in various formulations: Sample 1 (90% Butterfly Pea extract and 10% Okra mucilage), Sample 2 (75% Butterfly Pea extract and 25% Okra mucilage), and Sample 3 (50% Butterfly Pea extract and 50% Okra mucilage). The various formulations were then tested in terms of pH level, viscosity, drying time on bond paper, surface area, and color to determine the significant differences among the three samples.

Experiment Materials:

The researchers used the following materials and equipment: 100 petals of dried Butterfly Pea Flower, 5 pcs of Okra pods, 300 mL of water, mortar, and pestle, 4 syringes, a strainer, 3 disposable cups, a spoon, 3 containers, a knife, chopping board, gas stove, pan, graduated cylinder, 9 pH strips, marble, yarn, weighing scale, dropper, 3 empty pens, 2 bond papers, ruler, and stopwatch.

Experiment Procedure:

A. Okra Pods Mucilage Extraction

The Okra pods were washed in clean water and were sliced. To extract its mucilage, fifteen pieces of sliced okra were utilized, and it was boiled in a pan with 100 mL water and low heat for eight minutes. After that, the extraction was collected through a strainer and was then placed in a container. The okra mucilage collected was 23 ml.

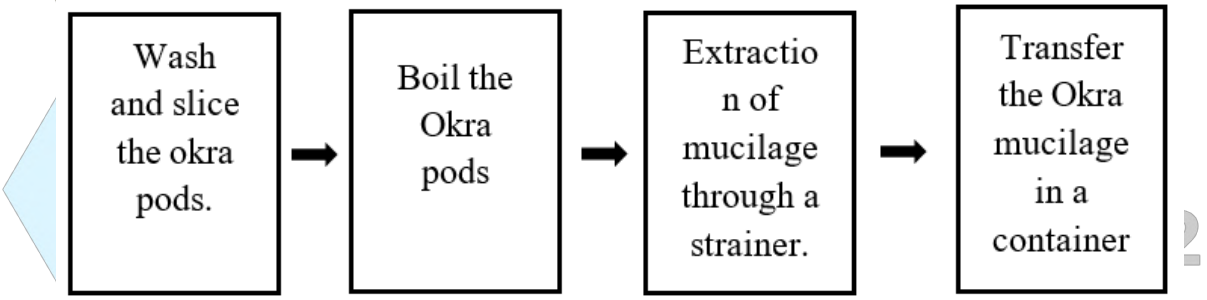

Figure 2. *Okra Pods Mucilage Extraction Diagram*

B. Making Alternative Gel Ink in Various Formulations

The researchers made 20 mL of alternative gel inks in three different formulations. Sample 1 was 90% (18 mL) Butterfly Pea flower extract and 10% (2 mL) okra mucilage. With a mortar and pestle, fifteen pieces of dried Butterfly Pea flower were crushed and pounded with 18 mL water to get the blue extract. Then the blue extract was filtered through a strainer and placed in a clean disposable cup. It was then mixed with 2 mL of okra mucilage and placed in a clean container with a label. Sample 2 was 75% (15 mL) of Butterfly Pea flower extract and 25% (5 mL) okra mucilage. With a mortar and pestle, fifteen pieces of dried Butterfly Pea flower were crushed and pounded with 15 mL water to get the blue extract. Then the blue extract was filtered through a strainer and placed in a clean disposable cup. It was then mixed with 5 mL of okra mucilage and placed in a clean container with a label. Sample 3 was 50% (10 mL) of Butterfly Pea flower extract and 50% (10 mL) of okra mucilage. With a mortar and pestle, fifteen pieces of dried Butterfly Pea flower were crushed and pounded with 10 mL water to get the blue extract. Then the blue extract was filtered through a strainer and placed in a clean disposable cup. It was then mixed with 10 mL of okra mucilage and placed in a clean container with a label. The researcher used a syringe to put the alternative gel inks in an empty ink cartridge.

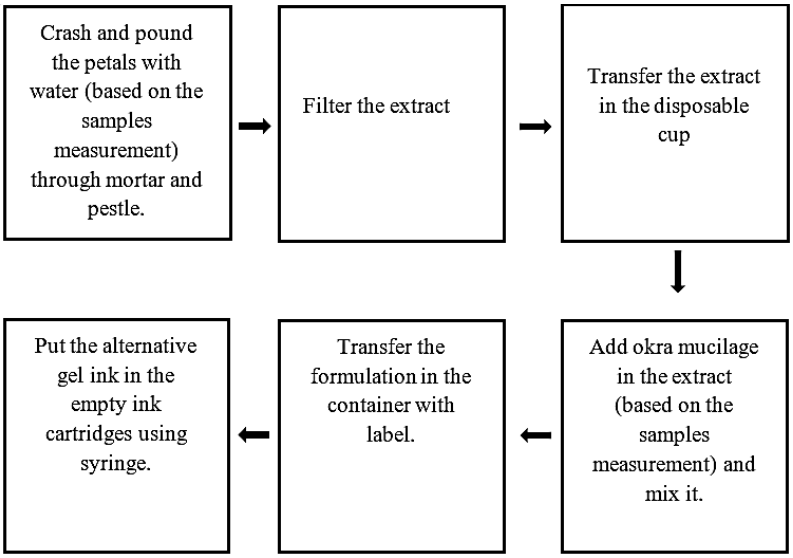

Figure 3. *Making Alternative Gel Ink in Various Formulations Diagram*

C. Testing the various formulations

The various formulations were tested in terms of pH Level, viscosity, drying time (on bond paper), surface area of the dropped ink on the bond paper, and color. The pH level was tested since it affects the ink's viscosity, drying time, and surface area. When the pH level is high the viscosity decreases, and the drying time process lengthens which results in the ink spreading in the paper. The researchers used a pH scale to determine the pH level of each formulation. The researchers dipped the pH strip in the alternative gel ink for 2 seconds and waited for 10 seconds. The result was then compared to the pH scale to determine its pH level. In testing the viscosity, researchers measured the speed of a marble dropped in each sample that was placed in the graduated cylinder. Then the viscosity was calculated using this formula [2(ps-pl)ga2] / 9v. In drying time, the researchers used 1 sheet of bond paper and a dropper. One drop of each sample was put in the bond paper. A timer was used to measure the time took for the alternative ink to dry. The length and width of the dropped or dried ink were measured using a ruler to calculate the surface area of each sample. The formula is A= lw. The color was determined as dark blue, blue, light blue, and violet.

Table 1. *Criteria for Color*

Score	Color
0	Violet
1	Light Blue
2	Blue
3	Dark Blue

Statistical Treatment:

The researchers used the F-test to analyze the data collected and to determine the significant differences between the three samples of the alternative gel ink for pens in terms of pH level, viscosity, drying time (on paper), surface area, and color. The results of each test were tallied in the Excel sheet and were computed to determine its p-value. The results of the p-value were compared to the alpha level of 0.05 to determine if the hypothesis would be accepted or rejected.

III. RESULTS AND DISCUSSION

Problem 1:

Is there a significant difference of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of:

a) pH Level
b) Viscosity
c) Drying Time (on bond paper)
d) Surface area of dropped ink on the bond paper
e) Color?

Table 2. *Test of Significant Difference of Butterfly Pea Flower Extract and Okra Mucilage as an Alternative Gel Ink for Pens of Various Formulations in Terms of pH Level*

Samples	Replicates	x̄	F-Value
S1			
	T1		
	T2	9	
	T3		
S2			
	T1		
	T2	7	65535ns
	T3		
S3			
	T1		
	T2	7	
	T3		

Legend: *** = Highly significant
** = Significant at 0.01 where 0<P<0.001
ns = Not Significant at 0.05 alpha

Table 2 presents the significant difference of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of pH Level. Based on the table, Sample 1 has a mean of 9 and both samples 2 and 3 have a mean of 7 with the F-value of 65535 and p-value of #DIV/0!. It suggests that there is no significant difference among the three samples of alternative gel ink for pens in terms of pH level. According to Water Science School (2019), a pH value of 7 is considered neutral, and a pH exceeding 7 signifies basic or alkaline. Hence, it can be inferred that the alternative gel ink for pens in various formulations does not possess acidic characteristics. Therefore, the null hypothesis of this study that there is no significant difference of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of pH level is accepted.

Two ingredients are being used in this study. Butterfly Pea flower extract has anthocyanin compounds that are heavily influenced by the pH of the surrounding solution, primarily when it comes to the color of the extract. Its normal pH is 6-8 and it produces a deep blue color (Campbell et al., 2022). Conversely, Okra mucilage has a pH level of around 7.5 which means that is neutral (Pal, 2020). Given the non-acidic nature of these ingredients, it follows that the alternative gel ink various formulations for pens do not exhibit acidic properties. Furthermore, since gel ink is primarily water-based, it tends to operate within alkaline pH ranges, typically ranging from 8 to 9.5, as highlighted by Any Flexo (2022). However, the pH levels could drop; at higher pH values, viscosity decreases, and drying periods lengthen. As the alternative gel ink for pens shows acid-free characteristics, then it can be compared to the Zebra Sarasa Clip Gel Retractable Pen, Zebra Sarasa Push Clip Gel Pen, Pilot G-2 Gel Pen, and Dong-A My Gel which is some of the gel pens found here in the Philippines that are acid-free.

Table 2.1. *Test of Significant Difference of Butterfly Pea Flower Extract and Okra Mucilage as an Alternative Gel Ink for Pens of Various Formulations in Terms of Viscosity*

Samples	Replicates	F-Value
S1		
T1	0.00013	
T2	0.00012	
T3	0.00015	
S2		12.85**
T1	0.00016	
T2	0.00021	

T3	0.00019	
S3		
T1	0.00019	
T2	0.00021	
T3	0.00021	

Legend: *** = Highly significant
** = Significant at 0.01 where 0<P<0.001
ns = Not Significant at 0.05 alpha

Table 2.1 presents the significant difference of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of viscosity. Based on the table, the F-value of 12.85 with the p-value of 0.007 suggests that there is a significant difference among the three samples of alternative gel ink for pens in terms of viscosity. Based on the data above, the marble in Sample 1 is the fastest to drop in 5 mL from 20 mL of the graduated cylinder and Sample 3 is the slowest to drop in 5 mL from 20 mL of the graduated cylinder. This result is related to the pH level. Among the three samples, Sample 1 is the least viscous due to its higher pH level, and among the three Samples, Sample 3 is the most viscous due to its low pH level and the 50% okra mucilage. Therefore, the null hypothesis of this study that there is no significant difference of Butterfly Pea Flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of viscosity is rejected.

Even though there was a noticeable difference in the results, all of the samples had low viscosity. The difference in viscosity arises from distinct formulations of the three Samples. This phenomenon is attributed to the high water content present in Butterfly Pea flower extract, given that water inherently possesses low viscosity properties (Mitchell, 2021). Additionally, the viscosity of okra mucilage is similarly low (Apolinario, 2020) but it is more viscous than the water. Based on the data collected, Sample 1 is less viscous among the samples since it contains 90% Butterfly Pea flower extract and 10% okra mucilage. Sample 3 is the most viscous among the samples since it contains 50% Butterfly Pea flower extract and 50% Okra mucilage. Gel inks, as indicated by Reinol (n.d.), inherently exhibit low viscosity traits, resulting in the ink running back from the refills if the tip is not sealed. Low viscosity means that less pressure is needed to write clearly with gel ink as the ink is a thin liquid that flows easily and produces smooth writing. Users benefit from this because they can hold the pen with less strain on the hand (Pen, 2022). As the alternative gel ink possesses a low viscosity this means that it can write smoothly and has the possibility that the ink will leak if not sealed.

Table 2.2. *Test of Significant Difference of Butterfly Pea Flower Extract and Okra Mucilage as an Alternative Gel Ink for Pens of Various Formulations in Terms of Drying Time on Bond Paper*

Samples	Replicates (hr: min: sec)	F-Value
S1		6.19**
T1	0:25:41	
T2	0:25:54	
T3	0:27:08	
S2		
T1	1:06:07	
T2	1:12:54	
T3	1:11:32	
S3		
T1	1:52:39	
T2	3:21:52	
T3	1:19:04	

Legend: *** = Highly significant
** = Significant at 0.01 where 0<P<0.001
ns = Not Significant at 0.05 alpha

Table 2.2 presents the significant difference of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of drying time on bond paper. Based on the table, the F-value of 16.19 with the p-value of 0.03 suggests that there is a significant difference among the three samples of alternative gel ink for pens in terms of drying time on bond paper. Based on the data above, Sample 1 is the fastest to dry and Sample 3 is the longest to dry. Therefore, the null hypothesis of this study that there is no significant difference of Butterfly Pea Flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of drying time on the bond paper is rejected.

These results are also related to the results in pH level and viscosity. Notably, when the pH level is higher, viscosity decreases, and drying periods lengthen. All samples are not fast-drying, it takes 25 minutes to an hour before the alternative gel ink for pens dries, and it's because all samples have low viscosity. This is because gel ink takes longer to dry and absorbs into paper (Pen, 2022). But despite having the lowest viscosity and a higher pH level than Samples 2 and 3, Sample 1 dried the fastest.

This comes as a result of the 10% okra mucilage. The mucilage found in okra is a gel that is not easy to evaporate (Alipio M., 2020). Sample 2 and Sample 3 had more okra mucilage than Sample 1, which only had 10% of it. Sample 2 contains 25% and sample 3 has 50% okra mucilage, respectively. As a result, sample 3 took the longest to dry since the more okra mucilage there is, the longer it takes to dry.

Table 2.3. *Test of Significant Difference of Butterfly Pea Flower Extract and Okra Mucilage as an Alternative Gel Ink for Pens of Various Formulations in Terms of the Surface Area of Dropped Ink on the Bond Paper*

Samples	Replicates (cm^2)	$\bar{x}$ (cm^2)	F-Value
S1			
T1	6.3		
T2	10.2	7.42	
T3	5.75		
S2			
T1	5		
T2	4.73	5.04	0.85ns
T3	5.4		
S3			
T1	6.6		
T2	1.92	5.56	
T3	8.16		

Legend: *** = Highly significant
** = Significant at 0.01 where 0<P<0.001
ns = Not Significant at 0.05 alpha

Table 2.3 presents the significant difference of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of surface area of the ink dropped on the bond paper. Based on the table, Sample has a mean of 7.42 cm2, Sample 2 has a mean of 5.04 cm2, and Sample 3 has a mean of 5.56 cm2, with the F-value of 0.85 and p-value of 0.47, it suggests that there is no significant difference among the three samples of alternative gel ink for pens in terms of the surface area of the ink dropped on the bond paper. Since the ink in its various formulations spread out in the bond paper during its drying time, all of the samples have a large surface area. Therefore, the null hypothesis of this study that there is no significant difference of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of the surface area of the dropped ink on the bond paper is accepted.

The three Samples of the alternative gel ink for pens spread on the bond paper. This is because gel ink takes longer to dry and absorbs into paper, and it is more prone to spreading and "bleeding" through the paper (Pen, 2022). Even though the surface area of the samples does not significantly differ, based on the table, Sample 1 has the largest surface area among the samples, indicating that it spread out more. Throughout the drying process, Sample 1 spread out more since it contains 90%

Butterfly Pea flower extract, which means it has more water in it. Sample 2 which contains 75% Butterfly Pea flower extract and 25% Okra mucilage and Sample 3 which contains 50% Butterfly Pea flower extract and 50% Okra mucilage have a closer surface area.

Table 2.4. *Test of Significant Difference of Butterfly Pea Flower Extract and Okra Mucilage as an Alternative Gel Ink for Pens of Various Formulations in Terms of Color*

Samples	Replicates	x̄	F-Value
S1			
D1	2		
D2	2	2	
D3	2		
S2			1.5ns
D1	2		
D2	2	1.67	
D3	1		
S3			
D1	2		
D2	1	1.33	
D3	1		

Legend: *** = Highly significant
** = Significant at 0.01 where 0<P<0.001
ns = Not Significant at 0.05 alpha

Table 2.4 presents the significant difference of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of color. Based on the table, Sample 1 has a mean of 2, Sample 2 has a mean of 1.67, and Sample 3 has a mean of 1.33, with an F-value of 1.5 and p-value of 0.30. It suggests that there is no significant difference among the three samples of alternative gel ink for pens in terms of color. The color of the ink was blue then it changes into light blue. Although the color of Sample 1 didn't change after 3 days, it will still change after a few days, since at the time it was made, all samples changed color, from dark blue, it turned to blue, light blue, and purple, and vice versa. Therefore, the null hypothesis of this study that there is no significant difference of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of color is accepted.

The data above reveals that the alternative gel ink is color-changing. This is all because one unique feature of Butterfly Pea flower extract is the ability of the extract to change color, four different colored forms of anthocyanin exist, and they can change back and forth purely based on the pH (Campbell et al., 2022). The study of Torres (2018) revealed that Butterfly Pea extract is labile to pH, light, and temperature: In an acidic environment (pH 4.0), the Butterfly Pea anthocyanin extract solution turned red; at higher pH levels (pH 11.0), it turned purple. It has the highest total anthocyanin content when the solution is 4°C in a dark area and has the lowest anthocyanin content when the solution is stored at 50°C. Thus, all samples are color-changing caused by the change in pH level. At the time it was made all samples were dark blue, then they turned blue, light blue, and violet after some minutes depending on the temperature and light. To maintain the blue color of the alternative gel ink, the researchers decided to store it in the refrigerator. With 2° Celsius, the alternative gel ink maintained its dark blue color.

IV. CONCLUSION and RECOMMENDATIONS

Summary of Findings:

The summary of findings is presented according to the sequence of presentation of data.

From the discussion of the results, the data revealed the following:

pH level

The three samples were not acidic. The pH level of Sample 1 was 9 which indicates that it is alkaline and Samples 2 and Samples 3 were both 7 which indicates that it is basic. The results indicate that there is no significant difference of Butterfly Pea flower extract and

Okra mucilage as an alternative gel ink for pens of various formulations in terms of pH level.

Viscosity

Among the three samples, Sample 1 has the lowest viscosity, and Sample 3 has the highest viscosity. The results indicate that there is a significant difference ($p<0.05$,) of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of viscosity. However, the three samples have low viscosity.

Drying Time (on bond paper)

Sample 1 takes 26:14 to dry, Sample 2 takes 1:10:11 to dry, and Sample 3 takes 2:11:12 to dry. Therefore. Sample 1 is the fastest to dry and Sample 3 is the slowest to dry. The results indicate that there is a significant difference($p<0.05$) of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of drying time on bond paper.

Surface area of dropped ink on the bond paper

The surface area of Sample 1 was 7.42 cm2, Sample 2 was 5.04 cm2, and Sample 3 was 5.56 cm2. All samples have a closer surface area, but Sample 1 spread more than Samples 2 and 3. The results indicate that there is no significant difference ($p>0.05$) of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of surface area of dropped alternative gel ink on bond paper.

Color

The color of ink written on the bond paper was observed within 3 days. Sample 1 maintained its blue color after 3 days, Sample 2 changed to light blue on day 3, and Sample 3 changed color to light blue on day 2. However, all samples show changes in color by the time it was made. This color-changing effect is one of the unique features of Butterfly Pea flower extract. Thus, all samples are color-changing and the results show that there is no significant difference ($p>0.05$) of Butterfly Pea flower extract and Okra mucilage as an alternative gel ink for pens of various formulations in terms of color.

CONCLUSION

In this study, the alternative gel ink for pens made from Butterfly Pea flower extract and Okra mucilage in various formulations shows qualities that make the alternative gel ink possible to be used in refilling empty pen ink cartridges. Compared to commercial inks, this has no chemicals and helps reduce plastic waste which makes it eco-friendly. Based on the data collected, the three samples have no significant difference in terms of pH level, surface area of the dropped ink on the bond paper, and color. Hence, in terms of viscosity and drying time on bond paper, results show that there is a significant difference among the various formulations of the alternative gel ink. Among the samples, Sample 1 has the greatest pH level, and lowest viscosity, dries the fastest, broadest surface area coverage, and can change color. Sample 2 has the same pH level as Sample 3, ranks as the second most viscous, second fast-drying, with the smallest surface area coverage, and also changes color. Sample 3, mirroring the pH level of Sample 2, is the most viscous, the slowest to dry, with the second largest surface area coverage, and can change color as well.

RECOMMENDATIONS

The researchers have several recommendations that can be made to enhance the quality of the Butterfly Pea flower extract and Okra pods as alternative gel ink for pens.

1. May try different formulations to find the best formulation.
2. May try other thickening agents to make the alternative gel ink more viscous.
3. Use Zahn Cup Viscometer or Vibrational Viscometer for accurate measurement of viscosity.
4. Put some additives to enhance and maintain the blue color of the alternative gel ink as well as to make it fast-drying.
5. Conduct other tests based on the components, characteristics, or qualities of the ink.

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