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Development of Banana Fiber Yarn for Crochet

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ABSTRACT

Researchers have developed a crochet yarn made from banana fiber, exploring sustainable alternatives in the textile industry and offering an eco-friendly option to synthetic yarns. This initiative supports the biodegradability and recyclability of banana fiber, addressing environmental concerns linked to synthetic yarns. Through various experiments, the best method for fiber extraction was identified using a DIY decorticator machine, with decayed banana stems providing stronger fibers. Despite challenges in softening the fibers, blending them with cotton fiber, guided by the Department of Science and Technology-Philippine Textile Research Institute, enhanced the yarn's strength and softness. Natural dyes from sources like annatto seeds and turmeric were used, further minimizing environmental impact. Feedback from yarn merchants, manufacturers, and crocheters has been positive, noting the yarn's satisfactory color and softness. Tensile strength tests and twist measurements indicate good physical properties, making banana fiber yarn a promising sustainable alternative for the crochet community.

Keywords: *banana fiber, banana pseudostem, crochet, natural fiber, sustainable yarn, and synthetic yarn*

1.0 Introduction and Background Information

The future of sustainable fibers is bright. As more people become aware of the textile industry's environmental impact, there is a growing need for sustainable yarns using natural fiber with natural dyes to create a beautiful and vibrant range of colors on banana fiber that can be used to construct various crochet projects.

1.1 Background of the Study

1.1.1 Environmental Impact of Synthetic Textiles

The global textile industry is considered a significant polluter. As stated by the United Nations Environment Programme (UNEP), it is responsible for 20% of global wastewater, 10% of carbon emissions, and massive volumes of garbage. Synthetic yarn manufacture is particularly polluting because it involves using fossil fuels. Singh et al. (2020) state that although the impacts of these synthetic fiber pollutants are still mostly unknown, the scientific community is gradually studying them because it is anticipated that MF environmental contamination will rise rapidly in the near future.

1.1.2 Banana Fiber as a Sustainable Alternative

Agricultural waste from banana plants grown exclusively for fruit production often increases yearly as banana cultivation expands to meet the needs of a growing global population—the evaluation of banana plant agricultural waste as fiber expands the range of usage of banana fiber. The areas of usage of banana fibers, notably valued in composite materials, are expanding daily due to their sustainable, biodegradable, renewable, and easily accessible

1.1.3 The Philippines: A Leading Banana Producer with Untapped Potential

The Philippines is one of the leading producers of bananas in the globe. In 2014, it was recognized as the world's third-largest banana producer, trailing only India and China (Banana: Industry Strategic Science and Technology Plans (ISPs)). As stated by Tenerife et al. (2019), fiber is growing more popular as a raw material for various products. It can be taken from seeds, leaves, fruits, and stems. The banana is one of the most extensively produced in the Philippines. Every year, a large amount of banana stems are discarded after harvesting. It is considered a waste product after fruit harvesting and cutting the banana plant. This cylindrical pseudostem included natural fiber known as banana fiber, a lingo-cellulosic fiber formed from the banana fiber and may be gathered manually. Currently, tons of banana pseudostems are dumped as waste, and most of our farmers are having significant issues disposing of them. As a result, collecting banana fiber and developing possible products such as yarn alternatives for synthetic fibers is a realistic economic solution to tackling this environmental challenge.

1.1.4 The Benefits of Natural Fibers for the Economy and Environment

The natural fiber industry can create jobs for more than 2 million people, tiny farmers and cottage industries. It will help rural residents make money by generating employment in the fiber extraction industry (Sangamithirai & Vasugi, 2020). In addition, it is an alternative approach to overcoming the issue of pollution by producing natural fibers. Due to its accessibility, renewability, and sustainability, banana plant waste is used as a fiber for various applications, including composite materials, biodegradable materials, and essential textile materials (Unal et al., 2022).

1.1.5 Innovation in Yarn Production: Banana Fiber and Natural Dyes

The researchers are the first in the Philippines to create a yarn using banana fiber for crochet. The study by Subagyo and Chafidz (2020), which claims that a variety of products, comprising handicrafts, absorbent polymer/fiber composites, fishing nets, rope, cordage, mats, packing material, paper sheets, textile fabrics, bags, tablecloths, and other related items are already available on the market, provides support to this claim. Wijanto (2019) stated that banana fiber treated with a 5% concentration of NaOH shows largest moduli of elasticity and tensile strength. However, this study did not follow this method because it made the product stiff and coarse, which is unsuitable and not recommended for crocheting yarn. Also, the researchers decided to combine the banana and cotton fiber so that it would be softer and stronger. This claim is supported by the study of Doshi (2017) stating that banana fiber is stiff due to its high lignin content. Furthermore, it needs to be softened to be used in a textile. The researchers used natural dyes such as annatto seeds and coconut husk to color the yarn because according to the research done by Ardila-Leal et al. (2021), the textile industry is the highest contributor to colored wastewater. About 20% of the dye used to color textile fibers is improperly discarded in the wastewater, leading to high pollution. Because of their chemical content and structure, synthetic colors damage the environment as their components are not biodegradable.

1.1.6 Banana Fiber as a Sustainable Substitute for Synthetic Yarn

The study explored using banana fiber as a substitute for synthetic yarn. Natural fiber made from bananas is biodegradable, recyclable, and has several benefits over other natural fibers, including affordability, lightweight, non-toxic, comparable durability, and little waste disposal issues. An overview of banana fiber behavior under chemical and environmentally friendly treatments is provided in this article. An overview of banana fiber behavior under chemical and environmentally friendly treatments is provided in this article. (Mamun et al., 2021). The yarn for crochet made from natural resources such as banana fiber, cotton, and natural dye will be an effective alternative to synthetic yarn for crochet; the respondents evaluated the color and stiffness of the yarn that is made from banana fiber to assess its effectiveness. This study aims to boost farmers' profits, create jobs in rural fiber extraction, reduce pollution, reduce chemical usage, and promote biodegradable natural resources in the textile industry.

1.2 Objectives of the Study

The main objective of the study is to produce a natural alternative yarn for crochet, boost farmers' profits, reduce pollution, reduce chemical usage, and promote biodegradable natural resources in the textile industry.

2. Statement of the Problem

General

The general problem of the study is: How can banana fiber be an alternative material for synthetic yarn?

Specific

Specifically, it aims to answer the following questions:

1. How is yarn made from banana fibers for crocheting made?
2. How may the banana fiber yarn for crochet be evaluated based on:

3.1 color; and

3.2 stiffness?

3. How may Department of Science and Technology-Philippine Textile Research Institute (DOST-PTRI) evaluate the developed banana yarn crochet in terms of:

2.1 tensile strength and elongation;, and

2.2 twist?

2.1. Review of Related Literature

This study has three themes: Banana fiber is a natural fiber that has been used for centuries to make various products including textiles, paper, and handicrafts. It is a strong, durable, versatile fiber that is also sustainable. Crochet is a textile-making process that uses a hooked needle to interlock loops of yarn or thread, and crafters can use it as a popular craft to make various items, such as clothing, blankets, and accessories. Natural Resources, in recent years, had a growing interest in using natural fibers in crochet. This is due to some factors including the increasing awareness of the environmental impact of synthetic fibers and the desire to use sustainable materials.

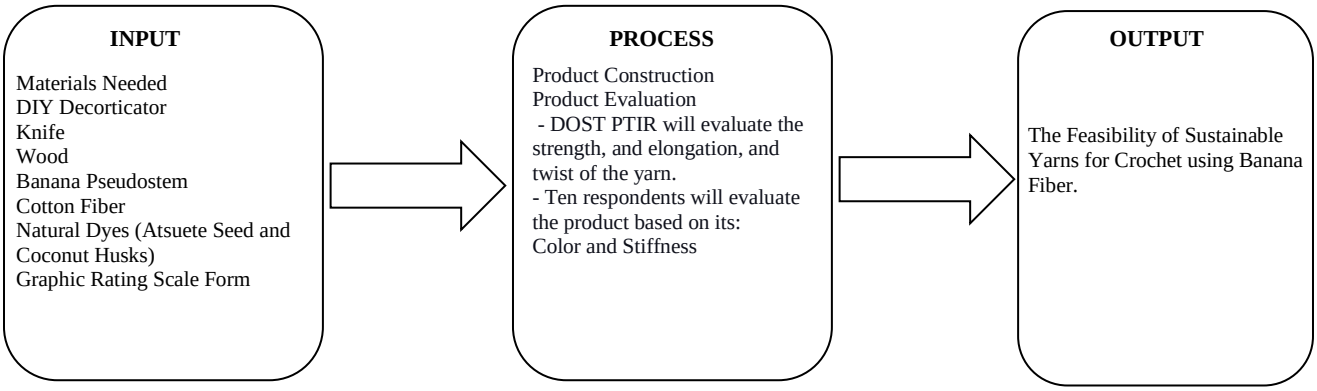
A natural fiber from the banana pseudostem is becoming increasingly popular as an eco-friendly alternative to synthetic fibers. Its practicality, durability, and biodegradability make it a promising material for various applications. Researchers explore the use of banana fiber in textile manufacturing, as it is biodegradable, can replace synthetic fibers, and offers numerous applications. Banana fibers are also used in various industries, such as reusable sanitary pads, foreign currency, fabrics, and hair extensions. The DOST-Philippine Textile Research Institute is developing banana textile fibers for sustainable solutions in the textile industry.

An art form involving crochet hooks and fiber is used to create various products like hats, scarves, and blankets. Researchers at the University of Wollongong are exploring its potential as a mindfulness tool, with crochet being highly therapeutic. Tetel Cuevas, a doctor and crocheter, shares her experiences as a creative outlet, therapy, and connection maker. Crochet also provides academic and educational support to public school students and helps people cope with stress by focusing on the present.

This study explored the potential of natural fiber in creating advanced bios, durable, and biocomposite materials. Natural fiber composites offer unique qualities and low density, making them a cost-effective, renewable, and eco-friendly alternative to synthetic fibers. Banana pseudo-stem waste can be used as a bio-source for weaving yarn, providing advantages over synthetic materials like low density, stiffness, and mechanical qualities.

2.2 Conceptual Framework

Figure 1: Conceptual Framework of the Study



3.1. RESEARCH APPROACH

The researchers may use quantitative methods in studying the development of banana fiber yarn for crochet. Specifically, the study utilized a quasi-experimental method to examine the usage of banana fiber yarn for crochet as an alternative to synthetic yarns readily accessible on the market.

3.2. AREA OF STUDY

The study was conducted in Bulacan and Taguig City. These places were purposely selected because Bulacan has a yarn manufacturing factory, particularly in the industrial area of Marilao. This manufacturer produces various types of yarn for crocheting and other textile applications.In addition, there is one (1) manufacturer from Taguig City which was involved in the study since no other yarn manufacturers existed in Bulacan. However, there were crochet enthusiasts and professionals residing in Bulacan.

3.3. SAMPLE SIZE

The researchers utilized purposive sampling because the population sample consisted of two (2) manufacturers of yarn for crochet, three (3) experts in crocheting, and five (5) sellers of yarn for crochet. The study only needed ten (10) respondents because the researchers only used a do-it-yourself decorticator machine which led them to produce a limited crochet yarn made from banana fiber.

3.4. RESEARCH INSTRUMENT

In gathering the needed data for the study, the researchers utilized a researcher-made questionnaire based on the ISO standard of the yarn. The survey for the quantitative approach has two sections; the first section of the graphic rating scale is the demographic profile of the respondents, such as name, age, occupation, company name, and gender. The second section of the questionnaire focuses on participants' evaluations regarding the color and stiffness of the yarn made of banana fiber.

3.5. DATA PROCESSING AND STATISTICAL TREATMENT

After developing the banana fiber yarn, researchers provided participants samples to examine and assess. Using a Likert scale survey to measure agreement with statements about color and stiffness, the respondents were asked to indicate their level of agreement with the statement (strongly agree = very satisfied, strongly disagree = very dissatisfied). The researcher analyzed the data with mean and standard deviation to understand the overall satisfaction and variation in opinions on color and stiffness.

4. DATA ANALYSIS AND PRESENTATION

4.1. PROCESS OF BANANA FIBER EXTRACTION

The researchers utilized a D-I-Y decorticator, sliced the pseudo-stem, and removed the banana stem's inner sheath (IS). Smash the stem's outer half until softened, then strip the fiber with a D-I-Y decorticator. This procedure makes it easier to obtain the fiber since the fiber from the pseudo-stem is softer, separates its fiber, and fails to cut. This idea came from the video tutorial by Jennings, R. (2023); as stated by him, it helps to get more fiber than the cards he is scraping.

Figure 2: ***Decortication of fiber using D-I-Y decorticator made out of wood and knife***.

4.2 CHOOSING OF BANANA PSEUDOSTEM

The researchers opted to use a rotted banana stem. Its fibers are readily separated, and it is not as hard as a fresh stem since it is decayed. Even if the fiber is rotting, it is not difficult to cut, has good quality, and gains much fiber. As stated by Scispace (2022), the fibers removed from the pseudo stem of bananas offer good mechanical qualities, such as high elongation at breakage and tensile strength. This method satisfies the researchers because, due to its softness and not being easy to cut, it achieves the ideal length and appearance of the fiber.

Figure 3: ***Getting of fiber from decayed banana pseudostem***

4.3 SOFTENING OF BANANA FIBER

The researchers decided to use the untreated fiber to see if it would achieve the desired softness of the banana fiber. The excess cellulose fiber was removed manually and air-dried. This trial achieved the desired softness of banana fiber, which the researchers wanted.

Figure 4: ***The outcome of untreated banana fiber***

4.4 DYEING AND FINISHING

4.4.1 Coconut Husk

The coconut husks were divided into smaller pieces to increase the surface area for extraction. After that, the crushed husks were boiled in two (2) cups of water to extract the tannins. After boiling, the liquid was strained to remove any solid particles. Then, the fabric was immersed in the dye bath containing the extracted color from coconut husks. The fabric remained in the dye bath for five (5) hours. Finally, the fabric was rinsed thoroughly to remove any excess dye.

Figure 5: ***Coconut husk and the color of the varn usina coconut husk as a dve***

4.4.2 Turmeric

The first step was to grate the turmeric and boil one cup of water. Then, the researcher added the grated turmeric to the boiling water. Once the water boiled, the researcher soaked the banana yarn for one (1) hour.

Figure 6: ***The color of the yarn using turmeric as a dye***

4.4.3 Annatto

The researchers used three (3) sachets of annatto seed and 1 cup of water and mixed the annatto seed and water. It is an organic dye made from the annatto tree. Annatto is a suitable substance for cotton cloth and gives it an orange color. More mordant is needed to produce a color ranging from pale orange to reddish-orange. It provides a nice scent in the fabric materials (Fibre2Fashion, n.d.). The researcher soaked the fiber in the mixture for 30 minutes for the fiber to absorb extra water then dried.

Figure 7: ***The color of the yarn using annatto seeds***

4.4.4. Bougainvillea

The researchers also tried to make a dye using bougainvillea. The flowers are soaked, and the petals are gently steamed briefly. After extraction, strain the petals and put an equal amount of dye into one stainless pot, followed by one bougainvillea-dyed yarn sample. The results showed that natural colorant from bougainvillea flowers was as good as natural dye.

Figure 8: ***The color of the yarn using bougainvillea***

4.5 PERCEPTION OF THE COLOR AND STIFFNESS OF BANANA FIBER YARN

This section likely explores how users perceive banana fiber yarn based on evaluations of its color and stiffness. The table summarizes user evaluations of the color and stiffness of banana fiber yarn using a Likert scale. The scale ranges from 1 (Strongly Disagree/Very Dissatisfied) to 4 (Strongly Agree/Very Satisfied)

4.5.1 Descriptive Measure of the Color of Natural Yarn

Table 1

Seller

Indicators	Ave Rating	SD	Descriptive	Interpretations
1. The color tones of natural yarn are softer than those of synthetic yarn. (Ang kulay ng mga natural na yarn ay mas malambot kaysa sa mga sintetikong yarn)	2.80	0.45	Agree	Satisfied
2. Natural yarns have a unique color appearance than synthetic yarn. (Ang natural yarn ay may kakaibang kulay kaysa sa sintetikong yarn)	2.80	1.10	Agree	Satisfied
3. The color of natural yarn is more vibrant than synthetic yarn. (Ang kulay ng natural na yarn ay mas matingkad kaysa sa sintetiko na yarn)	1.60	0.55	Disagree	Dissatisfied
4. Natural yarn retains its color well over time. (Nananatili nang matagal na panahon ang kulay ng natural yarn)	2.40	0.55	Disagree	Dissatisfied
5. The color of natural yarn is more aesthetically pleasing and appealing than the color of synthetic fiber. (Ang kulay ng natural yarn ay mas maganda at kaakit-akit kaysa sa kulay ng sintetiko na yarn.	3.00	0.71	Agree	Satisfied
OVERALL	**2.52**	**0.67**	**Agree**	**Satisfied**

Table 1 showed that sellers are most satisfied with the colors of natural yarn. Particularly, the average was 3.0– this is likely because the coloring agents, being made out of natural ingredients, resulted in softer colors than those of synthetic yarn. The standard deviation of 0.71 suggested some commonality in respondents' experience. Natural dyes have never gone out of style for their beauty, and now they're gaining even more interest because they're better for the environment. Samanta (2020) highlights the growing environmental consciousness among consumers, leading to a renaissance of eco-friendly products and processes, including natural dyeing of fabrics.

However, there were also sellers who were dissatisfied with the lack of vibrancy in natural colors. The low average rating of 1.60 for vibrancy shows that, on average, respondents were unhappy with the brightness or intensity of natural colors. The SD value of 0.55 for this group further reinforces

the idea of a shared experience regarding the lack of vibrancy in natural colors. This suggests they likely found the colors to be too muted or dull to a similar degree. According to Harsito, et., al (2021) the co-pigmentation offers a potential solution to the issue of muted colors in natural dyes. By using this technique, dyers could have achieved brighter and more stable colors, potentially increasing the appeal of natural dyes compared to other options.

Table 2

Crocheter

Indicators	Ave Rating	SD	Descriptive	Interpretations
1. The color tones of natural yarn are softer than those of synthetic yarn. (Ang kulay ng mga natural na yarn ay mas malambot kaysa sa mga sintetikong yarn.)	3.00	0.00	Agree	Satisfied
2. Natural yarns have a unique color appearance compared to synthetic yarns. (Ang natural yarn ay may kakaibang kulay kaysa sa sintetikong yarn.)	2.67	1.15	Agree	Satisfied
3. The color of natural yarn is more vibrant than synthetic yarn. (Ang kulay ng natural na yarn ay mas matingkad kaysa sa sintetiko nayarn.n)	2.50	0.71	Agree	Satisfied
4. Natural yarn retains its color well over time. (Nananatili nang matagal na panahon ang kulay ng natural yarn)	2.67	0.58	Agree	Satisfied
5. The color of natural yarn is more aesthetically pleasing and appealing than the color of synthetic fiber. (Ang kulay ng natural yarn ay mas maganda at kaakit-akit kaysa sa kulay ng sintetiko na yarn.	2.33	0.58	Disagree	Dissatisfied
OVERALL	**2.63**	**0.60**	**Agree**	**Satisfied**

Table 2 showed that crocheters are most satisfied with the color tones of natural yarn. With an average of 3.00, this is likely due to the coloring agents being made out of natural ingredients, resulting in softer colors than those of synthetic yarn. The standard deviation of 0.00 suggested some commonality in respondent experience. Natural dyes have never gone out of style for their beauty, and now they're gaining even more interest because they're better for the environment. Samanta (2020) highlights the growing environmental consciousness among consumers, leading to a renaissance of eco-friendly products and processes, including natural dyeing of fabrics.

However, there were also crocheters who were dissatisfied that the natural colors are not aesthetically appealing. The SD value of 0.58 for this group further reinforces the idea of a shared experience regarding the aesthetically appealing in natural colors. Perhaps the selection of natural colors was restricted, with a lack of shades they found appealing. According to Harsito, et., al (2021) the co-pigmentation offers a potential solution to the issue of muted colors in natural dyes. By using this technique, dyers could have achieved brighter and more stable colors, potentially increasing the appeal of natural dyes compared to other options.

Table 3

Manufacturer

Indicators	Ave Rating	SD	Descriptive	Interpretations
1. The color tones of natural yarn are softer than those of synthetic yarn. (Ang kulay ng mga natural na yarn ay mas malambot kaysa sa mga sintetikong yarn)	3.00	0.00	Agree	Satisfied
2. Natural yarns have a unique color appearance than synthetic yarn. (Ang natural yarn ay may kakaibang kulay kaysa sa sintetikong yarn)	3.00	0.00	Agree	Satisfied

3. The color of natural yarn is more vibrant than synthetic yarn. (Ang kulay ng natural na yarn ay mas matingkad kaysa sa sintetiko na yarn)	2.00	0.00	Disagree	Dissatisfied
4. Natural yarn retains its color well over time. (Nananatili nang matagal na panahon ang kulay ng natural yarn)	3.50	0.71	Strongly Agree	Very Satisfied
5. The color of natural yarn is more aesthetically pleasing and appealing than the color of synthetic fiber. (Ang kulay ng natural yarn ay mas maganda at kaakit-akit kaysa sa kulay ng sintetiko na yarn.	3.00	0.0	Agree	Satisfied
OVERALL	**2.90**	**0.14**	**Agree**	**Satisfied**

Table 3 showed that manufacturers are most satisfied with natural-colored yarn because it retains its color well. The average rating of 3.50 is most likely due to coloring agents derived from natural ingredients generally offering good colorfastness compared to synthetic dyes. This is because natural dyes can form strong bonds with the fiber, making them less likely to fade over time. The standard deviation of 0.71 suggests high consistency in respondent experience. This could mean most respondents found the natural yarn to retain color well. Mohamed (2023) mentions the idea of dyeing banana-based fabric with reactive dyes, which are noted for their colorfastness. This suggests that dyed banana garments will likely hold their color well during washing, possibly better than cotton.

However, there were also manufacturers who were dissatisfied with the lack of vibrancy in natural colors. The low average rating of 2.00 for vibrancy shows that, on average, respondents were unhappy with the brightness or intensity of natural colors. The SD value of 0.00 for this group further reinforces the idea of a shared experience regarding the lack of vibrancy in natural colors. This suggests they likely found the colors to be too muted or dull to a similar degree. As suggested in the research, according to Hosseinnezhad et., al (2021) to improve the performance of natural dyes. Biomordants can be a more sustainable alternative to traditional mordants to improve dye quality.

4.5.2 Descriptive Measure of the Stiffness of the Natural Yarn

Table 4

Seller

Indicators	**Ave Rating**	**SD**	**Descriptive**	**Interpretations**
1. Yarn made out of banana fiber is softer than synthetic yarn. (Ang yarn na gawa sa fiber ng saging ay mas malambot kaysa sa sintetiko na yarn)	2.20	1.10	Disagree	Dissatisfied
2. The yarn made from banana fiber is comfortable and feasible to use. (Ang yarn na gawa sa fiber nang saging ay kumportable at maaaring gamitin.)	3.00	0.71	Agree	Satisfied
3. The yarn that is made out of banana fiber is not elastic. (Ang yarn na gawa sa fiber ng saging ay hindi nababanat.)	3.60	0.55	Strongly Agree	Very Satisfied
4. The yarn that is made out of banana fiber feels like a premium yarn. (Ang yarn na gawa sa fiber ng saging ay parang isang premium na sinulid.	2.80	0.84	Agree	Satisfied
5. The softness of the yarn that is made out of banana fiber is more suitable for crocheting than synthetic yarn. (Ang lambot ng yarn na gawa sa fiber ng saging ay mas angkop para sa pag gantsilyo kaysa sa sintetiko na yarn.	3.00	1.00	Agree	Satisfied

OVERALL	**2.92**	**0.84**	**Agree**	**Satisfied**

Table 4 showed that sellers are most satisfied with the yarn that was made out of banana fiber and is not elastic. With an average of 3.60, this is likely because banana yarn, with its low elasticity, is a good fit for some sellers' needs, particularly those working on projects that benefit from a less stretchy material. The standard deviation of 0.55 suggests some commonality in respondent experience. This can be attributed to banana yarn's low elasticity, which aligns well with the needs of certain sellers, especially those creating projects that benefit from a less stretchy material. Low stretch yarn is used in textiles to help create products and fibers with better shape retention and less wrinkling. Elastic yarn is a type of yarn that causes minimal stretching under tension (Incognito Insights, 2023).

However, there were also sellers who were dissatisfied with the softness of banana yarn. The low average rating of 2.20 suggests that softness may be a limitation for certain projects. The SD value of 1.10 for this group suggests that softness may be a limitation of banana yarn for some sellers, while others may have found the softness acceptable for projects requiring firmer materials. According to Sewport (2021) it is utilized for coarse purposes, banana fiber has evolved with technological expertise, now being utilized in home décor and business, despite its historical limitations.

Table 5

Crocheter

Indicators	**Ave Rating**	**SD**	**Descriptive**	**Interpretations**
1. Yarn made out of banana fiber is softer than synthetic yarn. (Ang yarn na gawa sa fiber ng saging ay mas malambot kaysa sa sintetiko na yarn)	2.67	1.15	Agree	Satisfied
2. The yarn made from banana fiber is comfortable and feasible to use. (Ang yarn na gawa sa fiber nang saging ay kumportable at maaaring gamitin.)	2.33	0.58	Disagree	Dissatisfied
3. The yarn that is made out of banana fiber is not elastic. (Ang yarn na gawa sa fiber ng saging ay hindi nababanat.)	3.67	0.58	Strongly Agree	Very Satisfied
4. The yarn that is made out of banana fiber feels like a premium yarn. (Ang yarn na gawa sa fiber ng saging ay parang isang premium na sinulid.	2.33	0.58	Disagree	Dissatisfied
5. The softness of the yarn that is made out of banana fiber is more suitable for crocheting than synthetic yarn. (Ang lambot ng yarn na gawa sa fiber ng saging ay mas angkop para sa pag gantsilyo kaysa sa sintetiko na yarn.	2.00	0.00	Disagree	Dissatisfied
OVERALL	**2.60**	**0.58**	**Agree**	**Satisfied**

Table 5 showed that crocheters are most satisfied with the yarn that was made out of banana fiber and is not elastic. With an average of 3.67, this is likely because banana yarn, with its low elasticity, is a good fit for some sellers' needs, particularly those working on projects that benefit from a less stretchy material. The standard deviation of 0.58 suggests some commonality in respondent experience. This can be attributed to banana yarn's low elasticity, which aligns well with the needs of certain sellers, especially those creating projects that benefit from a less stretchy material. Elastic fibers have the potential to impart stretching behavior into fibers. Stretching characteristics improve the welcoming features of textiles, such as comfort, flexibility, and fit (Smm et al., 2020).

However, crocheters were also dissatisfied with the softness of the banana yarn, despite it being suitable for crocheting in other ways. The low average rating of 2.00 suggests the inherent softness of the yarn was the issue. The SD value of 0.00 indicates that crocheters in the study found the softness equally unacceptable for crocheting, likely because it's not suitable for projects requiring soft materials. According to Sewport (2021) it is utilized for coarse purposes, banana fiber has evolved with technological expertise, now being utilized in home décor and business, despite its historical limitations.

Table 6

Manufacturer

Indicators	Ave Rating	SD	Descriptive	Interpretations
1. Yarn made out of banana fiber is softer than synthetic yarn. (Ang yarn na gawa sa fiber ng saging ay mas malambot kaysa sa sintetiko na yarn)	2.00	0.00	Disagree	Dissatisfied
2. The yarn made from banana fiber is comfortable and feasible to use. (Ang yarn na gawa sa fiber nang saging ay kumportable at maaaring gamitin.)	3.00	0.00	Agree	Satisfied
3. The yarn that is made out of banana fiber is not elastic. (Ang yarn na gawa sa fiber ng saging ay hindi nababanat.)	3.00	0.00	Agree	Satisfied
4. The yarn that is made out of banana fiber feels like a premium yarn. (Ang yarn na gawa sa fiber ng saging ay parang isang premium na sinulid.	3.00	0.00	Agree	Satisfied
5. The softness of the yarn that is made out of banana fiber is more suitable for crocheting than synthetic yarn. (Ang lambot ng yarn na gawa sa fiber ng saging ay mas angkop para sa pag gantsilyo kaysa sa sintetiko na yarn.	3.00	1.4	Agree	Satisfied
OVERALL	**2.80**	**0.28**	**Agree**	**Satisfied**

Table 6 showed that manufacturers are most satisfied with the softness of the banana yarn, despite it being suitable for crocheting in other ways. The average was 3.00 this is likely because banana yarn softness is suitable for crocheting. The standard deviation of 1.4 suggests that most manufacturers found the softness of banana yarn to be acceptable for crocheting. However, there was some variation in their experiences, possibly due to differing project requirements. According to Hossain et., al (2017) banana fiber was blended with cotton in ratios, and yarn was produced using ring and rotor spinning systems and strength of the yarn has grown with an increase in banana fiber content, and hairiness of the yarn has increased with an increase in banana fiber component

However, there were also manufacturers who were dissatisfied with the softness of banana yarn. The low average rating of 2.20 suggests that softness may be a limitation for certain projects. The SD value of 1.10 for this group suggests that softness may be a limitation of banana yarn for some sellers, while others may have found the softness acceptable for projects requiring firmer materials. According to Sewport (2021) it is utilized for coarse purposes, banana fiber has evolved with technological expertise, now being utilized in home décor and business, despite its historical limitations.

4.5.3 Descriptive Measure of the Overall Responses of Seller, Crocheter, and Manufacturer

Indicators	Ave Rating	SD	Description	Interpretation
SELLER				
1. Color (kulay)	2.52	0.67	Agree	Satisfied
2. Stiffness (tigas)	2.92	0.84	Agree	Satisfied
OVERALL	2.72	0.75	Agree	Satisfied
CROCHETER				
1. Color (kulay)	2.63	0.60	Agree	Satisfied
2. Stiffness (tigas)	2.60	0.58	Agree	Satisfied

OVERALL	2.62	0.59	Agree	Satisfied
MANUFACTURER				
1. Color (kulay)	2.90	0.14	Agree	Satisfied
2. Stiffness (tigas)	2.80	0.28	Agree	Satisfied
OVERALL	2.85	0.21	Agree	Satisfied

Overall

The overall rating of every respondent is considered satisfied. The standard deviation (SD) overall rating for color and stiffness in the seller was 0.75, which indicates some commonalities in the respondents' experiences with the synthetic yarn and indicates that the respondents agree with the color and stiffness of the banana fiber yarn. This means that it can be improved when it comes to the color and stiffness of the yarn. Cold muted hues are peaceful and comforting, and vibrant colors create feelings of liveliness and happiness.(How Do Colors in My Home Change My Mood? Color Psychology Explained, n.d.). Similarly, the standard deviation (SD) for the crocheter was 0.59, which indicates some commonalities in the respondents' experiences with the synthetic yarn and indicates that the respondents agree. Pertaining to the stiffness, synthetic yarn is slightly different because of its softness, The manufacturer with the lowest standard deviation, 0.21, indicates a few commonalities in the respondent's experiences using synthetic yarn and indicates that the respondents agree that the yarn stiffness is made of banana fiber. The elastic yarn is a type of yarn that produces minimal stretching under strain and the use of low stretch yarn in textiles assists in the manufacturing of products and fibers with better form retention and less wrinkling (Incognito Insights, 2023).

4.6 PERCEPTION OF TENSILE STRENGTH AND ELONGATION, AND TWIST OF BANANA FIBER YARN

This section shows the test and analysis that has been done by the Department of Science and Technology - Philippine Textile Research Institute to evaluate the tensile strength and elongation, and twist of the banana fiber yarn.

4.6.1. TENSILE STRENGTH AND ELONGATION OF BANANA FIBER YARN

The provided data represents the tensile strength characteristics of bananas blended with cotton yarn, obtained from a series of tests conducted under specific conditions using the Zwick/Roell Z010. The initial tension is applied to the sample before the actual testing begins, which in this case is 106 cN, and the rate at which the test is conducted is set at 180 mm/min, indicating how quickly the material is pulled until it breaks. The initial distance between the grips holding the sample was set at 500.00 mm, determining the initial conditions of the test.

Figure 9. ***Analysis of the Tensile Strength and Elongation of Banana Fiber Yarn***

The number of samples tested, which is 30 in this case, providing a sufficient sample size for statistical analysis and for the maximum force applied to the sample before it breaks, was recorded as 74.4 N or the strength of the yarn is almost equivalent to 7.5 kilos of rice or sand to attain the total rupture. According to the study by Latif, W. et al. (2018), the staple length and elongation at the break of cotton fiber are 6.6%. While the maximum elongation of the banana fiber yarn before it breaks is expressed as a percentage of the original length, which is 11.2%, and 58.6 N was measured as the force at

which the sample breaks. The elongation of the sample at the point of breakage is given as a percentage of 11.8% this measurement shows the flexibility and resilience of the product.

4.6.2. TWIST OF BANANA FIBER YARN

The twist of the yarn was counted using the ASTM D1423M-16 method, as suggested by the testing laboratory of DOST-PTRI because it was most applicable during the testing. ASTM D1423M-16 is a direct counting of twists per unit length that offers a straightforward and accurate approach (*Standard Test Method for Twist in Yarns by Direct-Counting*, n.d.). It can evaluate twist characteristics, such as twist per inch or direction. This approach ensures a comprehensive twist uniformity and consistency assessment across the entire yarn bundle.

Figure 10: ***Analysis of the Twist of Banana Fiber Yarn.***

RN: PTRI-022024-PHY-0210

Sample Code	Trial	Twist
PHY-0297	1	1.7
	2	1.5
	3	1.4
gl,cm	4	1.6
2.5	5	1.7
tw	average	1.580
5 cN	sd	0.130
direction	cv	8.252
Z	twist/cm	0.632
	twist/inch	1.580
No. of ply : 20	twist/m	63.200

Based on the data collected, the twist factor of the yarn is 5 cN (centinewtons). The yarn was subjected to five (5) trials, resulting in twist values of 1.7, 1.5, 1.4, 1.6, and 1.7 cN (centinewtons), respectively, and the average twist of the yarn across the five trials is calculated to be 1.580 cN (centinewtons) this measurement shows that the twist of banana fiber yarn is not tight compared to synthetic yarns. The standard deviation of 0.130 cN (centinewtons) and coefficient of variation of 8.252% indicates moderate variability in the twist measurements, suggesting relative consistency across the trials. The yarn exhibits a twist of 0.632 cN (centinewtons) per cm, 1.580 cN (centinewtons) per inch, and 63.200 cN (centinewtons) per meter. According to Kiron., M.I. (2021), the twist can be either in the Z direction or the S direction, depending on the orientation of the surface fiber with the yarn axis. The banana fiber yarn is twisted in the Z direction, likely indicating a Z-twist where fibers are twisted in a clockwise direction when viewed along the axis of the yarn.

5. Summary of Findings, Conclusions and Recommendations

1. **The process to create a banana fiber yarn for crochet.**

The research explored various methods for extracting fibers from banana pseudostems. Trial 1.1: Manual scraping using a knife followed by washing, boiling, and drying resulted in stiff fibers, which were ineffective for the desired outcome. Trial 1.2: Combining knife scrubbing and steel brush combing showed improved results but proved difficult with the steel brush. Trial 1.3: A DIY decorticator made from wood and nails resulted in rough fibers due to waste and manual scraping, proving ineffective. Trial 1.4: Utilizing a DIY decorticator machine yielded better results, especially with a decomposed stem, as it avoided cutting the fiber. The researchers decided to use the DIY decorticator and manually remove the excess cellulose by stripping it with their hands.

When choosing which stem has more suitable fiber, freshly cut banana stems were found to be too rigid for fiber extraction. The decayed pseudostem is much easier to get the fiber from and is stronger than the fresh stem. Attempts to soften banana fiber using sodium hydroxide solutions and boiling water were unsuccessful. The best results were achieved by air-drying untreated fibers after manually removing excess cellulose.

2. **The crocheters, yarn merchants, and yarn manufacturers evaluated the banana fiber yarn based on its color and stiffness.**

Merchants generally found natural yarn's color tones softer than synthetic yarn, while manufacturers appreciated its color retention over time. Crocheters were satisfied with natural yarn's softness and color tones but desired more vibrancy. Regarding stiffness, sellers and crocheters were generally pleased with the non-elasticity of banana fiber yarn.

3. **The Department of Science and Technology-Philippine Textile Research Institute (DOST-PTRI) evaluated the developed banana yarn crochet in terms of tensile strength and elongation, and twist.**

Tensile strength tests revealed a maximum force of 74.4 Newtons, equivalent to approximately 7.5-kilogram force, and a maximum elongation of 11.2%. Twist measurements indicated an average twist of 1.580 cN (centinewton) per inch or 63.200 cN (centinewton) per meter, with relative consistency across trials. The yarn exhibited a Z-twist, indicating clockwise fiber twisting along the yarn's axis.

Conclusion

The study revealed that using a DIY decorticator machine to extract fiber from the banana pseudostem produced the highest quality fiber. It is emphasized that it is better to utilize the rotted banana stem since it also contains the color employed, and it is better to do the second trials that satisfy the standard in color.

The respondents' feedback indicates satisfaction with the resultant yarn from banana pseudostems combined with cotton, particularly considering its color and stiffness. Suggested that the vibrant color is better than the light color since it becomes visually appealing. In terms of stiffness, the synthetic yarn is slightly different because of its softness, but generally, the other participants had a blast with the yarn developed from banana pseudo-stem.

The results highlight the potential of banana fiber yarn as a viable alternative for crochet, owing to its notable attributes of strength and elongation. The findings of the tensile strength tests showed a maximum force of Newton and an average twist, measured in centinewtons; these tests were found to be relatively consistent between experiments. In essence, banana fiber yarn is an excellent alternative for crochet because of its resilience. Nonetheless, users must conduct individual assessments to ascertain their adherence to specific yarn requirements.

Thus, this study serves as an initial reference for establishing standards in yarn utilization and provides valuable evidence supporting the durability of yarn derived from natural fibers, like synthetic yarn.

Recommendations

1. Based on the study's findings, it is recommended that crochet enthusiasts consider exploring banana fiber yarn as a viable alternative. A DIY decorticator machine for fiber extraction from banana pseudostems can produce high-quality fiber with desirable attributes such as strength and elongation.
2. Respondents' feedback further supports the potential of banana fiber yarn, particularly when combined with cotton, due to its favorable color and stiffness. However, making the colors more vibrant and bold is much better.
3. The consistent results from tensile strength tests validate the resilience of banana fiber yarn, making it a compelling choice for crochet projects. It is recommended for use in various applications where resilience is required. Also, it is recommended to ensure that the twist of the yarn is tight so that it will reduce the hairiness of the product.
4. However, users must conduct individual assessments to ensure the yarn meets specific requirements. This study provides valuable evidence supporting the durability of natural fiber yarns like banana fiber, serving as a reference for establishing standards in yarn utilization. Crochet enthusiasts are encouraged to explore the possibilities banana fiber yarn offers and incorporate it into their projects for a sustainable and resilient alternative. For the future, researchers are also recommended to explore the feasibility of this banana fiber yarn for crochet on the market.

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