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Banana Fiber: Environmental Friendly Fabric: A way to Health and Wealth

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Abstract: ***Banana is one of the rhizomatous plants and currently growing 129 countries around the world. It is the fourth most important global food crop. Different parts of banana trees serve different needs, including fruits as food sources, leaves as food wrapping, and stems for fiber and paper pulp. Historically, banana stems had been used as a source of fiber with the earliest evidence around the 13thcentury. But its popularity was faded after other convenient fibers such as cotton and silk were made available. As fiber industry has been developing to increase production efficiency, new fibers were then developed to effectively respond the consumer's need, including the production of man-made fibers using petroleum to optimize the fiber properties. The chemical use inevitably causes contamination in every environmental medias - water, soil and air, which directly affects human well-being and environment.***

In banana plantations, after the fruits are harvested, the trunks or stems will be wasted. Billion tons of stems and leaves are thrown away annually. Such waste provides obtainable sources of fibers, which leads to the reduction of other natural and synthetic fiber's production that requires extra energy, fertilizer, and chemical. The properties of banana fiber are good absorbent, highly breathable, quickly dry with high tensile strength. This research is to develop banana fiber from the plant that is available locally throughout the country of Thailand but rarely used as fiber source in textile industry. The focus of the study is to optimize the fiber producing processes of in an environmental friendly manner and decrease chemicals and toxic agents incurred. The findings were 25-30% yield for fiber collection and the mechanical process (fresh method) is an appropriate method of fiber extraction.

The yarn spinning and knitting were experimented but the results have not been satisfied, yet. Further study should be developed. As banana fiber can provide a wide variety of uses in textile and paper industry, the study the application of this locally and widely grown plant species for the sustainable development would be beneficial

Keywords: Banana fibers, Banana fabric, Environmental friendly textiles, Sustainability, Banana Buttermilk, Banana Pickle

I. INTRODUCTION

After the industrial revolution, synthetic component and chemistry have been developed to increase efficiency to fulfill the needs in textile production. It became one of many industries highly affecting on the environment, especially water and soil pollution.Textile production processes release some chemicals that contaminate water and soils resources, including fume emission. Cultivation of natural fiber, including fibers from plants and animals, requires the use of hazardous pesticide and chemical fertilizers to control and increase the quality.

Some of chemicals used during the process are toxic, not-biodegradable and thus change the physical environment. These unbalance natural resources resulting draught, heat, and high temperature of the world's atmosphere. Textile production processes are now shaping toward the concept of environmental-friendly and sustainable development. These ideas are not very new in textile industry. The progresses have been improving ranges of natural and environmental (eco)-friendly textile processes. Many efforts have been made in sciences and technology to develop environmental-friendly process to sustain relationship with the ecosystem. However, alternative materials should be considered. This research proposes an option of natural fiber, by- product from banana fruit cultivation, by suggesting a use of leftover banana trunk as fiber source in textile process.This research is to develop banana fiber collection. It is a continuation of fully utilizing banana plant from the researcher's previous research, Banana sap printing. The ultimate goal of the whole research is to fully utilize banana plant, which is an indigenous plant in india. The objectives of this research are(1) to study the use of banana trunk after its fruits are harvested,(2) to explore the possibility of using useless leftover banana parts as source of natural fibers for environmental friendly textile process, (3) to compare and develop the processes of fiber extraction, and finally (4) to investigate the use of banana fiber. The experiments include yield testing for fiber extraction, comparison for banana fiber extraction methods, investigation of banana yarn spinning, and banana fabric production trial. Utilizing this useless material will create another option to reduce using new material, including other cultivated fibers and synthetic petroleum base fibers.

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II. BANANA TREE INFORMATION

Banana is in Musa family. Banana plant is a large perennial herb with leaf sheaths that form pseudo stem. Its height can be 10-40 feet (3.0-12.2 meters) surrounding with 8-12 large leaves. The leaves are up to 9 feet long and 2 wide (2.7 meters and 0.61meter). Its fruits are approximately 4-12 inches (10.2-30.5centimeters). Different parts of banana trees serve different needs, including fruits as food sources, leaves as food wrapping, and stems for fiber and paper pulp. It is available through out india and Southeast Asian, Indonesia, Malaysia, Philippines, Hawaii, and some Pacific islands. This source of fibers provides great strength, used generally in particular products, such as tea bags and Japanese yen notes. Typically, banana plants are grown in 3 types; (1) food source, (2) decorative plants, and (3) starch and fibers sources (abaca). Abaca fiber has along history as a leading cordage fiber of the world, known as Manila hemp. Abaca is one kind of banana plants. The fiber is obtained from outer layers from the stalks of the abaca plant. It is light, strong, and durable. After extraction and dry, it provides a white lustrous color fiber. One particular characteristic of the abaca fiber over all other fibers of its class is the great strength and resistance to the action of water, therefore its particular adaptability for marine ropes. However, abaca's fruit is not human food source. It is specifically grown for fiber cultivation. Instead of growing banana tree only for fruit consumption and discard the trunks, the use of banana fibers after the fruits are harvested should be explored. Therefore, the focuses of this research is on banana fruit plant.

Figure - Indigenous banana plant in India

Indian indigenous banana plant in Musa family was selected for this research. It is a breed of Musa cuminata and Musa balbisiana banana plants. This banana, also called sweet banana, or kluay nam wa, from its taste, composes of various nutritious substances, such as, protein, fats, carbohydrate, ferrous, calcium, potassium, magnesium, Vitamin A, Vitamin C, riboflavin, and niacin. Generally, it takes approximately 12-16 months to yield. After banana fruits are harvested, their trunk will be wasted. Three trillion banana trees were thrown away every year. Hence, it will be highly advantageous to investigate the potential of this locally grown plant as fiber source. Textile production has been developing to increase efficiency to serve consumer's needs. As the convenience increases, villagers tend to neglect traditional fiber harvesting process and turn to synthetic fibers and chemicals to achieve production capability, including expensive imported fibers and yarns purchased from foreign traders, whereas the local cheap material available in their hometown is ignored. The significances of this study is using left-over banana trunk as raw material in environmental-friendly manner to optimize natural fiber processes and decrease chemical and toxic agents in the process. As the material is available locally, villagers are not necessary to purchase or grow new plant and using extra chemicals, fertilizers, or pesticides. Utilizing banana fibers will promote sustainable development in the community, since villagers will be able to produce this fiber in their household.

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III. DEVELOPMENT OF USING BANANA FIBER AND OTHER NATURAL FIBERS

Development of Using Banana Fiber and Other Natural Fibers. The research and development in utilizing banana fiber have not been generally conducted. Currently, there are only a few developments trying to fully utilize natural fibers, including banana fibers and its parts. In Australia, the researcher has developed paper technology by using banana trunk as raw material and cross-plying technique (papyrus paper technique) to produce banana paper. Banana paper is much stronger than regular paper. They use it for cement bags (25 kilograms weight)and other heavy duty bags. Since the tenacity of banana fibers very high, therefore some automobile companies use it to reinforce the body of the vehicle. The European Union's legislation forced producers to increase their products' recyclability and biodegradability. Efforts have been made in the environmental conscious to avoid high disposable cost according to the legislation. For example, Daimler Chrysler, a global corporation, maintains the standards of environmental concern in their operation in other countries where these requirements are not yet exist. Since natural fibers such as coconut, banana, is 100% biodegradable, there is no significant energy costs associated with processing waste and recycling because the waste fibers are wither fed back into the processing cycle. Coconut fiber is employed for headrest and car seat. Consequently, using natural fiber products provides value in projecting a positive public image. Scholars have explored banana fibers in composite material. Cellulosic fibers, such as banana fiber, are used decrease cost as filler in plastic industry (composite material). The composite with high tensile strength can be obtained using banana combined with glass fiber in the fabric form. The strength impact of the composites increases with the number of layers and fiber volume fraction.

Table - Banana fiber properties

Fiber properties	
Tenacity	29.98 g/denier
Fineness	17.15 Denier
Moisture Regain	13.00 %
Elongation	6.54
Alco-ben Extractives	1.70 %
Total Cellulose	81.80 %
Alpha Cellulose	61.50 %
Residual Gum	41.90 %
Lignin	15.00%

The data is compiled of information from: (1) Fiber Properties. Philippines Textile Research Institute (2022), (2) Indian Textile Institute (2022), and this research experiment.

Banana fiber is a natural fiber with relatively good mechanic properties. The diminutive second-generation Mercedes-Benz A-Class designed the spare tire recess covered with a composite material, polypropylene thermoplastic with embedded bananafibers, abaca, with high tensile strength and rot-resistant. It can withstand stone strikes and exposure to the environment, such as ultraviolet from the sun, water, some chemicals. Using abaca fiberis saving energy because conventional glass fibers production requires 60% more energy than this natural fiber. According to environmental concerns in European countries, recently, natural fibers play an important role as reinforcing fillers in polymer composites. The advantages of natural fibers over synthetic fibers are their low cost, less tool wear during the process, low density, environmental friendliness and biodegradability. For that reason, banana fibers will be another option to be investigated for its fiber source potential. This research focused on the amount of fiber extraction, the comparison of fiber extraction methods, the investigation of yarn spinning, and knitted fabric. The findings from this research presented that the yield test of is acceptable for house hold production. The result expresses the possibility for more exploration in industrial arena, which should include the whole process of fully utilizing banana plant after fruit harvesting, covering banana sap, banana fiber, and banana pulp.

IV. EXPERIMENT

Indian indigenous banana plant in Musa family was selected for fiber extraction. The research employed motor drive invented machine to extract banana sap, banana pulp, and banana fiber. After cleaning, banana fiber was air dried. The researcher compared the fiber collection methods, fermented extraction and fresh extraction. Then, the fibers was combed and carded in regular natural fiber production process. The fiber property tests include fiber fineness, tensile strength, elongation, and moisture regain. The research utilized open-ended spinning process for this study.

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A. Banana Fiber Collection Process

In banana plantations, after the fruits are harvested, the trunks or stems will be discarded. These wastes provide obtainable sources of fibers, which leads to the reduction of other natural and synthetic fibers' production that requires extra energy, fertilizer, and chemical. The properties of banana fiber are good absorbent, highly breathable, quickly dry with high tensile strength.

Figure - Banana trunk from the plantation to Final Fibers

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B. Banana Fiber Extraction

Historically, banana fiber was extraction by hand. The process requires a long period of time and skilled practice to collect fibers. This research employed an invented motor-driven machine as extraction tool.

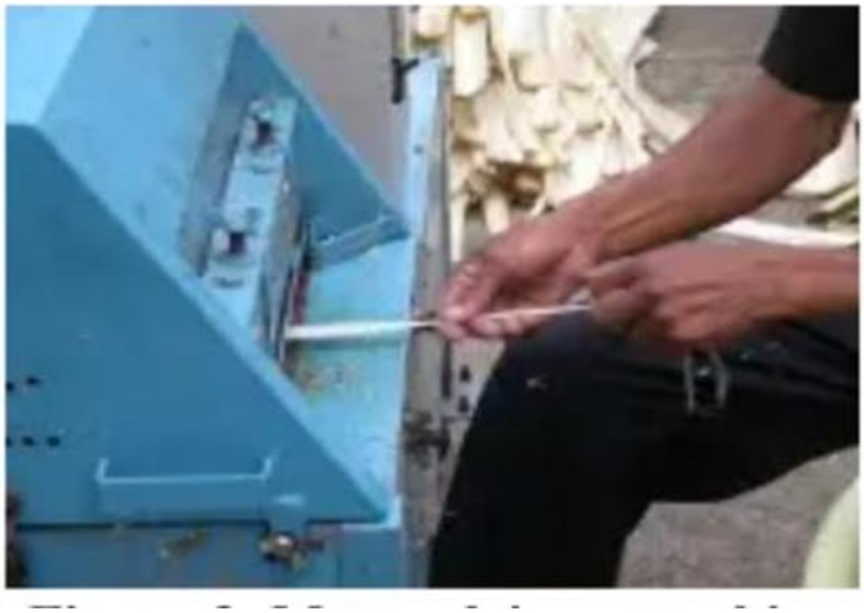
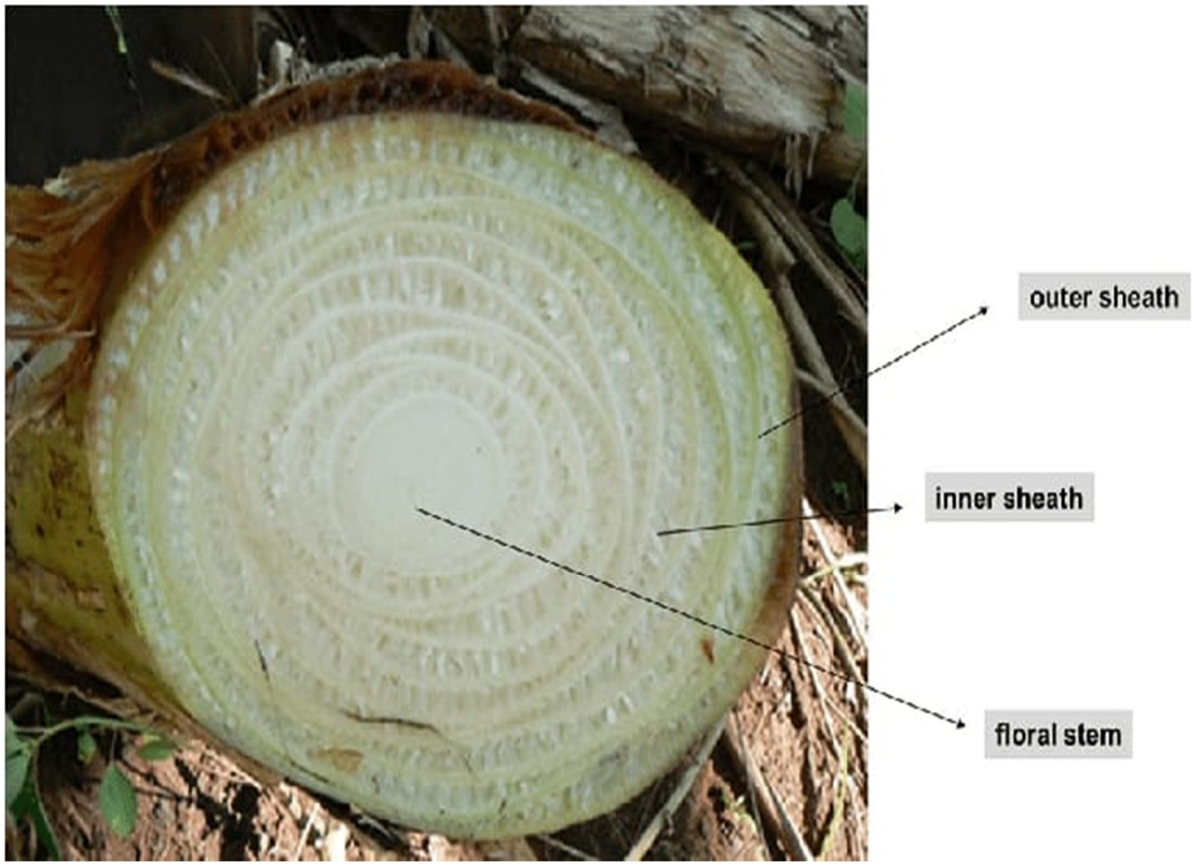


Figure - Motor-driven machine



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V. NUTRITIOUS CONSUMABLE PRODUCTS OUT OF STEM

A. Banana Stem Buttermilk Drink Recipe | Vazhaithandu Mor

Constipation is becoming a very frequent discomfort among elders and a habitual problem among youngsters. Kway gives its readers, recipes' which not only gives different flavours to your taste buds but also helps to stay healthy. This month we share a simple but yet a very exotic drink which will definitely help your constipation flee away. Every part of the banana is packed with nutrition and health benefits. Banana stem is said to be a diuretic and helps detoxify the body. It is used prevent and treat kidney stones.

1) Ingredients

Banana stem / Plantain stem / Vazhaithandu – 1/2 feet
Curd – 1/4 cup
Salt – to taste
Finely chopped fresh coriander leaves.
Note: using tender stem straining the juice can be skipped.
Banana stem is a rich source of fibre and helps in weight loss. Its high fibre content creates a feeling of satiation. It helps ease constipation. Banana stem is rich in potassium and vitamin B6 just like the fruit. Vitamin B6 helps in production of haemoglobin and insulin. It also helps prevent high blood pressure, and maintain fluid balance within the body.

B. Vazhapindi (Vazhakambu) Achar | Banana Stem Pickle

Vazhapindi (Vazhakambu) or banana stem has many health benefits. The popular health benefits include ample amount of fiber, increases production of haemoglobin, and acts as a diuretic thereby prevents constipation, treats anaemia and prevents urinary tract infections. Today's recipe is a pickle recipe with Vazhapindi(banana stem) which may not yield all the benefits of vazhapindi (banana stem). But for a change,you can give this a try. I have already posted a stir fry recipe with vazhapindi (banana stem) thoran which is a much healthier version. This is quite simple to make and the only work is removing of the strings that can be pulled while cutting. This was liked by many of my friends and there was a big demand for this pickle in my lunch pack. The flavor is regular like any other pickle but there is something unique about this pickle. Try and enjoy !

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Preparation time~ 20 minutes
Cooking time ~20 minutes
Serves ~ a small bottle
Author ~ Julie

1) Ingredients
banana stem / vazhapindi 2 cups cut in 1" or 3/4"
ginger 1 tbsp. chopped
garlic 1 tbsp. chopped
asafoetida / kayam podi 1/2 tsp
uvula podi/ fenugreek powder 1/2 tsp
chilli powder 4 tsp
turmeric powder 1/2 tsp
salt to taste
gingelly oil 3 tbsp.
mustard seeds 1 tsp
curry leaves 2 sprig
vinegar 2 tsp (optional)

VI. HOW DID I PREPARE?

Wash the banana stem (vazhapindi) and use only the core of the banana stem (vazhapindi).The other flaps around can be discarded(see pic below). Cut the banana stem(vazhapindi) roundels in 2" length. Remove the strings using fingers and then slice or chop the banana stem in medium thick vertical strips(it shrinks on frying so its better to keep slightly bigger pieces). Keep aside.

1) Heat oil in a pan and add gingelly oil. Add the chopped banana stem(vazhapindi) and saute for 5 minutes until the banana stem leaves out water and shrinks. Keep stirring until the water content is completely dried up and the banana stem(vazhapindi) looks slightly fried (read notes).
2) Drain the banana stems in a plate and keep aside.
3) Splutter mustard seeds, curry leaves. Add in ginger and garlic chopped. Saute until raw smell disappears.
4) Add in the spice powders and salt on low flame, saute. Add in the banana stems(vazhapindi) and mix well.
5) Switch off flame and when it's warm, add the vinegar. Give a quick stir and leave to cool completely. Store in clean dry glass bottles.

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Notes

* Don't over do the step of frying or else the banana stem becomes soft once its mixed as pickle but if you are making a big batch this should be done to increase the shelf life of the pickle (if you are making a small batch then you can fry the banana stem very lightly and leave it slightly crunchy. There will be oozing from the banana stem and make it slightly watery but that's fine).
* Adding vinegar is optional for smaller batches, I generally don't add or add 2 tsp of lemon juice. If making a larger batch you should definitely use vinegar. But at home I generally making small baches that empties within two weeks and so go by the natural way of adding lemon juice. Also refrigerate the bottle, only scoop out as much needed each time and keep the bottle back in fridge.

VII. RESULTS AND DISCUSSION

A. Yield Test for Banana Fibers from Unused Banana Trunk.

For the process explored, the yield for fibers that can be used in spinning process is approximately 30%.

Banana Fibers

Table – Banana Fiber Yield Test

Fiber collection	Yield (%)
Fibers (used for spun yarn).	25-30
Short-length fibers (used for banana paper pulp).	25-30
Sap (used for banana sap printing.	35-40
Unused waste for mulch and fertilizer.	10-15

B. Comparison of Fiber Collection Methods

Natural fiber extraction processes could be employed in different procedures, including mechanical (extracting when the trunk is green and fresh), biological (extracting after banana trunk was fermented), and chemical methods. Different techniques offered advantages and difficulties according to the quality and amount offibers obtained. The research explored only mechanical and biological methods. The chemical extraction method was not experimented because the ultimate goal of the whole research is to eliminate the unnecessary use of chemical in the process. Although both mechanical and biological methods provided similar yields, the results showed that fibers collected from biological method are darker than mechanical methods. The darker color is more difficult during dyeing and finishing process. In this research, the mechanical was employed because of the fiber's quality achieved.

C. Yarn Spinning Development

After fiber is collected, the process goes to yarn spinning. The researcher investigated the traditional process, which use the filament yarns in weaving banana fabric. The finding showed that the convention process was very time-consuming, thus not appropriate for today's use. Therefore, this research explored open-ended spinning process for yarn development. The fiber was cut in to 3-centimeter length for spinning process.

Figure - Banana spun yarn

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Figure - Banana fiber knitted trial

VIII. CONCLUSION

The findings from this research presented 25-30% yield from mechanical process. For a comparison of fiber extraction, the mechanical extraction should be employed. The mechanical process was appropriate for fiber collection since the color offibers is lighter than biological process. The yarn spinning and knitting were experimented. The results were not satisfied, yet. The improvement of fabric hand feel and yarn quality should bedeveloped.The research presents sustainable use of alternative materials, banana fibers, and suggests applications that reflect concerns forthe environment. The environmental benefits of utilizing left-over products have offered options instead of using new fibers, where it could increase the demand of new natural material and high energy consumption.

It also promotes awareness of environmental issue on excessive chemical in textile industry from using synthetic and petroleum-based fibers. As the environment changes rapidly, textile industry has also investigated alternatives that express cares for the natural resources and the future of the environment with less affect on ecosystem. Therefore, the awareness of environmental issues through the use of eco-friendly material that is locally available and easily renewable, is one of necessary responses to the development in textile processes.

IX. RECOMMENDATION FOR FUTURE RESEARCH

Further research on banana fiber processes is essential. The results of this research express the possibility of exploration more in the industry arena. The future research should include the whole process of fully utilizing banana plant after fruit harvesting, which covered banana sap, banana fiber, and banana pulp.

It can also be combined with other natural fibers for a better hand feel and provides variety of fabric use, including improving the bananafiber properties and investigating factors influencing consistency of natural fiber for environmental-friendly processes. Understanding and improving the method of collecting bananafiber and systemization will aid natural textile in Thailand and other banana grown countries.

This method of natural fibers will help reducing the chemical and agents used in general textile's current practice. Since the properties of bananafiber are good absorbent, highly breathable, quickly dry with high tensile strength, it can provide a wide variety of uses in textile and paper industry, it is highly beneficial to study the application of this locally and widely grown plant species for the sustainable development.

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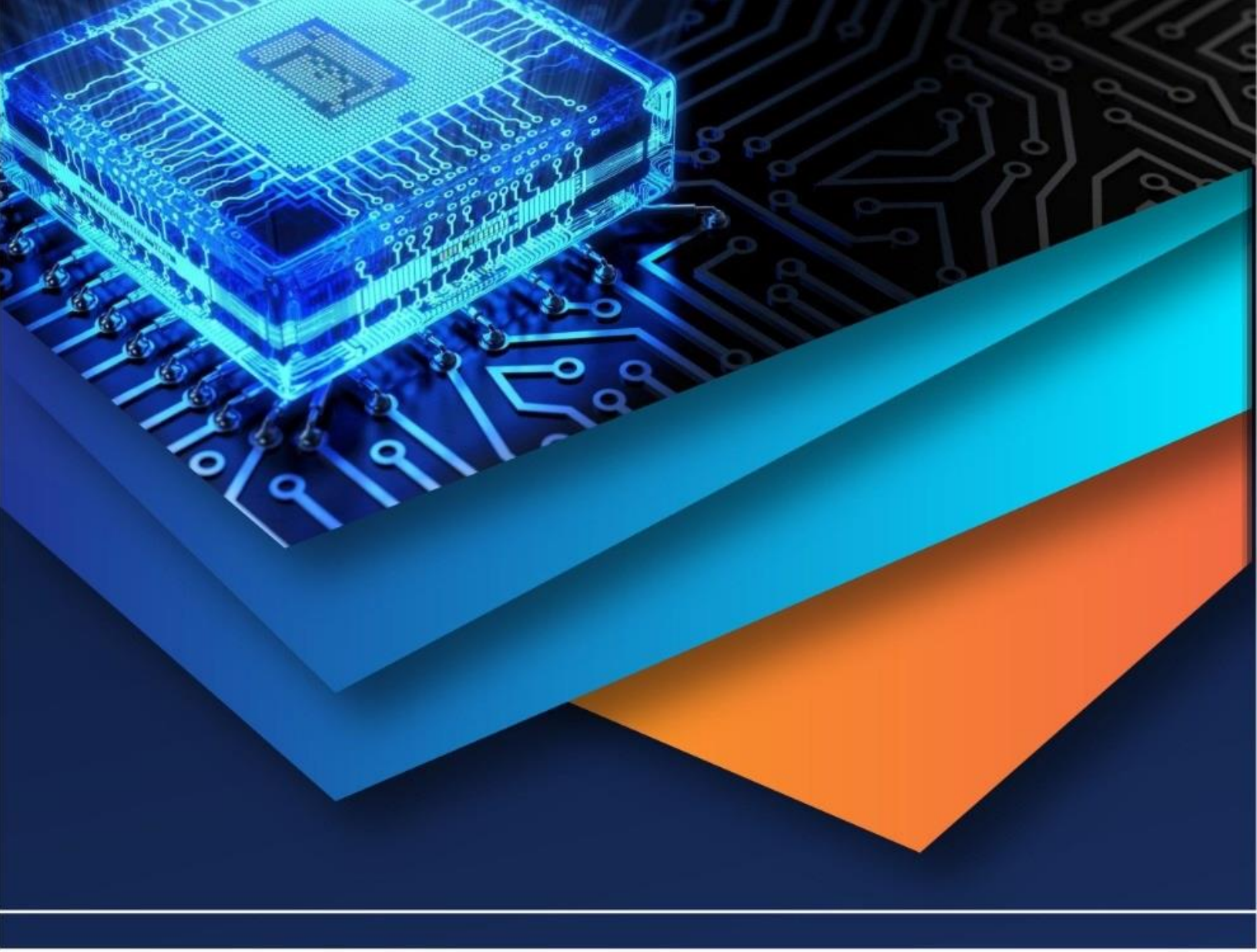

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