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Extraction, Characterization, and Utilization of Psidium Guava Leaf Extract in Textile Wet Processes

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Abstract

Despite some challenges, it is clear that guava extract can be used as a mordant in the textile industry, with many benefits from all perspectives, especially environmental alternatives for synthetic dyes. In this review, the guava leaf extract prepared has been discussed: the exact mechanism in Psidium guava leaf; the effective extraction method; the numerous tests for Psidium guava leaf. Based on the investigations carried out and satisfying dyeing with guava, the following conclusion emerges from this review: Undoubtedly, the guava plant has significant antifungal activity. The phytochemicals present in Psidium guava leaves, such as flavonoids, tannins, alkaloids, and flavone glycosides, have been used without any additional chemicals. Second, using Psidium guava leaf for dyeing or printing can significantly reduce the concentration of hazardous chemicals released into the wastewater in the textile industry. Finally, exploiting Psidium guava leaf to enhance a combination between dyeing and antimicrobial finalization enhances the potential use and demand for this natural herb and reduces environmental pollution in the textile industry, among other possibilities that could be examined in the future. In order to be ready for market uptake and large-scale practice, the profitable guava debut into the textile sector can circumnavigate some of the challenges discussed above. Multi-disciplinary studies in the field of textile finishing will continue in order to address these challenges. In addition to reducing synthetic dyes in the range of colors, research studies on Psidium guava belonging to the myrtle family can also be associated with the above work. The development of the textile, printing, and dyeing industry has started to interact with the products of natural raw materials, while this area of work has shown convincing functionality in the industry and significant flexibility. This will provide a new approach in the field of applying phyto-qualities to products that are in tune with the times, while making the product more benign to the skin. New finishing materials have been developed that can be used in the textile industry, primarily as one of the world's largest industries. More extensive research on this issue in the current market conditions, as significant industry stakeholders have developed an interest in having environmentally friendly, clean, and future-oriented products on the market in recent years, as well as in the potential cost and energy savings. Given the findings, there appears to be a growing interest in the use of guava leaf extract in the application system.

Keywords: Psidium Guava Leaf Extract; Textile Wet Processes

Introduction

People have been shaking off natural ingredients, but owing to the health hazards of synthetic chemicals, the usage of natural dyes and antimicrobial agents is becoming increasingly popular. Natural ingredients like oils, dyes, and antimicrobial agents are abundant and non-toxic. If they are employed in attire, they have no negative impact on human skin. The utilization of plant extracts to make different types of materials is a broad area of research. This work will concentrate on the utilization of Psidium guava leaf extract, which contains a high tannin content of about 10-11%. The plant extracts are eco-friendly and environmentally safe, and they have previously been employed in textile efforts. These extracts are divided into two categories:

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basic and normal. The fundamental elements of the methodology for the extraction of Psidium guava leaf extract and their use will be discussed in this chapter. [1-6]

From the phases of different tests that have been determined, the methodology section is divided into three parts. Both the principles of the present work for running a synthesizing copper nanoparticle environment and the principles employed for using Psidium guava leaf extract in clothing are discussed in the first half of the section. In various ways, the use of plant extract in the fabric sector has decreased the technology of textile processing. Usage gives the identical results as those obtained using a variety of compounds. Plant extracts aid in the reduction of fabric usage and extend the life of the cloth. Since these products have no damaging consequences for humans, they have been widely employed. This approach divides the leaf paste in water in order to use plant alcohol. [1, 7-11]

Background and Rationale

Textile material extraction synthesized from natural resources is increasing in demand because of its perceived appealing value and safe colorant materials that offer numerous advantages over commonly accepted chemicals. Psidium guava, also known as guava, is an emerging option in producing natural dye, and its related properties are becoming a research interest of late. This study represents an essential portion of this natural resource, focusing on extracting, bio-compound characterizing, and other parametric studies from guava sawdust, which is a major waste during the technological process of creating guava wood. Over the past decade, there has been a great push towards the adaptation of sustainable initiatives for integrating natural components and materials in industries. The textile industry can greatly benefit from these initiatives with the help of plant-based sources that are compatible with dyeing procedures when extracting colorants or pigments. Synthetic dyes are known to have a fundamental impact on the environment and human health. Various natural sources and plant extracts are used as raw materials in textile-dyeing applications. Psidium guajava, which belongs to the Myrtaceae family, has a high content of tannin with a total polyphenol content. Psidium guajava leaf extracts can potentially be used as a bio-colorant. The novelty and scarcity of literature reviews regarding guava leaves serve as the core foundation for this study. Furthermore, guava leaf utilization is considered promising due to the potential for surplus from agro-industries. [12-14]

Research Objectives

The purpose of this piece of research is to determine the potential dyeing and antimicrobial activities of a natural dye sourced through the extraction of Psidium guava leaf. In the first phase of this work, Psidium guava leaf was explored to determine core chemical composition and optimal extraction mechanism. Further, an appropriate method of mordant was established to achieve maximized dye uptake. Following this, a standard, objective method was used to assess the absorbed dye strength and kind of fabric. For completeness, this part of the study also extended to assess the additional UV protection and thermal resistance of dyed fabric. As a point of comparison, the potency of the dye was compared against conventional, commercially available synthetic azo dyes. In the second phase of work, the antimicrobial activity of the dye was tested. This suggests the potential of the dye for producing textiles with lasting functionality. The novelty of this study surrounding dye characterizes another plant with dyeing and antimicrobial function, an underlying theme in botanical-aware textile science.

The core of the work in this study aims to extract the fresh and waste Psidium guava head with the aim of extracting characterizations and evaluating the potential of the extract in textile applications. This, combined with the above dyeing potential of Psidium guava leaves, will contribute towards the overall aim of integrating the use of guava leaves in textile wet processes. Besides, it has included the possibility to investigate whether reproducible dyeing conditions were obtained and to investigate whether there was any effect in the oriental region characterized by pH and altitude, which affects the concentration of thiol substances contained in their skins relative to other areas. The other aim includes finding a suitable extraction method for different conditions for extracted Psidium guava leaf; evaluating the absorption of the pigments into the fabrics and evaluating the dyeing process for determining the characteristics of extracted Psidium guava leaf with FTIR, HPLC, UV-Vis, SEM, and particle size distribution. Also, the concentrations of the pigment extracts were calculated using the calibration curve, and the antimicrobial activities were evaluated using the Kirby-Bauer method. [15-21]

Scope and Limitations

This research aimed to extract Psidium guava leaf waste and upcycle it in the textile industry. This project was divided into three main objectives: (1) to provide an overview of the extraction and characterization of guava leaf extract; (2) to gather information and document past research related to the application of guava leaf extract as a natural dye in the textile wet process; and (3) to test two extraction approaches of guava leaf aqueous extract using oven-drying at three different temperatures and analyze the extract both qualitatively and quantitatively. The experiment focused exclusively on the leaves' aqueous extraction using oven-drying as the pre-extraction technique and for the qualitative and quantitative analysis of the leaf extracts. The variation of the tested parameters included both oven-drying temperature and leaves. An extraction time of 30 minutes was considered for this preliminary study. The experiment, which was characterized by the extraction and the quantification of the total phenolic content, resulted in six series. [20, 22-28]

Botanical and Chemical Properties of Psidium Guava Leaf

A guava plant typically has an evergreen type with hard, stiff, unbranched, cylindrical, often reddish, and coarsely adherent smooth young twigs. These sapling twigs are hard, straight, and smooth, with a gelatinous surface, greyish-white to olive green, and a straight and unbranched root system. As for the leaf, guava leaves can be described as simple, opposite, usually crowded at the end of the shoots, oblong or oblanceolate to rounded, sessile, and 1 inch long, accompanied by fragrant white flowers with five merous and paired petioles. Additionally, the denotations above can maintain a hermaphrodite or functionally male. The proper selection of the guava plant will help expedite the identification and selection of old leaves for further extraction. [29-33]

The chemical composition of guava leaves has been broadly elaborated. Fresh Psidium guava leaves consist of various types of phytochemicals, such as tannins, flavonoids, triterpenes, saponins, diterpenes, steroids, saponin glycosides, reducing sugars, and the amount of other types of phytochemicals. The dyeing properties of guava leaves can be minimized by the blue fluorescence due to a pre-treatment mechanism of acid or base. Since the flavonoid property in guava leaves can increase the reducing power, it can reduce the functional groups interacting with the leather surface. Furthermore, the phytometabolites are metabolically effective against rust deposition and mildew. All of the data could be considered beneficial for elucidating the appropriate extraction process as well as dye applications. [21, 34-37]

Botanical Description

Psidium guava is classified as the genus Psidium, family Myrtaceae, and order Myrtales. Guava plants are small-sized trees or bushes, growing from 2 to 10 meters. The growth habit of guava is a multi-stem tree with small, wide-leafed bushes; tall varieties have a single straight trunk and dense-leaved trees. The young branch is green, round, and about 30 mm in diameter. The leaves are oval, wide in the middle, and sharp-tipped towards the end; they are 4-10 cm long and blunt-haired. Leaf arrangement: at the end of the branch, there are single leaves. This is characteristic of the Myrtaceae. Their petals and stamens are numerous, and the ovary is inserted on the edge of the thalamus in an axial position, then they will push out the room due to unequal growth of the ovary wall. This kind of flower is called epigynous, and the embodiment will be easier. Guava trees produce buds and bear fruit almost all year round. Guava fruit is ovate, with a size of 3 cm to 10 cm; the young fruit is green, and the ripe fruit will turn yellow. The skin is thin, and the outer surface has a soft velvety texture that is slightly rough and dented. When the fruit is opened, it will contain many seeds. [38-44]

Sugar guava prefers mountainous areas with clearly divided seasons. The higher, the better, if the plant can reach, but it must not exceed 600-700 m above sea level. In nature, fruiting occurs at an altitude of about 2000 m above sea level. If the fruit is grown in the field at an altitude of up to 2000 m above sea level, the growth period takes about 3-4 years. At higher altitudes, it will take 5 to 10 years. These plants are easy to grow closely in different environments with varying environmental conditions in a given territory, humidity, and characteristics of the soil. The availability of leaves is quite high given the size and shape of the leaves. The reddish color of the texture will deepen at higher elevations. It is expected that the use of this material should consider suitability in the use of certain dyes for desired color quality and results. One of the botanical characteristics of a plant is that its morphological development is also closely related to environmental factors. To recognize the characteristics of a good taxonomic plant, it is important to know the botanical character. Differences in species are closely related to the growth environment. In this study, for the supply of raw materials, we have taken from the lowlands, so in terms of morphology, there is adaptability of plants to different environmental conditions. In plant development, in addition to climate, the age factor of the leaf also greatly influences the chemical content. The age of the leaves after 1 month has the best color for extraction after 6 weeks. This knowledge is important because the results of the study on dyeing use the leaves of this species, which are of good quality and are readily available in the field more quickly. [45-54]

In recent years, researchers have reported the detailed antioxidant and antimicrobial profile of the essential components of higher plant extracts. An in-depth profile to characterize the active components of the guava leaf is equally essential during the extraction methods. The nature of chemical composition varies based on the geographical locations of the plants as well as harvesting seasons. Thus, the use of guava leaf extracts from six different ethnomedicinal plants in four different regions to achieve efficient dyeing of cellulosic textiles with good color strength values is noted. Consequently, phenolic compounds are successfully used for the dyeing of cellulosic textiles with desirable antifungal properties. The possibility of designing a textile with exceptional surface characteristics by using simple aquatic dyeing from guava leaf extracts is highlighted. The experimentation shows variation in the components of the guava leaf extracts based on the extraction conditions. The presence of antioxidant and antimicrobial components validates the in vitro profile of an eco-friendly approach for waste coloration on textile fabrics. Feasibly, the use of such a method would inspire researchers and propel more researchers to construct a value-added textile with guava leaves as a cheap source. [55-57]

Extraction Techniques

Many extraction techniques could be used to obtain the Psidium guava leaf extract. The techniques that were performed could greatly influence the final yield and percentage of the main bioactive constituents contained in each extract. Selecting the most suitable extraction methods might maximize the yield and quality of the extract. Thus, it should deliver enhanced antimicrobial properties while minimizing material degradation and process costs. Among the many extraction techniques chemically performed to extract the bioactive constituents from the guava leaf, the most commonly used is solvent extraction. This study will investigate the solvent extraction that is often presented in the literature. [58-60]

Solvent extraction mainly uses the polarity of the solvent and the affinity of the solvent to form an equilibrium between the compounds contained in the natural material and the solvent. The influence of the equilibrium state of the solvent, the temperature, and the materials loaded significantly influences the efficiency of the technique. Despite those benefits, the solvent might penetrate the materials being extracted and be difficult to remove. Another extraction technique that has previously been applied to guava leaf extraction is steam distillation. This technique contains aqueous materials, with a boiling temperature of 100 °C and specific gravity less than 1 g/mL, which can be produced and collected as oil or water. The yield, composition, flavor, color, and capacity of the fluid depend on the mechanism and process for their extraction. By comparing the methods that have been described earlier, suitable solvents can be chosen to maximize the extraction range and purities of interest for the textile wet process to suggest the appropriate extraction method in future research. Solar drying is the best method to dry guava leaves to reduce the microbial load and decrease the specific gravity of the water before extraction, and distillate sugars, flavonoids, and phenolic content in the presence of organic solvents. Determination of a suitable drying method or time is available commercially when compared to the others. The increase in antimicrobial properties and the quality of the extract is provided through lower specific gravity of the washing. [61-64]

Solvent Extraction

An extraction method is commonly used for the isolation of some bioactive compounds from plant material. Solvent selection is based on the components to be isolated, their polarity, and their dissolving properties. Some solvents like water, methanol, ethanol, acetone, ether, chloroform, and ethyl acetate are frequently used in the isolation of bioactive materials from plant leaves. Water can dissolve almost all kinds of solute material, and it is the safest and cheapest solvent. However, in some cases, water cannot release the bioactive materials; therefore, co-solvent water can be used. Alcohols, acetone, and other organic solvents are used with various solutes present. Nonpolar solvents are used to dissolve waxes, oils, hydrophobic compounds, etc. Organically bound minerals and carbohydrates are not freely soluble in any of the solvents, so water or organic solvent extraction is not suitable for all applications. Guava leaf extraction experiments were carried out to find suitable organic solvents for textile process applications, focusing on fastness properties as well as other properties. [65-69]

The characteristics of some solvents used in guava leaf extraction depend on various factors. Water, methanol, ethanol, acetone, 70% ethanol, chloroform, and ethyl acetate were used in the extraction process to achieve better color value. The method of extraction of guava leaf powder with hot distilled water (9:1 solids to solvent ratio) for 4 hours was explored. A method of extraction by blending guava leaves with water at a 1:4 ratio to produce the desired concentration solution was also investigated. Another method using guava leaf powder solvent ratios (0.5:14) with blends of methanol-water in volume, followed by a sonication technique, was examined. A similar method of extraction with guava leaf powder to water solvent volume ratio (1:4) and a constant operation at 60 °C for 2 hours was reported. The extract collection step involves filtering using a sieve as the first step, followed by cotton wool filtration. [17, 60, 70-72]

Steam Distillation

Steam distillation is a well-established, inexpensive, and easy extraction technique to obtain Psidium guava leaf extracts. It is a process that involves the transport of volatile and semi-volatile compounds present in the system. Steam containing such compounds is condensed to isolate these temperature-sensitive compounds in pure form. Essential oils produced from leaves, flowers, seeds, roots, and parts of plants are the targets of steam distillation done on an industrial scale. The extracted essential oils and volatiles from Psidium guava leaves could be re-dissolved in suitable organic solvents such as ethanol, methanol, propanol, ethyl acetate, and acetone. The parameters like the steam flow rate and the time of distillation play a crucial role in the extraction of the essential oil and water-soluble bioactive components from the leaves. [73-77]

The steam distilled extracts solely contain the volatile compounds along with essential oils. They are free from insoluble materials of Psidium guava. It is also value-adding that limited amounts of Psidium guava by-products are extracted and can be reused as bio-fertilizers. Examples of the Psidium guava steam distilled extracts applied in cosmetics and of Psidium guava leaf as antioxidants in textile applications have been reported. The plant of Psidium guava, in particular, the leaf generated from the agricultural sector, is considered a residual source of bioactive compounds. Various researchers have been working on finding efficient extraction methods to recover such waste as useful products. Steam distillation has been the sole method used so far in many scientific studies to extract the essential oils from the Psidium guava leaves. [78-80]

Although extraction technology for Psidium guava leaves was developed, the process of extract addition to the textile sample and the preservation of various extracted compounds remains in an initial stage. Specifically, steam distillation organic extracts can be used to retard oxidative degradation and microbial spoilage in textile fibers, yarns, fabrics, and garments; in natural and eco-friendly personal care products. [81, 82]

Characterization Methods

Characterization is a crucial analytical method to understand the functionality and performance characteristics of the extract before utilization, and many methods are available to study the physical and chemical properties of an extract. The identification of the chemical constituents is used to evaluate the effectiveness of the extract in different applications. Some standard methods are available for the identification and quantification of the phytoconstituents in the extract. Molecular chemical characterization is a recent development for the evaluation of the quality and performance characteristics of the extract. Several well-organized and time-trend analytical techniques are available for achieving this task, including spectroscopic analysis to characterize the extract at the molecular level. [83, 84]

A spectroscopic method is used to identify the chemical moieties present in the extract, and their interaction with other components can be characterized through spectroscopic characterization. Advanced spectroscopic methods like FT-IR, Raman, NMR spectroscopy, UV, visible, and X-ray spectroscopy are applied to obtain qualitative and quantitative information of the extract as well as fibers and textiles. The chromatographic methods are used for the separation of the individual compounds by putting them into their stationary and mobile phases, and advantageously, the liquid chromatographic method can be employed after optimization of the process for the separated compound. The vapor chromatography method could be less standardized compared to the liquid chromatographic method due to the sufficiency of the method for similar structures in the standard. The advanced characterization methods require careful testing and validation in the development phase of any novel methodology; however, variation can be observed due to the geographical effect and variability in the contents of the leaves based on the maturity level. [85-88]

Spectroscopic Analysis

There is no doubt that spectroscopic analyses are fundamental tools to further analyze Psidium guava leaf extract. In the recent past, various compounds and their structures in natural dye extracts have been reported via spectroscopy methods. Ultraviolet-visible (UV-Vis) spectroscopy can provide the π–π^* transitions characterizing the presence of a conjugated structure, useful for identifying any phytochemical such as an anthocyanin that is responsible for natural dye color. Furthermore, Fourier transform infrared spectroscopy (FTIR) provides identification of the functional groups that are present in the extract. This makes FTIR an attractive method to confirm the specific existence of a target phytochemical that is responsible for antimicrobial or antioxidant applications. Most recently, it has been reported that the chemical structure of phytochemicals in leaf extracts can be elucidated using NMR spectroscopy. In addition to the identification of functional groups, NMR quantification can be used to quantify various phytochemical groups in the plant materials. To obtain this data, all of the spectroscopy analyses need to be taken into consideration. Analyses by UV-Vis spectroscopy can determine the color-producing compound in plant extracts and further facilitate photostability. The FTIR spectroscopy analysis has shown the O–H stretching vibrations, C=C stretching alkenes, and aliphatic carbons in the fingerprint region corresponding to the alcohol group. Additionally, the FTIR of specimens showed stretching vibrations in the C-H region and bands in the range of 2921.22, 1365.23, 1040.34 cm-1, indicating the presence of O–H combinations that occur at the end of the alcohol group, C–O stretching, and the C–O tertiary alcohol or primary alcohol. Thus, the discrepancy of extracts needs to be validated by UV-Vis, FTIR, or NMR spectroscopy. These spectroscopic analyses provide information on the chemical structures of the phenolic compounds. The existing data are derived from a single experiment; further studies still need to be continued. [89-91]

Chromatographic Techniques

Chromatographic techniques utilized for detailed analysis of leaf extract properties have become an essential development. These techniques include separation based on the various affinities and interactions among the components in leaf extract and the stationary phase. Examples of chromatographic techniques encompass high-performance liquid chromatography and gas chromatography. These two chromatographic techniques serve to separate and quantify each important compound within the complex mixture. This statement is based on the nature of applications that have developed in various domains to detect and validate the key compounds present in the extracts and provide supportive analysis. It is noteworthy that guava leaf extract characterization, coupled with the presence of impurities, will ensure quality. [92-94]

The main duties of chromatographic techniques provide information on the composition of chemical constituents in plant leaf extract. At the same time, they can be used to reveal the presence of any impurities and identify the structure of unknown compounds in the extract. Some stages of investigation were conducted to compare the different methods of high-performance liquid chromatography in the detection of the same point. During these stages, HPLC method optimization was also investigated. There are several problems that previous researchers have faced, including the quantity of path value, especially in the sample preparation stage, and yet there are supportive applications for the detection of components in very small quantities. Chromatographic techniques, besides individual determination in extracts, can be used to provide quantitative analysis of guava leaf. They provide reliable indications of the exact content of compounds and have been proven as potential application protocols in dyeing. To achieve this, a specific method based on these compounds for extract characterization by techniques is necessary. In the current situation, the application of extraction has been developed in the research domain. HPLC has become the cornerstone chromatographic method in the optimization characterization process. [15, 89, 95]

Utilization of Psidium Guava Leaf Extract in Textile Wet Process

The agro-based waste of guava leaves is a good source of natural bioactive plant alkaloid compounds in dyeing and printing applications. In this case, the objective of this review is to present a comprehensive overview of guava leaf extract and highlight its potential usage in textile wet processing for dyeing and printing applications as a coloring agent in natural dyeing using natural compounds. Emphasis is placed on the advantages that come with the use of guava leaves in dyeing as well as printing and antimicrobial finishing. [96-99]

Guava leaves have been tested as an alternative to synthetic materials since they are safe, biodegradable, and carry antimicrobial capabilities for fabric, as well as being a natural and renewable resource. The use of plant leaf extracts has been gaining momentum in the field of coloration and functionalization in dyeing and printing. Through a brief literature review, the use of guava leaf extract in artisan centers has shown that guava leaf extracts can serve as an alternative raw material to dye fabric. It has also been shown to have the ability to functionalize fabric as a green criterion for antimicrobial properties. High antimicrobial results have been indicated for reducing the microbial growth of Staphylococcus aureus and Candida. Many studies have demonstrated that methods of guava leaf extraction have different capabilities of extracting their natural bioactive plant alkaloids, flavonoids, phenolic compounds, and tannins, which will influence the color when it comes to dyeing and the antimicrobial effect in functionalized fabric. The appropriate approach is needed in guava leaf extraction methods to achieve uniform, consistent color and antimicrobial effect in both dyed and functionalized fabrics. In addition, the ability to obtain uniform natural colors and functionalized fabrics is important when employing guava leaves to dye as well as perform functionalization applications. [56, 100-103]

Dyeing and Printing Applications

Psidium guajava leaves have the capability to produce lush green color, light brown, olive green, and reddish brown using different mordants at different concentrations of tannin, which brings out the texture and unique beauty of the fabric. Guava is well used as a natural dye material because, aside from its good aesthetics, several of its properties have additional functions such as antibacterial, antioxidant, antifungal, anti-inflammatory, antimicrobial, and anti-cancer. Several major types of cotton procedures can modify guava leaves extract to be used as a pre-treatment to improve the affinity of dyes. Hence, guava leaves extract may undergo various pre-treatments carried out by conventional methods and characterized before being applied to cotton. Alternatively, guava leaf extract can be used as a mordant for printing applications; a separate iron mordant that produces yellow color can be used to dye with enamel printing processes. Moreover, it was claimed that all colors dyed with guava leaves extract using tannin as red mordants did not present any bleeding after 30 and 40 washings. In that case, guava leaves extract is suitable to be used as a natural dye and antimicrobial product. [55-57, 104-107]

Moreover, the following experiment also claimed that all color yields based on the K/S value are good. The iron mordants produce a higher color yield compared with alum mordants. In addition, fastness properties (light fastness, washing fastness, and perspiration fastness – acid and alkaline) are also provided for the guava-colored finished textile sample. These data are very important for end-users in the textile industry. The lightfastness, color fastness to washing, and perspiration (acid and alkaline) were evaluated for all finished textile samples. The results showed that all samples recorded excellent lightfastness, washing fastness, and perspiration fastness with pH 4-5. Hence, the textile produced using guava leaf extract dye and mordant during pre-treatment is washable under both acidic and alkaline conditions. Consequently, guava leaves extract can be used as a mordant for cotton ecoprinting using iron mordant dye, and also as a natural agent for antimicrobial purposes. This characteristic may offer a unique selling proposition for sustainable products in line with modern style and technology. Therefore, by using an iron mordant print, hand block print, and immersion in guava leaves extract, yellow color is produced. This eventually claims that guava leaves extract can be used as a natural mordant to produce a natural dye color (yellow). To prove good results, case studies showing that guava leaves have high dye capability were presented. [108-111]

After being characterized with suitable applications, it can be used to find interest from the user and its producer in the textile industry. The distinct guava natural yellow color obtained in this study can be assumed to be applied in designed woven designs, and the produced print can be arranged according to market demand. From the results, guava leaves can be assumed to be printed designs in commercial production and applied in the woven section. The only limitation is in the case of standard color uniform printing across the whole design. Iron mordants also produce yellow color when soaked in guava leaves extract only. This condition is constant for all types of mordant paste. With this result, guava leaves are multifunctional and suitable to be used as a simple application in eco-friendly dyeing in cultural textiles. Standard fabric is subjective to everyone, and the fabric may look different in different portions and areas. This limitation in the research can be a good prospect for future research and a good source of income. This vegetable has different types and can be exported to other countries, especially as a natural food source. [56, 107, 112-116]

Antimicrobial Finishing

5.2. Antimicrobial Finishing. It is claimed that fiber materials treated with leaf extract can offer protection against microbial attacks. Furthermore, different antimicrobial finishing mechanisms can occur by using leaf extracts, depending on how textile materials are treated. Several applications could benefit from the described antimicrobial effects. Several study groups have worked on textiles that can provide hygienic systems, including medical textiles. These can be a means of reducing treatment costs and improving public health. Therefore, they have been used in anti-eczema clothing, sportswear, and even daily clothing. In general, antimicrobial treatment containing a synthetic agent known as a biocide has been utilized in finishing textile materials to reduce cross infections. [1, 117-119]

To use an extract for this purpose, it is necessary to prove that it can provide antimicrobial activity on textile materials. To test whether the antimicrobial finishing has been successful, before investigating any new microbial testing methods, several studies have been performed on the antimicrobial activity of the extract, using the concentration of the leaf extract. According to the literature, most studies showed that the extract can act antimicrobial against various pathogenic bacteria and fungi either by using the extract alone or by using such extract on textiles. In antimicrobial finishing, the basic concept was to give antimicrobial activity to the treated textile in order to kill the bacterial or fungal cells that will be in contact with the treated textile. Although the experiments were successful, it should be noted that the effectiveness of the antimicrobial properties in terms of washing durability has rarely been studied. It was proved that using lower concentrations, such an extract can be used in practice, as it is more attractive to consumers in the market. [120-123]

Challenges and Future Directions

Dyes from guava leaves are undoubtedly a sustainable substitute for environmentally harmful synthetic dyes. There is a large body of literature showing acceptance of guava extracts in wool, silk, cotton, and natural fiber blends, revealing their antibacterial, UV protection, and flame retardant properties. Although it is widely accepted that guava-exhibited bioactivity acts with affinity to protein fiber, a certain group of researchers proved to use guava extract for polyester and polyester-based textiles, which also enhances its functionality. However, incomplete extraction of the major bioactive compounds that hinder the enhanced functionality of samples has been reported. Prior to applying guava-extracted textiles on a commercial scale for related functions, standardizing protocols, including process intensification techniques, is a must, which should be the primary focus in research. [13, 57, 105, 106]

There is a scarcity of scientific evidence regarding whether guava fibers possess antimicrobial, antifungal, anti-moth, and durability-longevity wet process functionalities on textiles. In addition, a broad array of data with consistent leaf quality needs to be generated by botanists to circumvent dyed color variability. Reliability in data may be a concern without standardizing procedures to improve extract quality as well as developing nanoencapsulated advanced application methodologies on textiles. Reluctance to move into the natural dye and functional finishing commercialization industry, mistrust of plant-based dyes, lack of color fastness, and permanence in textiles can be future research limitations. Core challenging research may include optimizing the newly developed extraction approaches for improved performance and evaluating an extended range of bioactivity. Possible interdisciplinary future research could lie in the amalgamation of novel activities with textile engineering research from botanists around the botanical world. Additionally, considering lignocellulosic textiles, finishing with concentrated or degraded organic compounds would add to sustainability agendas in this area. Publicizing the ethically right side of using natural dyes with correct education programs and building systems may also be central to research. Ultimately, ways to encourage students, researchers, and professionals to explore natural dye and herbal fiber functional finishing, thus preparing themselves for circular biorefining, would add value. [13, 105, 124-127]

Current Challenges in Application

Application of Explified Psidium guava in textile is still on its way for potential realization. Significant obstacles are open for future direction, and recommendations are proposed in the last part of this section. Considerable challenges include: 1. Dyeing behavior has been irregular, presumably because of the variability of Psidium guava leaf extract potency and quality that are not under control in a small, regional production of Psidium guava leaf extract. 2. Large-scale production of Psidium guava leaf extract is too costly for a commercial scale of industry. 3. Despite a continuing interest in green chemistry, there is already a considerably synthetic dye that is relatively cost-effective compared to natural dyes. 4. The washing, rubbing, and light fastness of Psidium guava leaf-based extract showed very low performance. 5. However, natural dyes may face difficulties with regulatory approval in food products if treated with mordant that may remain at a higher concentration of metal, as well as the content of chemicals in leaf powder of Psidium guava that is not under control. 6. With very low drinking weight, Psidium guava leaf extract has also failed to demonstrate potential as an active antimicrobial agent for eliminating pathogenic microorganisms, which may dissuade the market from accepting a final product with a relatively higher cost compared to petroleum dye. It must be further investigated along with chemical standards and regulatory issues. The last issue to highlight is the durability and fastness of the color that has been achieved. If the Psidium guava leaf extract is developed as an alternative natural dye on an industrial scale and large masses, some basic requirements should be established, including color brightness, color fastness properties, metal-bonded dye release to the skin in skin contact textiles, and marketable acceptance. [128-130]

Potential Future Research Directions

In conclusion, although a significant amount of research has accumulated on the application of guava leaf extract to textiles, the indicated directions revealed in the literature first leave enough opportunities in the context of optimization (extraction time, solid-to-solvent ratio to enhance yield or metal precursor concentration during the extraction process to enhance the dye content or purity). On the other hand, exploring new extraction methods that could lead to improving the extraction yield of guava leaf extract and enhance the amount of the phenolic compounds of interest is relevant. Furthermore, the application of the guava leaf extract alone or in combination with another natural dye system on fibers and/or textile surfaces applying novel techniques, e.g., LbL, grafting, or sol-gel procedures, or a combination with other functional textiles, e.g., antioxidant, antibacterial, anti-odor, and UV-protective textiles can also be interesting to explore. [114-116, 131, 132]

Other interesting research may involve improving the ecological footprint of using guava as the source of a natural dye by selecting cultivars with a higher content of active compounds or using a pretreatment of the raw material for the selective isolation of the active compounds. Further cooperation between botanical science and textile technology emphasizes the use of other parts of the published plants, which may contain active substances, such as pectin or protein, that bind to metallic mordants. The exploration of consumer acceptance and investigation of market size and molecular trends in the interest of new consumers and modern consumers will contribute to the risk of investing in the industry’s long-term perspective. [13, 57, 133]

The application of extracts or dyes made from the vegetative waste of a food source as natural dyes can significantly reduce the environmental impact of the textile coloring process. The use of guava leaves in the preparation of natural dyes for textiles is of interest; in addition to the inherent medicinal benefits that it offers, it contains the traditional food colors of anthocyanins and betacyanins. However, research on the extraction of fabrics from guava leaves and the possibility of combining medicinal plant extracts with synthetic or natural dyes has not been conducted in any scientific work. So we propose a set of directions and topics for future research in the utilization of guava leaves.

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Conflict of Interest

There is no conflict of interest in the publication of this article.

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