Program Profile		
Program	Program name	Impact of Maturity Level of Guava Leaf Extract Dye on Cotton Fabric: An Approach Towards an Environment-Friendly Dyeing
	Category	A3

Summary of Program	
Program Name	Impact of Maturity Level of Guava Leaf Extract Dye on Cotton Fabric: An Approach Towards an Environment-Friendly Dyeing.)
Category	A3
Abstract of Program	The potential of guava leaf extracts as a sustainable alternative to synthetic dyes in textile coloration was investigated in this study. The eco-friendly appeal of natural dyes has been increasingly recognized, though their functional performance has been observed to vary with the characteristics of the dye source. Guava leaves at three maturity stages (premature, mature, and old) were examined for their dyeing performance on 100% cotton fabric. Colorfastness, visual quality, fabric shrinkage, bursting strength, and GSM variations were assessed. Superior results were achieved with mature leaves, demonstrated by excellent colorfastness (rating 4), uniform and deep coloration, and minimal shrinkage (3%). Enhanced structural integrity was retained in fabrics dyed with mature leaves, as reflected in a bursting strength of 7.5 kg/cm², which surpassed the values recorded for premature and old leaves. Increases in fabric weight were observed after dyeing, with the highest GSM (150 g/m²) found in samples dyed with old leaves. Despite this, mature leaves were found to deliver the most balanced aesthetic and functional properties. The viability of guava leaf extracts, particularly from mature leaves, as a renewable, biodegradable, and non-toxic dyeing agent was affirmed, thereby supporting the development of sustainable textile coloration practices and lowering the environmental impact.
Details of Program	
Planning	
Objectives — Long-term Goals	• The project aims to refine extraction techniques and dyeing methods to improve efficiency, vibrancy, and colorfastness. • It seeks to align with the growing demand for eco-conscious and ethically produced textile products. • By promoting guava leaf dyes, it will strengthen environmental sustainability by reducing waste and dependence on synthetic dyes. • Scaling up production and technology improvements are expected to reduce costs and make natural dyes more competitive. • Strong collaborations among researchers, manufacturers, and environmental organizations will drive innovation and wider adoption.
Objectives — Short-term Targets	• The project explores the use of guava leaf extracts as a natural dye for 100% cotton knit fabric. • It examines the effect of guava leaf maturity (premature, mature, and old) on dyeing performance. • The team evaluates key dyeing properties such as color fastness, K/S value, and dye uniformity. • It assesses the commercial viability of guava leaf dyes as a sustainable

		alternative to synthetic dyes. • The project promotes eco-friendly practices in the textile industry through the adoption of plant-based dyes.
	Rationale	• Natural dyes are biodegradable, non-toxic, and derived from renewable resources, helping reduce water pollution compared to synthetic dyes. • Their production supports sustainable agriculture, empowers local communities, and preserves indigenous cultural traditions. • Synthetic dyes release harmful chemicals and heavy metals, are mostly non-biodegradable, consume large natural resources, and pose health risks for workers and users. • Guava leaves are abundant, rich in flavonoids and tannins, and yield a range of natural colors while reducing costs and carbon footprint. • They also possess antioxidant and antimicrobial properties and have long-standing traditional medicinal uses, adding ecological and cultural value.
Subject (Leader)	Initiator(s)	HOQUE, Mohammad Bellal
	Champion(s)	HOQUE, Mohammad Bellal
	Major team member(s)	RAHMAN, Md. Mostafizur, RUBEL, Md., OYSHI, Tanzim Hossain, AYMAN, Umma and SHEIKH, Md. Sohan
Environment	Nature/Society	This study is relevant to the field of textile engineering, specifically focusing on the use of natural dyes. Its societal impact lies in promoting sustainable and environmentally friendly alternatives to synthetic dyes.
	Industry/Market	The research directly relates to the textile industry, particularly the wet processing sector involved in dyeing and finishing.
	Citizen/Government	The findings of this study could impact conventional synthetic dyeing practices in the textile industry. They may also interest academic and research institutions investigating alternatives to synthetic dyes.
Resources	Human resources	4 students were involved in the program work
	Financial resources	BDT 5,00,000/-, Funding is essential for the application and characterization of natural dyes. Additionally, financial support is needed to cover salaries for researchers and technical staff involved in the project.
	Technological resources	The study requires modern tools and machinery for technological support, including an infrared lab dyeing machine, blender, spectrophotometer, color fastness assessment instruments, FTIR equipment, and software such as Origin.
Mechanism	Strategy (Weight/Sequence)	• Chemical Composition Analysis: Perform detailed studies to identify key compounds in guava leaves responsible for dyeing, including phytochemical analysis to isolate pigments and understand their properties. • Colorfastness Studies: Assess the stability and durability of guava leaf dyes on various materials such as textiles and papers, investigating the effects of light, washing, and environmental exposure on dye performance. • Extraction Methods: Experiment with different extraction techniques such as solvent extraction, steam distillation, and microwave-assisted extraction, to maximize dye yield and efficiency. • Optimization Parameters: Determine optimal extraction conditions, including temperature, time, and solvent type, to improve dye

		concentration and quality. • Textile Dyeing Techniques: Explore various application methods for guava leaf dyes, including immersion, painting, and printing, and evaluate their effects on different fabric types and blends.
	Organization	• Department of Textile Engineering of World University of Bangladesh leads the program with faculty expertise and student research involvement. • University leadership provides strategic direction aligned with innovation and sustainability goals. • University governance links strategic priorities with on-ground program execution. • Collaborative structure ensures academic rigor, applied research focus, and industry relevance. • Institutional priorities emphasize environmental responsibility and sustainable textile innovation.
	Culture	• The university promotes a culture of sustainability and innovation that directly supports the program's eco-friendly goals. • Faculty and students in the Department of Textile Engineering are encouraged to pursue applied research addressing environmental challenges. • Collaborative practices within the university foster teamwork, knowledge sharing, and problem-solving, which strengthen the program's execution. • Institutional values emphasize environmental responsibility and social impact, aligning well with the objectives of natural dye research. • The culture of academic rigor and industry collaboration creates an enabling environment for the successful adoption of sustainable dyeing practices.
Doing		
Launch date		August 2025
Responsible organization		World University of Bangladesh
Program content and process		The program explores guava leaf extracts as a sustainable alternative to synthetic dyes for cotton fabrics. It highlights the environmental, industrial, and economic value of introducing natural dyes in the textile sector. Guava leaves at three maturity levels (premature, mature, and old) serve as the primary dye source. These leaves contain pigments such as flavonoids and tannins, which provide distinct shades and qualities when applied to cotton. Led by the Department of Textile Engineering at the World University of Bangladesh, the program combines faculty expertise with student participation to provide both academic rigor and practical applicability." The process begins with the collection of guava leaves from different maturity stages. The leaves undergo preparation and boiling to extract natural dye solutions under controlled conditions. Cotton knit fabrics are treated with these extracts through the exhaustion method. After treatment, the fabrics undergo laboratory analysis. Color intensity is measured using a spectrophotometer, while color fastness tests evaluate resistance to washing, rubbing, and light exposure. FTIR spectroscopy provides insights into chemical structures, and bursting strength tests confirm fabric durability.

	To achieve reliable results, the program standardizes conditions such as extraction time, temperature, and mordant use. Swatch-level trials precede larger-scale applications to ensure consistency and cost efficiency. The program also evaluates economic feasibility, with guava leaves identified as an abundant, renewable, and low-cost resource. The program content combines scientific study with real-world application. It addresses environmental concerns, supports innovation in textile engineering, and aligns with global sustainability goals. The structured process connects raw material preparation, laboratory analysis, and performance evaluation. In doing so, it positions guava leaf extracts as a viable natural dye and offer both environmental benefits and industrial potential.
Key highlights of the content/process	• Guava Leaves: Guava leaves can be used as a natural dye due to compounds that produce a range of colors, typically in shades of green and brown. Using guava leaf dye adds a unique, eco-friendly touch to textiles, and experimenting with different materials and mordants can yield a variety of beautiful, subtle hues. • 100% Cotton Knit Fabric: Dyeing 100% cotton fabric with guava leaf extract results in lovely natural colors. Natural dye experimentation offers a sustainable way to create unique textile finishes. • Color Fastness: While natural dyes provide an eco-friendly alternative to synthetics, their color fastness can be less predictable. Careful selection of mordants, optimization of dyeing conditions, and proper fabric care can enhance the durability and longevity of natural dyes. • FTIR Spectroscopy: FTIR spectroscopy is a valuable analytical technique for characterizing natural dyes. It offers insights into chemical structures and interactions, aiding in understanding dye properties and improving their application in textiles and art conservation. • Bursting Strength: Bursting strength measures fabric durability, critical for assessing suitability in various applications. Understanding this parameter helps manufacturers and designers ensure fabrics perform reliably under intended use conditions.
Differences from traditional approaches	Guava leaves are a natural, plant-based source of dye, containing compounds such as flavonoids and tannins that impart color to fabrics. Often locally available, guava leaves provide a sustainable dyeing option, especially in regions where guava trees are common. Traditional dyeing methods typically rely on synthetic dyes, which are chemically manufactured and can produce a wide range of vibrant colors but often involve harmful chemicals and processes. In contrast, guava leaves offer an environmentally friendly and sustainable alternative to these synthetic dyes.
Progress as of today	On warding
Problems in implementation	• Color intensity from guava leaf extract can vary depending on factors such as extract concentration, fabric type, and dyeing duration, making it challenging to achieve consistent, uniform shades. • The dye's colorfastness may be limited, leading to faster fading compared to synthetic dyes and some other natural dyes. • Uneven dye absorption is a common issue, often causing patchy or inconsistent coloration influenced by fabric type, pre-treatment, and mordant application.

	• Proper mordanting is essential, as the dye may not adhere well to fabric without it, increasing the risk of color bleeding or fading during laundering. • Guava leaf dyes generally exhibit lower durability, with reduced resistance to repeated washing, sunlight exposure, and daily wear compared to synthetic alternatives.
Approaches to solve the problems	• Standardize the extraction process by carefully controlling variables such as boiling time, leaf quantity, and water volume. Conduct experiments to determine optimal conditions for consistent results. • Increase the concentration of guava leaf extract to achieve deeper, more uniform colors by using a higher leaf-to-water ratio or by reducing the dye liquid to concentrate the pigment. • Perform test dyeing on small fabric swatches to evaluate color outcomes and fine-tune the process before scaling up to larger batches. • Pre-mordant fabrics with appropriate mordants like alum or iron to enhance dye uptake and fixation, ensuring adherence to recommended ratios and application methods. • Use leaves from the same batch or source to minimize color variation, as leaf age and type significantly influence the final dye color.
Completion date, if completed	December 2025
Seeing	
Impacts on students	Students expressed high satisfaction with the program, noting that it enhanced their knowledge of sustainable textile dyeing, improved their research and problem-solving skills, and gave them valuable hands-on experience. They appreciated the opportunity to apply theory to real-world challenges, which boosted their confidence, motivation, and career readiness. Overall, the program was viewed as a rewarding and impactful learning experience.
Impacts on professors	Professors gained opportunities to advance research by exploring eco-friendly dyeing methods that contribute to sustainability in textiles. The project enhanced their academic prestige and created scope for publications, conferences, and future collaborations. They also experienced professional growth as they applied advanced methodologies and guided students through practical experiments. The program built stronger links between the university and industry, allowing professors to deliver practical solutions to environmental challenges. Overall, it enriched teaching, research, and outreach, and positioned faculty members as leaders in sustainable textile innovation.
Impacts on university administration	The university administrators expressed satisfaction with the outcomes of the program. They recognized its role in strengthening the university's reputation in sustainable textile innovation and contributing to global environmental goals. The initiative also highlighted the university's commitment to research excellence and student development. Administrators valued the program's potential to attract funding, foster industry collaboration, and enhance academic visibility. Overall, the administration viewed the project as a successful step toward aligning the university's mission with sustainability and innovation.
Responses from industry/market	Not applicable

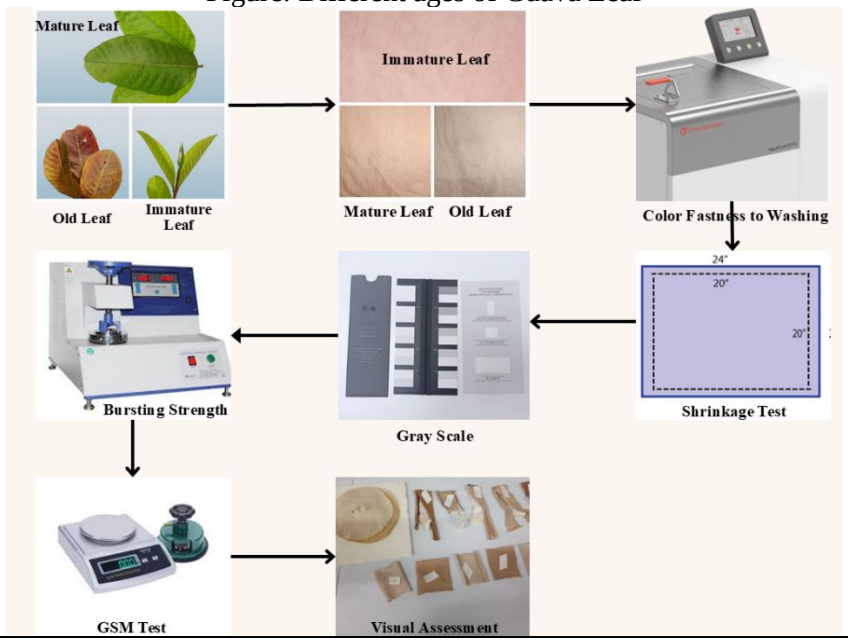
Responses from citizen/government	Not applicable
Measurable output (revenues)	Not applicable
Measurable input (expenses)	Not applicable
Cost-benefit analysis for effectiveness	Not applicable
Future Planning	
Where does the project go from here?	The project is set to move forward with improvements in extraction methods and application techniques to enhance efficiency and colorfastness. Future plans include expanding collaborations with industry partners and environmental organizations to increase adoption of natural dyes. Rising consumer demand for eco-friendly products will further strengthen the project's relevance. By lowering production costs and scaling up processes, the initiative aims to establish guava leaf extract dyeing as a practical, sustainable alternative to synthetic dyes. Ultimately, the project will position the university as a leader in environmentally responsible textile innovation.
Addendum	
Exhibits, pictures, diagrams, etc.	 Figure: Different ages of Guava Leaf 

	Figure: Process Flow Chart
Reports, mimeos, monographs, books, etc.	It is expected to publish a Scopus-indexed scientific article within six months.
Others which may help explain the program (including website links)	A final report will be submitted to the university for record-keeping purposes.