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A Comparative Study of Direct and Microencapsulation Techniques for Development of "*Coleus Amboinicus*" and "*Magnoliachampaca*" Finished Sweat Pads

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ABSTRACT

This study explores the integration of herbal extracts derived from *Coleus amboinicus* leaves and *Magnolia champaca* petals extracts into microencapsulated and direct finished sweat pads, utilizing bamboo fabric as the substrate material. Employing a dual approach, microencapsulation technology was employed to encapsulate the herbal extracts within microcapsules, which were then incorporated into the bamboo fabric, while the direct finished method involved the application of the herbal extracts onto the surface of the bamboo fabric. Extensive analysis revealed significant enhancements in both antibacterial efficacy and physical properties in the microencapsulated sweat pads, owing to the sustained release of active compounds. Furthermore, the incorporation of bamboo fabric facilitated superior moisture management and breathability, enhancing overall user comfort. This innovative amalgamation of natural herbal extracts and sustainable bamboo fabric offers promising avenues for applications in sportswear, healthcare, and personal hygiene products, addressing the escalating demand for eco-friendly and antimicrobial solutions in modern textile

engineering.

I Introduction

Personal hygiene is vital for maintaining health and well-being. It encompasses practices like handwashing, dental care, and grooming. In today's world, where diseases spread easily and social interactions are frequent, the significance of personal hygiene cannot be overlooked. This research explores the importance of personal hygiene in preventing illness, boosting self-esteem, and fostering social acceptance, (Chaturvedi, Preeti, et al,2021).

By prioritizing hygiene practices, individuals can protect their health and contribute to a healthier society. A natural finish sweat pad is a product designed to absorb sweat and prevent sweat stains on clothing, particularly in areas like the underarms. Unlike traditional sweat pads made with synthetic materials, natural finish sweat pads are typically made from organic or eco-friendly materials such as bamboo, cotton, or other plant-based fibers. These pads are often biodegradable and environmentally friendly. They provide a discreet and comfortable solution for managing sweat and maintaining clothing freshness throughout the day, (Krishnaveni, et al,2022).

Microencapsulation has become increasingly important in the textile industry due to its ability to imbue fabrics with enhanced functionalities. By encapsulating active agents within microcapsules, textiles can offer a wide array of benefits. Fragrance retention, for example, allows textiles to maintain a pleasant scent over extended periods, while moisture management properties ensure comfort by regulating body temperature and perspiration levels. Additionally, microencapsulation facilitates the incorporation of skincare ingredients directly into fabrics, promoting skin health and hydration. UV protection, antibacterial properties, and color retention are further advantages conferred by microencapsulation, making textiles more durable, hygienic, and aesthetically pleasing. Furthermore, the technology enables the development of smart textiles with capabilities such as temperature sensing and energy harvesting. As such, microencapsulation plays a crucial role in advancing the functionality and performance of textiles, enhancing their appeal across various industries and applications, (Rani, et al, 2021).

In the present work, herbal plant extracts of *Coleus amboinicus*and *Magnolia champaca*are directly applied onto bamboo fabric as anti-microbial finishing agent. The microencapsulation of *Coleus amboinicus*and *Magnolia champaca*is done and applied onto the textiles by automizer spray coating method.

II Material and Methods

Materials

Scoured and desized 100% bamboo fabric was used for the application of antibacterial finish. The leaves of *Coleus amboinicus*and petals of *Magnolia champaca*were used for the antibacterial finish.

Methods

Extraction process

The collected *Coleus amboinicus*leaves were shadow dried to remove the moisture content, proper drying is carried out otherwise the compounds may get contamined. After drying, the griding was carried out to the break the leaves into small units. 50g of *Coleus amboinicus*was soaked in 500ml of methanol for 24 hours and then filtered. The petals of *Magnolia champaca*is collected and boiled for 1hr and filtered.

Direct Application Method

The collected extract is coated in the fabric using the automizer spray technique. To use an atomizer spray, start by preparation of extract, ensuring it's well mixed. Carefully fill the atomizer without overfilling it, then prime it if necessary by pumping or pressing a button. Adjust the spray settings if available to suit your needs. Hold the atomizer comfortably and aim the nozzle where you want to spray. Depress the trigger or button to release the spray, controlling the amount by adjusting pressure. Move the atomizer in a sweeping motion for even coverage, (Sharshir, et al, 2022).

Microencapsulation

Simple coacervation method

Microencapsulation was done using the *Coleus amboinicus*extract, *Magnolia champaca*extract as core material and gelatin as shell material. For 45 minutes, 5 g of gelatin was dissolved in hot distilled water. After that, the soaked gelatin was heated to 50°C and agitated for 30 minutes at 400 rpm. Ten ml of a 3% alcohol solution containing shell material was added to the mixture once the reaction period had expired. To achieve a phase separation of the gelatin and the extracts of the core material, 10 mL of a 20% Na and SO solution were added gradually to the mixture after it had been further agitated at 400 rpm for 35 minutes at 50°C. The polymer shell that formed around the oil core material was aided in its production by the phase inductor effect of sodium sulfate. We kept stirring for an additional thirty-five minutes. In addition, the temperature dropped to 4°C. Thus, when the mixture was stirred, a gel eventually developed. After that, 2 milliliters of a 30% alcoholic formalin solution were added while continuously stirring for an additional fifteen minutes. After forming, the microcapsules were taken out and refrigerated at 4°C, (Stainslav&Bayryamov, 2020).

Human ethical clearance

The ethical clearance form for the survey on sweat pad usage among college students ensures transparency, confidentiality, and voluntary participation, prioritizing the well-being and rights of the participants.Overall, the ethical clearance form serves as a crucial document in upholding ethical standards and ensuring the integrity of the survey process.

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III RESULT AND DISCUSSION

Physical & Mechanical test

Tensile strength

To determine tensile strength, a specimen is placed in a tensile testing machine, which applies a uniaxial force until the specimen breaks. The maximum force before breaking, divided by the original cross-sectional area, gives the tensile strength. This procedure is essential for understanding a material's mechanical properties and ensuring its suitability for various applications. The tensile strength of miceonecapsulated fabric is higher compared to original and direct treated fabric.

Table I Tensile strength of Original, Direct treated and Microencapsulated Bamboo fabric

S.No	Nomenclature	Tensile Strength (mm)	% Gain or Loss over the	T Test	Tensile Strength (mm)	% Gain or Loss over the	T Test

		Lengthwise	**original**		**Crosswise**	**original**	
1.	Original	15.6		0.060845	15		0.064806
2.	Direct treated	18.6	16.1	0.12169	17.5	14.2	0.129612
3.	Microencapuslated	26	40	0.1873	20	25	0.213666

Fabric stiffness

Fabric stiffness is assessed to understand the rigidity and flexibility of a textile, which are crucial for its suitability in different applications. The fabric is typically subjected to bending tests, where a sample is placed on a testing machine that measures the force required to bend it at a specific angle or deflection. The stiffness is then calculated based on the resistance to bending. This procedure helps determine the fabric's performance characteristics, such as drape and handle, ensuring it meets the necessary standards for its intended use.As compared to the original sample. Microencapsulated fabric is less stiff when compared to original and direct-treated fabric.

Table II Stiffness of Original, Direct treated and Microencapsulated Bamboo fabric

S.No	Nomenclature	Stiffness (cms) Lengthwise	% Gain or Loss over the original	T Test	Stiffness (cms) Crosswise	% Gain or Loss over the original	T Test
1.	Original	1.8		0.054321	1.6		0.049472
2.	Direct treated	1.6	12.5	0.108624	1.4	14.2	0.098945
3.	Microencapuslated	1.6	12.5	0.28719	1.5	6.6	0.06318

Fabric thickness

Fabric thickness is measured to determine the material's bulk and suitability for various applications. The fabric is placed between the anvil and the presser foot of a thickness gauge, which applies a consistent pressure. The distance between the anvil and the presser foot, measured in millimeters or inches, indicates the fabric's thickness. This measurement is crucial for quality control, ensuring the fabric meets the specifications required for its intended use, such as insulation, durability, and comfort**.**Direct-treated fabric has excellent thickness compared to original and encapsulated fabric.

Table III Thickness of Original, Direct treated and Microencapsulated Bamboo fabric

S.No	Nomenclature	Thickness (mm)	% Gain or Loss over the original	T Test
1.	Original	0.54		0.007547
2.	Direct treated	0.66	18%	0.015095
3.	Microencapuslated	0.57	5.2%	0.587223

Fabric abrasion

Fabric abrasion testing is conducted to evaluate a textile's resistance to wear and tear, which is crucial for determining its durability and longevity in various applications. In this test, a fabric sample is placed in an abrasion testing machine, where it is rubbed against a standardized abrasive surface under controlled conditions of pressure and motion. The test continues until the fabric shows signs of wear, such as thinning, pilling, or holes. The abrasion resistance is then quantified based on the number of cycles the fabric withstands before showing significant damage.Direct-treated fabric shows less abrasion when compared to original and encapsulated fabric.

Table IV Abrasion of Original, Direct treated and Microencapsulated Bamboo fabric

S.No	Nomenclature	Abrasion (g)	% Gain or Loss over the original	T Test
1.	Original	20		0.028704
2.	Direct treated	5.4	27	0.057408
3.	Microencapuslated	14.4	39	0.123606

Absorbency test

Sinking

Sinking tests are conducted to assess the sinking behavior of fabrics, particularly in applications like marine environments or flotation devices. In this test, a fabric sample is placed in a water container to observe whether it sinks or floats. The time taken for the fabric to sink and reach the bottom is recorded. Factors such as fabric density, weight, and water absorption rate are critical in determining its sinking properties. This test helps in evaluating the fabric's suitability for specific applications where buoyancy and water interaction are crucial considerations. The original, direct treated and microencapsulated fabrics shows excellent absorbency property.

Table V Sinking of Original, Direct treated and

S.No	Nomenclature	Sinking
1.	Original	Sinking
2.	Direct treated	Sinking
3.	Microencapuslated	Sinking

Chemical test

Phytochemical screening of *Coleus amboinicus*

Table VI Phytochemical screening of *Coleus amboinicus*

S.No.	Metabolite	Test performed	Observation	Result
1	Alkaloids	+Mayer’sreagent	PresenceofCreamcolouredprecipitate	+
		+Dragendorff’s reagent	Presenceofreddish-brownprecipitate	+
2	Flavonoids	+H_2SO_4	Presenceofreddish orangecolour	+
		+leadacetate	Presenceofwhite precipitate	+

3	Sterols (Libermanntest)	+ CHCl3+ Acetic anhydride + Conc.H2SO4	Presence of reddish-brown ring	+
4	Carbohydrates	Molisch's test	Presence of Violet ring	+
		Fehling's test	Presence of Red precipitate	+
5	Saponins	Shakenwithwater	Presenceoffoam	+
6	Cardiacglycosides	Keller-killanitest	Presenceofbrownring	+
7	Volatileoils	Fluorescencetest	Pinkishfluorescence	+

Phytochemical analysis of *Coleus amboinicus* revealed a diverse array of bioactive compounds, underscoring its potential therapeutic and nutritional benefits. The examination unveiled the presence of polyphenols such as flavonoids, phenolic acids, and tannins, known for their antioxidant properties. These compounds play a crucial role in scavenging free radicals, thereby mitigating oxidative stress and reducing the risk of chronic diseases like cancer and cardiovascular ailments. Alkaloids exhibit various pharmacological activities, including analgesic and antimicrobial effects, while terpenoids possess anti-inflammatory and antimicrobial properties. Saponins, on the other hand, are recognized for their cholesterol-lowering effects and potential anticancer activities, (Katnoria, et.al,2016).

Table VII FTIR of *Coleus*

Sample	**Wavelength**	**Appearance**	**Functional group**	**Compound class**
***Coleus amboinicus* (CA)**	3302.13	Strong	O-H	Alcohol
	2947.23	Medium	C-H	Alkene
	2044.54	Strong	N=C=S	Isothiocyanate
	1589.34	Strong	N-H	Amine
	1411.89	Medium	O-H	Alcohol
	1111.00	Strong	S=O	Sulfonse compound
	601.79	Strong	C-Br	Halo compounds
	547.78	Strong	C-Br	Halo compounds

FTIR analysis of *Coleus amboinicuss*

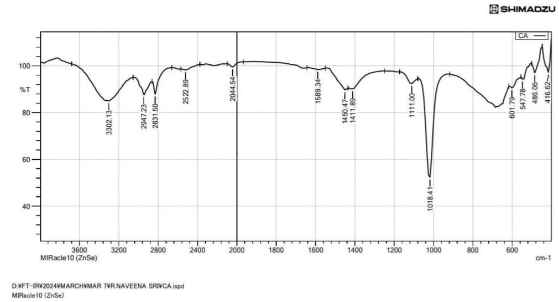


Figure 1

Figure 1, show the presence of functional groups such as alkene, alcohol, amine, sulfonse and halo compounds. Alkene and amine group have antibacterial properties and effectiveness depending on the factors. Halogenated compounds are aromatic compounds used in production of dyes and pigments, (Narayanan *et.al*,2011).

FTIR analysis of *Magnolia champaca*

Table VIII FTIR analysis of*Magnolia*

Sample	Wavelength	Appearance	Functional group	Compound class
***Magnolia champaca* (MC)**	725.23	Medium	C=C	Alkene
	648.08	Strong	C=C	Alkene
	586.36	Strong	C=C	Alkene
	486.06	Strong	C-I	Halo Compounds
	447.49	Strong	C-I	Halo Compounds

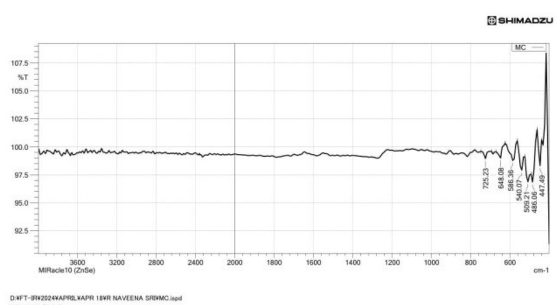
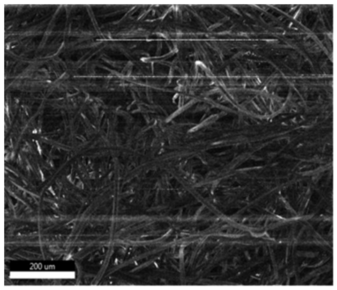


Figure 2

Figure 2, show the presence of functional groups such as alkene and halo compounds. Alkene has antibacterial properties and effectiveness depending on the factors. Halogenated compounds are aromatic compounds used in production of dyes and pigments and aromatic compounds are rich in fragrance property, (Rane *et.al*, 2016).

Specialization test

SEM Test



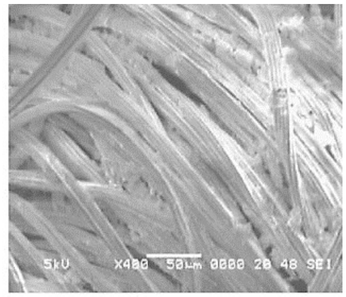


Figure 3 **Figure 4**

The SEM analysis of the untreated bamboo fabric & microencapsulated bamboo fabric are showed in figure 3 & 4 respectively. Figure 3 show the even distribution of the fiber and the size of the fiber is 200 micrometer, which means that fibers very thin and minute. The fibers are visible in hallow form. On comparing both the figures it is very clear that figure 4 shows tiny particles embossed on the fiber. Hence, the SEM analysis concludes that capsules are present in microencapsulated fabric. The interpreted result is found to similar with the article entitled "The significance of scanning electron microscopy (SEM) analysis on the microstructure of improved clay: An overview" by Ural &Nazile, 2021.

Table IX Antibacterial

Samples	**Zone of Inhibition (mm)**	
	Staphylococcus aureus	***Escherichia coli***
Original fabric- Control	0mm	0mm
CC- Capsule coated fabric	24mm	0mm
DA- Direct application of extract	0*	0mm

Anti-bacterial test

Figure 5

*There is no bacterial growth on the beneath of the fabric

The anti-bacterial analysis results in Table XI reveal that when *Staphylococcus aureus* has been used, there is a 24mm zone around the capsules coated fabric, but no bacterial growth is found when the fabric is applied directly.The obtained result bears a resemblance to the article done by Sotiriou*et al*, 2010.

4 Conclusion

In conclusion, integrating herbal extracts from *Coleus amboinicus* and *Magnolia champaca* into microencapsulated and direct finished sweat pads made of bamboo fabric significantly enhances antibacterial effectiveness and physical properties. Microencapsulated pads, in particular, excel due to sustained release of active compounds. This innovation promises eco-friendly, antimicrobial solutions for sportswear, healthcare, and personal hygiene products, highlighting the potential of natural extracts in textile engineering. Further research is essential for optimizing and scaling these advancements.

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