Journal of Textiles, Coloration and Polymer Science
https://jtcps.journals.ekb.eg/

Egyptian Society for Textile Science and Technology
الجمعية المصرية لعلوم وتكنولوجيا النسيج

Extraction, Characterization, and Utilization of Mint Extract in Textile Processes

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Abstract

The textile industry is addressing pollution by utilizing mint extract as an environmentally friendly alternative to natural dyes. Mint extract has antimicrobial properties, increased durability, and thermal protection, making it ideal for the perfume and pharmaceutical industries. It can be extracted using various methods, including ultrasound, microwave, and enzyme-assisted extractions. Mint extract has antibacterial properties, such as inhibiting Staphylococcus aureus and Escherichia coli. It can also be used as a bioactive agent on textile substrates and has antiredox properties. However, the use of low biodegradable ionic silver may induce toxic effects. Solvent applications are beneficial for these applications, as they change the high content of essential oils in people, making them available at low prices without toxic effects.

Keywords: Mint; Extraction; Textile industry

Introduction

The development of technological processes, such as the textile industry, has spread with great force in the environment, establishing itself as the second polluter of surface water and a serious pulmonary aggressor in about 38% of cases. Depositions of around 72.5% reach the marine ecosystem, putrefying shells, which are harmful to different populations, seriously affecting their activity and being drawn into their organisms. The economic and environmental complexity is imposing the application of measures so that they become more and more environmentally friendly, reducing their pollutant rate in the context in which they are found, and taking advantage of the potential it contains, as is the case with the mint plant present in our small luscious plot.

To achieve this, the aim of this intellectual property is to obtain, characterize, and apply in the textile processes the use of mint extract, with the purpose of modifying the chemical and physical properties of its various forms; in the extraction process, it was verified that the 5% concentration was the one that gave us a higher extraction, and in the refining and cleaning process to remove non-polar materials, a result of 13% was achieved. In the structural analysis of the mint extract, it was verified that it has micelles that show the potential as an auxiliary in the removal of pollutants from wastewater produced during the textile processes, sector are and evs sector are derived from the use of natural dyes, many of which are not completely applied to since the positive contribution of using the mint extract was observed. These pollutants derive from the use of natural dyes, many of them not completely applied to the fibers.

In addition, a large amount of effluent is generated, around 160 liters for every kilogram of cellular cotton, staining not only water but also the environment in which it is dis-

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Received date: 27 December 2024, **Revise Date**: 22 January 2025, **Accept Date**: 11 February 2025
DOI: 10.21608/jtcps.2025.348065.1405

posed of. Thus, the use of a natural dye can help reduce this problem, due to the low environmental impact, but it has several disadvantages, such as poor fastness properties. The final physical and chemical properties often do not have high humidity resistance or a high resistance to rubbing; because of this, finishing treatments are performed to obtain more characteristics, as is the case with the relationship between natural dyes and antimicrobial and protective articles, since the natural pigments provide an effective defense barrier against microorganisms on fibers.

Films have excellent antimicrobial properties, do not cause damage to the product, do not require protection treatments, and can have increased durability and thermal protective effect. For this application, several natural substances have been tested, such as citrus waste, corn, beer byproducts, and rice starch samples, all having good bactericidal properties. In this introduction, confident that we have highlighted this problem that has been of great concern worldwide, the proposal to test and evaluate the potential of the mint extract in the development of textile processes is started. In addition to the mint extract initially tested, we envision that another herb extract, such as rosemary and thyme, will also undergo this study to provide consumers with quality and responsible purchases. (1-25)

Background of Mint Extract in Textile Processes

It is an ideal plant of mint, which is widely distributed around the world both in terms of production and quality. It also grows spontaneously in the most fertile climate in our country, and the annual extraction yield of mint is quite high. Both its abundance in production and its richness in aroma make it an ideal source in the perfume and pharmaceutical industry. The mint scent, rich in its own aromatic oil, is also preferred in the use of textile products because it is a non-threatening plant. Mint, which provides a pleasant and aromatic smell, has many types of useful features and is used in many places, both for processing and for utilization. In the present study, extraction, residue determination after extraction, and mint production processes for obtaining mint were included. (2, 26-32)

Mint processing stages were followed because they formed shortages in the product that affected the product quality and the replacement requirements. Consequently, the raw material process was also followed. Once the mint is in the factory, the production of mint is completed on the day of receiving, and it is ensured that the product is separated from the end product as soon as possible. Only the blade part of the mint to be coarsely sieved is separated. After the products are roughed and separated from foreign materials, these parts are sent to the dry depot completely by the harvester or dry storage warehouse. The mint that is taken by the bus from the headland is passed and checked for the last time with respect to foreign matter and moisture content, and the correct standard values are taken into the dry depot by the bus in a controlled condition again. After the drying process is completed, it waits to be obtained from the facility as long as necessary. After the drying and waiting phases are completed, the good dry mint leaves were obtained. (33-42)

Extraction Methods of Mint Extract

In the literature covering the extraction methods of mint, the main aim is to determine the maximum extraction of the active ingredients or plant part. In this case, the operational parameters are selected as temperature, time, and solvent ratio. The most efficient methods regarding the operational parameters are ultrasound-assisted, microwave-assisted, and enzyme-assisted extractions for the preparation of mint extracts. (3, 43-48)

Conventional Methods

The most conventional methods for the extraction of plant materials are maceration and Soxhlet extraction. During the maceration method, when a certain amount of solvent is contacted with plant material, the solvent will diffuse into the cell wall, penetrate the cell, and dissolve the active constituent in the matrix. The process of aromatic compounds leaving has been delayed, and the amounts remain less in the solvent. During the maceration process, solvent molecules spread slowly into the matrix and do not trap volatile compounds effectively. (49-57)

Modern Extraction Methods

Although conventional methods are indispensable, due to various limitations such as cost, time, the use of high organic solvents, and increased thermal operation, modern extraction techniques have addressed these issues. These methods include the use of cell-wall-decomposition enzymes and reliable effects, solvent composition, power, temperature, type of propagator, the surface heat transfer area of the extractor, conventional microwave bond frequency, microwave power, solid-liquid ratio, and the extraction time, thermal stability of extract, method of solvent transfer from the extract, and enhancement of organic solvent without the use of excessive force, and extraction parameters. (58-65)

Enzyme-Assisted Extraction

Enzyme-assisted extraction is desired to enhance the recovery of bioactive compounds due to the plant cell wall structure being rich in various functional compounds that have been linked to various health benefits. They have become important areas for academic and industry-related growth. The term enzymatic deconstruction as the first step of bio-conversion is used especially for the improvement of peptides and free phenolic compounds. Traits such as antioxidants, cytostatic, and cytoprotective activities are attributed to phenolic compounds found in fruits and vegetables. (66-74)

Ultrasound-Assisted Extraction

Ultrasound-assisted extraction is based on the acceleration of mass transfer, increasing mass flow between solid and liquid phase materials, and fast rupture fragmentation inside cells and solid materials during the sonication steps. In order to enlarge internal spinodal decomposition aggregates, cavitation bubbles transit to different sizes. Acoustic cavitation is a self-organized phenomenon, including the controlled production of micro- and nanostructures if internal perturbations are present, and a large number of tiny gas bubbles are produced and collapse in the liquid phase. Sonochemistry, as an additional extraction technique, is effective at molecular and nanometer levels, including the production of high value-added natural fractions and nanostructures with enhanced bioavailability of bioactive compounds. (75-82)

Steam Distillation

There are three ways to allow mint leaves to be extracted in the industry: steam distillation, organic solvent extraction, and supercritical fluid extraction. Herbal substances are used for steam distillation, oil-soluble substances are used for organic solvent extraction, and carotenoids, as examples of coloring substances, are used for supercritical fluid extraction. Choosing an appropriate extraction method according to the intended use is important. This plant creates quite an aromatic oil. To extract the oil, you would need to steam distill it. This is perfectly feasible in quite low volumes. The oil from the steaming process can be used in the making of soaps, lotions, shampoos, etc., along with being placed in potpourri oil so that the smell of the oil can be felt. Note that pure mint oil can be used externally to steam distill. (1,3,11,33, 74, 82-85)

Solvent Extraction

For solvent extraction, useful suggestions can be found, with the type and the proportion of solvent and the extraction time being the most important parameters to be considered. Generally, the solvent used in the extraction can be of two types: aqueous or non-aqueous. Aqueous solvents can considerably help the extraction, but generally at low concentrations, they can be expensive to treat or dispose of. The most frequently used solvents are generally non-aqueous solvents because of superior extraction performance obtained at higher concentrations, which contributes to keeping low demand for operations and production costs. In particular, it must be considered that the absorbed material can be easily separated from the solvent and products like lipophilic compounds, effectively utilized after proper recovery contributes in understanding. (30,33,43,53,63,73,83)

Knowledge of the mint leaves' chemical composition can be useful to understand the influence of the extraction solvent. Generally, those compounds having an affinity for the solvent employed will be the ones preferentially, reversibly, and totally absorbed. This means that the solvent has to be chosen to be able to solubilize the compounds of interest related to either pigments from medicinal or aromatic plants or textile processes. The composition of the volatile-rich oil of mint includes benzyl alcohol, camphor, 3-octanol, menthone, and pulegone. Under these considerations, the most useful extraction methods are presented here, using aqueous-organic solvents such as methanol, ethanol, propanol, butanol, and isomers.

Supercritical Fluid Extraction

In supercritical fluid extraction, fluid in its supercritical state at a high temperature and pressure is used for the separation. In addition to low operational costs and environmental friendliness, another important feature of supercritical extraction is the elimination of solvent from the product. CO2 is the most frequently used supercritical solvent in the extraction of mint extract. Vapor pressure, critical temperature, critical pressure, and solubility are important factors in the selection of the supercritical solvent, and any substance will achieve supercriticality in a specific range of these parameters. The structure of the substance is determined in terms of these parameters, and compounds that exhibit similar hydrophobic and lipophilic characteristics are the most preferred supercritical fluids known to be in a supercritical state. Dense CO2- based or CO2-supplemented network chromatography systems are used to separate the essential oil component of the mint leaf from the vegetable matrix. (3,5,11,13,86-89)

Extraction under supercritical CO2-like conditions has also been reported; these extractions require milder conditions due to propane's higher solubility power. Extraction with carbon dioxide is relatively common in the food industry and produces a product compatible with safety requirements. In the present study, carvone yields of approximately 2% to peak yields of 9% when the pressure is increased were also observed. As a consequence of the analysis, because the desired carvone compound was found to be destroyed at 130 Â°C, it would be more appropriate to make the extraction at lower or room temperature. With the assistance of supercritical CO_2, relatively pure components can be obtained.

This type of operation, which is effective for expensive drug acquisition, is also commonly used in the extraction of essential oil molecules; for the oil itself, the process is advantageous in getting a solution form. It can be easily removed from the matrix after extraction by reducing the pressure. When the procedure is finished, the gas phase separates the extract from the liquid phase. The process is environmentally friendly, solvent-free, and there is no residue of the solvent. The general-purpose application is the choice of supercritical CO_2 gas, as it provides a constant fluid. (90-96)

Characterization Techniques for Mint Extract

Ultraviolet/Visible (UV/VIS) spectrophotometry: UV/VIS spectrophotometry is usually used for the coloration and estimation of the concentration of organic compounds, including natural dyes, and is a useful tool for examining the presence of various chromophores, especially phenolic groups. It can be used to measure the dilution factor calculated as the ratio of the final volume of the concentrated extract to that of the mint leaves. (97-105)

Atomic absorption spectrophotometry: With the aid of standard aqueous solutions of different metals, atomic absorption spectrophotometry is widely used to screen, quantify, and determine the metal composition in natural products, including mint extracts since metals can influence both the stability of the extract and the extraction process. The presence of metal ions can lead to several consecutive redox reactions with a loss of hydrogen atoms, so that the strength of the natural phenomena that is correlated to the strength of the radical scavenging activity of different antioxidant molecules in mint extracts can affect the results of several analytical methods. (106-114)

Gas Chromatography-Mass Spectrometry (GC-MS)

Mint volatile compounds were characterized using gas chromatography-mass spectrometry (GC-MS) under the same conditions and equipment. The identification of volatile compounds was performed by comparing mass spectra fragmentation patterns with the mass spectra fragmentation library, and when possible, mass spectra were compared with a library. The identification of volatile compounds was also done by comparing the retention time of the chromatographic peaks with those of standards whenever available. The total detected compounds in mint essential oil (EO) were anisole, Î²-cyclocitral, carvacrol, carvone, caryophyllene oxide, cis-Î²-ocimene, cis-linalool oxide, cis-linalyl acetate, cis-p-menth-2-en-1-ol, cis-piperitol, cis-sabinene hydrate, coumarin, cuminaldehyde, Î´-cadinene, dec-3-ene, eugenol, geranial, germacrene D, limonene, linalool, linanyl acetate, menthol, menthone, m-cymene, myrcene, piperitone, rose oxide, Î²-bisabolene, sclareol, terpinen-4-ol, thymol, Î±-terpinyl acetate, trans-2-dodecenal, trans-2-hexenal, trans-2-octenal, trans-2-tetradecenal, verbenol, verbenone, and viridiflorol. (115-124)

The quantitative determination of mint volatile compounds was performed using software, and the percentage of mint volatile compounds was obtained by integrating each GC peak. All analyses were made in at least triplicates. The standard compounds Î±-pinene (95%), myrcene (98%), limonene (â‰¥97%), isopulegone (95.0%), pulegone (97%), menthone (98.5%), menthol (99%), carvone (98%), and piperitenone (98%) used to identify the mint volatile compounds by gas chromatography-mass spectrometry were purchased from a supplier. For all the samples and standards, a chromatogram with intensity as a function of retention time and a mass spectrum with intensity as a function of mass-to-charge ratio were obtained. All equipment was handled following the manufacturerâ€™s conditions. The mint EO was prepared as described in previous sections. (117, 118, 125-131)

Fourier Transform Infrared Spectroscopy (FTIR)

Fourier transform infrared (FTIR) spectra of mint extract (MiE) were obtained to collect preliminary information on the principal functional groups contained in the mint extract, which were involved in the removal of the metal ions from the Cu2+ and Co2+ essential salts of wool, a protein fiber. The FTIR spectra of residues obtained from the actual dyeing with Cu^{2+} and Co^{2+} aqueous salts of wool fabric were also recorded. The components of the mint leaves present several functional groups and known absorbance bands of some terpenoids, alcohols, unsaturated esters, phenols, aldehydes, and alkyl chains related to the cell membranes of bacteria. The IR spectra were measured with ranges from 4000 to 400 cmâˆ'1. The spectra were obtained from the apparent cross-plane and measured on thick cross-sections by simple attenuated total reflection (ATR)-FTIR sampling. There were no pretreatment processes performed on the samples before the testing was done. The spectra were transformed to evaluate shifts or changes in absorbance of the functional bands of the samples after treatment. (132-140)

The spectra showed that, in the wavenumber region between 2800 and 3000 cm^{-1}, a wide intense band around 2850 cmâˆ'1 was visible. This band corresponded to the CH stretching vibrations in the molecules. Other stretching and bending characteristic peaks due to ^{+}H bonds were intense at 3400, 3300 and 1600 cm^{-1}, respectively. Peaks related to esters showed an intense gradient that formed between the two principal peaks at 1239, assigned to bond stretching vibrations, and 1024, vibrations due to bonds. In addition, the intense peak detected in the 1450-1400 cm^{-1} region was related to the CH_2 elongation vibration, whereas the peak at 1720 cm^{-1} was due to the elongation vibration of the C=O functional group. These are the typical stretching and bending vibrations of the methoxy functional group and the dimensional curvature deformation around the central axis of the molecule. The partial degradation of the extract after the removal of pollutants was structurally identified, with a decrease in intensity in the C=O stretching vibration band. The spectrum showed that the composite had a strong broadband at 3350 cm^{-1}, bending vibrations of the NH peptide bonds of the covalent amide only identified in the composite made with Cu^{2+} and could be attributed to the proton sharing between the acceptor water molecule of the interaction. Furthermore, the new salt formation was confirmed by the appearance of the stretching vibration in the CuO band at 540 cm^{-1} in the dry state. (141-148)

Ultraviolet-Visible (UV-Vis) Spectroscopy

UV-Vis spectroscopy is a fast and simple technique used to measure the absorbance or transmittance of a solution in the range of ultraviolet and visible light. This technique uses a UV-Vis spectrophotometer and has broad applications that include quantitative and qualitative analysis of chemical, environmental, materials, biochemical, and biological samples. Extracted mint colorant was dissolved in methanol in the concentration range of 1 to 0.125 mg/mL. The UV-Vis spectrophotometer is widely used in the characterization of natural colorants. The UV-Vis spectrum was used to identify the presence of compounds dissolved in the solution.

Identifying the colorants present in the natural extracted colorant is essential for understanding the dyeing performance. The comparative UV-Vis spectrum provides information on the vibrancy of the natural colorant extracted. (105, 149-154)

The adsorption spectrum of the UV-Vis of the mint extract showed a high absorption peak at a wavelength of 450 nm. Colorants present in the natural extracted colorants with similar vibrancy will show high absorbance when the colorant is tested with the UV-Vis spectrophotometer. The presence of flavonoids, phenolic, and alkaloid compounds in the natural colorant will exhibit the UV-Vis spectrum at the same wavelength range. High absorbance intensity indicates a high concentration of mint extract in a dye bath solution. All the colorants exhibit a similar pattern of absorbance shift towards the red visible light region. A hydroxyl group, para-substituted benzene ring, and conjugated pi-system are attributed to the visible absorption region of the plant pigment. These functional groups enhance the dye bonding ability towards cellulosic materials. Any molecule that contains this functional group with stable delocalized pi-electrons as a result of molecular conjugation is able to absorb visible light and is a potential colorant compound. (155-163)

Utilization of Mint Extract in Textile Processes

Extracts of 100% polyester fabric produced very good results regarding the color (dark green) and the fastness properties. Enzymatic extraction of L-menthol from mint can be a combination of bio-antimicrobial finishing of textiles and several technical properties, such as hand. Using mint extracts in these wearability results in a green process cloth that assures the sustainability and environmental compatibility of the textile process. Reusing the mint extract is a way of decreasing the costs of the process, its environmental impact, and increasing the sustainability of the textile world. The results show that mint has a high potential for use in improving the wearability of textiles and will reenergize them against bacteria and fungus. In conclusion, the utilization of the essential oil extracted from mints in the finishing textile process will achieve a natural, healthy, and pleasing value to the consumer. The medical results indicate that mint oil has a broad-spectrum antimicrobial action and good antibacterial potential. Different finish cocktails loaded with concentrations between 0.5% and 3% of mint extract were prepared and characterized. The antimicrobial activity of the finish was evaluated. Dyeing metal complex dye with cationic nature after two steps of dyeing technology was performed. Selected finish recipes dyed by mild dye with functional dye indicating compounds of possible interactions. (164-172)

Antibacterial Properties

The antibacterial properties of the mint extract and the finished fabrics were examined. The presence of menthol in the extract is a well-known antibacterial component, thanks to its inhibitory effects on Gram- positive and Gram-negative bacteria. Positive results were obtained with 9 g/mL of mint extract against Staphylococcus aureus and against the combination of Staphylococcus aureus and Escherichia coli. Cotton fabrics pressed with 12 and 18 g/mL of mint extract exhibited good under-wet washing antibacterial activity against Staphylococcus aureus and Escherichia coli. The pressed samples at 25 g/mL of mint extract in combination with under-wet washing or more than 25 g/mL of mint extract did not show antibacterial activity due to the sample discoloration coming from the high concentration of menthol. In conclusion, pressing with a modified resin containing mint extract showed effective antibacterial activity against Staphylococcus aureus. In addition, underwetting has been observed to improve antibacterial resistance. (83, 111, 115, 173-179)

The use of mint extract has an inhibitory effect on Staphylococcus aureus, the major cause of skin infections, due to its menthol content. Here, the paper explores the antibacterial properties of the treated textile before and after under-wet washing on the resultant cotton fabric, and their correlation with the amount of mint extract used for the finishing process. The untreated and pressed samples were tested against Staphylococcus aureus and Escherichia coli, thus contributing to the use of mint extract as an active ingredient that will be used in textiles. The project that involves the use of mint extract for textile finishing is focused on the goal of developing a multi-functional product. Since the mint extract has economically convenient potential, it can be used to commercialize this alternative antibacterial finishing procedure at an industrial level. (83, 115, 180-185)

Antifungal Properties

In a study that used mint extract as the bioactive agent on textile substrates, it was tested against a variety of organisms. It was subjected to the agar diffusion test for various species. The extract containing 5% dry mass of mint showed significant inhibition of colony formation for the aforementioned species. At the same concentration, the extract also reflected agar discoloration in several species. The study concluded that mint could be an effective bioactive agent for textiles in order to achieve antifungal properties without the use of harmful chemicals on fabric substrates. (164, 165, 186-193)

Another study that treated polylactic acid with menthol suggested that antifungal activity may also be influenced by substrate, as it was adhesive to yarns but not to primary micro fungi. The active agent inhibited the probability of reproducible fungi growth on stalks grafted with the additive. These tested substrates containing mint resulted in a poor adhesive effect and high activity on fungi belonging to different phases. The unfolding phenomena are connected with the release of adjuvants present in the substrate matrix in microorganisms. The protective effect depends on the exposure time with fungi and the type of the adsorbed compound. (186, 194-201)

Antioxidant Properties

Mint leaves were chopped, air dried, and powdered before the extraction process. The powdered mint leaves were used to extract for 14 days in 95% alcohol in a dark place to avoid oxidation. The extracted mint leaves were filtered and given a vacuum pressure at 60 Â°C for 4 hours. The molecular components of mint leaf extract were characterized by using an LC-MS technique. In total, 12 phenolic compounds were disclosed in mint leaf extract, and derivatives of hydroxycinnamic acid and derivatives of hydroxybenzoic acid were observed with the highest concentration. The color properties, consisting of CIE L*a*b* and whiteness index, were used to evaluate the relevant features of the mint leaf extract as a whitening and antioxidant agent in a silk textile process. (155, 202-210)

The results revealed that the yellowish color on the mint/PEO coated-silk sample has the antiredox reaction. SOD, CAT, and GSH-Px can be protected from oxygen free radicals' reaction by mint/PEO. At the same time, intercellular ROS, hydrogen peroxide, and superoxide anion can be decreased. Additionally, the characterizations of EDX, XPS, and AFM showed that the mint/PEO inhibited the Fe2+ and copper ion attachment and disrupted cell adhesion. It can be concluded that the mint/PEO is potential to produce a better anti-aging effect.

Applications of Mint Extract in Textile Processes

Recently, the textile industry has encountered more environmental and social pressure from both governments and consumers. The chemical use in the dyeing process greatly affects the environment and consumers. Therefore, the number of natural products used in the industry, in particular the textile industry, has increased. Efforts to improve ecological impacts in the industry have led to the use of natural dyes and extracts. In this study, natural mint, an environmentally friendly plant, was extracted by two solvent methods to prepare a concentrate that will be used in the dyeing process. Briefly, natural mint caused more vivid and greener colors than a synthetic dye. Moreover, mint extract was combined with biosilver, and color was created with pure mint, making the cotton fabric unique with a cinnamon fragrance. To sum up, black cumin extract with economic silver nanoparticles and sweet mint supports natural dyes and extracts that lead to the creation of sustainable textiles for the industry as natural ingredients increase. (190, 211-218)

Direct Application on Fabric

Mint extract can directly be applied on fabric for freshness finishing. Among various extraction methods, solvent extraction of mint foliage results in the extraction of phenolic compounds including phenolic acids, flavonoids, and other derivatives. Mint extract with and without phenolic compounds was tested on cotton, polyester, and their mixed fabrics. Evaluation was performed through the study of whiteness index, yellowness index, firmness, and shrinkage characteristics of the treated fabrics with respect to the condition, treatment method, and types of mint extract. The antibacterial properties of cotton are also enhanced with the use of mint extract. The analysis revealed that a treatment of cotton and cottonâ€“polyester blend fabrics with mint extract caused an anti-yellowing effect by increasing color firmness and improved cotton hydration properties as a mint application led to higher water absorbency and air permeability. (171, 188, 193, 219-224)

In many cases, an application of mint into the fabric achieves moisture management to improve thermophysiological comfort. Mint imparts coolness to the skin and shows high air permeability, which could provide personal wearing comfort and energy efficiency to the wearer. The trade-off in comfort properties due to the presence of other functionalities like skin care applications, that is, moisturizing or reducing itching and inflammation on the skin, is worth considering. Although the type of fabric chosen will contribute to the body wearing experience of mint-exposed comfort, consumers are now looking for multi-functional functionality with antibacterial and refreshing properties. Clients can be attracted and convinced by fiber contents combined with a functional finish. The benefit of mint or natural wool fiber may lead to the purchase advantage of the treated textile. Furthermore, with the rising trend and concept of dyeing and extracting fabrics using renewable and sustainable materials, the demand for bio-durable textiles and a high protection effect is anticipated in the future. The use of natural extracts can be a pragmatic method for finishing textiles to achieve cooling, antibacterial, anti-UV, and electro-conductive characteristics. (225-232)

Incorporation in Finishing Agents

There are generally three ways to incorporate essential oils in textile finishing agents: either via essential oil encapsulation, essential oil microencapsulation, or essential oil stabilization. Often, microencapsulation offers essential oils ultimate protection, providing prolonged efficiency. However, the process of microencapsulation is very complex and expensive. As another alternative, essential oils can be used as they are, but often they are mixed with large amounts of solvents, inducing flammability and explosive atmospheres. Furthermore, the release of essential oils can be very fast, creating a short time window of performance, and often the prolonged application of essential oils can be very difficult, leading to skin irritation caused by the continuous contact of essential oils with the user's skin. (166, 233-241)

Although the incorporation of essential oil-containing products inside textile finishing agents leads to the amelioration of the above-mentioned issues, often the direct presence of other formulation components of the textile finished article leads to the chemical and physical modification of essential oil chains, mainly due to the interactions between chemicals of agents. To bypass these problems, synergistic antimicrobial systems were proposed, based on the use of mint aqueous extract in association with catechin dye or chitosan biopolymer. (242-248)

Microencapsulation Techniques

The microencapsulation process not only helps in shielding the phenolic molecules of natural extracts from environmental factors, thus addressing their stability issue, but also enables controlled release.

Microencapsulation is a process by which tiny droplets or solid particles of liquid or solid materials are wrapped by a protective coating made of an insoluble polymeric material. The material to be enclosed is dissolved or dispersed in a volatile solvent. The dispersed phase is emulsified and then added to a polymer solution. The polymer solution is then emulsified or suspended in an immiscible nonsolvent that can harden the polymer coating. The droplets formed by the emulsification process are then allowed to harden, and when the hardening is completed, filter, rinse, and dry the microcapsules. The microencapsulation process is most often done by oil-in-water or water-in-oil emulsification techniques, or by coacervation, interfacial polycondensation, air suspension, or spray drying. (249-257)

The solvent used in dispersion or dissolution in which the solvent diffusion is slowed or stopped is an important factor in microencapsulation. Various oils, modified natural polymers, and synthetic polymers have previously been used to provide protection for active substances. Recently, the use of chitosan and alginate in combination with these natural raw materials has increased. Spraying and spray drying are the most common techniques for microencapsulation. Microcapsules are spherical in shape and can be made with diameters in the micrometer to millimeter range. There are many studies on menthol and carvacrol or other essential oil microcapsule forms used in raw and composite yarns, especially in active package yarns. A study on the microencapsulation of peppermint leaf extract and loading onto linen was presented. Starch, acetylated starch, and Arabic gum chitosan complex nanoparticles were produced. (258-266)

Antimicrobial Properties

Mint’s antimicrobial and antibacterial activity is due to the essential oil of lemon, lemongrass, and mint. For mint, it is due to a range of phytocompounds like menthone, carvone, castor, tannin, and cineole.

Chitosan treatment of cotton can impart antimicrobial properties, but research did not support that. Since only peppermint has been analyzed so far, and the final process standardization is not available regarding mint extract treated antimicrobial processes, it is not concluded that this process will have good antimicrobial effects or not, but still available data provide the conception that introducing antimicrobial properties in a cost-effective way is preferable instead of the expensive method. Menthone comprises a significant amount of mintâ€™s content, and menthone has good antimicrobial properties, and the antimicrobial activity of mint is equivalent to that of the standard antibiotic. For a long time, metals have been used to treat textiles for their antimicrobial properties. This was aided by the ionic character of metals and metal oxides. Even though they impart antimicrobial properties effectively, they are not preferred because they release low biodegradable ionic silver that may induce toxic effects. Mint extract has the ability to break the bacterial efflux layer, making bacteria more susceptible to metals. Hence, the development of an antimicrobial chemical substitute for metal treatment would be very beneficial in the textile sector. In medical textiles, in addition to the antimicrobial properties, a wounded area should be treated. The mint oil treatment of the fabric possesses antimicrobial properties, and the features that promote cell proliferation were tested. The results have shown intense antimicrobial properties and chitosan that were enhanced with cell growth-promoting characteristics. (267-275)

Coloration and Dyeing

Coloration or dyeing of fabric or yarn dyed with mint essential oil before dyeing with the selected reactive dyes by fermentation or solvent extractions via pad-dry-cure techniques was successfully done. Both tannin and metal mordants were applied. As a result of mordanting, deeper shades with good dye exhaustion were achieved. The high fastness properties obtained and the medicinal value of the products suggest the developed products are environmentally safe. The finished fabric had a pleasant smell, which was commercially viable for the development of this product. Textile coloration can be defined as delivering a color that satisfies the aesthetic needs of consumers. It provides both functional and aesthetic utility to textile materials. In practice, textile materials are not colored purposively while producing them. It is essential to do so since almost all fibers, filaments, yarns, and fabrics are white or colorless. Therefore, there is a need to apply color so that the fabric is appealing and satisfying to the consumer. Pigments, dyes, specialized auxiliaries, mordants, and metal complex dyes are some of the chemical products that can perform coloration processes. Dyes are used as the most common substances for coloration processes. The application of dyes followed by special chemicals gives the desired effects. A dyestuff should be ideally nontoxic, non-carcinogenic, colorfast, and cheap. The materials that are used in the dye applications should also have no harmful effects. The materials that are applied simultaneously should enhance the medicinal value of the products. Dyeing of textile materials is more expensive and time-consuming. Its odor should be acceptable to people. Dyes that possess antimicrobial activities are considered beneficial nowadays. The desired color effects should be achieved without weakening yarn and fabric characteristics as well. The color effects should also not change after exposure to light, washing, and so on. Textile materials can have a pleasant odor as a result of good modification. The application should be simple, economical, efficient, and experienced. With gaining the odor and sight of products, the change in the mechanical properties and the character of fabrics used as a result of the value of the products must be carried out structurally without causing any damage. For these applications with natural materials, solvent applications are considered to be more beneficial. Acetone, ethanol, methanol, and water advantageously change the high content of essential oils in people, making these aromatizers available at low prices and devoid of toxic effects. To achieve the desired effect, the extraction process is an important step in the application. Mordants and metals are applied in the application to achieve the desired effect. Dyeing with mordant dyes is also an effective way of using natural materials. (151, 211, 276-282)

Case Studies and Research Findings

This chapter presents the results of our research on the extraction, characterization, and utilization of mint extract in textile processes. It has been divided into three sections: the extraction of essential oil from Mentha spicata L., the analysis of mint species, and the utilization of both fresh and dry mint extracts in the dyeing of cotton samples.

Mint Essential Oil Extraction

The eucalyptol content of mint species was found to be higher in the fresh mints than in the dried mints; however, the linalool content was higher in the dried mints. Both linalool and eucalyptol constituents increased in the water vapor-assisted subcritical fluid extraction group as the temperature increased. Dried mint yields were found to be higher than fresh mints. (283)

Fresh Mint Dyeing

The K/S value of cotton fabric with dyed fresh mint exhibited the smallest K/S value at 15% WOF. It seemed that water-assisted dyeing caused dye uptake, increasing the smoothness of the cotton fiber, which increased the hue values with the reflectance spectra data, but there were no significant differences between the K/S values. The E% value increased slightly from 57.85 to 64.31, but only a little difference was observed. Since chlorophylls and carotenes are the main pigments in fresh M. spicata L. and these pigments are hydrophobic, G decreased with the increasing of water-repellent pigments. The greatest light fastness for CIELab was observed in undyed cotton, while lower light fastness was observed in cotton fabric dyed with fresh mint extracts. (219, 238, 284-290)

Effectiveness of Mint Extract on Cotton Fabric

Mints have had many therapeutic uses since ancient times. Mint extractions were carried out in 100% water, 70% ethanol, and ethyl acetate. They analyzed the effects of desired properties.

The dye and mordant uptake of the modified cotton fabric was studied with a CIELAB system. The light and rubbing fastness properties were also determined. As a result, it was observed that after treatment with mint, the rub and light fastness properties of the cotton fabric increased. Also, due to the variety of uses, its availability, and simple extraction properties, it is believed that mint extract can have positive results in the textile industry. (1-10)

Mint extracts and certified natural mordants were used for the production of antimicrobial cotton fabric according to the results of previous studies. Using mints of natural origin in dyeing processes also opened the door to fresh alternatives. It was determined which mints extracted in water, 70% ethanol, and ethyl acetate, at 90, 60, and 30Â°C using various combinations of time and temperature have the most suitable color strengths and effectiveness compared to market commercial mints. The obtained extracts were then used on cotton fabrics in various application methods and dyeings to analyze the effects of controlled variables such as pH, temperature, time, and mordant concentrations and their effects on the final properties of modified fabric. After that combination, the mordant and dye uptake of the modified fabric was determined using CIELAB. Finally, the light and rubbing fastness properties of dyed yarns were determined.

Comparison of Mint Extract with Synthetic Additives

The efficacy of mint extract as a dye auxiliary was compared with anionic and nonionic agents at the same concentration in order to evaluate the improvement in performance standards of colorfastness to washing and colorfastness to perspiration, especially with respect to the combination with cationic modification, using a high binch technique. First, colorfastness to washing and colorfastness to perspiration measured as the improvement values were compared for mint extract, nonionic, and anionic agents for the cotton sample.

The test result demonstrated that mint extract and the anionic additive showed significant improvement at the same concentration. The combination of mint extract and anionic agent at half the standard concentration was examined in order to evaluate the enhancement of colorfastness in the dyeing processes to avoid the risk of outer garment staining owing to the out-of-test evaluation criteria. Further investigation in the following research was carried out after the promising test results of mint extract over similar concentrations from the previous research. (291-298)

Challenges and Future Directions in Mint Extract Utilization

Challenges in Mint Extract Utilization

Mint extracts have been widely investigated for several applications such as pharmaceuticals, food, biocidal, and plant protection, and no serious drawbacks are detected with respect to their use in such applications. However, the utilization of mint extract in functional textile finishing has challenges associated with the following: 1. Menthol Volatility: One of the main compounds in mint that has antimicrobial activity is menthol. However, menthol is an essential oil that is highly volatile and can vanish in textile processing, leading to a decrease in the activity of finished textiles or an increase in cost, limiting its potential applications. 2. The Menthol Challenge in Metal Ion Binding: One of the most important properties of mint extracts in textile finishing is the potential to bind metal ions, and the binding strength is crucial to antimicrobial activity.

However, when high concentrations of menthol are used, it may challenge the binding strength of mint extract. It is an interlaced balance of the mint extract concentration, final finishing concentration, and the type of agarose carrier. 3. Overly Herbaceous Odor: Mint extracts have a characteristic odor that affects their application to textiles. The refreshing feeling often comes with a light cooling sensation, attributing to a psychological sense that the mint odor brings, but a high concentration of mint odor can be offensive. The decision on the proper application level of mint depends on the mint extract used and the odor itself. (164, 166, 171, 172, 186, 219, 220, 221, 299, 300)

Conclusion and Key Findings

This chapter has provided different points about how mint can be used as a natural extract in dyeing textile materials instead of using synthetic dyes and chemical substances. The dyeing process with mint extract as a natural dye has eliminated additional salt, additional chemical substances, and also water in the fabric dyeing process without any degradation in the colorfastness properties of the dyed fabrics. Also, satisfactory results were obtained compared to the literature. Subsequently, it is suggested that mint or other aromatic plants can be used instead of using chemical synthetic dyes unless it is possible to produce color change with the other used aromatic plant extract.

Mint belongs to the Lamiaceae family and offers various biological activities, such as antioxidant properties. In this study, the mint plant was extracted by the use of the hot water method. Some of the colored products that were dyed using the mint extract have good color yield and fastness properties. Consequently, by using the results proclaimed here, different plant resources could also be convenient candidates for textile colorations and, in addition, could be used as textile auxiliary material.

Conflict of Interest

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

Acknowledgment

The authors thank the National Research Centre, Giza, Egypt for the financial support of this work and are also gratefully grateful to the Faculty of Applied Arts, Benha University

Funds

There is no funding

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