



High-impulse electrophoretic deposition of TiO₂ nanoparticles on bacterial cellulose

Aline R. Almeida · Julio César Sagás · Cristiane Stegemann · Jair Nunes · Henrique de Souza Medeiros · Luis César Fontana · Daniela Becker

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Abstract In this work, a modified electrophoretic deposition method, named High-Impulse Electrophoretic Deposition (HI-EPD), was used to coat bacterial cellulose with TiO₂ nanoparticles to modify the material wettability. Different samples were produced by varying the deposition time (8.0–22.0 min) and the concentration (0.32–0.88 wt%) of the nanoparticles in the suspension. The water contact angles of the samples were measured, so that three samples were selected, the one with the lowest contact angle ($11.8 \pm 0.1^\circ$), the intermediate value ($30.7 \pm 0.2^\circ$)

and the higher value ($41.1 \pm 0.3^\circ$), for more detailed characterizations. It was observed that the higher the TiO₂ concentration in the suspension, the greater the hydrophilicity and homogeneity of deposition, as verified by scanning electron microscopy (SEM). Deposition was confirmed by Fourier transform infrared analysis (FTIR) and X-ray diffractometry (XRD). Thermogravimetric analysis (TGA) shows that the higher the TiO₂ concentration in the suspension used for deposition, the better the thermal resistance of the material.

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Keywords Electrophoretic deposition · BC surface modification · TiO₂ nanoparticle

Introduction

The bacterial cellulose (BC) is a moist and gelatinous skin species, with a chemical structure equivalent to vegetable cellulose (VC), being an unbranched polymer composed of glucose residues connected by β -1–4 glycosidic bonds. BC exhibits unique properties compared to plant-derived cellulose, including higher purity, greater crystallinity index, and a higher degree of polymerization after washing treatment following its purification (Brown AJ 1886; Hibbert and Barsha 1931; Szymańska et al. 2022).

The most well-known and studied BC-producing bacterium is *Komagataeibacter xylinus* (formerly *Gluconacetobacter xylinus*). Another way to obtain



Article

Photosensitized Methylene Blue Nanoparticles: A Promising Approach for the Control of Oral Infections

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Abstract: Introduction: Oral infections pose significant public health challenges, often exacerbating other comorbidities and increasing systemic health risks. Traditional treatments often fail to eliminate persistent micro-organisms and contribute to the rise of antimicrobial resistance. Nanoparticulate systems offer a promising solution by delivering active agents directly to targeted sites, providing more effective and localized treatment options. **Objective:** This study aimed to synthesize and characterize methylcellulose nanoparticles containing methylene blue at different concentrations using the nanoprecipitation method. We also evaluated their biocompatibility and antimicrobial activity against key micro-organisms commonly found in oral infections. **Methods:** The study involved physicochemical and morphological characterizations, including encapsulation efficiency, particle size, polydispersity index, zeta potential, and transmission electron microscopy (TEM). Additionally, controlled release profiles, antimicrobial efficacy against major oral pathogens, and biocompatibility in vitro assessments were performed. **Results:** The results revealed encapsulation efficiency between 99.1 and 98.8%, with particle sizes ranging from 186 to 274 nm and a zeta potential of 1.7 to 2.9 mV achieved at lower concentrations of methylene blue and methylcellulose. The nanoparticles demonstrated sustained drug release of 85% for the smaller particles and 45% for the larger particles for more than 10 h. The nanoparticles exhibited superior antimicrobial activity compared to pure methylene blue. Cell viability studies indicated that the nanoparticles were biocompatible with approximately 40% cell viability at lower concentrations of the nanoparticles. **Conclusions:** These findings suggest that methylene blue nanoparticles could serve as a promising adjunct in dental treatments. They offer targeted antimicrobial action while potentially reducing the development of antimicrobial resistance.

Keywords: nanotechnology; controlled release; antimicrobial resistance; biocompatibility

1. Introduction

Throughout life, humans are often infected by various micro-organisms, including bacteria, fungi, yeasts, and viruses. The oral cavity hosts a wide range of micro-organisms



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Trub, a Brewing Byproduct, Is an Innovative and Valuable Source of Nutrients and Natural Antioxidants Viable for Fish Dietary Supplementation

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ABSTRACT

The present study investigated the nutritional composition, phenolic profile, and antioxidant activity of trub, a byproduct of the brewing industry, for its use in the formulation of aquatic feeds. High performance liquid chromatograph-electrospray ionization-tandem mass spectrometry (HPLC-ESI-MS/MS) was used to determine the phenolic compound profile, and 2,2-azinobis (3-ethylbenzothiazoline-6-sulfonic acid)/2,2-diphenyl-1-picrylhydrazyl (ABTS/DPPH) assays were used to determine the antioxidant activity. Two samples of trub (approximately 500 g) were characterized: sample A, composed of malts Pilsen, Pale Ale, and Caramunich II and hops Herkules and Fuggle, and sample B, composed of malts Pilsen, Pale Ale, and Melanoidin and hops Cascade, Chinook, and Amarillo. The trub B contained carbohydrates and proteins, and its extracts had high total phenolic ($754.74 \pm 0.08 \text{ mg } 100 \text{ g}^{-1}$) and total flavonoid ($894.71 \pm 0.16 \text{ mg } 100 \text{ g}^{-1}$) contents. In the trub extracts, 21 (trub A) and 19 (trub B) polyphenols were identified, of which 17 and 14 were quantified in trub A and B, respectively. Ferulic and protocatechuic acids were found in greater concentrations, followed by isoquercitrin and p-coumaric acid. With respect to antioxidant activity, trub A showed greater activity in the DPPH assay ($2.13 \pm 0.01 \text{ mg mL}^{-1}$), whereas trub B showed greater activity in the ABTS assay ($29.07 \pm 0.15 \text{ mg mL}^{-1}$), which could be related to the content and variety of phenolic compounds in the samples. These results indicate that both trub extracts can be sources of natural antioxidants with significant potential for fish dietary supplementation.

KEYWORDS

Aquaculture; biological value; biomass valorization; brewing waste; feed additive

GRAPHICAL ABSTRACT



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Article

Antimicrobial and Cytotoxic Potential of Eucalyptus Essential Oil-Based Nanoemulsions for Mouthwashes Application

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Abstract: **Objective:** An eucalyptus essential oil-based nanoemulsion was produced and evaluated for its antimicrobial properties against *Streptococcus mutans* and its cytotoxicity in the surface mucous cells of rabbits. **Methods:** The essential oil-based nanoemulsion was synthesized with two species of eucalyptus—*Eucalyptus citriodora* and *Eucalyptus globulus*—followed by physicochemical characterization and the determination of antimicrobial activity and cell viability. Subsequently, the mouthwash formulations (fluoride and fluoride-free) were functionalized with the nanoemulsion, and their in vitro antimicrobial actions were evaluated against *S. mutans*. **Results:** The nanoemulsion presented an average particle size of around 100 nm, a polydispersity index close to 0.3, a zeta potential between −19 and −30 mV, a pH close to 7, a spherical shape, and a cell viability above 50%. The antimicrobial activity analysis showed that the nanoemulsion was effective in the control of *S. mutans*. The mouthwashes functionalized with the nanoemulsion also presented bacteriostatic and bactericidal properties. **Conclusions:** The bio-based material produced with eucalyptus essential oil presented adequate physicochemical characteristics, with the potential to be used as an innovative material in preventive dentistry, contributing to the maintenance of oral and systemic health.

Keywords: nanotechnology; preventive dentistry; antioxidant; bioactive compounds

ARTIGO ORIGINAL

FOOD
SCIENCE TODAY

Produção de celulose bacteriana (CB) em diferentes meios a partir de culturas de kombucha

Production of bacterial cellulose (BC) in different media from kombucha cultures

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Resumo

A celulose bacteriana (CB) despertou interesse científico significativo devido às suas aplicações potenciais em vários setores, incluindo indústrias médicas, cosméticas, alimentícias, ambientais e de moda. Esse interesse decorre de seus atributos como material biodegradável, biocompatível e com notáveis propriedades mecânicas, proveniente de origens renováveis. Além disso, o seu processo de produção é simples, produzindo apenas resíduos orgânicos e compostáveis. A produção de CB necessita de microrganismos e de um meio de cultura. Embora a bactéria Gram-negativa *Komagataeibacter xylinus* seja reconhecida como particularmente eficiente para a produção isolada de CB, consórcios de microrganismos como o kombucha demonstraram rendimentos promissores sob condições de cultura adequadas. Assim, este estudo busca verificar a diversidade de microrganismos presentes nas amostras de kombucha e sua respectiva produtividade de CB em diversos meios de cultura. Quatro amostras de kombucha (designadas A, B, C e D) juntamente com dois tipos de meios de cultura, HS e natural (composto por chá e açúcar), foram submetidas à experimentação. A enumeração de microrganismos revelou a amostra C como a mais abundante, seguida por A, D e B, com a identificação de três variedades distintas de colônias. Entre estes, dois exibiram características morfológicas semelhantes a bacilos Gram-negativos curtos, característicos de *K. xylinus*, e bacilos Gram-positivos, sugerindo uma cepa de levedura. A produção de CB mostrou-se mais eficiente quando se utilizou o meio de cultura natural, particularmente evidente na amostra C, possivelmente atribuível a parâmetros físicos e químicos favoráveis dentro deste meio de crescimento. Notavelmente, o meio de cultura natural exibiu maior eficácia na produção de CB com culturas derivadas da amostra C do kombucha.

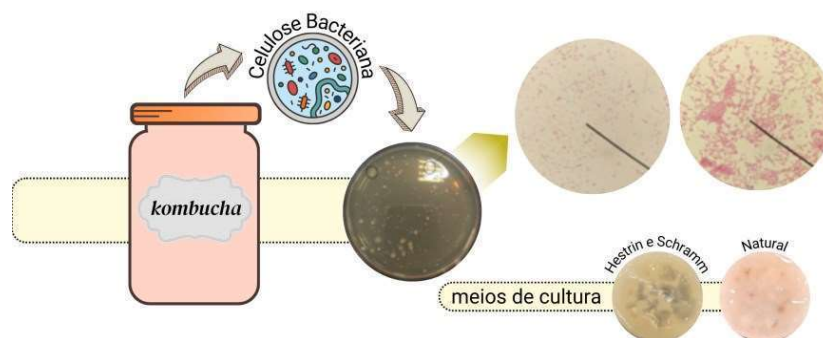
Palavras-chave: Celulose bacteriana (CB), produção de CB, rendimento de CB, kombucha, variabilidade de microrganismos.

Abstract

Bacterial cellulose (BC) has elicited significant scientific interest due to its potential applications across various sectors, including medical, cosmetic, food, environmental, and fashion industries. This interest stems from its attributes as a biodegradable, biocompatible material with notable mechanical properties, sourced from renewable origins. Furthermore, its production process is straightforward, yielding solely organic and compostable waste. The production of BC necessitates microorganisms and a cultured medium. While the Gram-negative bacterium *Komagataeibacter xylinus* is recognized as particularly efficient for BC production in isolation, consortia of microorganisms such as those found in kombucha have demonstrated promising yields under suitable culture conditions. Hence, this study endeavors to ascertain the diversity of microorganisms present in kombucha samples and their respective BC productivity across varied culture media. Four kombucha samples (designated A, B, C, and D), along with two types of culture media, HS and natural (comprising tea and sugar), were subjected to experimentation. Microorganism enumeration revealed sample C as the most abundant, followed by A, D, and B, with the identification of three distinct colony varieties. Among these, two exhibited morphological traits akin to short Gram-negative bacilli, characteristic of *K. xylinus*, and Gram-positive bacilli, suggesting a yeast strain. BC production proved more efficient when utilizing the natural culture medium, particularly evident in sample C, possibly attributable to favorable physical and chemical parameters within this growth medium. Notably, the natural culture medium exhibited heightened efficacy in BC production with cultures derived from kombucha sample C.

Keywords: Bacterial cellulose (BC), BC production, BC yield, kombucha, microorganism variability.

Graphical Abstract



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REVIEW ARTICLE

FOOD
SCIENCE TODAY

Lúpulo no Brasil: Uma cultura promissora em ascensão *Hops in Brazil: A promising and emerging crop*

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Resumo

Acreditava-se anteriormente que o cultivo do lúpulo no Brasil não era viável. No entanto, após inúmeras tentativas, um agricultor de São Bento do Sapucaí – SP, obteve a primeira colheita em 2016, utilizando a variedade Cascade de lúpulo. Desde então, a produção de lúpulo se expandiu para diferentes regiões do país, despertando o interesse das cervejarias em incorporar o lúpulo brasileiro em suas bebidas, além de incentivar pesquisas para caracterizar e compreender suas propriedades. Assim, torna-se crucial a realização de um estudo que apresente a situação atual da produção e da pesquisa científica sobre as variedades de lúpulo brasileiro, sendo esse o objetivo principal deste trabalho. Uma revisão integrativa de literatura, com abordagem qualitativa, foi conduzida nas bases de dados eletrônicas SciELO, ScienceDirect e Google Acadêmico entre os meses de fevereiro a outubro de 2023, utilizando os descritores “lúpulo”, “lúpulo brasileiro”, “produção de lúpulo no Brasil”, “brazilian hop” e “hops”. Verificou-se que atualmente o lúpulo é cultivado em 14 estados, destacando-se Santa Catarina, Rio Grande do Sul e Paraná, totalizando 75 mil plantas em todo o país. Quanto às pesquisas, foram identificadas 13 publicações, sendo 12 artigos científicos e 1 livro. Esses estudos discorrem sobre a qualidade e a importância do cultivo do lúpulo no Brasil. Embora acredite-se que seja longo o caminho para alcançar uma produção significativa, capaz de atender à demanda da indústria brasileira de cerveja, os primeiros passos foram dados, conforme evidenciado nos trabalhos publicados com qualidade.

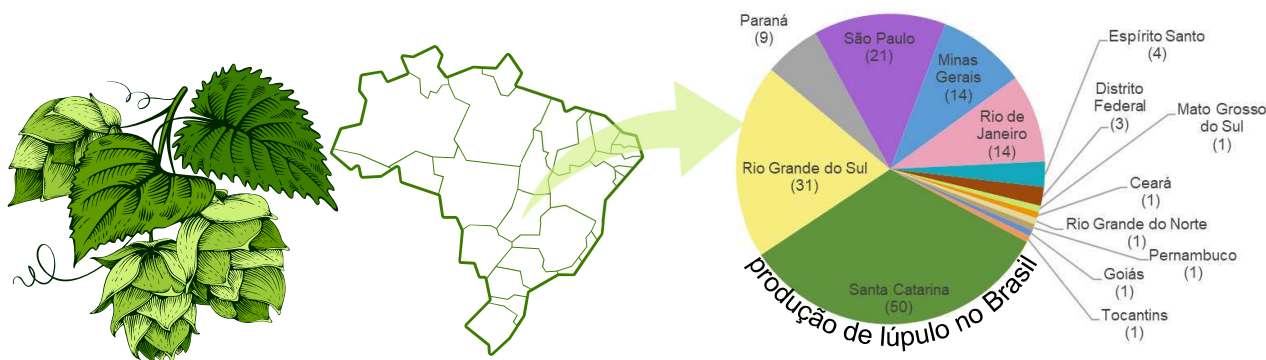
Palavras-chave: Lúpulo, lúpulo brasileiro, cultivo de lúpulo no Brasil, produção de lúpulo no Brasil, pesquisas com lúpulo no Brasil.

Abstract

Previously, it was believed that hop cultivation in Brazil was not viable. However, after numerous attempts, a farmer from São Bento do Sapucaí – SP, achieved the first harvest in 2016, using the Cascade hop variety. Since then, hop production has expanded to different regions of the country, sparking the interest of breweries in incorporating Brazilian hops into their beverages and encouraging research to characterize and understand their properties. Therefore, it becomes crucial to conduct a study that presents the current situation of hop production and scientific research on Brazilian hop varieties, which is the main objective of this work. An integrative literature review, with a qualitative approach, was conducted on the SciELO, ScienceDirect, and Google Scholar electronic databases between February and October 2023, using the descriptors “hops,” “Brazilian hops,” “hop production in Brazil,” “brazilian hop,” and “hops.” It was found that hops are currently cultivated in 14 states, with Santa Catarina, Rio Grande do Sul, and Paraná standing out, totaling 75 thousand plants nationwide. Regarding research, 13 publications were identified, including 12 scientific articles and 1 book. These studies discuss the quality and importance of hop cultivation in Brazil. Although it is believed that the journey to achieve significant production capable of meeting the demand of the Brazilian beer industry is long, the initial steps have been taken, as evidenced in the published works of quality.

Keywords: Hop, Brazilian hops, hop cultivation in Brazil, hop production in Brazil, hop research in Brazil.

Graphical Abstract



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ORIGINAL ARTICLE



Physicochemical analysis, antioxidant activity and research of saponins in fresh and blanched caruru (*Amaranthus deflexus* Linn) and ora-pro-nóbis (*Pereskia aculeata* Miller) leaves

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Abstract

Caruru and ora-pro-nóbis are unconventional food plants rich in proteins, essential amino acids, fibers, vitamins, minerals, and bioactive compounds but contain antinutritional factors. Blanching is one of the recommended methods to eliminate antinutrients, but it can change the chemical composition of foods. Therefore, the study's objective was to evaluate the physicochemical characteristics (pH and acidity), the proximate composition, the bioactive compounds (total phenolic compounds and vitamin C), the antioxidant activity and the presence of saponins in fresh caruru and ora-pro-nóbis leaves and subjected to blanching. The analyzed samples showed significant content of moisture, ash, protein, fiber, total phenolic compounds, vitamin C and antioxidant activity. In caruru, blanching increased pH, total solids, proteins, lipids, and carbohydrates while decreasing moisture, antioxidant activity and saponins. In ora-pro-nóbis, this processing increased pH, fiber, and total phenolic compounds and decreased vitamin C and saponins.

Keywords: PANC, antinutrients, blanching, centesimal composition, bioactive compounds, natural antioxidants.

Graphical Abstract



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Production of nanocomposite films functionalized with silver nanoparticles bio-reduced with rosemary (*Rosmarinus officinalis* L.) essential oil

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ABSTRACT

This study produced nanocomposite films with silver nanoparticles (AgNPs) bio-reduced with rosemary (*Rosmarinus officinalis* L.) essential oil. The nanocomposites were produced by the casting technique with gelatin/carboxymethyl cellulose/citric pectin and functionalized with 15, 30, and 50% (v/v) AgNPs. The results demonstrate that the rosemary essential oil presented various bioactive compounds, and the major compounds were α -pinene, bornyl acetate, and 1,8-cineol. The AgNPs showed a particle size lower than 50 nm, zeta potential of -30 mV, and polydispersity index of 0.35. UV-vis spectroscopy, TEM, SEM, and XRD confirmed the synthesis of AgNPs with spherical shapes, diameters of 50 nm, and crystalline structures. The nanocomposite films containing AgNPs demonstrated strong antimicrobial activity against eight pathogenic microorganisms. The incorporation of AgNPs affected the opacity and improved the mechanical properties of the nanocomposites. In conclusion, the eco-friendly nanocomposite produced can be a sustainable material for biological applications.

1. Introduction

The cleaner production of nanomaterials has gained attention, mainly due to their interesting physicochemical properties [1]. Silver nanoparticles (AgNPs) exhibit properties associated with their size, shape, and morphology [2], which allow their application in the pharmaceutical industry, biomaterials, biosensors, food industry, and agriculture [3,4]. In addition, the technique used in the production of nanoparticles can affect their characteristics and then change the toxicity, which affects the nanoparticle's applicability [5]. Several methods are described in the literature that can be employed to produce AgNPs [6]. Physicochemical methods present many limitations since they involve high costs and require highly polluting reducing agents, which results in unstable and toxic nanoparticles to human health. This fact restricts its applicability [7]. However, the biological synthesis of

AgNPs (bioreduction or biosynthesis) using plant bioactive compounds can produce nanoparticles quickly, sustainably, economically, and without toxicity [8–10].

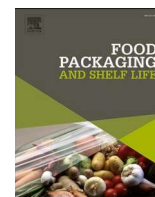
Essential oils are an indispensable source of phytochemicals [11]. The Brazilian biodiversity presents many plant species that can be used to extract essential oils. One of these plants is rosemary (*Rosmarinus officinalis* L.), and its essential oil has been used due to its high antioxidant, antimicrobial, and anti-inflammatory activities [12]. Rosemary essential oil has been used in various applications, especially for food, phytomedicines, nutraceuticals, cosmetics, agrochemicals, and aroma-therapeutic products [13,14]. Recently, several studies have applied rosemary essential oil to produce materials for biological applications. For instance, Stramarkou et al. [12] encapsulated rosemary essential oil into biopolymers to enhance efficiency, control their release, and replace agrochemicals. Alizadeh-Sani et al. [15] produced sodium

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Production of chitosan and poly (vinyl alcohol) films functionalized with hop extract (*Humulus lupulus* L. var. Cascade) for food packaging application

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ARTICLE INFO

Keywords:

Active packaging
Blends
Macromolecules
Food preservation
Controlled release
Food conservation

ABSTRACT

In this study, chitosan and poly(vinyl alcohol) (PVOH) films functionalized with hop (*Humulus lupulus* L. var. Cascade) extracts were produced for food packaging application. The film form solution was prepared by the casting technique, adding 30%, 50%, and 70% of PVOH (2% w/w) in chitosan (2% w/w), and then, functionalized with 10%, 20%, and 40% (v/v) of hop extracts. The mechanical, color, morphological, thermal, and antioxidant properties were investigated. The results indicated that the addition of PVOH improved the flexibility of the films, and the functionalization with hop extracts produced more rigid films. The addition of hop extracts decreased the luminosity, resulting in yellow and green colored films. High antioxidant capacity by DPPH and ABTS assays was observed in the films containing hop extracts. The release study demonstrated that the films can release antioxidant compounds in aqueous and acid food simulant. In conclusion, the physicochemical, mechanical, and antioxidant properties of chitosan/PVOH films were improved with the addition of the hop extracts, indicating that the functionalized material is a promising alternative for active packaging in food system.

1. Introduction

Nowadays, food packaging is based on the petroleum-based materials. However, due to its resistance to chemical and biological degradation, the extensive use of these non-renewable materials has become a serious environmental problem (Bajić, Jalšovec, Travan, Novak, & Likozar, 2019; Bajić, Ročnik, Oberlintner, Scognamiglio, Novak, & Likozar, 2019; Wang, Tan, Peng, Qiu, & Li, 2016). Therefore, replacing petroleum-based plastics has been a constant challenge for the food industry. Biodegradable biopolymers produced with poly(ethylene oxide) (da Rosa et al., 2020a, 2020b; Sganzerla et al., 2020b), poly(vinyl alcohol) (PVOH) (de Carvalho et al., 2019), carboxymethyl cellulose (Martelli et al., 2017), methylcellulose (Nunes et al., 2018), starch/citric

pectin (Sganzerla et al., 2019, 2020a), chitosan (Chang, Liu, Sharif, Huang, Goff, & Zhong, 2019; Aghighi, Licciardello, Fava, Siesler, & Pulvirenti, 2020; Priyadarshi & Rhim, 2020; Tian & Liu, 2021), gelatin (Ramos, Valdés, Beltrán, & Garrigós, 2016), and polylactic acid (Mohamad et al., 2020) are potential materials to substitute the conventional packaging used for foodstuffs (Mihindukulasuriya & Lim, 2014).

Nevertheless, the physicochemical properties of biodegradable polymers may limit its application for food packaging. Innovative research should focus on the production of blends with different macromolecules to improve biodegradability, biocompatibility, mechanical properties, water solubility, and antibacterial activity (da Rosa et al., 2020a, 2020b; Sganzerla et al., 2020b). It has been reported that the

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Microencapsulation by spray drying of red cabbage anthocyanin-rich extract for the production of a natural food colorant

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ARTICLE INFO

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Anthocyanins

Natural food additive

Spray drying

Microencapsulation

ABSTRACT

Food ingredients obtained from natural sources have been a constant demand from the food industry, since the consumers are avoiding the consumption of foods prepared with synthetic additives. In this study, red cabbage (*Brassica oleracea* L. var. *capitata* L. f. *rubra*) anthocyanin-rich extract was microencapsulated to produce a natural food colorant. For this, the microparticles were produced by spray drying using the concentrated (CE) and raw extract (RE) of red cabbage, in different concentrations of maltodextrin and arabic gum. The results obtained demonstrated that the CE presented 50.7 ± 1.13 mg anthocyanins 100 g^{-1} , which means 1.6-fold higher anthocyanins than the RE. Also, the microparticles obtained from CE showed up to 85 mg anthocyanin 100 g^{-1} . The formulations containing the highest amount of maltodextrin resulted in the highest yield, reaching 67%. The moisture content in macroparticles varied between 6.25 and 16.42% and the water activity ranged from 0.48 to 0.64, which is a positive value for future food application. The microparticles presented a uniform appearance and homogenous size distribution, with spherical shapes and smooth surfaces. The microparticles containing a high amount of arabic gum showed a tendency to degradation in the thermogravimetric analysis. Otherwise, the interaction between maltodextrin and arabic gum was beneficial to improve the thermal stability of microparticles, confirmed by the glass transition temperature between 37 and 90 °C. In conclusion, the microparticles produced with red cabbage anthocyanin-rich extract can be a promising approach to use as a natural food colorant.

1. Introduction

In the last years, there is a constant demand for the development of health products with environmental preservation. In the food industry, consumers have been constantly looking for foods with minimal processing and without synthetic additives (Hu et al., 2020). Otherwise, during food processing, the color can undergo significant changes, which affects the final consumer acceptance (Hamed

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Biofabricação: um horizonte sustentável para o mundo da moda

Biofabrication: a sustainable horizon for the fashion world

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Resumo

A indústria da moda tem elevada importância no cenário mundial por diversos aspectos, por exemplo, em termos de receita, o que repercute diretamente na geração de empregos. No entanto, o impacto ambiental causado pelos processos relacionados à produção e descarte de materiais no setor é bastante preocupante, principalmente quando consideradas as projeções de crescimento para os próximos anos. Para nortear uma evolução sustentável em nível global nesse incremento do setor produtivo, é de suma importância levar em consideração os Objetivos de Desenvolvimento Sustentável, que apontam para a tomada de decisões de empresas, ampliando a importância de aspectos relacionados a impactos ambientais, sociais e de governança. No tocante às soluções a serem empregadas na indústria têxtil, destaca-se o desenvolvimento de matérias-primas com apelo sustentável. Uma das alternativas mais promissoras para a síntese de materiais tecnológicos é a biofabricação, que basicamente utiliza fundamentos de biologia, ciência dos materiais, engenharia mecânica, entre outras áreas, para conceber biomateriais que, no contexto têxtil, sejam inovadores em termos da diminuição de impactos ambientais para confecção, com descarte facilitado e aplicabilidade semelhante à dos materiais mais usuais, como algodão e couro. Nesse cenário, estão na vanguarda os biomateriais confeccionados a partir de micélio e celulose bacteriana. Neste artigo, foram explorados alguns aspectos importantes pertinentes ao conceito de biofabricação e sua utilização no panorama nacional e internacional da indústria têxtil, direcionados principalmente para as tecnologias de micélio e celulose bacteriana, que, no momento, têm mais notoriedade em termos de volume de investimentos e divulgação publicitária de grandes marcas globais.

Palavras-chave: biofabricação; micélio; celulose bacteriana; sustentabilidade.



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Thymol loaded zein microparticles obtained by spray-drying: Physical-Chemical Characterization

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ARTICLE INFO

Keywords:

Thymol

Microparticles

Spray-drying

Controlled release

ABSTRACT

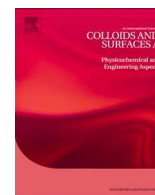
The use of thymol in the food industry may be restricted due to its high instability to temperature, oxygen, light and humidity. This disadvantage may be postponed by microencapsulation. Microparticles were obtained by spray-drying technique at a drying temperature of 130 °C and 0.385 g per 100 g of zein for thymol concentration. In these conditions, 49.5% encapsulation efficiency was achieved and microparticles featured an average size of 14.3 µm measured by laser beam diffraction on a Mastersizer 2000 equipment. Morphologically they revealed a spherical shape with smooth surface and mild roughness. Thermal analysis showed protection to thymol at a temperature above the degradation temperature of the compound (200 °C). Delivery tests presented a release of thymol at 90% on the first day, classified as burst release according to Fick's second law.

1. Introduction

Bioactive compounds in plants may have different biological functions featuring, for example, antioxidant and antimicrobial activity. Nevertheless, their usage may become restricted due to their instability to environmental events such as light, heat and humidity. Therefore, the storage and preservation of these ingredients during processing turn out to be a technological challenge (Parris et al., 2008). Thymol (5-methyl-2-(1-methylethyl) phenol) is the major compound found in oregano and thyme (Gonçalves da Rosa et al., 2020). This monoterpene phenol is biosynthesized as monoterpene hydrocarbon γ -terpinene and p -cymene that appear as the main components of the volatile essential oils derived from these delicacies (da Rosa et al., 2015). Its capacity to inhibit the liposome peroxidation from phospholipids and its antioxidant properties are highly relevant (da Rosa et al., 2015; Nhu-Trang et al., 2006; da Rosa et al., 2020).

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Development of poly (ethylene oxide) bioactive nanocomposite films functionalized with zein nanoparticles

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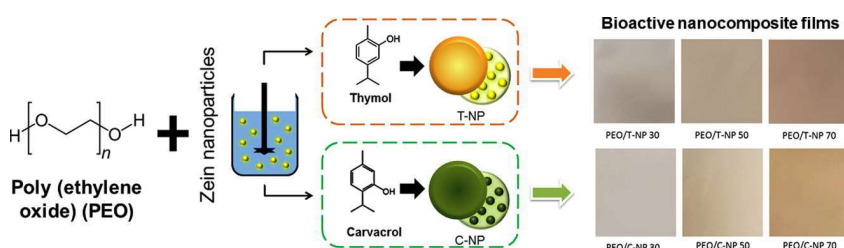
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GRAPHICAL ABSTRACT



ARTICLE INFO

Keywords:

Films
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Essential oil
Nanocomposite
Polymer composites

ABSTRACT

In this work, zein nanoparticles (NP) loaded with thymol (PEO/T-NP) and carvacrol (PEO/C-NP), were incorporated in poly (ethylene oxide) (PEO) films. Structural, mechanical, optical, wettability, thermal, morphological, antioxidant potential and controlled released properties were investigated in the nanocomposite films produced. The interaction between the zein nanoparticles and PEO was confirmed by Differential Scanning Calorimetry (DSC), Fourier Transform Infrared spectroscopy (FTIR), and Scanning Electron Microscopy (SEM) techniques. The antioxidant activity increased in three times, due to the incorporation of nanoparticles in the filmogenic matrix, compared to the control film. PEO nanocomposite with 30% of NP increased the hydrophobicity from $65.6^\circ \pm 0.4$ – $106.7^\circ \pm 0.3$, in the presence of polar solvent. The thermal stability was confirmed by the lower variability of melting point. An increase in color and opacity of the films was also observed while maintaining the brightness and plasticizing effect of the PEO film. Evaluating the controlled released, the stability was obtained for 12 days, with 13.6 and 15.6 mg g⁻¹ film, to PEO/C-NP and PEO/T-NP, respectively. By the model of Korsmeyer–Peppas, PEO films incorporated with zein nanoparticles were characterized as super case II transport. Based on the results obtained, the PEO nanocomposite films developed may be an alternative to packaging in food systems.

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Antibacterial activity, morphology, and physicochemical stability of biosynthesized silver nanoparticles using thyme (*Thymus vulgaris*) essential oil

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Keywords: nanomaterial, bioreduction mechanism, pH effect

Abstract

Considering the importance of biosynthesized silver nanoparticles (AgNPs) using plant phytochemicals, the aim of this work was to evaluate the effect of pH in the formulation of AgNPs, bioreduced with thyme essential oil. Biosynthesized AgNPs were prepared under different pH (7, 8, 9 and 10), and the physicochemical stability was evaluated during 90 days at 6 °C and 25 °C. Using GC/MS technique, 17 different compounds were observed in the thyme essential oil; however, borneol and α -terpineol were the majoritarian compounds, probably responsible to the formation of AgNPs. UV–vis spectroscopy with absorbance between 415 and 440 nm and Transmission Electron Microscopy (TEM) confirmed the synthesis of nanoparticles, with diameters of 40 nm and spherical shapes to pH 7, 8 and 9. Through DLS approach, was observed that the average particle diameter was around 90 nm for all pH tested. AgNPs presented homogeneous size distribution, and zeta potential values very close to the theoretical stability range. Moreover, biosynthesized AgNPs presented high antibacterial activity against *Escherichia coli* and *Staphylococcus aureus*. Through x-ray Photoelectron Spectroscopic (XPS) analysis was possible confirm the presence of crystalline silver nanoparticles. Thus, silver nanoparticles eco-friendly prepared using thyme essential oil can be considered as an alternative way to produce this nanomaterial with great stability and high antibacterial activity.

1. Introduction

Many techniques are widely used to synthesize the silver nanoparticles, among them, the physical ('bottom up') and chemical ('top down') methods [1]. However, the physical and chemicals methods results in toxic and non-ecological components to produce nanoparticles, which limit the use of these materials in many industrial areas, such as clinical, pharmaceutical and food [2, 3]. A solution to this problem is the use of new methods to produce innovative materials, minimizing the impact of toxic components in the environment and in the human health [4]. In this way, new mechanisms to produce silver nanoparticles are gaining prominence in the scientific field, as the use of natural phytochemicals to produce silver nanoparticles [5, 6]. Nanotechnology green-materials for the industry enhances the chemical stability of the compounds, control the results of release and improve as properties of the final product [7].

Thyme (*Thymus vulgaris*) is an aromatic plant belonging to the family Lamiaceae, whose properties are well studied for their antifungal and antioxidant properties, due the presence of phytochemicals in the essential oil [8–11]. The use of extracts of leaves, flowers and essential oils can act as chemical agents of metallic salts and stabilizers of the system due to its components as amino acids, flavonoids, phenolic compounds, terpenoids,

Brazilian Grown Cascade Hop (*Humulus lupulus* L.): LC-ESI-MS-MS and GC-MS Analysis of Chemical Composition and Antioxidant Activity of Extracts and Essential Oils

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ABSTRACT

The first harvest of *Humulus lupulus* (var. Cascade) in Brazil in 2016 originated as an aromatic hop that nowadays is gaining attention from the brewery industry. However, the chemical composition and the properties of this hop have not been well documented to date. In this study, the chemical profile of the phenolic compounds and essential oils of Cascade hops produced in Brazil (BH) and the USA (UH) was determined. The major phenolic compounds identified by LC-ESI-MS-MS in BH and UH were protocatechuic acid, isoquercitrin, and ferulic acid (4.18–11.39; 2.44–4.90; and 1.45–4.48 mg 100 g⁻¹, respectively). The profile of essential oils was shown to differ between the two samples. The compounds *trans*- β -farnesene (20.60%), β -selinene (18.78%), myrcene (16.57%), and α -selinene (16.22%) were the main compounds in the BH essential oil, while the essential oil of UH showed a high content of α -humulene (35.35%), myrcene (22.35%), β -caryophyllene (12.81%), and *trans*- β -farnesene (10.59%). A higher antioxidant activity (by DPPH and ABTS) was observed for hop extracts when compared to the essential oils. The results indicated that the Brazilian hop sample analyzed had higher radical scavenging when compared to an American hop sample (associated with its bioactive compound composition). The Cascade hop from Brazil appears to be a high-quality raw material showing significant potential for future industrial applications.

KEYWORDS

Antioxidant activity;
Brazilian hop; essential oil;
phenolic compounds;
terpenes

Introduction

Hops (*Humulus lupulus* L.) are widely used in the beer industry worldwide to impart bitterness and aroma, also contributing to the beer's shelf life. The production of hops is essentially directed for brewing (98%).^[1,2] However, some reports have indicated the use of hop in medicines for relieving mild symptoms of mental stress, insomnia, treatment for excitability, mood disturbances (restlessness, anxiety), and sleep disturbances.^[1–3] Antifungal⁴ and antioxidant^[5] activities of breads with added hop extracts, have been reported in the literature. Products such as shampoos, conditioners, and balms,^[6–8] flavored waters,^[9] liquor,^[10] and soda,^[11] produced with hop or hop extracts, are available for sale on different websites.

The lupulin glands, produced only by female inflorescences (named strobiles or cones), are mainly responsible for the characteristics of the hops.^[2,12,13] Adequate hop growth depends on crop location and climate conditions. Since the hops are a cold climate crop, the largest producers (USA,

France, and Germany) are in the northern hemisphere. Therefore, most of the hops used in Brazil are cultivated in the United States and Europe.^[14,15] Because of their unique aromatic characteristics, many different varieties of *H. lupulus* may be used by breweries. The Cascade variety was developed by the United States Department of Agriculture (USDA) in 1956, released for cultivation in 1971, and it has been used commercially since 1976. The Hop Growers of America reported that from 2013 to 2017, the Cascade hop variety occupied the major production area in the USA. A decrease of 14.9% in the production of Cascade hop was registered in the USA in the 2017/2018 harvest with 5257 tons, representing 8.5% of the total US production.^[16]

In Brazil, after many unsuccessful attempts, the first experiment with positive hop production was accomplished in the municipality of São Bento do Sapucaí (São Paulo state). This pioneering project took place at “Frutopia farm,” and the produced hop was named the “Mantiqueira hop” (Figure 1), which is a reference to Serra da Mantiqueira, the

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Green synthesis, characteristics and antimicrobial activity of silver nanoparticles mediated by essential oils as reducing agents

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Essential oil
Phenolic compounds
Antibacterial activity
SAXS

ABSTRACT

This study presents a green synthesis of silver nanoparticles (AgNPs) using essential oils as an environmentally friendly alternative to the toxic chemical reducing agents. A trial screening was performed using the essential oils of oregano (*Origanum vulgare*), thyme (*Thymus vulgaris*), clove (*Syzygium aromaticum* L.), rosemary (*Rosmarinus officinalis* L.) and *Poiretia latifolia*. The best results regarding the formation of AgNPs (tested by UV-Vis spectrophotometry) were observed when using clove essential oil, which major compound eugenol (80%) was chosen for another synthesis as a control sample. Transmission Electron Microscopy and Dynamic Light Scattering (SAXS) provided more accurate results, revealing a nanostructure with medium-sized particles between 18.6 nm (AgNP-Eugenol) and 22.4 nm (AgNP-Clove). The developed AgNPs presented antimicrobial activity against *Staphylococcus aureus* in different concentrations (40–100 $\mu\text{L mL}^{-1}$), with a Minimum Inhibitory Concentration of 40 $\mu\text{L mL}^{-1}$, thus considered bactericidal agents. This report showed that the AgNP-Clove present similar characteristics compared to AgNP-Eugenol, revealing the former as a cheaper and reliable alternative matrix to obtain silver nanoparticles, aiming at the future application of AgNPs in food packaging.

1. Introduction

The synthesis of silver nanoparticles (AgNP) is a very promising technique because of its wide applicability, especially in the treatment against pathogen microorganisms. The antimicrobial activity from AgNP is mainly due to their large surface area, which results in greater interaction between the nanoparticles and the cells of the microorganisms, inhibiting their growth even at very low concentrations in the medium (Castellano et al., 2007; Kotakadi et al., 2015; Palanisamy et al., 2017). For these reasons, nanoparticles can be applied as an agent to

control the growth of microorganisms in different food matrices such as cheese, fruit salad, and food packaging (Incoronato et al., 2011; Costa et al., 2011; Carbone et al., 2016; Li et al., 2017).

Although presenting many positive features, there are limiting factors in the application of AgNPs, such as the use of potentially toxic chemical agents to their synthesis as the case of sodium borohydride (Eising et al., 2011). Hence, green-based approaches that employ reducing agents from vegetable resources such as plant extracts and essential oils emerged as an alternative to conventional synthesis. The use of vegetable matrices for the AgNPs synthesis has gained attention

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OPTIMIZATION OF BREWING WASTE'S (TRUB) PHENOLIC COMPOUNDS EXTRACTION BY ULTRASOUND ASSISTED USING RESPONSE SURFACE METHODOLOGY

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The brewing waste, also known as trub, is an abundant by-product of the brewing industry. Such material presents high levels of phenolic compounds, which promote antioxidant, antimicrobial and antifungal effects, turning the trub economically attractive. In this study, the trub's phenolic compounds were extracted by ultrasound-assisted extraction technology. Such experiments were conducted according to a central composite rotatable design (CCRD), with the evaluated parameters being ethanol concentration, solid-liquid ratio and extraction temperature. Response surface methodology (RSM) described the effect of process' variables through second order polynomial models, adjusted appropriately for such analysis, and optimized the operating conditions, aiming to obtain the maximum extraction of phenolic compounds through the proposed technique. The extraction's optimal conditions for the evaluated variables were ethanol concentration of 58%, solid-liquid ratio of 1 g per 32 mL, and extraction temperature of 36 °C, during a 30 minute process. Considering such experimental conditions, the total amount of phenolic compounds was equal to 7.23 mg of gallic acid g⁻¹ trub, indicating that a great concentration of phenolic compounds can be extracted from this material through the proposed technique. Thus, this indicates that trub might be a promising by-product that can be used in different industrial fields.

Keywords: trub; ultrasound-assisted extraction; response surface; phenolic compounds.

INTRODUCTION

Phenolic compounds obtained from industry's by-products have been a prominent area of study in recent years, due to the wide number of different properties these compounds can offer, once they are recovered, such as antioxidant, anti-inflammatory, antimicrobial and antifungal activities.¹⁻³ Hence, due to their great range of applications, these compounds can be used in the pharmaceutical, cosmetic and food industries.⁴

Other factors that incentivize the recovery and application of these compounds are the increase in the byproduct's value, as well as the decrease in the amount of waste that must be treated after production, which reduces the process environmental impact. In addition to this, environmental and health concerns related to the use of antioxidant and antimicrobial products of synthetic origin also raise the interest in such by-product from low-cost natural sources.^{1,4}

During beer production, a large amount of organic waste is obtained, such as brewer's spent grain, trub and residual yeast.^{5,6} In the past few years, studies and applications have been conducted with malt^{5,7} and yeast by-products,^{5,8,9} however, there is still little information about trub's utility and its applications, thus, limiting its usage.^{5,10,11}

Trub is composed by large amounts of proteins and phenolic compounds, derived from the formation of protein-polyphenol complexes created during its processing, which involves wort boiling after adding the hops.^{5,10,12,13} Among phenolic compounds that create protein complexes, tannins are standing out due their antioxidant, antibacterial and antifungal properties, their function as a coagulating agent and their usage in pharmaceutical industries, as well as their participation in the production of resins and wood adhesives.¹⁴

Bioactive compounds recovery can be done through different extraction methods. Ultrasound-assisted extraction (UAE) is a

low-cost and highly efficient method, usually employed in the extraction of phenolic compounds from vegetable sources.¹⁵ This technique displays short extraction time and requires a lower amount of organic solvents, while also presenting high yields in the extraction of phenolic compounds.¹⁶

UAE is based on the propagation of ultrasonic waves (20 to 100 kHz through a liquid, causing cavitations to appear, which results in the rupture of cellular membranes. This process improves solvent penetration into the cells, increasing mass transfer and releasing bioactive compounds.^{15,16} Although various studies were conducted using vegetable matter, the optimization of the extraction of phenolic compounds from trub through UAE has not been yet investigated. Considering that the extraction efficiency depends on the raw material and its conditions, the UAE optimization process must be studied for each type of vegetable source.¹⁷

Bearing in mind the high number of phenolic compounds present in trub, the importance of the recovery of such compounds, as well as the necessity of research that focuses on new ways to utilize industrial by-products, this study seeks to optimize UAE parameters, such as ethanol concentration, extraction temperature, and solid-liquid proportions, through response surface methodology (RSM), making use of a central composite rotatable design (CCRD) in order to obtain the ideal conditions for the extraction of phenolic compounds from trub and determinate total phenolic content (TPC) of this trub extracts.

EXPERIMENTAL PART

Reagents

The following reagents were applied on the extraction process and trub's total phenolic content determination: gallic acid (Sigma-Aldrich Co., USA), ethanol (99,5% v/v) (Synth, São Paulo, Brazil), sodium

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