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ORIGINAL PAPER

Alkali-Extracted Feruloylated Arabinoxylans from Nixtamalized Maize Bran Byproduct: A Synonymous with Soluble Antioxidant Dietary Fiber

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Abstract

Feruloylated arabinoxylans were obtained from nixtamalized maize bran under alkaline conditions (0.5 N NaOH) at different times (2 h, 4 h and 6 h). They were analyzed for neutral sugars composition, dietary fiber and ferulic acids content, as well as the antioxidant capacity, to establish if they can be considered as soluble antioxidant dietary fiber. The yields of the arabinoxylans following alkaline extraction treatments were 4.89%, 8.23% and 7.17% for 2 h, 4 h and 6 h, respectively. The purity of arabinoxylans ranged from 55.58 to 61.16%, while arabinose to xylose (Ara/Xyl) ratio ranged from 0.82 to 0.87 which indicated that all arabinoxylans had a moderately branched structure. The soluble dietary fiber accounted for more than 85% of the chemical composition of feruloylated arabinoxylans. Monomeric and oligomeric forms of ferulic acid were influenced by the alkali extraction time. The monomeric form was the main phenolic acid in feruloylated arabinoxylans (77.05–86.97%), followed by dimers (11.57–14.20%), and trimer (0.93–9.36%). Total phenols ranged from 9.01 to 6.48 mg FAE/g, while antioxidant capacity ranged from 29.49 to 31.69 µmol TE/g, 16.60 to 21.27 µmol TE/g, 39.23 to 58.33 µmol TE/g and 17.03 to 60.65 µmol TE/g in DPPH, ABTS, FRAP and ORAC methods, respectively. The phenol content and antioxidant capacity were in the order: 2 h extract > 4 h extract > 6 h extract and in accordance to the ferulic acid content. The results indicated that alkali extracted feruloylated arabinoxylans obtained from nixtamalized maize bran byproduct are synonymous with soluble antioxidant dietary fiber.

Keywords Feruloylated arabinoxylans · Soluble antioxidant dietary fiber · Ferulic acids · Antioxidant capacity

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Physico-mechanical, barrier and antimicrobial properties of linseed mucilage films incorporated with *H. virginiana* extract

Propiedades físico-mecánicas, de barreras y antimicrobianas de películas de mucilago de linaza incorporadas con extracto de *H. virginiana*

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Abstract

Increased interest in providing safe food with excellent quality and shelf-life has resulted in increased efforts toward developing new bio-based packaging materials. The objectives of this study were to develop and characterize films based on linseed mucilage (LM) at concentrations of 2.0%, 2.5%, and 3.0% and the further development of antimicrobial films (AFs) incorporating *Hamamelis virginiana* (Hv) extract. The films with the greatest LM concentration was selected as the best formulation based on its mechanical properties, water vapor permeability and moisture sensitivity. Moreover, the antimicrobial activities of Hv extract against foodborne pathogens were evaluated. Minimum inhibitory concentrations were 1.18 mg mL^{-1} for *L. monocytogenes* and 2.37 mg mL^{-1} for *S. Typhi, S. aureus*, and *E. coli*. Finally, AFs were developed by incorporating Hv extract at 2.37 mg mL^{-1} into a base of 3.0% LM, increasing elongation at break, antioxidant activity to 80.56%, moisture sensitivity, and antimicrobial activity (increasing inhibition zones to 19.50 – 22.50 mm). It also decreased tensile strength, maximum force, and water vapor permeability. These results suggest that AFs based on LM with Hv extract have sufficient properties for a potential packaging material.

Keywords: Mucilage, *Hamamelis virginiana*, antimicrobial activity, antimicrobial films, physico-mechanical properties.

Resumen

El creciente interés en proporcionar alimentos seguros con excelente calidad y vida útil ha resultado en un incremento en los esfuerzos hacia el desarrollo de nuevos materiales de empaque de base biológica. Los objetivos de este estudio fueron desarrollar y caracterizar películas a base de mucílago de linaza (LM) en concentraciones de 2.0%, 2.5% y 3.0% y adicionalmente desarrollar películas antimicrobianas (AFs) que incorporen un extracto de *Hamamelis virginiana* (Hv). La película con la mayor concentración de LM fue seleccionada como la mejor formulación en función de sus propiedades mecánicas, permeabilidad al vapor de agua y sensibilidad a la humedad. Por otra parte, se evaluó la actividad antimicrobiana del extracto de Hv contra patógenos transmitidos por los alimentos. Las concentraciones inhibitorias mínimas fueron 1.18 mg mL^{-1} para *L. monocytogenes* y 2.37 mg mL^{-1} para *S. Typhi, S. aureus* y *E. coli*. Finalmente, se desarrollaron películas incorporando el extracto de Hv en 2.37 mg mL^{-1} en una base de 3.0% de LM, aumentando la elongación, la actividad antioxidante a 80.56%, la sensibilidad a la humedad y la actividad antimicrobiana (incrementando las zonas de inhibición a 19.50 - 22.50 mm). Esto también disminuyó la resistencia a la tensión, la fuerza máxima y la permeabilidad al vapor de agua. Estos resultados sugieren que las AFs a base de LM con extracto de Hv tienen propiedades adecuadas para un material potencial de empaque.

Palabras clave: Mucílago, *Hamamelis virginiana*, actividad antimicrobiana, películas antimicrobianas, propiedades físico-mecánicas.

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Article

Studied of Defatted Flour and Protein Concentrate of *Prunus serotine* and Applications

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Abstract: *Prunus serotine* seed, was processed to produce a defatted flour (71.07 ± 2.10% yield) without hydrocyanic acid. The total protein was 50.94 ± 0.64%. According to sensory evaluation of cookies with *P. serotine* flour, the highest score in overall impression (6.31) was at 50% flour substitution. Its nutritional composition stood out for its protein and fiber contents 12.50% and 0.93%, respectively. Protein concentrate (*Ps*PC) was elaborated (81.44 ± 7.74% protein) from defatted flour. Emulsifying properties of *Ps*PC were studied in emulsions at different mass fractions; ϕ = 0.002, 0.02, 0.1, 0.2, and 0.4 through physicochemical analysis and compared with whey protein concentrate (WPC). Particle size in emulsions increased, as did oil content, and results were reflected in microscope photographs. *Ps*PC at ϕ 0.02 showed positive results along the study, reflected in the microphotograph and emulsifying stability index (ESI) test (117.50 min). At ϕ 0.4, the lowest ESI (29.34 min), but the maximum emulsifying activity index (EAI) value (0.029 m^2/g) was reached. WPC had an EAI value higher than *Ps*PC at $\phi \geq 0.2$, but its ESI were always lower in all mass fraction values. *Ps*PC can compete with emulsifiers as WPC and help stabilize emulsions.

Keywords: *Prunus serotine*; defatted flour; soluble protein; protein concentrate; emulsifying properties; emulsion stability

1. Introduction

Nowadays, there is an increasing demand for products of high nutritional quality [1]. Proteins are one of the major components of the human diet because of their nutritional properties. They are also responsible for physicochemical properties such as solubility, water, and oil retention capacity, foaming and emulsifying capacity, viscosity, and gelation, among others. The proteins impact not only the quality of the products, but also acceptance by consumers [2].

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Development and Characterization of Gelled Double Emulsions Based on Chia (*Salvia hispanica* L.) Mucilage Mixed with Different Biopolymers and Loaded with Green Tea Extract (*Camellia sinensis*)

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Abstract: The aim of this research was to develop and characterize five gelled double emulsions based on chia mucilage (CM) and different biopolymers (κ-carrageenan, C; locust bean gum, L; thixogum, T; and whey protein concentrate, W) loaded with green tea extract (GTE). Gelled double emulsions consisted of W_1 (whey-protein-concentrate/sodium-azide/NaCl/GTE)/O and (PGPR/canola-oil)/W_2 (CM, CMC, CML, CMT and CMW), and were characterized based on physicochemical properties during 35 days of storage. Optical microscopy clearly showed the drops of the internal phase surrounded by droplets of oil dispersed in the second aqueous phase; the droplet size was higher for CMT and lowest for CMW. In addition, all emulsions were highly stable at creaming and were effective in reducing the loss of antioxidant activity (88.82%) and total phenols (64.26%) during storage; CMT, CML and CM were the most effective. Furthermore, all emulsions showed a protective effect by modulating the release of the GTE in a simulated gastrointestinal environment, allowing a controlled release during the gastric-intestinal digestion phases and reaching its maximum release in the intestinal phase (64.57–83.31%). Thus, gelled double emulsions are an alternative for the preservation of GTE and could be a potential alternative for their application in the development of functional foods.

Keywords: gelled double emulsion; chia mucilage; green tea extract; antioxidant activity; stability

1. Introduction

Nowadays, consumers are focusing their attention on the consumption of high-quality foods that provide basic nutritional properties and provide beneficial effects to health, reducing the risk of disease [1,2]. Green tea is obtained from the *Camellia sinensis* L. plant native to China and is one of the most popular and beverages consumed around the world [3,4]. Green tea extract (GTE) is mainly composed of polyphenols, such as catechins (e.g., (−) epigallocatechin gallate, (−) epicatechin gallate, (−) epillogallocatechin and (−) epicatechin), gallic acid, quercitin and caffeine, among other substances [5,6]. Due to its composition, green tea has a wide variety of antioxidant, antimicrobial, anticancer, anticardiovascular and antihyperglycemic properties, among others [2,7,8]. In recent years, interest in the development of a wide variety of food products (e.g., meat, lactic and bakery

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Effect of Linseed (*Linum usitatissimum*) Mucilage and Chitosan Edible Coatings on Quality and Shelf-Life of Fresh-Cut Cantaloupe (*Cucumis melo*)

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Abstract: We have evaluated the effect of edible coatings (ECs) based on linseed mucilage (LM), chitosan (CH), and their combination (LMCH) on the quality and shelf life of fresh-cut cantaloupe. Cantaloupe was washed, sanitized, and processed (peeled, seeded, and cut) and then coated by immersion, packed, and stored for 18 days at 4 °C. The ECs were effective at reducing the juice leakage and softening of the product. The EC based on CH was the most effective at preserving the color parameter and reducing the general microbiological growth. However, the LMCH combination decreased the antimicrobial effect of chitosan against microorganisms. Also, CH and LM ECs helped preserve the overall sensory characteristics, increasing the acceptance to 12–15 days. Finally, the LMCH combination helped preserve the characteristics of color and odor; however, it modified the texture and taste of fresh-cut cantaloupe and its sensory acceptance was similar to the control (up to 9 days).

Keywords: linseed mucilage; fresh-cut fruit; cantaloupe; quality; shelf life

1. Introduction

The present-day accelerated lifestyle has increased the production and consumption of minimally processed horticultural and ready-to-eat products [1–3]. However, the development of fresh-cut products from fruits such as pineapple, papaya, watermelon, mango, and cantaloupe, among others, has been limited because these foods are highly perishable compared to intact fruit. Also, processing operations, such as disinfection, washing, drying, cutting, and packaging, can cause alterations in physical integrity (e.g., mechanical damage of fruit tissue) and product safety (e.g., microbial cross-contamination), leading to a series of changes related to microbial susceptibility and physicochemical and sensory stability, which decrease overall quality and shelf life [4–6].

Cantaloupe is one of the most popular fresh-cut fruits on the market and is consumed worldwide [7–10]. Cantaloupe is characterized by its aroma, intense flavor [11], and dietary fiber content, as well as its vitamin (A, B, and C), calcium, potassium, iron, and β-carotene levels [8,12–14]. However, fresh-cut cantaloupe has a short shelf life (up to 9 days) because the processing and storage of the product trigger changes in physical integrity, loss of juice, softening of the pulp, enzymatic

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Original article

Physicochemical characterisation and *in vitro* Starch digestion of Avocado Seed Flour (Persea americana V. Hass) and its starch and fibrous fractions

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Summary The avocado seed is considered a by-product of their pulp exploitation and today it does not present relevant food or industrial applications. In this study, we evaluate the potential use of its flour, their isolated starch and fibre fractions. After processing, the flour yielded 46.28%, and showed 6.7% of protein and low fat and ash contents (3.4, and 2.71% respectively). The starch yielded 27.28% with low-fibre content that influenced its viscosity properties; as well as their water absorption index (WAI), water solubility index (WSI) and oil absorption index (OAI), that were 2.43%, 11.22% and 0.16% respectively. The *in vitro* starch digestion of the different obtained fractions showed higher amounts of rapidly digestible starch (56.8%–75.36%, flour and starch respectively). The functional properties of the materials were correlated with strong molecular interactions with their apparently unique amylose structure; for this, this by-product may have different potential for food applications.

Keywords avocado seed, dietary fibre, digestion, starch.

Introduction

The avocado fruit (*Persea americana*), native to Central America, has a dark and rough green crust, that covers a yellowish-green pulp rich in oils and appreciated for its sensory and nutritional characteristics. There are approximately 400 varieties of this fruit, being the 'Hass' the most popular in the international market, followed by the 'fuerte' and 'criolla' varieties (Barbosa–Martín *et al.*, 2016). Mexico contributes with 32% of the global production; placing it as one of the world's leading exporters. The avocado fruit is marketed all over the world and it is often transformed into value-added products such as guacamole, purée, oils and other derivatives (Maldonado–Zamora *et al.*, 2017). These products use only the pulp, leaving aside approximately 148 000 tons of seeds, considered as a by-product with no other food uses; hence, being discarded, causing contamination (Barbosa–Martín *et al.*, 2016). For this reason, diverse research has been conducted focusing on their carbohydrates fraction, which compromises more than 80% of the seeds. Although in raw state, it also presents phytates, oxalates and cyanogenic glycosides making the seed or its unprocessed by-products to be potentially toxic (Dabas *et al.*, 2013); however, they can be drastically reduced by using thermal processing (Talabi *et al.*, 2016). Due to this, some alternative uses of these materials have been related with their incorporation into diverse food products, or as copolymers to elaborate plant-based plastics (Lubis *et al.*, 2018). Nevertheless, there is a lack of information about the influence of the chemical composition of avocado flour and its starch and fibrous fractions over some technological characteristics that will help to suggest other potential uses. Therefore, the aim of this work was to evaluate the physicochemical, functional and *in vitro* digestion characteristics of avocado seed flour as well as their fractions.

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Material and methods

Avocado flour production

The avocado seeds (*Persea americana* v. Hass) were a gift from Super Salads Restaurants© (Monterrey, Nuevo León, México). These seeds were considered as residue after their pulp were used for food purposes.

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Article

Effects of the Addition of Flaxseed and Amaranth on the Physicochemical and Functional Properties of Instant-Extruded Products

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Abstract: The addition of flaxseed and amaranth on the physicochemical, functional, and microstructural changes of instant-extruded products was evaluated. Six mixtures with different proportions of amaranth (18.7–33.1%), flaxseed (6.6–9.3%), maize grits (55.6–67.3%) and minor ingredients (4.7%) were extruded in a twin-screw extruder. Insoluble and soluble fiber contents in extrudates increased as the proportions of amaranth and flaxseed increased. However, the highest flaxseed proportion had the highest soluble fiber content (1.9%). Extruded products with the highest proportion of flaxseed and amaranth resulted in the highest dietary fiber content and hardness values (5.2 N), which was correlated with the microstructural analysis where the crystallinity increased, resulting in larger, and more compact laminar structure. The extruded products with the highest maize grits proportion had the highest viscosity, expansion, and water absorption indexes, and the lowest water solubility index values. The mixtures with amaranth (18.7–22.9%), flaxseed (8.6–9.3%), and maize grits (63.8–67.3%) resulted in extruded products with acceptable physicochemical and functional properties.

Keywords: extruded products; flaxseed; amaranth; dietary fiber; extrusion-cooking

1. Introduction

Currently, an increasing trend in the demand for processed foods that include pro-health compounds such as soluble fiber is occurring due to evidence of potential health benefits to consumers. Reduction in various types of chronic diseases such as cancer, cardiovascular disease, type II diabetes, and various gastrointestinal disorders are among them [1]. The development of products and processes that incorporate high-fiber ingredients without altering the physical, functional, and sensory properties

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Chemical Composition and Biological Activities of Oregano Essential Oil and Its Fractions Obtained by Vacuum Distillation

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Abstract: Oregano (*Poliomintha longiflora*) essential oil (Ooil) is a product of high commercial value and many applications, including chemotherapy. Aiming to achieve the best use of this resource, the present study focuses on the characterization of separated fractions of Ooil by fractional vacuum distillation at low pressure. Four fractions (F1–F4) and undistilled oil (Unoil) were separated from Ooil and analyzed for their chemical composition and biological activities, such as antioxidant and antimicrobial activities. Gas chromatography–mass spectrometry shows differences in the composition among the fractions and Ooil. The amount of monoterpenes oxygenated (MO), sesquiterpenes hydrocarbon (SeH) and monoterpenes hydrocarbon (MH) varied between the fractions in ranges of 1.51–68.08, 3.31–25.12 and 1.91–97.75%, respectively. The major concentrations of MO and SeH were observed in F4 and Unoil. On the other hand, the highest concentrations of MH were found in F1 and F2, while the lowest were in F4 and Unoil. These results were correlated with the biological activity. Free-radical scavenging activity varied among fractions, with F4 and Unoil showing the highest activity. The antimicrobial test showed that F4 and Unoil had the highest activity in almost all cases. The correlation between the variables studied in the different fractions allows the definition of the particular properties for each one of them.

Keywords: oregano; *Poliomintha longiflora*; essential oil; antioxidant activity; antimicrobial activity; vacuum fractional distillation

1. Introduction

Essential oils are "volatile oils or essences derived from vegetation and characterized by distinctive odors and a substantial measure of resistance to hydrolysis" according to the Encyclopedic Dictionary of Polymers [1,2]. These are a complex mixture of different volatile compounds present in aromatic plants in a natural way that, due to their properties and their fragrance, are widely used in cosmetics, in the food industry to improve the taste and the organoleptic properties, and in a variety of household products. In addition to their flavor and fragrance, many essential oils and their isolated components exhibit muscle-relaxing, antibacterial and antifungal activities. These properties are used in applications such as the preservation of raw and processed foods, pharmaceutical products and alternative medicine [2–4].

In recent years, due to restrictions on the use of synthetic food additives and the constant increase in the survival capacity of detrimental microorganisms caused by resistance to antibiotics and preservatives, there has been an increase in the search for alternatives, such as natural antimicrobial

foods

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Effect of Agave Fructans as Carrier on the Encapsulation of Blue Corn Anthocyanins by Spray Drying

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Abstract: Effects of agave fructans as carrier agents on the encapsulation of blue corn anthocyanins using spray-drying were evaluated. Blue corn extract was mixed with 6%, 8%, 10%, and 12% (*w/v*) of agave fructans in duplicate and dried at 150 °C. The extract showed good contents of anthocyanins, polyphenols, and antioxidant activity. The increase of agave fructans in the encapsulated powders caused a significant increase ($p < 0.05$) in the humidity, water activity (a_w), pH, bulk density, water solubility index (WSI), and color L^* values. On the contrary, the agave fructan addition decreased the hygroscopicity, water absorption index (WAI), antioxidant activity, total anthocyanin, total polyphenol, and individual anthocyanin contents. The encapsulation of blue corn extract with 6% agave fructans (*w/v*) resulted in good physical, thermal, morphological, and high antioxidant properties. The results suggest that the use of agave fructans as wall material represents advantages in the conservation of anthocyanins and other bioactive compounds from blue corn extract during their encapsulation. The application of blue corn anthocyanin encapsulated powders as a food ingredient is promising for food pigmentation, representing additional advantages for their contribution as a soluble fiber that can benefit the health of consumers.

Keywords: blue corn; agave fructans; anthocyanins; encapsulation; spray-drying

1. Introduction

The interest in blue or pigmented corns (*Zea mays* L.) has increased in recent years due to their nutraceutical properties beneficial to the health of consumers. This is attributed to phenolic compounds, mainly anthocyanins, present in these grains [1,2]. These water-soluble pigments besides giving color, have biological activity including antioxidant, anticarcinogenic, anti-inflammatory, and neuroprotective effects, and they have been associated with the prevention of diabetes and obesity, cardiovascular diseases, and brain dysfunction, among other disorders [3,4]. The high content of anthocyanins in blue corn makes it competitive as a natural source of pigments and it can be considered as a substitute for synthetic food dyes. However, due to the instability of anthocyanins during processing and storage, their application as natural pigments in the food industry is limited [5]. Therefore, it is of general interest to apply techniques for their protection before their use in food. Microencapsulation is a promising alternative technique to improve the stability of natural pigments and protect them by entrapping with a carrier agent or wall material [6,7]. Microencapsulation by spray-drying is the most popular

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Application of a Multisystem Coating Based on Polymeric Nanocapsules Containing Essential Oil of *Thymus Vulgaris* L. to Increase the Shelf Life of Table Grapes (*Vitis Vinifera* L.)

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***Abstract*—In developing countries, the incidence of postharvest losses reduces the quantity and quality of food for human consumption and causes an economical damage along the food chain, especially, for primary producers. In this study, a multisystem coating (NC-EOt-C) based on pullulan and polymeric nanocapsules containing EO of *Thymus vulgaris* L. (EOt) was applied to increase the shelf life of table grapes (*Vitis vinifera* L.). The major components of EOt, chemically characterized by GC-MS, were *o-cymene* (32.68%), *thymol* (31.90%), and *γ -terpinene* (15.69%). The NC-EOt were prepared by nanoprecipitation and showed a particle mean size of 153.9 nm, a polydispersity index of 0.186, a zeta potential of −4.11 mV, and an encapsulation efficiency of 52.81%. The antioxidant capacity (DPPH and $ABTS^{+}$ methods) of EOt was maintained, or even improved, after its incorporation into NC. The shelf life study showed that grapes having the NC-EOt-C multisystem maintained their characteristics of color, firmness, TA, and SSC for longer time than those without the multisystem. NC-EOt-C multisystem acted as a barrier which reduced the metabolism of fruits. In addition, the compounds of EOt with antimicrobial activity avoided microorganism growth, while those with antioxidant activity reduced the oxidative stress induced during postharvest of grapes. Additionally, the polymeric structure of NC prevented the rapid evaporation of volatile compounds of EOt, increasing then their residence time on the fruit. Our study demonstrated that NC-EOt-C multisystem can be a viable alternative to preserve horticultural products for longer storage periods.**

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***Index Terms*—Edible coatings, essential oils, food preservation, polymeric nanoparticles, and *Thymus vulgaris* L.**

I. Introduction

FRUITS are perishable products because of their inherent tendency to deteriorate. During the postharvest period of fruit, it is necessary to guarantee a longer useful life of the vegetable. Reports from the Food and Agriculture Organization of the United Nations (FAO) mention that, in developing countries, there is a great deficiency in marketing infrastructure, therefore, postharvest losses of fresh products reach up to 50% of total production [1]. Losses of this magnitude trigger a considerable economic damage for food productive chain, especially, for primary producers. In addition, the presence of pests represents a serious health risk for the consumer. FAO, in collaboration with the Latin American Integration Association (ALADI) and the Economic Commission for Latin America and the Caribbean (ECLAC), prepared the Food Losses and Waste Plan (FLW) which promotes the development of innovative technologies that contribute to reduce food loss at all stages of the food production chain [2]. In recent years, different alternatives have been proposed in order to preserve the horticultural products, including the use of protective coatings. An edible coating is a thin layer of edible material formed as a coating on a food product. Using coatings modifies the interaction of the fruit with the environment due to their physicochemical properties, prolonging the shelf life of the treated fruits [3]. Different coating-forming compounds have been used, including chitosan, alginate, starch, and pullulan [4]–[7].

Pullulan is a polysaccharide produced by *Aureobasidium pullulans*; it can form edible coatings with several advantages over other polysaccharides. Concerning its properties, it has limited permeability to oxygen and carbon dioxide, has good adhesive properties, is colorless, and has no flavor [8]–[10]. The pullulan coating can influence on the physiology of fruit since it acts as a barrier between the environment and fruit. The protective effect of this coating can also be improved

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Feruloylated Arabinoxylans from Nixtamalized Maize Bran Byproduct: A Functional Ingredient in Frankfurter Sausages

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Abstract: Feruloylated arabinoxylans obtained from nixtamalized maize bran were evaluated in terms of physicochemical characteristics and antioxidant capacity when incorporated in frankfurter sausages. Concentrations of 0.15% and 0.30% of feruloylated arabinoxylans were incorporated in frankfurter sausages formulations and a control without feruloylated arabinoxylans was also prepared. Shear force, hardness, color measurement, proximate analysis, pH, titratable acidity, water-holding capacity, total phenols, and antioxidant capacity were evaluated. Phenolic content and antioxidant capacity were significantly higher ($P < 0.0001$) in all treatments, sausages containing feruloylated arabinoxylans compared to the control. The results showed that there was a significant difference ($P < 0.0001$) in total phenolic content and antioxidant capacity with all feruloylated arabinoxylans sausages treatments higher than control. Additionally, significant differences ($P < 0.0001$) were obtained in the physicochemical parameters.

Keywords: feruloylated arabinoxylans; nixtamalized maize bran by-product; frankfurter sausages; physicochemical properties; functional properties

1. Introduction

Cooked sausages are a complex mix of different food components, including proteins, salts, gels made from muscular proteins and emulsions that contain stabilized fat. Any type of meat can be used to make cooked sausages and they are commonly consumed either hot or cold. Frankfurters are short and small-diameter sausages, made in a finely chopped form and typically used as appetizers [1,2]. Frankfurter sausages are produced with a high fat content, therefore, it is necessary to use fat replacer ingredients in their production to get a product with less fat content, dietary fiber being a good ingredient

RESEARCH ARTICLE

Starch
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Optimization of an Extrusion Cooking Process to Increase Formation of Resistant Starch from Corn Starch with Addition of Citric Acid

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Effects of extrusion cooking process (ECP) with citric acid (CA) addition on the physicochemical changes and resistant starch (RS) formation in native corn starch (NCS) are evaluated. NCS at different feed moisture levels (18–32%) and CA concentrations (0–10.3%), are subject ECP under constant conditions of screw speed (233 rpm) and die temperature (127 °C). The obtained extrudates are stored at 4 °C for 120 h and then at room temperature. The water absorption index (WAI), water solubility index (WSI), RS content, peak temperature (Tp), ΔH, peak viscosity (PV), setback viscosity (SV), FT-IR, X-ray analysis and microstructural (SEM) properties are evaluated. RS content and WSI increased with decreasing moisture content (MC), WAI, PV and SV shows that increases in MC caused an increase, while ΔH and T_p decreases with decreasing MC. SEM shows that ECP with CA destroys the granular structure of NCS generated amorphous structures owing to gelatinization and dextrinization. FT-IR analysis shows that extruded samples with CA cause starch hydrolysis, increasing the intensity of bands 994 and 1016 cm^{-1} in comparison to NCS. The highest RS yield (1.15 g/100 g) is obtained at 18% moisture content and 5.2% of CA: an increase of 71% with respect to NCS.

1. Introduction

Corn starch has been used in the food industry for production of different types of food for many years; however, the current market demands ingredients with health benefits, for example resistant starch (RS). Resistant starch is modified starch or starch fractions that are indigestible in the small intestine and thus are similar to dietary fiber and offer comparable health benefits.[1] RS is classified as follows: (type 1) physically inaccessible starch, (type 2) granules of crude starch and starch rich in amylose, (type 3) gelatinized retrograded starch, and (type 4) chemically modified starch.[1–3]

For the production of RS, there are different production methods with high yields but with important limitations for production. One of the processes is acetylation: Kapelko-Żeberska et al.[4] increased RS content from 6.28% to 66.82% in potato starch, and Xu et al.[5] achieved an increase to 67.49% of RS in rice. Another process is acid hydrolysis: authors like Koksel et al.[6] and Hasjim and Jane[7] obtained an increase of 12–25% when they processed high-amylose corn starch. Additionally, for acid hydrolysis, there are different thermal treatments, one of them is autoclaving; authors such as Van Hung et al.[8] and Yadav et al.[9] used cereal flours such as potato and lentil flour to increase RS content up to 5%.

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Article

Comparative Reduction of Egg Yolk Cholesterol Using Anionic Chelating Agents

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Abstract: Egg yolk is used as an emulsifying agent. Nevertheless, its high concentration of cholesterol is linked to chronic degenerative diseases that cause cardiovascular disease. In this study, three methods for reducing the level of cholesterol in egg yolks were studied. The first method consisted of physical separation of the granules contained in the yolk (Na_G). The second method applied was the use of anionic chelating biopolymers, such as arabic gum solution (AG) and mesquite gum solution (MG), and the third method was extraction with a solvent (S_A). For this purpose, the cholesterol present in egg yolks, the microstructure, particle size, zeta potential, and its emulsifying capacity were determined. The amount of cholesterol removed was 97.24% using 1% mesquite gum ($MG_{1\%}$), and 93.26% using 1% Arabic gum ($AG_{1\%}$). The zeta potential was determined, and the isoelectric point ($\zeta = 0$) of egg yolk was identified as pH 4.6. While, at this pH, the zeta potential of mesquite gum was −14.8 mV, the zeta potential for the arabic gum was −16 mV. The emulsifying capacity of $MG_{1\%}$ was 62.95%, while the emulsifying capacity of $AG_{1\%}$ was 63.57%. The complex obtained can be used in the development of functional foods reduced in cholesterol.

Keywords: egg yolk; cholesterol extraction; granules extraction; anionic chelating biopolymers

1. Introduction

Egg yolk is a good source of lutein, zeaxanthin, proteins, lipids, and vitamins in human nutrition and is made up of practically 50% solids. The major constituents of the solid matter are lipids (65–70% on dry basis) and proteins (30% on dry basis). The proteins present are livetins, lipoproteins [1], and some particles including high-density lipoproteins (HDLs), low-density lipoproteins (LDLs), and phosvitin [2,3].

Egg yolk is an efficient ingredient in many food products, and its functional properties include emulsifying, coagulating, foaming, and gelling properties [4]. Moreover, it contains proteins, vitamins, minerals, essential fatty acids, phospholipids, and other compounds. However, it has high cholesterol

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Optimization of the enzyme-assisted extraction of fructans from the wild sotol plant (*Dasylirion wheeleri*)

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ABSTRACT

Enzymatic liquefaction conditions were evaluated to obtain fructan from wild sotol plant (*Dasylirion wheeleri*) using the commercial preparation Pectinex Ultra SP-L. Ground sotol head was subjected to enzymatic extraction at various enzyme activities (0.0–175.73 U/mL) and fresh sotol concentrations (4.47–28.52 g/100 mL) at 30 °C for 8 h, using the response surface methodology to optimize the fructan extraction. Reducing sugars (RS), total carbohydrates (TC), fructan content (FRU), fructan profile, and the average degree of polymerization (DP_n) were evaluated. Additionally, RS release kinetics and the enzyme rate constant (V_o) were calculated. Enzyme concentration and substrate significantly affected ($P < 0.05$) the RS extraction, FRU, and V_o, while DP_n was only affected ($P < 0.05$) by the substrate concentration. Higher RS contents were obtained at lower substrate concentrations for > 87.87 U/mL enzyme, and fructan extraction was maximal (39.08 g/100 g d.m.) at 83.04 U/mL enzyme and 6.70 g/100 mL substrate. V_o and RS content exhibited similar trends. DP_n increased as substrate concentration decreased. Optimal enzymatic liquefaction conditions were 11.6–45.6 U/mL enzyme and 9.15–12.6 g/100 mL sotol, yielding elevated fructan (38.58 g/100 g d.m.), DP_n of 8–10, and low fructose (1.8 g/100 g d.m.) and glucose (2.2 g/100 g d.m.) contents. These results demonstrate the feasibility of enzymatic liquefaction for extracting fructans from sotol heads without modifying the molecular structure.

1. Introduction

The use of prebiotics from complex carbohydrates, such as fructans, for food formulations continues to grow in the food industry owing to their benefits, such as dietary fiber (Zhu et al., 2016), low-calorie sweetener potential (Mensink, Prijlink, Maarschalk, & Hinrichs, 2015), and prebiotic action by stimulating the development of beneficial native microbiota (Roberfroid et al., 2010), contributing to gastrointestinal disease reduction (Gómez, Tuohy, Gibson, Klinder, & Costabile, 2010; López & Urías-Silvas, 2007). Fructans are contained in the cells of plant tissues (Vijn & Smeekens, 1999) and their efficient production is related to the rupture of the cell wall for their release. Pectins, cellulose, and hemicellulose form the insoluble polysaccharides of the cell wall of sotol (*Dasylirion* spp.) and similar plants, such as agave (Leach & Sobolik, 2010). Pectins and hemicellulose are rich in galacturonic acid, arabinose, galactose, and smaller quantities of xylose, rhamnose, and glucose (Levigne, Ralet, & Thibault, 2002) and their hydrolysis could favor the release of fructans contained in the cell wall. Some reports have shown that fructans can be obtained at a commercial scale by thermal extraction (Kelly, 2008) or by the grinding and compression of macerated tissues. Thermal extraction can lead to structural damage of molecules, limiting the functional properties of these components (Zhu et al., 2016), and physical methods (grinding-compression) result in low extraction yields. Sustainable alternative methods, such as enzymatic liquefaction, could have advantages. Enzymatic treatments for plant cell wall liquefaction are important in the processing of fruits and vegetables (Puri, Sharma, & Barrow, 2012). These methods have been used for the production of fermentable sugars (Cara, Ruiz, Oliva, Sáez, & Castro, 2008), clarification of juices (Sin, Yusof, Hamid, & Rahman, 2006), and in the production of biomass (Ladisch, Lin, Voloch, & Tsao, 1983) or other metabolites of interest contained in cell walls, such as β-carotene, lycopene, pectins, fibers, or

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Physicochemical, Functional, and Nutraceutical Properties of Eggplant Flours Obtained by Different Drying Methods

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Abstract: The importance of consuming functional foods has led the food industry to look for alternative sources of ingredients of natural origin. Eggplants are a type of vegetable that is valued for its content in phytochemical compounds and it is due to the fact that this research is conducted towards the development of eggplant flour as a proposal to be used as a functional ingredient in the food industry. In this study, the eggplant fruits were divided into four groups, based on the drying method and the equipment used: Minced, drying oven (T1); sliced, drying oven (T2); sliced and frozen, drying tunnel (T3); and sliced, drying tunnel (T4). All the eggplant flours showed the same trend regarding their antioxidant capacity and phenolic content in the order T2 > T4 > T1 > T3. The freezing of eggplant was found to have a negative effect on functional and antioxidant properties. With respect to their nutritional composition, the flours did not change in their crude fiber, protein, and fat contents. In general terms, the T2 flour is a potential ingredient for the preparation of foods with functional properties since it is rich in phenolic compounds and antioxidants.

Keywords: eggplant; flour; phenolics; antioxidant activity; functional ingredient

1. Introduction

In recent years, the food industry has focused its efforts in the development of new products with properties that not only provide the necessary nutrients for human food, but also help prevent diseases related to nutrition such as diabetes, obesity, hypertension, and cardiovascular complications. It has been found that there is a significant correlation between the regular intake of phytochemicals and the prevention of these lifestyle-related diseases [1]. Antioxidants have attracted great attention as possible agents to prevent and treat diseases related to oxidative stress [2]. The antioxidants used by the food industry can be either from natural sources or from a synthetic origin (such as butylated hydroxytoluene and butylated hydroxyanisole). The latter has been found to be potentially carcinogenic and toxic [3]. Consequently, a niche in the food industry is opened to replace the existing synthetic antioxidants with those of natural origin found in fruits and vegetables, which are mainly vitamins and polyphenols [2].

Eggplant is an economically important vegetable crop from the tropical and subtropical zones of the world [4]. This crop produces fruit of different colors, sizes, and shapes [5]. Eggplant is a

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Increasing Antioxidant Activity and Protein Digestibility in *Phaseolus vulgaris* and *Avena sativa* by Fermentation with the *Pleurotus ostreatus* Fungus

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Abstract: The aim of the research was to determine the impact of fermentation with *Pleurotus ostreatus* on kidney beans, black beans, and oats. The results indicate that the fungus has a positive effect on the substrates when compared to the controls. The antioxidant activity (39.5% on kidney beans and 225% on oats in relation to the controls) and content of total polyphenols (kidney beans three times higher regarding the controls) increased significantly by the presence of the fungus mycelium, even after simulated digestion. There was a significant increase in protein digestibility (from 39.99 to 48.13% in black beans, 44.06 to 69.01% in kidney beans, and 63.25 to 70.01% in oats) and a decrease of antinutrient tannins (from 65.21 to 22.07 mg in black beans, 35.54 to 23.37 in kidney beans, and 55.67 to 28.11 in oats) as well as an increase in the contents of some essential amino acids. Overall, this fermentation treatment with *Pleurotus ostreatus* improved the nutritional quality of cereals and legumes, making them potential ingredients for the elaboration and/or fortification of foods for human nutrition.

Keywords: *Pleurotus ostreatus*; antioxidant activity; polyphenols; digestibility; fermentation; cereals; legumes

1. Introduction

Foods today are intended not only to satisfy hunger and provide the necessary nutrients for humans but also to prevent nutrition-related diseases that impact physical and mental wellness [1]. Functional foods have been introduced in markets, and they are usually defined as "modified foods which contain ingredients that have demonstrated actions that increase the welfare of the individual or decrease disease risk beyond the traditional role" [2]. The legume, a particularly common bean (*Phaseolus vulgaris*), is one of the main sources of vegetable protein available in developing countries [2]. The high lysine content protein of *Phaseolus vulgaris* makes it an ideal cereal protein; it supplements the deficiency in this essential amino acid and is also a staple ingredient in developing countries, where the availability of animal protein is low. Also, it provides adequate nutrition due to its contribution of carbohydrates [3] and high-quality protein. *Phaseolus vulgaris* has also been associated with various health benefits, including the reduced risk of diabetes and cardiovascular disease attributed to the presence of polyphenols [4,5]. *Phaseolus vulgaris*, however, contains antinutritional factors such as protein inhibitors (inhibitors of trypsin, chymotrypsin, and amylase), lectins, phytates, and tannins [6].

RESEARCH ARTICLE

Resistant Starch

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Resistant Starch Formation from Corn Starch by Combining Acid Hydrolysis with Extrusion Cooking and Hydrothermal Storage

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Acid hydrolysis process (AHPS) combined with hydrothermal storage process (HSPS) and extrusion cooking process (ECPS) are performed to obtain resistant starch (RS) from corn starch (CS). CS is subjected to AHPS citric, phosphoric acids, and HCl and thermal processes: 1) ECPS at 100 °C, 18% moisture content, and 220 rpm; 2) HSPS at 120 °C for 1 h, then storing at low temperature (4 °C) for 24 h. Evaluations in the different treatments are: RS, water absorption index (WAI) and solubility index (WSI); rheological, thermal, and microstructural properties. Treatment HAL results in the highest yield of RS (13.19 g/100 g), which increases WAI and WSI, low viscosity, gel hardness, ΔH and microstructural analysis showing agglomerated structures (30 μm) of diameter. On the other hand, HAC and HAP generated values of RS (8.47–9.19 g/100 g), respectively. Results show that pre-treatment by AHPS combined with HSPS is an alternative for obtaining RS, which exhibits suitable physical properties and is applicable to different dietary matrixes, at a 20-fold increased yield.

1. Introduction

Starch is a complex carbohydrate and is the main source of energy for humans.[1,2] However, its high consumption has led to health problems; therefore, there is an increase in the development and production of food that minimizes these components by replacing starch with soluble fibers to make the food healthier for consumers.[2] In recent years, starch has been modified for different purposes such as formulating food to improve its functionality for consumption and obtaining RS, which showed similar benefits. RS is defined as the sum of starch and the product of starch degradation not absorbed in the small intestine of healthy individuals.[2,3] RS is a physically inaccessible starch (type 1), raw starch granules and high-amylose starch are type 2 starches, retrograded gelatinized starch or dispersion granules are type 3 starches, and chemically modified starch is a type 4 starch.[3–5]

Recently, several processes have been described for RS generation. One of the processes is AHPS; using native corn starch with HCl, Mun and Shin[6] obtained a RS yield of 25.9%, but the disadvantage was the long processing time (upto 30 days). However, Koksel et al.[7] generated 12% of RS in normal corn starch using high temperature storage (95 °C for 48 h), and Chung et al.[8] increased the yield of RS to 25% after hydrolysis with reduced processing time using starch high in amylose, but the availability of raw materials was low. Besides, corn starch can be subjected to thermal treatments with high temperature; one of the thermal treatments is the hydrothermal process performed at temperatures of 100–120 °C. Onyango et al.[9] reported obtaining RS yield of 9.6% using yucca starch subjected to autoclave processing for 1 h. However, Hasjim and Jane,[10] and Koksel et al.[7] reported increased RS yield of 8.1–12.4% using native corn starch, and Kim et al.[11] reported obtaining a yield of 12.2–20% using rice starch. Moreover, Ozturk et al.[12] and Dundar and Gocmen[13] obtained the highest RS yield by autoclaving the samples, obtaining RS yields of 25–39% using starch high in amylose, respectively. Autoclaving the samples highly increases the RS yield, but its disadvantage is that it is

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Ultrasound-assisted extraction of fructans from agave (*Agave tequilana* Weber var. azul) at different ultrasound powers and solid-liquid ratios

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Abstract

The effects of ultrasound-assisted extraction (UAE) at different ultrasound power densities (UPDs; 40, 80, and 120 mW/mL) and solid:liquid (S:L) ratio (1:2, 1:3, and 1:6) on the extraction of carbohydrates from *Agave tequilana* plant of different ages were evaluated. Extracts obtained (6- and 7-year-old plant) were analyzed in the yield of carbohydrates (YC), fructan (FRU) content, simple sugars, fructan profile and the average degree of polymerization (DP_n). UPD, S:L ratio, and plant age all affected YC, FRU, and DP_n. Maximum YC and FRU were obtained from the older agave with UPD and S:L ratio of 120 mW/mL and 1:6, respectively; while glucose, fructose, and sucrose were highly released from the younger plant. Agave of 7-year-old presented the highest DP_n. Fructan degradation occurred at high UPD, increasing the simple sugars and decreasing the DP_n. Thermal-traditional extraction without sonication caused more fructan degradation; and overall, ultrasound enhanced fructan extraction and minimized fructan damage, representing a technological alternative for fructan extraction from agave.

Keywords: agave; fructans; ultrasound; power density; solid:liquid ratio; plant age.

Practical Application: *Agave tequilana* Weber var. azul plants have significant amounts of fructans. Extraction of these components by alternative methods such as ultrasound could represent advantages, improving the extraction and product quality. This research presents an alternative for the extraction of fructans assisted with ultrasound, evaluating different powers and solid-liquid ratios from agave heads of two different ages. Both variables, as well as age of agave showed a strong effect on fructan extraction. Ultrasound enhanced the extraction and minimized fructan damage, representing a technological alternative.

1 Introduction

Fructans are carbohydrates composed mainly of fructose units linked through fructosyl-fructose bonds in either linear or branched form. These are natural prebiotics that act as dietary fiber and are used in food technology, particularly for texture modification, moisture retention, gel formation, and food stabilization. Accordingly, fructans are considered a healthy food ingredient and their use in the food industry, primarily as fat and sugar substitutes, continues to grow (Apolinário et al., 2014; Zhu et al., 2016). Fructans are naturally present as storage carbohydrates in many species of plants and are associated with stress responses (cold and drought tolerance) of plants (Ritsema & Smeekens, 2003). In Mexico, fructans are mainly obtained from agave plants; where the highest biodiversity of the *Agave* genus (~75% of the 300 known species) is found (López & Urías-Silvas, 2007). *Agave tequilana* Weber var. azul, commonly called blue agave (Waleckx et al., 2008), is the *Agave* species of the highest economic importance in Mexico, since it is the raw material for the production of tequila, which is the principal Mexican alcoholic beverage with denomination of origin, recognized, and consumed worldwide (López et al., 2003). However, according the Norma Oficial Mexicana (2006), the above-mentioned variety must be cultivated in the Jalisco state or in one of the other restricted regions of Mexico established as protected territories in order to obtain a product with denomination of origin of tequila. Because a lot of agave production takes place outside of these specified regions, and because tequila production has achieved an upper limit, the search for alternative products from these plants represents an important research focus. Due to the high level of fructans (>60%) in agave (Mellado-Mojica & López, 2012), the use of these plants as a source of fructans and different products such as agave syrup or fructan powders has been investigated. Agave fructans consist of a complex mixture of highly branched neo-fructans (agavins) with both β-(2-1) and β-(2-6) linkages between fructose moieties (López et al., 2003; Mancilla-Margalli & López, 2006). This configuration renders the fructans resistant to enzymatic hydrolysis by human digestive enzymes, and they therefore pass undigested into the colon where they are fermented by colonic microflora. This prebiotic effect offers new alternative uses for agave fructans as functional ingredients in the food industry (López & Urías-Silvas, 2007).

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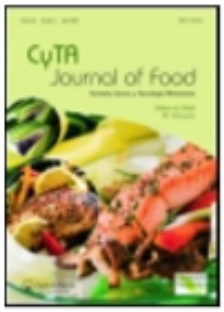

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Chemical composition, antimicrobial, and antioxidant activities of orange essential oil and its concentrated oils

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Antioxidant activity and influence of *Citrus* byproduct extracts on adherence and invasion of *Campylobacter jejuni* and on the relative expression of *cadF* and *ciaB*

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Abstract Adherence and invasion to cells are the key processes during infection development by *Campylobacter jejuni* (*C. jejuni*). In this study, extracts from the byproducts of *Citrus limon*, *Citrus aurantium*, and *Citrus medica* were added to the cultures of *C. jejuni*, and the adherence and invasion of *C. jejuni* to HeLa cells and the expression of *cadF* and *ciaB* genes were analyzed. The relative expression of the genes was determined by quantitative reverse transcription PCR (qRT-PCR). The antioxidant activity was determined using spectrophotometric methods. Byproduct extracts at sub-inhibitory concentrations affected the adherence (reduced 2.3 to 99%) and invasion (reduced 71.3 to 99.2%) to the HeLa cells. The expression of *cadF* and *ciaB* was reduced from 66 to 99% and from 81 to 99%, respectively. The total phenolic content of the byproducts varied from 92 to 26 mg GAE/g and the total flavonoids varied from 161 to 29.29 mg QE/g. *C. aurantium* showed the highest percentage of radical scavenging activity (RSA, 90.1). These extracts can prove as effective alternatives for devising new strategies to control *Campylobacter* infections.

Keywords: *Campylobacter*, adhesion, invasion, citrus extract, antimicrobial activity, antioxidant activity

Introduction

Campylobacter jejuni is one of the most important foodborne pathogens in the world. Although it primarily causes self-limiting diarrhea, *C. jejuni* is also associated with severe neuropathologic disorders such as Guillain–Barré and Reiter syndromes (1). Upon consuming *C. jejuni*-contaminated water or food items such as poultry or raw milk (2), the pathogen interacts with the host cells. Adherence is a key step in the establishment of the infection (3). In this process, fibronectin-binding protein (CadF), which is expressed in all *C. jejuni* and *C. coli* strains (4), plays an important role by binding to the cell matrix protein, fibronectin (5). Invasion antigen B (CiaB), the first secreted factor identified in *C. jejuni*, has an important role in invasion and has been identified as essential for the secretion of other Cia proteins (4).

Recent observations of the antibiotic resistance for some *Campylobacter* strains indicate a need to develop new approaches to block not only growth but also key steps during the infection process (6). Compounds present in plants have been historically studied for their antioxidant and pharmacological activities. *Citrus* plants are among the world's major fruit crops and can be consumed fresh or as processed products. Specifically, extracts from the *Citrus* species show a wide spectrum of antimicrobial activity (7) and hold potential for use in antioxidant-based therapies against cancer, inflammation, and heart disease (8).

Citrus oils and derivatives are generally recognized as safe by the Food and Drug Administration. The juice industry wastes large amounts of fruit byproducts, especially seeds, bagasse, and peels (50–65% of total fruit weight) (9,10). Use of *Citrus* byproducts is growing and studies suggest their potential use as alternatives to prevent fatty acid deterioration in the food industry (9). These byproducts contain high amounts of phenolic compounds such as phenolic acids and flavonoids (which are responsible for the antioxidant activity, 11) and are present in high concentrations (up to 15%) in *Citrus* peels and seeds (9). Although the content of these compounds can be influenced by many factors and could vary during harvest, postharvest, and among species (12-14), studies about their use as alternatives for effective antimicrobials have increased because of the development of antibiotic resistance by various microorganisms, including the *Campylobacter* species (6).

Pathogenesis of *Campylobacter* is initiated with adherence to intestinal epithelial cells, followed by internalization by bacterial invasion. Once inside the cell, a cytolethal distending toxin is produced that results in host cell death (3). Although *Citrus* extracts

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EFFECT OF ULTRASOUND ON THE CARBOHYDRATE EXTRACTION FROM SOTOL PLANTS (*Dasylirion wheeleri*) AT DIFFERENT POWERS AND TEMPERATURES

EFECTO DEL ULTRASONIDO EN LA EXTRACCIÓN DE CARBOHIDRATOS A PARTIR DE PLANTAS DE SOTOL (*Dasylirion wheeleri*) A DIFERENTES POTENCIAS Y TEMPERATURAS

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Abstract

Ultrasound-assisted extraction (UAE) of carbohydrates from powdered sotol plant (*Dasylirion wheeleri*) at different ultrasonic powers (UPs) (32.13-85.9 W) and temperatures (20.85-49.14 °C), in a 1:24 sotol:water ratio for 10 min was evaluated; a treatment control was done under thermal-traditional extraction. Total carbohydrates (TC), reducing sugars (RS), total fructan (FRU), glucose, fructose content, and average polymerization degree (DP_n) were evaluated. Fructan extraction kinetics and mass transfer coefficients (K_L) were calculated. RS and TC were significantly affected ($P < 0.05$) by temperature; FRU, by UP. Glucose, fructose, DP_n, and K_L were affected ($P < 0.05$) by UP and temperature. TC and FRU reached maximum values at 54-59.0 W and 36.0 °C. K_L reached a maximum at 55 W and 33.5 °C. The opposite trend was observed for glucose and fructose, presenting minimum values under these conditions, indicating minimal fructan damage. Under these conditions, DP_n values ranged from 4.18 to 4.7 with maximum FRU of 7.97 g·100 g^{-1} sotol d.m. Thermal treatment led to higher release of TC and RS and lower DP_n compared with UAE, but showed similar FRU. UAE (54-59.05 W at 36.0 °C) can be used to obtain FRU from sotol heads.

Keywords: *Dasylirion*, carbohydrates, fructans, extraction, ultrasound.

Resumen

Se evaluó el efecto del ultrasonido durante la extracción de carbohidratos a partir de sotol en polvo (*Dasylirion wheeleri*) a diferente potencia ultrasónica (PU) (32.13-85.9 W) y temperatura (20.85-49.14 °C), en una relación de 1:24 sotol:agua durante 10 min; asimismo un tratamiento control fue realizado utilizando extracción térmica tradicional. En los extractos obtenidos se determinó el contenido de carbohidratos totales (CT), azúcares reductores (AR), fructanos totales (FRU), glucosa, fructosa y grados de polimerización promedio (GP_n). A partir de cinéticas de extracción de fructanos se calcularon los coeficientes de transferencia de masa (K_L). Los contenidos de AR y CT fueron afectados significativamente ($P < 0.05$) por la temperatura y los FRU por la PU. Los contenidos de glucosa y fructosa, así como GP_n y K_L fueron afectados ($P < 0.05$) tanto por la PU como por la temperatura. Los CT y FRU alcanzaron valores máximos en 54-59.05 W y 36.01 °C, K_L generó un valor máximo en 55 W y 33.5 °C, sin embargo una tendencia opuesta fue observada para glucosa y fructosa, presentando un valor mínimo bajo las mismas condiciones, indicando un daño mínimo en los fructanos. Los valores de GP_n oscilaron de 4.18 a 4.7 con un contenido máximo de fructanos de 7.97 g·100 g^{-1} sotol b.s. El tratamiento térmico causó una mayor liberación de CT y AR con un menor GP_n comparado con la extracción asistida con ultrasonido, pero con valores similares de fructanos. La extracción asistida con ultrasonido (54-59.05 W a 36.0 °C) puede ser usada para obtener fructanos a partir de piñas de sotol.

Palabras clave: *Dasylirion*, carbohidratos, fructanos, extracción, ultrasonido.

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Research Article

Use of Red Cactus Pear *(Opuntia ficus-indica)* Encapsulated Powder to Pigment Extruded Cereal

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Encapsulated powder of the red cactus pear is a potential natural dye for the food industry and a known antioxidant. Although the use of this powder is possible, it is not clear how it alters food properties, thus ensuing commercial acceptability. The aim of this study was to evaluate the effect of encapsulated powder of the red cactus pear on the physicochemical properties of extruded cereals. The powder was mixed (2.5, 5.0, and 7.5% w/w) with maize grits and extruded (mix moisture 22%, temperature 100°C, and screw speed 325 rpm). The physical, chemical, and sensory characteristics of the extruded cereal were evaluated; extruded cereal without encapsulated powder was used as a control. All cereal extrudates pigmented with the encapsulated powder showed statistically significant differences ($P < 0.05$) in expansion, water absorption, color, density, and texture compared to the control. The encapsulated powder had a positive effect on expansion and water absorption indices, as well as color parameters, but a negative effect on density and texture. Extruded cereal properties were significantly ($P < 0.05$) correlated. Sensorially, consumers accepted the extruded cereal with a lower red cactus pear powder content (2.5% w/w), because this presented characteristics similar to extruded cereal lacking pigment.

1. Introduction

The percentage of consumers who are paying attention to food labels is increasing; this increase is related to the presence of chemical additives in processed food and their potentially negative effects on health [1]. To meet the challenge, food producers have turned to natural or organic ingredients. However, this is a complex issue, as the food must have sensorial characteristics that are attractive to the consumer. An important food property is color, because this is the first attribute of the product perceived by the consumer and therefore it can be a decisive factor for food acceptance or rejection. Food pigmentation is a practice that goes back to ancient times [2]; however, currently, most foods are formulated using synthetic pigments, as they possess advantages over natural pigments such as stability under certain processes and storage conditions. Among the factors affecting pigment stability, and therefore the natural pigment color, are pH, water content, presence of oxygen, and temperature [3, 4]. Temperature is the main determinant, as food processing is often based on the application of heat. A very important color in the food industry is red, which is used in many products, such as cookies, pastries, candies, cereals, yogurt, dairy drinks, ice creams, snacks, jams, juices, nonalcoholic drinks, nectars, puree, condiments, prepared flours, and meat products. Red color is achieved through the use of synthetic pigments, such as aborigine, amaranth, red rondeau, erythrosine, red 2G, and red allure as well as the

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Layer-by-layer edible coatings based on mucilages, pullulan and chitosan and its effect on quality and preservation of fresh-cut pineapple (*Ananas comosus*)

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ABSTRACT

Edible coatings (ECs) based on chitosan (CH), pullulan (PU), linseed (LM), nopal cactus (NM) and aloe mucilage (AM) were applied by layer-by-layer technique to preserve the quality and prolong the shelf-life of fresh-cut pineapple. Pineapples were washed, disinfected, dried and cut into 2 cm side cubes. Fresh-cut fruit was coated by dipping using four treatments (CH + PU, CH + LM, CH + NM and CH + AM), packed into polyethylene terephthalate containers and stored for 18 d at 4 °C. Uncoated fruit was used as control. Application of layer-by-layer ECs decreased ($P < 0.05$) the weight loss, pineapple softening, and, retarded the fall on total soluble solids content and color (L^* and a^*). CH + AM EC was effective in delaying ($P < 0.05$) ascorbic acid degradation. In contrast, ECs did not affect titratable acidity ($P > 0.05$). Microbiological analyses demonstrated the effectiveness ($P < 0.05$) of the layer-by-layer ECs against spoilage microorganisms, *L. monocytogenes* and *S. typhi*. CH + PU EC was the most effective in controlling microbial levels. Sensory analysis demonstrated that layer-by-layer ECs helped to preserve ($P < 0.05$) the quality properties (color, odor, flavor, texture and overall acceptance). In conclusion, layer-by-layer ECs based on CH + PU, CH + LM, CH + NM and CH + AM improved the quality and prolonged the shelf-life of fresh-cut pineapple by six days compared with control.

1. Introduction

Production of minimally processed fresh foods has increased recently due to the consumer demand. However, production and distribution of fresh-cut fruit has been limited due to their short shelf-life. Furthermore, processing operations such as washing, sanitizing, peeling, cutting, slicing, dicing or shredding and packaging (Corbo et al., 2010) can alter the integrity, safety, and decrease the quality and shelf-life of product, thus, limiting their marketing.

Pineapple (*Ananas comosus*) is a popular tropical fruit consumed worldwide (Montero-Calderón et al., 2008; Azarakhsh et al., 2012; Gabri et al., 2014). Fresh cut-pineapple is a good source of antioxidants (vitamin C and phenolics compounds) and is characterized by its acid taste, aroma and juiciness (Mantilla et al., 2013; Azarakhsh et al., 2012; Montero-Calderón et al., 2008). Nevertheless, fresh-cut pineapple shelf-life is short (5–7 d at 4 °C), because processing operations damage the cell membrane (Russo et al., 2014; Gabri et al., 2014; Mantilla et al., 2013), increase metabolic activities (respiration rate, enzyme activity and ethylene production) and cause deterioration (tissue softening, browning, off-flavor among others) (Azarakhsh et al., 2014). Besides, the fresh-cut fruit is susceptible to microbial spoilage because of the absence of protective peel that facilitates the microbial adhesion to tissue, which contains nutrients (vitamins, minerals, sugars and other) and pH suitable for microbial growth (Mantilla et al., 2013; Corbo et al., 2010; Gabri et al., 2014; Russo et al., 2014).

Recently, some strategies such as ozone treatments, UV light, gamma irradiation, modified atmosphere packaging, films and

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Physicochemical Changes and Resistant-Starch Content of Extruded Cornstarch with and without Storage at Refrigerator Temperatures

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Abstract: Effects of extrusion cooking and low-temperature storage on the physicochemical changes and resistant starch (RS) content in cornstarch were evaluated. The cornstarch was conditioned at 20%–40% moisture contents and extruded in the range 90–130 °C and at screw speeds in the range 200–360 rpm. The extrudates were stored at 4 °C for 120 h and then at room temperature. The water absorption, solubility index, RS content, viscoelastic, thermal, and microstructural properties of the extrudates were evaluated before and after storage. The extrusion temperature and moisture content significantly affected the physicochemical properties of the extrudates before and after storage. The RS content increased with increasing moisture content and extrusion temperature, and the viscoelastic and thermal properties showed related behaviors. Microscopic analysis showed that extrusion cooking damaged the native starch structure, producing gelatinization and retrogradation and forming RS. The starch containing 35% moisture and extruded at 120 °C and 320 rpm produced the most RS (1.13 g/100 g) after to storage at low temperature. Although the RS formation was low, the results suggest that extrusion cooking could be advantageous for RS production and application in the food industry since it is a pollution less, continuous process requiring only a short residence time.

Keywords: extrusion cooking; resistant starch; thermal properties; viscoelastic properties; cornstarch

1. Introduction

Starch is a complex carbohydrate composed of glucose units consisting of amylose and amylopectin [1,2] and is widely used in food production. However, current market trends demand functional ingredients with health benefits, and starch transformed into resistant starch (RS) shows advantages in a diverse range of applications. RS has modified starch or starch fractions that are indigestible in the small intestine, so it is similar to dietary fiber and shows similar health benefits [3,4].

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Research Article

Antibacterial and Antibiofilm Activity of Methanolic Plant Extracts against Nosocomial Microorganisms

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Biofilm is a complex microbial community highly resistant to antimicrobials. The formation of biofilms in biotic and abiotic surfaces is associated with high rates of morbidity and mortality in hospitalized patients. New alternatives for controlling infections have been proposed focusing on the therapeutic properties of medicinal plants and their antimicrobial effects. In the present study the antimicrobial and antibiofilm activities of 8 methanolic plant extracts were evaluated against clinical isolated microorganisms. Preliminary screening by diffusion well assay showed the antimicrobial activity of *Prosopis laevigata*, *Opuntia ficus-indica*, and *Gutierrezia microcephala*. The minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) were determined ranging from 0.7 to >15 mg/mL. The specific biofilm formation index (SBF) was evaluated before and after the addition of plant extracts (MBC × 0.75). *Opuntia ficus-indica* caused the major reduction on SBF in dose-dependent manner. Cytotoxic activity of plant extracts was determined using brine shrimp lethality test (*Artemia salina* L.). Lethal Dose concentration (LD_{50} values) of the plant extracts was calculated. LD_{50} values for *P. laevigata* and *G. microcephala* were 141.6 and 323.3 μg/mL, respectively, while *O. ficus-indica* showed a slight lethality with 939.2 μg/mL. Phytochemical analyses reveal the presence of flavonoids, tannins, and coumarines.

1. Introduction

Microbial biofilms are communities of bacteria, embedded in a self-producing matrix, forming on living and nonliving solid surfaces [1]. Biofilm-associated cells have the ability to adhere irreversibly on a wide variety of surfaces, including living tissues and indwelling medical devices as catheters, valves, prosthesis, and so forth [2].

They are considered an important virulence factor that causes persistent chronic and recurrent infections; they are highly resistant to antibiotics and host immune defenses [3]. Bacteria protected within biofilm exopolysaccharides are up to 1,000 times more resistant to antibiotics than planktonic cells (free-floating) [4], which generates serious consequences for therapy and severely complicates treatment options [5]. An estimated 75% of bacterial infections involve biofilms that are protected by an extracellular matrix [6].

Biofilm resistance is due to several reasons, like restricted diffusion of antibiotics into biofilm matrix, expression of multidrug efflux pumps, type IV secretion systems, decreased permeability, and the action of antibiotic-modifying enzymes [7]. The increased biofilm resistance to conventional treatments enhances the need to develop new control strategies [8].

Biofilm inhibition is considered as major drug target for the treatment of various bacterial and fungal infections, and pharmacological development of this drugs is now extensively studied [9]. In recent years, several green nonlethal strategies for biofilm control have been developed, because the mode of action of these novel antibiofilm agents is

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Effect of Extrusion Cooking on Bioactive Compounds in Encapsulated Red Cactus Pear Powder

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Abstract: Red cactus pear has significant antioxidant activity and potential as a colorant in food, due to the presence of betalains. However, the betalains are highly thermolabile, and their application in thermal process, as extrusion cooking, should be evaluated. The aim of this study was to evaluate the effect of extrusion conditions on the chemical components of red cactus pear encapsulated powder. Cornstarch and encapsulated powder (2.5% w/w) were mixed and processed by extrusion at different barrel temperatures (80, 100, 120, 140 °C) and screw speeds (225, 275, 325 rpm) using a twin-screw extruder. Mean residence time (tr_m), color (L^*, a^*, b^*), antioxidant activity, total polyphenol, betacyanin, and betaxanthin contents were determined on extrudates, and pigment degradation reaction rate constants (k) and activation energies (E_a) were calculated. Increases in barrel temperature and screw

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Factores que influyen en el contenido de escualeno, fitoesteroles totales y esterificados en el subproducto ácidos grasos destilados de soya para su potencial aprovechamiento
Factors affecting the content of squalene, total and esterified phytoesterols in soybean distillated fatty acids by-product for its potential use

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2(5H)-Furanone, epigallocatechin gallate, and a citric-based disinfectant disturb quorum-sensing activity and reduce motility and biofilm formation of *Campylobacter jejuni*

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Abstract Brominated furanone and epigallocatechin gallate (EGCG) are naturally occurring polyphenolic compounds that can be derived from sources such as *Delisea pulchra* algae and green tea, respectively. These compounds may have potential health benefits and antimicrobial properties. Biofilm formation and bacterial motility are virulence factors that seem to be involved in the autoinducer 2 (AI-2)-mediated quorum sensing (QS) response of *Campylobacter*. In this study, the anti-QS activities of 2(5H)-furanone, EGCG, and a citric-based disinfectant were tested against *Campylobacter jejuni*. The minimal bactericidal concentration (MBC) was determined by a microdilution method, and the AI-2 activity was measured by bioluminescence. For motility tests, subinhibitory concentrations of each compound were mixed with semisolid Muller Hinton agar. Biofilm formation was quantified in broth-containing microplates after staining with safranin. The MBC of tested compounds ranged from 0.3 to 310 μg/mL. Subinhibitory concentrations of all of the antimicrobial compounds significantly decreased (19 to 62 %) the bacterial motility and reduced biofilm formation. After treatment with EGCG, furanone, and the disinfectant, AI-2 activity was decreased by 60 to 99 % compared to control. In conclusion, 2(5H)-furanone, EGCG, and the disinfectant exert bactericidal effects against *C. jejuni* and disturb QS activity and reduce motility and biofilm formation. These compounds may be naturally occurring alternatives to control *C. jejuni*.

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Introduction

Campylobacter jejuni is an important food-borne pathogen that causes gastrointestinal illness worldwide. Contaminated chicken and other poultry are the main sources of infection in humans (Ganan et al. 2012). Many chickens raised for food are contaminated with *C. jejuni*. Therefore, it is essential to reduce the incidence of contamination during food production to reduce subsequent disease (Hald 2010). *Campylobacter* pathogenesis depends on the expression of virulence factors, several of which control motility and biofilm formation (Svensson et al. 2009). Motility is essential for intestinal colonization and invasion (Guerry 2007). *Campylobacter*-forming biofilms demonstrate superior resistance to environmental and pharmacological treatments (Gunther and Chen 2009). Due to the increasing incidence of antimicrobial resistance, new strategies are continually being evaluated to control microorganisms without inducing resistance (Steenackers et al. 2010). Such strategies involve finding alternative drugs that selectively inhibit virulence without affecting the planktonic growth of bacteria (Steenackers et al. 2010; Clatworthy et al. 2007).

Most efforts to inhibit the regulation of virulence factor expression have focused on quorum sensing (QS), a complex regulatory process that is dependent on the bacterial cell density. QS is involved in physiological processes, such as biofilm formation, bioluminescence, antibiotic synthesis, and virulence factor expression (Landini et al. 2010). QS systems employ a wide range of signaling molecules. These so-called "autoinducers" regulate changes in gene expression and the subsequent initiation of cooperative bacterial processes that allow pathogenesis (Galloway et al. 2012). Autoinducer 2 (AI-2) is a key molecule to control QS in *Campylobacter* (Annous et al. 2009; Moorhead and Griffiths 2011).

Various QS inhibitors have been reported. An important class of QS inhibitors includes the brominated furanones

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Edible Active Coatings Based on Pectin, Pullulan, and Chitosan Increase Quality and Shelf Life of Strawberries (*Fragaria ananassa*)

Mayra Z. Treviño-Garza, Santos García, Ma. del Socorro Flores-González, and Katiushka Arévalo-Niño

Abstract: Edible active coatings (EACs) based on pectin, pullulan, and chitosan incorporated with sodium benzoate and potassium sorbate were employed to improve the quality and shelf life of strawberries. Fruits were washed, disinfected, coated by dipping, packed, and stored at 4 °C for 15 d. Application of EACs reduced ($P < 0.05$) weight loss and fruit softening and delayed alteration of color (redness) and total soluble solids content. In contrast, pH and titratable acidity were not affected ($P > 0.05$) throughout storage, and ascorbic acid content was maintained in pectin-EAC coated strawberries. Microbiological analyses showed that application of EACs reduced ($P < 0.05$) microbial growth (total aerobic counts, molds, and yeasts) on strawberries. Chitosan-EAC coated strawberries presented the best results in microbial growth assays. Sensory quality (color, flavor, texture, and acceptance) improved and decay rate decreased ($P < 0.05$) in pectin-EAC, pullulan-EAC, and chitosan-EAC coated strawberries. In conclusion, EACs based on polysaccharides improved the physicochemical, microbiological, and sensory characteristics, increasing the shelf life of strawberries from 6 (control) to 15 d (coated fruits).

Keywords: antimicrobials, edible active coating, quality, shelf-life, strawberry

Practical Application: Consumer demands for high quality foods have led to development of technologies for preserving the quality of these products. The present work focuses on improving quality and increasing the shelf life of strawberries using edible coatings based on polysaccharides and antimicrobial agents. The results of this work are applicable to industrial food production and postharvest handling to enhance overall quality and shelf life of strawberries.

Introduction

Strawberries are one of the most economically important fruits worldwide, and the United States is a main producer (FAOSTAT 2013). Strawberries are a nonclimacteric fruit, susceptible to mechanical injury. They are also highly perishable due to high rates of respiration (Campaniello and others 2008). Furthermore, fungal infections, caused by molds *Botrytis cinerea* and *Rhizopus stolonifer*, are the main causes of altered color, firmness, quality, and postharvest loss (Mali and Grossmann 2003; Peretto and others 2014). The most prevalent methods of maintaining quality and controlling the decay of strawberries is by rapid cooling, storage at low temperatures (0 to 4 °C) with high humidity, and elevating CO_2 and decreasing O_2 levels (García and others 1998a; Xiao and others 2004). However, control of temperature during transport and storage of strawberries is difficult, therefore other means of preservation have been sought (Mali and Grossmann 2003; Campaniello and others 2008).

Edible coatings (ECs) protect perishable food products from deterioration (Atress and others 2010). An EC consists of a thin layer, which is pre-formed or formed directly on the surface of the product as a protective cover. These materials act as barriers that produce modified atmospheres, minimizing respiration rates, reducing moisture exchange, delaying deterioration, controlling microbial growth, and carrying functional ingredients (antioxidants, antimicrobials, and so on). ECs can be elaborated with polymers such as proteins, lipids, and polysaccharides including pectin, chitosan, and pullulan (Costa and others 2010).

Pectin, consisting of 1,4-linked α-D-galacturonic acid, is a complex anionic polysaccharide present in the cell wall of many fruits and vegetables (Iijima and others 2000). Additionally, chitosan, β-(1→4)-2-amino-2-deoxi-D-glucosa or D-glucosamine, is a natural polymer derived by deacetylation of chitin, which is a major component of crustacean shells (crabs, shrimps, and crawfish). This compound, which has been used to elaborate ECs, is a cationic polysaccharide that exhibits bactericide and fungicide activities (Campos and others 2011; Dutta and others 2009). Finally, pullulan is an extracellular linear homopolysaccharide that is formed by maltotriose and maltotetraose units having both α-(1→6) and α-(1→4) linkages. Produced by *Aerobasidium pullulans*, pullulan is capable of forming edible films and coatings. However, this polymer has not yet been thoroughly explored as a coating or packaging material (Diab and others 2001; Kandemir and others 2005; Eroglu and others 2014).

In most fresh or processed products, microbial contamination is found mainly on the surface. Therefore, EC based polysaccharides are applied and formed directly on the surface of food products and can be added with a paintbrush or by spraying, dipping, or fluidizing (Mchugh 2000; Sorrentino and others 2007; El-Anany and others 2009; Falguera and others 2011). Moreover, active ingredients, such as antimicrobials or bioactive compounds (essential oils), can be incorporated into ECs to form edible active

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