LGAC-MODERNIZACIÓN E INNOVACIÓN DE PROCESOS ALIMENTARIOS

Las investigaciones desarrolladas dentro de la LGAC en Modernización e Innovación de Procesos Alimentarios, reflejan tanto la participación de los estudiantes adscritos a esta LGAC, como los proyectos de investigación dentro de sus líneas de trabajo.

Hasta Junio de 2014, la LGAC, MIPA, estaba conformada por 3 profesoras: La Dra. Juliana Morales Castro, Dra. Luz Araceli Ochoa Martínez y M.C. Silvia Marina González Herrera. Durante el período 2012-2017, la M.C. González Herrera obtiene su grado de Doctor (2016) desarrollando investigación con prebióticos y la Dra. Olga Miriam Rutiaga Quiñones, se incorpora a esta línea, MIPA, (2014) para participar en el área de biotecnología de alimentos y obtención decompuestos activos por fermentaciones o bioconversiones microbianas, como Aromas, entre otros. Hasta la fecha se cuenta con 4 investigadoras con grado de doctor. Es por ello que la productividad de la Dra. Rutiaga Quiñones, en esta línea, se ve reflejada a partir del año 2014.

Tal como puede apreciarse de la productividad que se presenta, los artículos reflejan investigaciones en el uso de tecnologías tanto tradicionales como emergentes, como son: la fermentación, el deshidratado, la aplicación de ultrasonido y de Altas Presiones Hidrostáticas. La innovación se evidencía por los trabajos en nanoemulsiones con actividad antimicrobiana con aceites esenciales, así como el uso de fructanos de agave como agentes prebióticos y la microencapsulación de compuestos bioactivos.

Esta línea, tambien realiza investigaciones para desarrollar ingredientes tecnofuncionales y con propiedades bioactivas, como la obtención de harina de camote naranja para la obtención de betacarotenos, obtención de pectinas de tomate verde, estabilidad de jugo de granada y estudios sobre la producción de compuestos bioactivos por fermentaciones microbianas, aprovechamiento de residuos agroindustriales y bioconversión de aromas.

Con respecto al desarrollo de nuevos productos y procesos, se ha trabajado con tortillas de harina adicionadas con masas madre, nixtamalización asistida con ultrasonido, estabilidad de jugo de granada con altas presiones , chips de tortilla adicionadas con harina de frijol y una lámina de manzana adicionada con ingredientes prebióticos. Así como el aprovechamiento de residuos agroindustriales con potencial de producción de compuestos biactivos, producción de aromas y enzimas, entre otros.

Como puede observarse, la productividad presentada, refleja la calidad y diversidad de los trabajos de tesis experimentales realizados en el posgrado en Ing. Bioquímica y dentro de la LGAC de MIPA.

PRODUCCIÓN ASOCIADA PTC-ESTUDIANTES DE LA LÍNEA MODERNIZACIÓN E INNOVACIÓN DE PROCESOS ALIMENTARIOS.

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ORIGINAL ARTICLE

Ultrasound in orange sweet potato juice: Bioactive compounds, antioxidant activity, and enzymatic inactivation

Evelyn Alicia Rios-Romero, Luz Araceli Ochoa-Martínez, Juliana Morales-Castro, Luis Arturo Bello-Pérez, Armando Quintero-Ramos, José Alberto Gallegos-Infante

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Abstract

Orange flesh sweet potato contains bioactive compounds which have nutritional and

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Influence of essential oils and pectin on nanoemulsion formulation: A ternary phase experimental approach

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abstract

A pseudo-ternary phase experimental approach was used to model the influence of the mixture components concentration on the nanoemulsions properties as ternary systems. For this, several types of essential oils (EO) were used as lipid phase, being oregano (OR-EO), thyme (TH-EO), lemongrass (LG-EO) and mandarin (MN-EO), while pectin and Tween 80 were studied as emulsifiers. All formulations were processed by microfluidization at 150 MPa and 5 cycles. Polynomial models were fitted to experimental data and their adjusted R^2 and p-values were obtained. Remarkably, a pectin concentration of 1% (*w/w*) allowed the formation of submicron emulsions between 350 and 850 nm in the absence of Tween 80 for all the studied EOs, thus confirming its emulsification capacity. In general, increasing the pectin concentration up to 2% (*w/w*) enlarged the particle size of emulsions and their viscosity thus suggesting decreased emulsification efficiency during microfluidization. Nonetheless, nanoemulsions with particle sizes below 500 nm were obtained when a minimum Tween 80 concentration of 1.8% (*w/w*) was used, regardless the pectin or EO concentrations. The modest decrease in the z-potential that was observed depending on the type of EO at increasing pectin concentrations indicated that pectin is not or weakly adsorbed at the oil-water interface. All nanoemulsions were transparent at high surfactant and low EO concentrations due to a weak light scattering of the nano-sized oil droplets. Thus, this work contributes in elucidating the role of pectin and small molecule non-ionic surfactants on the formation of submicron emulsions and nanoemulsions containing essential oils.

1. Introduction

Essential oils (EOs) are natural compounds that contain a complex mixture of terpenoids, with non-volatile and volatile nature produced by aromatic plants as secondary metabolites (Fisher & Phillips, 2008; Salvia-Trujillo, Rojas-Graü, Soliva-Fortuny, & Martín-Belloso, 2014). EOs have been traditionally used as natural flavorings and more recently as natural antimicrobials for food preservation (Guerra-Rosas, Morales-Castro, Ochoa-Martínez, Salvia-Trujillo, & Martín-Belloso, 2016). Due to their lipophilic nature, they are able to interact with biological membranes of microbial cells causing the leakage of cytoplasmatic content and the subsequent cell collapse (Burt, 2004; Guerra-Rosas et al., 2016). Besides the benefits of adding EOs to food matrices, their poor water solubility, their intense aroma or their potential toxicity at high concentrations needs consideration (Svoboda, Brooker, & Zrustova, 2006). Therefore, the design of adequate delivery systems able to encapsulate, protect and release lipophilic bioactive compounds into food matrices more efficiently represents a challenge for the food technology field.

Recently, nanoemulsions have been described as colloidal dispersions of oil droplets with particle size diameters lower than 500 nm, which are suspended within an aqueous phase (Otoni, Avena-Bustillos, Olsen, Bilbao-Sainz, & McHugh, 2016). Nanoemulsions seem to be a promising tool for incorporating antimicrobial EOs in foods and they have been reported to present several potential advantages in comparison with conventional emulsions. Nanoemulsions present a higher active surface area/volume ratio due to their small droplet size, thus enhancing the transport of active compounds through biological membranes. Therefore, the use of nanoemulsions as carriers of antimicrobial essential oils

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Effect of ultrasound pre-treatment on the physicochemical composition of *Agave durangensis* leaves and potential enzyme production

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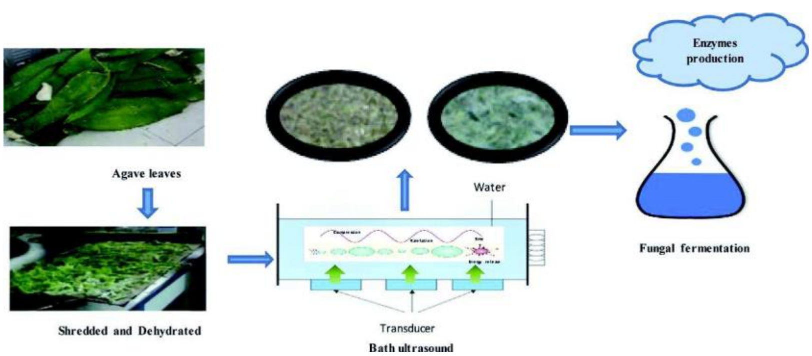
GRAPHICAL ABSTRACT



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ABSTRACT

Approximately 1 million tons of agave plants are processed annually by the Mexican tequila and mezcal industry, generating vast amounts of agroindustrial solid waste. This type of lignocellulosic biomass is considered to be agroindustrial residue, which can be used to produce enzymes, giving it added value. However, the structure of lignocellulosic biomass makes it highly recalcitrant, and results in relatively low yield when used in its native form. The aim of this study was to investigate an effective pre-treatment method for the production of commercially important hydrolytic enzymes. In this work, the physical and chemical modification of *Agave durangensis* leaves was analysed using ultrasound and high temperature as pre-treatments, and production of enzymes was evaluated. The pre-treatments resulted in modification of the lignocellulosic structure and

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Pectin from Husk Tomato (*Physalis ixocarpa* Brot.): Rheological behavior at different extraction conditions

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ABSTRACT

A rheological study was carried out to evaluate formulations of test dispersions and gels of high methoxyl pectins (HTHMP) obtained at different conditions from husk tomato waste (*Physalis ixocarpa* Brot.). The effect of extraction agent (hydrochloric acid or citric acid), blanching time (10 or 15 min) and extraction time (15, 20 or 25 min) on the rheology of the tested samples was evaluated. Flow behavior and activation energy were evaluated on the test dispersions, while (E_a) frequency sweeps, temperature sweep, creep-recovery test and penetration test were performed on the gels. HTHMP dispersions showed shear thinning flow behavior, while showing a good fit to Cross model. Extraction agent, blanching time and extraction time did not have effect on Cross parameters (η_0, η_∞, C, and m). E_a decreased as blanching time and extraction time increased. Frequency sweeps revealed high dependence on frequency for both G' and G", while temperature sweeps (25- 95 °C) showed thermostable husk tomato pectin gels. Hydrocloric acid (HCl) extracted pectin gels showed stronger structure than citric acid (CA) gels.

1. Introduction

Pectins are one of the most sought out ingredients in the food industry for their unique gelling capacity and health benefits; as a result, they have become extensively used as gelling, stabilizing, thickening, and texturizing agents (Nascimento, Simas-Tosin, Iacomini, Gorin, & Cordeiro, 2016). In addition, health benefits of pectins as soluble fibers, have been reported: control of cholesterol level, improvement of gastrointestinal functions, and, preventive properties in diseases such as diabetes, obesity, coronary heart diseases and certain types of cancer (van der Gronde, Hartog, van Hees, Pellikaan, & Pieters, 2016; Wicker & Kim, 2016; Zhu et al., 2015).

Pectins, as substances of vegetal origin, are complex heteropolysaccharides composed of three main domains: one "lineal domain" corresponding to homogalacturonan (HG), and, two "branched domains" corresponding to rhamnogalacturonan I (RG-I) and rhamnogalacturonan II (RG-II) (Morris, Ralet, Bonnin, Thibault, & Harding, 2010). HG is the most abundant pectic component, it consists of units of D-galacturonic acid (α-1,4-linked) which can be methoxylated at C6 and/or acetylated at C2 or C3. (Cameron, Kim, Galant, Luzio, & Tzen, 2015).

Pectins are classified into two groups according to their DE: Low Methoxyl Pectin (LMP) and High Methoxyl Pectin (HMP), with a proportion of methoxyl groups lower and greater than 50%, respectively (Fishman et al., 2015). The gelation mechanism in LMP is mediated by the formation of calcium bridges between two carboxyl groups from two chains in close contact, specifically, in an interaction described by the "egg box" model (Axelos & Thibault, 1991). In HMP, junction zones are stabilized by a combination of hydrogen bonds and hydrophobic interactions between pectin molecules (Oakenfull, 1991). Both LMP and HMP, can form gels under different conditions with wide characteristics (Löfgren, Guillotin, & Hermansson, 2006), which expands their potential applications (Löfgren & Hermansson, 2007). Chemical composition of pectin expressed by DE, molecular weight (MW) and neutral sugars composition, have a major role in their rheological behavior (Axelos & Thibault, 1991), thus influencing their possible uses (Morris & Ralet, 2012).

Commercially, pectin production is mainly obtained from agro-industrial by-products from juice processing, apple pomace and citrus peels. However, since the applications of this polysaccharide have been

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Husk Tomato (*Physalis ixocarpa* Brot.) Waste as a Promising Source of Pectin: Extraction and Physicochemical Characterization

Blanca Elizabeth Morales-Contreras, Juan Carlos Contreras-Esquivel, Louise Wicker, Luz Araceli Ochoa-Mart´ınez, and Juliana Morales-Castro

Abstract: Husk tomato (*Physalis ixocarpa* Brot. var. Rendidora) waste was evaluated as a source of specialized pectin, and pectin extracted from this waste was characterized physicochemically. Fruit was blanched for 10 or 15 min and extracted in 0.1 N HCl for 15 to 25 min. Extracted pectin was subjected to physicochemical analysis. For all extraction conditions, the percentage of anhydrogalacturonic acid exceeded 60%, indicating that husk tomato was a good source of pectin. The degree of esterification of pectin molecules was 63% to 91%. The amount of extracted pectin decreased with increasing extraction time. The apparent viscosity of husk tomato pectin showed the characteristic behavior of pseudoplastic fluids. Neutral sugars were identified, and the amounts of 6 sugars (fucose, rhamnose, arabinose, galactose, glucose, and xylose) were quantified. Sugars identified in husk tomato pectin and present in the Rhamnogalacturonan I region, arabinose, galactose, and rhamnose suggest a highly branched structure, which will influence its future applications. Molecular weight values were 542 to 699 kDa, exceeding molecular weight values reported for commercial citrus pectins from 134 to 480 kDa. The extraction process significantly ($P < 0.05$) influenced the physicochemical properties of pectin. Up to 19.8% from the total amount of pectin in the husk tomato was extracted by 10 min of blanching and 20 min of a more heat treatment. Our findings indicate that husk tomato can be a good alternative source of pectin having highly distinctive physicochemical characteristics.

Keywords: apparent viscosity, husk tomato, pectin, *Physalis ixocarpa* Brot., tomatillo

Food Chemistry

Introduction

Pectin is a complex polysaccharide that is found in plant cell walls (Voragen and others 1995). It is formed of 3 main domains: the linear homogalacturonan (HG) domain, the rhamnogalacturonan I (RG-I) domain, and the rhamnogalacturonan II (RG-II) domain (Mohnen 2008; Voragen and others 2009). HG consists of α (1-4) linked-D-galacturonic acid, the most abundant component of pectin, which can be methoxylated at C-6 and/or acetylated at C-2 or C-3. Proportions of methyl and acetyl groups determine the pattern and DE of the HG domain. These features, together with the degree of polymerization, determine the functionality of pectin in food products (Willats and others 2006). The RG-I is one of the domains of the main structure of pectins. The proportion of RG-I domain depends on the source and extraction method of the pectin (O'Neill and others 1990). L-rhamnose residues may be attached to other neutral sugar side chains, such as arabinose and galactose. Compounds such as ferulic acid or coumaric acid may also be attached to this structure (Saulnier and Thibault 1999). Composition differences specific to pectins from different sources contribute to functional characteristics (such as gel-forming ability), depending on which interactions are favored in the branched portion of the molecule (Round and others 2010).

Global demand for pectins is estimated to be about 40000 tons per year, with an annual growth of about 5%. The food industry uses citrus waste and apple pomace to obtain pectin, but these sources are not sufficient to meet the market demand (Willats and others 2006; Ciriminna and others 2015). Innovation in food product development and the need for specialized hydrocolloids have driven the search for new ingredients and stabilizers. Pectin is commonly used as a gelling agent in different products, including bakery fillings and confectionary products in the food industry (Willats and others 2006). In recent years, its use has spread to other sectors, such as pharmaceuticals and cosmetics. The reported biological activity of pectins (Wang and others 2016), owing to the presence of proteins, ferulic acid, acetyl groups, and polyphenols, could further increase global demand for this product.

Research has focused on identifying new sources of pectin and features that may confer new functional properties. Novel sources of pectin that have been studied include passion fruit (Kulkarni and Vijayanand 2010), banana peel (Gopi and others 2014), gold kiwifruit (Yuliarti and others 2015b), pomegranate peel (Pereira and others 2016), grapefruit (Wang and others 2016), tomato waste (Ninčević Grassino and others 2016), *Artocarpus heterophyllus* waste (Moorthy and others 2017), and others. Husk tomato plants (*Physalis ixocarpa* Brot.) originated in Mexico but are grown in different countries. Its fruit, the tomatillo, as it is known in Latin America, is an important culinary fruit that has a distinctive flavor, both in raw and cooked form and it is added to sauces and salsas to increase consistency. Due to a husk tomato surplus or lower quality product, the fruit is discarded and food waste is generated; in

JFDS-2017-0186 Submitted 1/31/2017, Accepted 5/1/2017. *Authors Morales-Contreras, Ochoa-Mart´ınez, and Morales-Castro are with Dept. de Ingenier´ıas Qu´ımica y Bioqu´ımica, TecNM/ Inst. Tecnolo´gico de Durango, Blvd. Felipe Pescador 1830 Ote., Col. Nueva Vizcaya, 34080 Durango, Me´xico. Author Contreras-Esquivel is with Facultad de Ciencias Qu´ımicas, Univ. Auto´noma de Coahuila, Ing J. Cárdenas Valdez, República, Saltillo, Coahuila, México. Author Wicker was formerly with Dept. of Food Science and Technology, Univ. of Georgia, Athens, GA 30602-7610, U.S.A. and is now with School of Nutrition and Food Sciences, Lousiana State Univ. Agricultural Center, Baton Rouge, LA, 70808, U.S.A. Direct inquiries to author Morales-Castro (E-mail: jmorales@itdurango.edu.mx).*

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Enzymatic Potential of Native Fungal Strains of *Agave* Residues

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Twelve strains of fungi from residues of *Agave durangensis* were isolated and identified by molecular techniques for evaluation of their hydrolytic enzyme production capability. A proportion (50%) of the fungal strains belonged to the *Aspergillus* genus and the other strains used belonged to *Alternaria, Neurospora crassa, Mucor* sp, *Rhizopus* sp., *Botryosphaeria* sp., and *Scytalidium* sp. The isolated strains were evaluated for their potential to produce extracellular enzymes using different substrates (cellulose, xylan, inulin, *Agave* fructans, starch, and tannic acid). It was observed that most of the tested strains were capable of simultaneously secreting cellulases, xylanases, inulinases, fructanases, and laccases. *Botryosphaeria* sp. ITD-G6 was selected for its evaluation in the production of inulinase, using different substrates. Showing high inulinase activities (5.22 U/ ml for *Agave* waste, 4.37 U/ ml for inulin and 5.00 U/ ml for *Agave* fructans).

Keywords: Inulinase; Fructanase; Molecular identification; Agave durangensis leaves; Botryosphaeria

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INTRODUCTION

Agave is the main genus of the Agavaceae family with about 200 different species. *Agave durangensis* Gentry is a plant belonging to this family that is used for the production of Mexican alcoholic beverages (Tequila and Mezcal), a process that generates various agroindustrial waste products. Approximately 1 million tons of *Agave durangensis* are produced and processed annually, generating large quantities of agricultural waste, of which about 1200 tons are *Agave* leaves; these are considered to have potential as agroindustrial residue (Contreras-Hernández *et al.* 2017). The waste leaves present a high content of cellulose (38 to 50%), whereas the lignin is 15 to 25% and the hemicellulose is 23% to 32% (Vieira *et al.* 2002; Sun *et al.* 2016). *Agave* leaves also have a high fructan content (Orozco-Cortés *et al.* 2015). This agroindustrial waste has characteristics making it a substrate for the production of fungal enzymes with biotechnological interest.

Fungi are remarkable microorganisms due to their plasticity and physiologic versatility. They have the capability to grow and develop in inhospitable habitats with extreme environmental conditions because of their efficient enzymatic system. Among the

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Antimicrobial activity of nanoemulsions containing essential oils and high methoxyl pectin during long-term storage

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The antimicrobial activity against *Escherichia coli* and *Listeria innocua* of nanoemulsions containing oregano, thyme, lemongrass or mandarin essential oils and high methoxyl pectin was assessed during a long-term storage period (56 days). On one hand, a higher antimicrobial activity was detected against *E. coli* compared to *L. innocua* regardless the EO type. Transmission Electron Microscopy (TEM) images showed a significant damage in the *E. coli* cells for both the cytoplasm and cytoplasmic membrane, led to cell death. The antimicrobial activity of the nanoemulsions was found to be strongly related to the EO type rather than to their droplet size. The lemongrass-pectin nanoemulsion had the smallest droplet size (11 ± 1 nm) and higher antimicrobial activity reaching 5.9 log reductions of the *E. coli* population. Nevertheless, the freshly made oregano, thyme and mandarin EO-pectin nanoemulsion led to 2.2, 2.1 or 1.9 *E. coli* log-reductions, respectively. However, the antimicrobial activity decreased significantly during storage regardless the EO type, which was related to the loss of volatile compounds over time according to our results. The current work provides valuable information in order to make progress in the use of nanoemulsions containing EOs as decontaminating agents in food products.

1. Introduction

Essential oils (EOs) are volatile substances obtained from aromatic plant materials (flowers, buds, seeds, leaves, twigs, bark, herbs, wood, fruits and roots) (Noorizadeh, Farmany, & Noorizadeh, 2011; Bakkali et al., 2008), usually extracted by steam vaporization and cold-press techniques (Saad, Muller, & Lobstein, 2013). EOs are commonly used as antioxidants, flavorings or colorants in a wide range of food products (Edris, 2007; Santin, Oliveira, Cristina, Ferreira, & Ueda-nakamura, 2009). Moreover, EOs have been described as strong natural antimicrobial agents for food preservation purposes (Muriel-Galet et al., 2012). The antimicrobial properties of EOs are mainly due to their volatile components, including terpenoids and phenolic compounds (Cosentino et al., 1999). The mechanism of EOs to inactivate food-borne microorganisms relies on their interaction with the microbial membrane. EOs phenolic compounds are known to penetrate through the microbial membrane and cause the leakage of ions and cytoplasmatic content thus leading to cellular breakdown (Burt, 2004; Bajpai, Baek, & Kang, 2012). Several studies have shown that EOs are effective antibacterial agents against a wide spectrum of pathogenic bacterial strains including *L. monocytogenes*, *L. innocua* (Solomakos, Govaris, Koidis, & Botsoglou, 2008), *E. coli* O157:H7, *Shigella dysenteria*, *Bacillus cereus*, *Staphylococcus aureus* and *Salmonella typhimurium* (Saad et al., 2013). However, antimicrobial EOs are rarely used directly in food products as bulk oils since they present limitations such as intense aroma and low water solubility (Salvia-Trujillo, Rojas-Graü, Soliva-Fortuny, & Martín-Belloso, 2014).

Nanotechnology is a tool used to modify nano-scale material characteristics, in this case, to improve the EOs properties, which can be incorporated as nano-sized delivery systems in order to overcome their limitations (Huang, Yu, & Ru, 2010). A wide variety of delivery systems have been developed to encapsulate active in- gredients, including colloidal dispersions, biopolymer matrices or emulsions (Weiss, Takhistov, & McClements, 2006). Emulsions containing very small oil droplet size are desirable for certain ap- plications since they present advantages over systems containing larger particles. Nanoemulsions are defined as conventional emulsions that contain tiny particles (diameter between 100 and

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Effect of osmotic dehydration on the physical and chemical properties of Mexican ginger (*Zingiber officinale* var. Grand Cayman)

Efecto de la deshidratación osmótica sobre las propiedades físicas y químicas de jengibre mexicano (*Zingiber officinale* var. Gran Caimán)

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The aim of this study was to evaluate the effect of osmotic dehydration of ginger on the properties of color, total polyphenol content (TPC) and antioxidant capacity (AC). Fresh samples were pretreated with scalding (100°C/1.0 minute). Water loss (WL) and solid gain (SG) kinetics were performed using three sucrose concentrations: 35%, 50% and 65% at three temperatures: 40°C, 55°C and 70°C. WL and SG simulated kinetics by Diffusion model for cubes averaged a R^2 of 0.95. The diffusivities for water and solid by Fick's Law obtained maximum values of 6.81×10^{-7} and 2.65×10^{-7} m^2/s, respectively. WL results were obtained up to 60.83% and SG 32.24%. Ginger treatments without blanching (GWB) at 40°C with 35% and 50% sucrose, respectively, showed a similar fresh ginger color. The GWB treatments showed the higher TPC using 50% sucrose at 40°C (753 μg GAE/mL) and AC (341.96 mg AAE/mL).

Keywords: osmotic dehydration; total polyphenol content; water loss; *Zingiber officinale* var. Grand Cayman

El objetivo de este estudio fue evaluar el efecto de la deshidratación osmótica de jengibre sobre las propiedades del color, contenido de polifenoles totales (CPT) y la capacidad antioxidante (CA). Las muestras frescas fueron pretratadas con escaldado (100°C/1.0 minuto). Las cinéticas de pérdida de agua (PA) y ganancia de solidos (GS) se realizaron con tres concentraciones de sacarosa: 35, 50 y 65% a tres temperaturas: 40, 55 y 70°C. Las cinéticas de PA y GS simuladas por el modelo de Difusión para cubos promediaron una R^2 de 0,95. Los difusividades de agua y sólidos calculadas por la Ley de Fick obtuvieron valores máximos de $6{,}81 \times 10^{-7}$ y $2{,}65 \times 10^{-7}$ m^2/s, respectivamente. Los resultados de PA obtuvieron hasta un 60,83% y la GS hasta un 32,24%. Los tratamientos de jengibre sin escaldar (GSE) a 40°C con 35 y 50% de sacarosa respectivamente, mostraron un color similar al jengibre fresco. Los tratamientos GSE mostraron el mayor CPT utilizando 50% de sacarosa a 40°C (753 mg EAG/mL) y CA (341,96 mg EAA/mL).

Palabras clave: deshidratación osmótica; contenido de polifenoles totales; pérdida de agua; *Zingiber officinale* var. Gran Caimán

Introduction

Osmotic dehydration (OD) is a process that involves immersing a solid food in a hypertonic aqueous solution, which leads to the loss of water and a solids gain from the solution into the food. The process of osmotic solutes transferring from the solution into the product is directly related to the water exchange from the product into the osmotic solution (Barbosa Júnior, Cordeiro-Mancini, and Dupas-Hubinger (2013). The driving force for this process originates from the solids concentration gradients through the activity of the sample and the solution interface. The variables affecting the rates of water removal and solute impregnation are the composition and the concentration of the osmotic solutes, the temperature of the osmotic solution, the immersion time, the level of agitation, the specific characteristics of the food, and the solution-to-food ratio (Fernandes, Rodrigues, Law, & Mujumdar, 2011). The OD of common fruits and vegetables, such as banana, pineapple, guava, papaya, and carrot, has been described by several authors (Jain, Verma, Murdia, Jain, & Sharma, 2011; Silva, Fernandes, & Mauro, 2014). Additionally, OD is gaining considerable attention as a method of minimal processing because of advantages such as energy savings and low temperatures. Moreover, OD is a drying process that provides better control of flavor loss and tissue damage as well as improved color and nutrient retention (Nowacka, Tylewicz, Laghi, Dalla-Rosa, & Witrowa-Rajcher, 2014). Sugars and salts are the two most commonly used solutes for OD, with relevance to sodium chloride and sucrose (Jokić, Gyura, Lević, & Zavargó, 2007). Because of its many advantages, OD has been widely used in various foods and can be used in tubers and leaves, such as Chinese ginger (An et al., 2013). Ginger (*Zingiber officinale* var. Grand Cayman) has been extensively used as a traditional medicine in the East. The main bioactive components of ginger are the gingerols, which possess antioxidant, anticancer, and anti-inflammatory attributes (Ghasemzadeh, Jaafar, & Rahmat, 2010). However, the high moisture content (70–75%) of ginger makes it susceptible to microbial contamination and insect infestation, resulting in significant loss and deterioration of product quality, drying could be a useful process to reduce product damage. Conventional drying reduces the moisture content and thus increases the shelf life of the product; however, it often results in the loss of nutrients and has an adverse effect on the

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FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Quality evaluation of tortilla chips made with corn meal dough and cooked bean flour

Luz Araceli Ochoa-Martínez[1]*, Karla Castillo-Vázquez[1], Juan de Dios Figueroa-Cárdenas[2], Juliana Morales-Castro[1] and José Alberto Gallegos-Infante[1]

Abstract: A mixture of cornmeal dough and cooked bean flour (BF) was prepared at different ratios (50/50, 60/40, and 70/30 w/w), and processed to chips. Viscosity profile, temperature of gelatinization and enthalpy, texture, protein content, and *in vitro* digestibility were measured. Pasting temperature tended to be lower when the flour bean concentration was lower. Maximum viscosity increased significantly in both samples (dough mixture and chips) when the BF concentration was lower. In general, gelatinization temperature remains constant, while the heating enthalpy was higher with lower BF concentration. The addition of BF was correlated with greater crispiness, suggesting improved chip texture at higher BF concentrations. The final protein content in the corn-bean chips was very similar, despite the concentration of BF used. Protein digestibility in the chips was affected by the proportion of BF added, being higher when the amount of the BF was lower.

Subjects: Beverages; Food Additives & Ingredients; Food Science & Technology; Preservation; Product Development

Keywords: cornmeal dough; bean flour; viscosity; texture; chips

1. Introduction

Snacks have gained importance and acceptability worldwide in recent years and are now part of the contemporary culture. Typically, snacks are dense calorie foods consisting of high carbohydrate and fat content, but with respect to the amount of protein content, they have low nutritional value. Because they traditionally provide less than 2% of the protein requirement, they are referred to as foods that provide “empty calories” (Almeida, Valencia, & Higuera, 1990). The current trend in the

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L.A. Ochoa-Martínez, is researcher professor in the Technical Institute of Durango, México, in the Chemistry and Biochemistry Department. She works on research projects about food processing and new products development from fruits, vegetables, and cereals. Her research involves new products development, studying the preservation of main components either as the complete matrix or as extracts. Her research studies also involve shelf life and sensory evaluation. She uses traditional processing methods such as dehydration (convective, osmotic, spray drier), as well alternative and complementary technologies such as microwaves and ultrasound. This research deals about the enrichment of a corn snack by adding a popular legume in México like beans.

PUBLIC INTEREST STATEMENT

The consumption of snacks all around the world is constantly increasing, as a result, it is necessary to offer more nutritional products. In that sense, it is important to try the enrichment of traditional products to give an added value from the nutritional and economical point of view. This experimental work was conducted to assess the feasibility to produce a corn snack containing a certain proportion of bean flour and having the proper characteristics of a snack.

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Long-term stability of food-grade nanoemulsions from high methoxyl pectin containing essential oils

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abstract

Nanoemulsions have shown potential advantages over conventional emulsions due to their large active surface area, but are also susceptible to destabilization. Therefore, the purpose of this work was to assess the long-term stability (56 days) of nanoemulsions containing EOs (oregano, thyme, lemongrass or mandarin) stabilized by high methoxyl pectin and a non-ionic surfactant (Tween 80). The initial droplet size of nanoemulsion was below 50 nm regardless the EO type, which was confirmed by Transmission Electron Microscopy (TEM). Lemongrass and mandarin nanoemulsions remained optically transparent over time (56 days) and their droplet sizes were in the nano-range (between 11 and 18 nm), whereas the droplet size of oregano and thyme nanoemulsions increased up to 1000 nm probably due to Ostwald ripening. This fact induced creaming and a higher whiteness index in the latter nanoemulsions. The electrical charge (æ-potential) of nanoemulsions was negative due to the anionic nature of pectin molecule adsorbed at the oil-water interface, ranging between −6 and −15 mV depending on the EO type. However, lemongrass and mandarin nanoemulsions exhibited a more negative æ-potential than thyme or oregano EO indicating a stronger adsorption of pectin at the oil surface, and therefore a higher stability. The viscosity of nanoemulsions remained practically constant between 20 and 24 mPa s, during storage for all EOs. This work represents the starting point for future applications of nanoemulsions containing EOs to be incorporated in food products due to their high long-term stability.

1. Introduction

Essential oils (EOs) are natural compounds found in aromatic plants and herbs as secondary metabolites that present antioxidant and antimicrobial activity and also have been widely used as functional ingredients in food as flavorings (Burt, 2004). However their incorporation in food products presents several limitations due to their low solubility and intense aroma at high concentrations (Sa nchez-Gonzalez, Vargas, Gonzalez-Martínez, Chiralt, & Chafer, 2011). The emulsification of EO is currently used for their disper- sion into food products but their functionality and long-term sta- bility largely depends on the oil droplet size and distribution (Tadros, Izquierdo, Esquena, & Solans, 2004). In this sense, nano- emulsions can be used as carriers of lipophilic bioactive compounds for their incorporation in food products. Nanoemulsions consist of at least one immiscible liquid dispersed in another with a surfac- tant (nonionic or polymeric) in the form of small droplets, with an average droplet size between 20 and 200 nm (Burguera & Burguera, 2012; Solans, Izquierdo, Nolla, Azemar, & Garcia-Celma, 2005; Wulff-Perez, Torcello-Gomez, Galvez-Ruíz, & Martín-Rodríguez, 2009). Nanoemulsions exhibit several advantages over conven- tional emulsions (Qian & McClements, 2011; Tadros, Izquierdo, Esquena, & Solans, 2004). First, they are optically transparent so they might be good candidates to be incorporated in clear drinks or beverages (Qian & McClements, 2011). Second, nanoemulsions are kinetically stable colloidal systems (Solans et al., 2005). Third, they present a high active surface area thus having a potentially higher functionality (Qian & McClements, 2011). There are several methods to form nanoemulsions, but high-energy methods are the most commonly used. They require specialized mechanical devices such as high-pressure homogenizers and ultrasounds capable of generating intense mechanical disruptive forces inducing the breakup of the oil droplets (Mason, Wilking, Meleson, Chang, &

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"El saber de mis hijos hará mi grandeza"

EFECTO DEL TRATAMIENTO CON ULTRASONIDO SOBRE LAS PROPIEDADES FUNCIONALES Y ESTRUCTURALES DE ALMIDÓN PROCEDENTE DE DIVERSAS FUENTES: UNA REVISIÓN

EFFECT OF ULTRASONIC TREATMENT ON STRUCTURAL AND FUNCTIONAL PROPERTIES OF STARCH FROM DIFFERENT SOURCES: A REVIEW

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RESUMEN

El ultrasonido representa un método de procesamiento no térmico que emplea ondas de sonido con frecuencias por arriba del umbral del oído humano. El tratamiento con ultrasonido es uno de los métodos físicos utilizado para la modificación del almidón y ofrece la oportunidad de aplicarlo para mejora de sus propiedades. El almidón es ampliamente utilizado en la industria de los alimentos como espesante, gelificante, microencapsulante, etc., dependiendo de sus propiedades funcionales. Los efectos del ultrasonido se deben al fenómeno de cavitación acústica, el cual ejerce un impacto sobre la estructura de los gránulos de almidón, por el colapso de las burbujas de cavitación, afectando las propiedades fisicoquímicas de éste. El efecto del ultrasonido sobre los gránulos, depende de la potencia y frecuencia de sonicación, temperatura y tiempo de tratamiento, propiedades de la dispersión de almidón, concentración, así como su origen botánico. Este documento, presenta una revisión de reportes actuales sobre el impacto del ultrasonido sobre las propiedades estructurales y funcionales de almidón de diferentes fuentes.

Palabras clave: Ultrasonido, Almidón, Propiedades funcionales, Morfología, Estructura.

ABSTRACT

Ultrasound represents a non-thermal processing method that uses sound waves at a frequency above the threshold of human hearing. Ultrasound treatment is one of the physical methods used for starch modification and offers the opportunity to be applied to improve its properties. Starch is widely used in the food industry as a thickening, gelling, microencapsulating agent, etc., depending on their functional properties. The effects of ultrasound are due to the acoustic cavitation phenomenon, this has an impact on the structure of the starch granule, affecting their physicochemical properties. The effect of ultrasounds on starch granules depends on power and frequency of sonication, temperature and time of the treatment, properties of the starch dispersion, concentration, and botanical origin. This document presents a review of recent reports about the impact of ultrasound on the structural and functional properties of starch from different sources.

Keywords: Ultrasound, Starch, Functional Properties, Morphology, Structure.

INTRODUCCIÓN

En los últimos años, ha crecido considerablemente el interés por utilizar tecnologías no térmicas con fines de investigación fundamental y aplicación comercial, como es el caso del ultrasonido de alta frecuencia. El ultrasonido consta de ondas elásticas cuya frecuencia se transmite sobre el umbral del oído humano (Gómez-Díaz y López-Malo, 2009) y su aplicación ofrece la oportunidad de desarrollar nuevos productos con propiedades únicas. El almidón es uno de los principales componentes naturales de cierto grupo de alimentos, como cereales y raíces, y es generalmente modificado, genética, enzimática, física o químicamente para mejorar las propiedades tecnológicas particulares (solubilidad, capacidad de retención de agua, capacidad de hinchamiento, capacidad de gelificación, etc) y tener mayores aplicaciones en la industria de los alimentos en comparación con el almidón nativo (Zhu *et al*., 2012). Se ha reportado que el ultrasonido es un método eficaz para modificar los polisacáridos. El proceso ocurre a través de los efectos de la cavitación y puede involucrar dos mecanismos: el colapso de las burbujas de cavitación y la degradación de los polímeros como resultado de la reacción química entre el polímero y moléculas de alta energía producidas a partir del fenómeno de cavitación (Chemat *et al*., 2011). Esta revisión resume reportes actuales sobre la aplicación del ultrasonido y su efecto sobre las propiedades funcionales y estructurales de almidones procedentes de diferentes fuentes.

Ultrasonido

Principios del ultrasonido

La tecnología de ultrasonido está basada en ondas mecánicas a frecuencias por arriba del umbral del odio humano (>16 kHz). Las ondas viajan a través del material o sobre la superficie a una velocidad la cual es característica de la naturaleza de la onda y del material a través del cual es propagada (Soria y Villamiel, 2010). El ultrasonido se puede dividir en diferentes rangos de frecuencia, ultrasonido de alta frecuencia (100 kHz–1 MHz), con niveles de intensidades menores a 1 W cm^{-2}, el cual se ha utilizado con éxito en la detec-

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Effect of pre-treatment on physicochemical and structural properties, and the bioaccessibility of b-carotene in sweet potato flour

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abstract

The aim of this research was to evaluate the effect of microwave or steam pre-treatment of raw sweet potato on physicochemical and microstructural properties, and the bioaccessibility of b-carotene in sweet potato flour. This is the first report on using the *in vitro* digestion model suitable for food, as proposed in a consensus paper, to assess the bioaccessibility of b-carotene in sweet potato flour. The pre-treatments produced a rearrangement of the flour matrix (starch, protein and non-starch polysaccharides), which was greater by using microwaves (M6) conducting to a greater increase in the phase transition temper- atures up to 4.14 ºC, while the enthalpy presented the higher reduction (4.49 J/g), both parameters in respect to the control. The resistant starch fraction was not modified, with about 3% in all samples. Microwave (M6) and all the steam pre-treatments showed the higher bioaccessibility of b-carotene. This flour can be used in the development of new products with high b-carotene content.

1. Introduction

The sweet potato (*Ipomoea batatas* L.) is a root with positive attributes such as geographical variety in terms of production, adaptability to marginal conditions, a short production cycle, a high nutritional content and sensorial versatility in terms of flesh color, taste and texture. It is the sixth most important world crop, after rice, wheat, potato, corn and cassava (Faostat, 2013). While the Mexican climate is suited to its cultivation, the limited produc- tion options for the sweet potato and the lack of awareness of its nutritional properties have contributed to lags in production and industrialization. Depending on flesh color, the sweet potato is rich in b-carotene, anthocyanins, phenolic compounds, dietary fiber, ascorbic acid, folic acid and minerals (Grabowski, Truong, & Daubert, 2008; Woolfe, 1992). Numerous benefits, such as antiox- idant, cardioprotective and anti-diabetic effects, have been attribu- ted to sweet potato consumption, with the orange-fleshed sweet potato recognized for its pro-vitamin A activity, which contributes to preventing deficiencies of this vitamin (van Jaarsveld et al., 2005).

While sweet potato is generally consumed cooked, the dried form of the root is also used in the production of flour, which is used in the manufacture of bread and breakfast cereal products, as well as baby foods and alcoholic drinks (Grabowski, Truong, & Daubert, 2007; Teramoto, Hano, & Ueda, 1998; Truong & Avula, 2010; Wireko-Manu, Ellis, & Oduro, 2010). There is no standard- ized procedure for the production of sweet potato flour, but in some regions a blanching process is used before drying and then milling. Different dehydration methods have also been used, such as solar, rotary drum, tray and spray drying (Grabowski et al., 2007; Truong & Avula, 2010). On laboratory or commercial scales, sweet potatoes are treated with a sodium metabisulfite solution to inhibit enzymatic darkening (Aprianita, Purwandari, Watson, & Vasiljevic, 2009; Sablani & Mujumdar, 2007). The extraction of compounds using microwave radiation improves the yield, such as anthocyanins in the purple-fleshed sweet potato (Lu et al., 2010), and the retention of vitamins, such as thiamin and riboflavin in the orange-fleshed sweet potato (Dawkins & Lu, 1991). Further- more, the use of microwave blanching on products such as rose- mary (*Rosmarinus officinalis* L.) and marjoram (*Marjona hortensis* Moench.) has led to improved results in terms of color, ascorbic acid and chlorophyll retention compared to steam and water immersion pre-treatments (Singh, Raghavan, & Abraham, 1996). Although there is a large market for foodstuffs prepared with

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Functional Properties, Color and Betalain Content in Beetroot-Orange Juice Powder Obtained by Spray Drying

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Keywords: Spray drying, Beetroot, Betalains, Stability, Juices.

ABSTRACT

Betalains are water-soluble pigments mainly found in red beetroots. Stability of betalains in processed and storaged products is generally affected by numerous factors such as the matrix constituent, chelating agents, water activity, pH, temperature, oxygen and light. This research paper reports the functional properties, color, and betalain content in beet root-orange juice powder produced by spray drying. A mixture of beet root juice and orange juice (60/40) was spray dried using 3, 5 and 7% (w.b.) of maltodextrin DE 10, three different inlet air temperatures of 130 °C, 140 °C and 150 °C and two feed flow rates (8 and 10 mL/min). The powders obtained were analysed for moisture content, bulk density, hygroscopicity, wettability, solubility, color and total pigments. It was found that processing juice at 140°C with feed flow rate of 8 mL/min and 5% of maltodextrin gave the best functional properties and the conservation of betalains was high.

INTRODUCTION

Food coloring of fruits and vegetables suffer, in general, color degradation during processing, losing an important quality indicator parameter. The beetroot is a great source of antioxidant components called betalains, which are divided into betacyanins and betaxhantins, the former imparts the purple color to beetroot and the latter gives the yellow-orange color. Red beet has been reported as one of the ten vegetables with most potent antioxidant capacity [1]. Medical studies have demonstrated health related beneficial properties of beetroot such as lowering cholesterol and arterial pressure, and it has being considered a good source of vitamin B complex and folic acid. Stability of betalains is affected by quelating agents, water activity, nitrogen atmosphere, degree of glucosylation or acylation, pH, temperature, light, oxygen and moisture [2-4]. Pedreno and Escribano [5] reported that at pH 3.5 the degradation of betanine was slight, while at pH 8.5 the betanine concentration fell more than 60%, they also reported high antiradical activity at pH 3.5. A pH range between 5 and 7 has been reported to be ideal for the stability of betalains. Von Elbe [6] found that the highest stability of betanins in a model system was between pH 4 and 5, and pointed that pH=5 were most suitable to preserve the betanins in beetroot juice at 100 °C. Stintzing and Carle [7] have reported a pH about 4 as suitable for processing. Addition of antioxidants like ascorbic and isoascorbic acids has been reported to improve betalain stability by oxygen removal. Herbach found better stabilizing effect of betacyanins in pitaya juice heated at 85 °C for 1 hour at pH 4 adjusted with 1.0% ascorbic acid, probably due to that the electrophilic center of betanin was partially neutralized. In order to preserve components of interest in liquid food products, spray drying technique has been widely investigated and used [8-11]. Juices of different vegetable products, contain varied proportions of glucose, fructose, and organic acids, these components have very low glass transition temperature (Tg), high hygroscopicity, low melting point and high solubility resulting in a sticky product when spray dried, leading to different state transitions properties, which are related with collapse, stickiness, agglomeration, crystallization, and caking [12,13]. Dried

Effect of harvest year on the physical properties, chemical composition and cooking time of three common bean varieties that are grown in Mexico

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REsEaRch aRtIclE

abstract

It is important to consider the physical properties of legume seeds in the design of bean storage and processing systems. The variation in the physical properties of three common bean (*Phaseolus vulgaris* L.) varieties (Bayo Victoria (BV), Negro San Luis(NSL) and Pinto Saltillo(PS)) accordingto harvest year (2008 and 2010) was studied. Harvest year and variety affected (P<0.05) the following tested variables: 100-grain weight, hardness, water absorption capacity, length, width, thickness, arithmetic diameter, geometric diameter, surface area, volume, sphericity, chemical composition, and cooking time. Weight ranged from 27.72 to 50.39 g among the three varieties. BV exhibited the highest weight (50.39 g), length (14.75 mm), width (9.52 mm in 2008; 9.09 mm in 2010), thickness (6.40 mm in 2008; 6.34 in 2010) and surface area (293.69 mm^2). Hardness was highest in NSL and PS in 2008 (181.1 N) and lowest in BV and NSL in 2010 (103.23 N). Hardness in BV and NSL did not differ (P>0.05) between years. Sphericity was highest overall in NSL (70.97% in 2008; 68.91% in 2010). Moisture content was highest in NSL and PS (11.76 g H_2O/100 g). In all varieties, moisture content was higher in 2008 than in 2010, although this was not significant (P>0.05). Harvest year affected (P<0.05) protein, crude fibre, ash and carbohydrate content. The highest protein content was found in BV. Varieties harvested in 2008 had the highest cooking time according to default hard-to-cook development during storage; however, PS was unaffected by harvest year and presented the shortest cooking time.

Keywords: hardness, nutritional properties, sphericity.

1. Introduction

The common bean (*Phaseolus vulgaris* L.) is among the most important foodstuffs worldwide and plays a vital role in the diet of low-income human populations, particularly in developing countries, where it often constitutes the most substantial source of protein, carbohydrates, dietary fibre and minerals (Prolla *et al.*, 2010; Tharanathan and Mahadevamma, 2003). Despite its importance, limited data has been published on its linear and geometric properties, and even less data is available on how these properties vary according to harvest year. Extensive research has been conducted on the response of these properties to moisture content in the following legume grains: lentil, moth bean, fenugreek, fava bean, barbunia bean, rashti bean, white bean and common bean cv. Kantar-05, cv. Elkoca-05 (Altuntas and Yildiz, 2007; Altuntas *et al.*, 2005; Amin *et al.*, 2004; Cetin, 2007; Firouzi *et al.*, 2012; Işik and Unal 2011; Nimkar, 2005; Ozturk *et al.*, 2009, 2010). In all these studies, moisture content strongly influenced grain and seed physical properties.

Size and shape are seed-type specific and are largely determined by genetics. However, these parameters can also be influenced by the environment during and after seed formation, which also affects other seed physical properties (Lorestani *et al.*, 2014; Mendes *et al.*, 2011). Physical properties determine seed and grain separation

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MICROENCAPSULACIÓN MEDIANTE SECADO POR ASPERSIÓN DE COMPUESTOS BIOACTIVOS

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Palabras clave: microencapsulación, secado por aspersión, compuestos bioactivos.

RESUMEN

La microencapsulación es un proceso que se usa para convertir líquidos en sólidos, agregar funcionalidad y mejorar la estabilidad oxidativa de alimentos y extractos e ingredientes alimenticios. Entre sus principales ventajas, se encuentra: enmascarar sabores y olores desagradables de los productos encapsulados, proteger los compuestos bioactivos de oxidación y de reacciones indeseables, así como de condiciones adversas de luz, calor y gases, además de alargar su vida útil. Aunque existe un considerable número de técnicas que permiten realizar el proceso de microencapsulación, el secado por aspersión es un proceso ampliamente utilizado en la industria de alimentos debido a las ventajas que presenta, especialmente cuando se desea proteger aquellos compuestos que presentan una actividad antioxidante y que se encuentran dentro de una matriz alimentaria. Las frutas y vegetales son fuentes importantes de compuestos bioactivos cuyos beneficios a la salud se ha documentado ampliamente, principalmente debido a la actividad antioxidante que poseen. Sin embargo su perecibilidad hace necesaria la aplicación de procesos de conservación que permitan mantener los compuestos de interés y alargar su vida de anaquel. Esta revisión aborda el proceso de secado por aspersión como técnica de encapsulación, incluyendo principalmente sobre los materiales encapsulantes y las diferentes etapas del proceso. Posteriormente se revisa sobre la microencapsulación de compuestos bioactivos como betalaínas, polifenoles, carotenoides y antocianinas.

MICROENCAPSULATION OF BIOACTIVE COMPOUNDS BY SPRAY DRYING

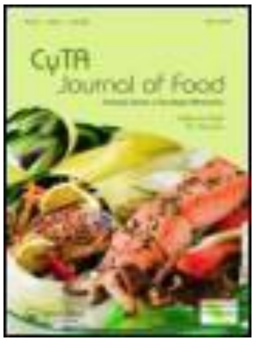
Key words: microencapsulation, spray drying, bioactive compounds

ABSTRACT

The microencapsulation process is used to convert liquids in solids, to add functionality and to improve the oxidative satability of food and food extracts and ingredients. The main advantages of this technique are to hide flavors and undesirable odors from the encapsulated material, protect bioactive compounds from oxidative reactions, and from environmental conditions like heat, light and gases, as well as to enhance the shelf life. There are several techniques that allow to encapsulate materials, however, spray drying is the most widely used in the food industry due to the advantages presented, especially when it is desirable to protect bioactive compounds from a food matrix having a potential as antioxidant. Fruits and vegetables are important sources of bioactive compounds and their health benefits are well documented, mainly due to the antioxidant activity. However, due to their perishability, it is necessary to apply any kind of processes to allow the conservation of compounds of interest and to extend the shelf life. This review deals about the spray drying as a microencapsulating method, mainly including about encapsulating materials and the steps of the method. Then, it includes about the microencapsulation of bioactive compounds such as, betalains, poliphenols, carotenoids and anthocyanins.

INTRODUCCIÓN

La microencapsulación se define como una tecnología de empaque de materiales sólidos, líquidos o gaseosos en miniatura, cápsulas selladas que pueden liberar su contenido a velocidades controladas bajo condiciones específicas. Esta tecnología se ha utilizado en la industria de alimentos por más de sesenta años a la fecha. En un sentido amplio, la tecnología de encapsulación en el



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Effect of nixtamalization conditions ultrasound assisted on some physicochemical, structural and quality characteristics in maize used for pozole

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IMPACT OF ULTRASOUND PRETREATMENT ON THE OSMODEHYDRATION KINETICS AND SENSORY EVALUATION OF BEETROOT SLICES

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Abstract: The use of emerging technologies for the preservation of plant products is a good pretreatment choice. The objective of this research was to evaluate the effect of ultrasound using probe and bath systems as pretreatment in osmotic dehydration of beetroot. Moisture loss, solids gain, color, texture and betalain content were evaluated. A sensory evaluation on samples treated by ultrasonic bath was carried out. It was found that samples treated with ultrasonic probe and dehydrated at higher concentration of osmotic solution showed the largest effects on the evaluated parameters. The acceptability of the product was better when the application of ultrasound was shorter.

Keywords: Ultrasound pretreatment, osmotic dehydration, beetroot, betalains

INTRODUCTION

The beetroot (*Beta vulgaris* L.) is a vegetable of the family *Chenopodiaceae*, its intense purple color is due to the betalains content. Betalains are pigments containing water-soluble nitrogen exhibiting staining patterns ranging from yellow to dark purple. Betalains are divided into betacyanins (betanin and bethanidine) and betaxantinas (vulgaxanthin I and II) of red and yellow color respectively[1]. Such pigments have been recognized as biomolecules with high antiradical and antioxidant effect[1,2,3]. As the consumption of beetroots is associated with reducing risk of developing cardiovascular disease, cancer, and those associated with aging[4,5], among other health benefits.

The constant interest of consumers towards functional foods has grown in recent years. The most common processing method is based on the application of heat, however under severe conditions it leads to chemical and physical changes that negatively alter the organoleptic properties, and minimize nutrients or decrease bioavailability. For these reasons the food industry is constantly looking for processing technologies not only for food quality but to preserve the characteristics of a fresh product[6]. Usually these technologies are used as a pretreatment and are useful in reducing the initial content of water[7], also are used to modify the structure of the fruit tissue, to reduce the total time of the drying process. A relatively new technology in the food industry is ultrasound[8], which provoke a cavitation phenomenon creating microscopic channels because the forces involved in the mechanism are greater than the surface tension of the food, which facilitates moisture removal [9].

Because of the efficiency that has been reported in the use of osmotic dehydration assisted with ultrasound such as the increase in water diffusivity and reduction of drying time in fruits, this method has been chosen. Osmotic dehydration is an operation that is based on osmosis process in which the molecules of certain solution pass through a semipermeable membrane to a less concentrated solution of the molecules concerned.

Therefore the aim of this study was to evaluate the effect of ultrasound (US) as pretreatment using two systems: ultrasonic bath (UB) and ultrasonic probe (UP) on the osmotic dehydration of beetroot slices.

ULTRASONIDO Y SUS APLICACIONES EN EL PROCESAMIENTO DE ALIMENTOS.

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Palabras clave: Ultrasonido, procesamiento de alimentos, calidad, industria de alimentos

RESUMEN

Actualmente, el empleo de ultrasonido (US) en el procesamiento de alimentos está basado en la ventaja que representa sobre los procesos tradicionales, al reducir tiempos de proceso y mejorar atributos de calidad. Además es considerada una tecnología limpia y de gran potencial de aplicación en procesos como secado, congelado, descongelado, extracción, entre otros. Fundamentalmente está establecido que el efecto de cavitación gaseosa es el que produce el efecto conservador del US, ya que de esta manera se promueve la implosión de microburbujas las cuales generan la liberación de energía. Esto permite aumentos de temperatura que producen los diferentes cambios físicos, químicos y bioquímicos en el micro entorno de las células de los diferentes productos procesados. Los US se aplican en diferentes modalidades de alta y baja intensidad así como alta y baja frecuencia. De esta manera, variando su longitud de onda, frecuencia e intensidad es que se promueven mejores tiempos y formas de mezclado, al igual que transferencia de energía y masa, para reducir tiempos de extracción e incrementar la producción y elaboración de alimentos. En esta revisión se presenta una visión actual del uso de US en diferentes modalidades y en procesos de gran importancia en la industria de alimentos actual, enfatizando las ventajas y los efectos en los diferentes procesos.

ULTRASOUND AND THEIR APPLICATIONS IN FOOD PROCESSING

Key words: Ultrasound, food processing, quality, food industry

ABSTRACT

Currently, the use of ultrasound (US) in food processing is based on the advantage that represents on the traditional processes, reducing processing times and improved quality attributes. It is also considered a clean technology and great potential for application in processes such as drying, freezing, thawing, extraction, among others. Essentially, it is established that the gaseous cavitation caused during application of US provoke the preservation effect on foods, since in this way promotes the implosion of microbubbles which generate energy release. This allows temperature increases to produce different physical, chemical and biochemical changes in the micro environment of cells of different products processed. The US is applied in various forms of high and low intensity and high and low frequency. Thus, varying the wavelength, frequency and intensity leads to better forms and time of mixing, as well as energy and mass transfer, to reduce extraction times and increase production and food processing. This review presents a current view of the use of US in different forms and processes of great importance in the food industry today, emphasizing the advantages and effects on the components of foods in different processes.

INTRODUCCIÓN

El ultrasonido de potencia representa una tecnología novedosa, la cual ha creado bastante interés debido a sus efectos promisorios en las áreas de procesamiento y conservación de alimentos; sin embargo, y aunque actualmente es considerada una tecnología emergente, el uso de la tecnología de ultrasonido no se ha promovido para su aplicación en productos comerciales. Solo se

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Efecto de la aplicación de alta presion hidrostática sobre la inactivación microbiana y las propiedades fisicoquímicas de arilos de granada

Effect of high hydrostatic pressure processing on microbial inactivation and physicochemical properties of pomegranate arils

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The objective of this research was to evaluate the effect of high pressure processing on the microbiological shelf life and physicochemical properties (pH, acidity, antioxidant activity, polyphenols, total soluble solids, and color) of the pomegranate arils during refrigerated storage. Pressures of 350, 450, and 550 MPa for 30, 60, and 90 s were applied on pomegranate arils and stored at 48C during 35 days. Microbiological and physicochemical parameters were determined during storage. High hydrostatic pressure treatments were able to reduce the initial microbial load (1.0 and 1.60 CFU/g) to 51.0 CFU/g. Independently of the applied treatment the self-life was extended more than 35 days. During the storage time, the total polyphenol content and antioxidant activity decreased significantly (*p*50.05) compared to the control sample.

Keywords: Pomegranate arils; hydrostatic high pressure; shelf-life; microbial inactivation; physicochemical parameters.

El objetivo de este trabajo fue evaluar el efecto de la APH sobre la vida útil microbiológica y parámetros físico-químicos (pH, acidez, actividad antioxidante, contenido de polifenoles, SST y color) de arilos de granada durante su almacenamiento a temperatura de refrigeración. Se aplicaron tratamientos de 350, 450 y 550 MPa durante 30, 60 y 90 s, posteriormente las muestras se almacenaron a 48C durante 35 días. Las muestras fueron sometidas a recuentos microbianos y análisis físico-químicos. Todos los tratamientos de APH ensayados lograron reducir la carga microbiana inicial (1,0 y 1,6 log UFC/g) a 51,0 log UFC/g. La vida útil se logró extender a más de 35 días, independientemente del tratamiento aplicado. El contenido de polifenoles totales y la actividad antioxidante de las muestras procesadas disminuyeron significativamente (*p* 5 0,05) durante el tiempo de almacenamiento en comparación con la muestra control.

Palabras claves: arilos de granada; alta presión hidrostática; vida útil; inactivación microbiana; parámetros fisicoquímicos.

Introducción

La granada (*Punica granatum* L.) es una fruta no climatérica que presenta una baja velocidad de respiración. La parte comestible de la fruta se encuentra en el interior de una corteza coriácea y se denominan ''arilos''; éstos están compuestos en un 78% de jugo y un 22% de semilla (Kurkarni & Aradhya, 2005). El jugo de granada contiene una cantidad considerable de sólidos solubles totales, azúcares, antocianinas, polifenoles, ácido ascórbico y proteí- nas; además es una fuente rica de antioxidantes (Gil, Tomas- Barberan, Hess-Pierce, Holcroft, & Kader, 2000). Los principales compuestos antioxidantes presentes en el jugo de granada son los taninos hidrolizables, aunque las antocianinas y derivados del acido elágico también con- tribuyen a la capacidad antioxidante total del jugo (Gil et al., 2000). Se sabe que el consumo de granada tiene múltiples beneficios nutricionales y médicos. Y así, algunas investigaciones clínicas sugieren que el jugo de granada cambia en la sangre los parámetros de Lipoproteínas de Baja Densidad (LDL), Lipoproteínas de Alta Densidad (HDL) y del colesterol, y puede ser útil en enfermedades del corazón, Alzheimer y cáncer, además de mejorar la calidad del esperma y la disfunción eréctil del hombre (Tezcan, Gültekin-Özgüven, Diken, Özcelik, & Erim, 2009). Desafortunadamente, los compuestos bioactivos son rápidamente afectados por factores exógenos tales como oxígeno, luz, y especialmente pH y temperatura. Por lo tanto, existe una verdadera necesidad por minimizar la degradación de compuestos con propiedades funcionales durante el procesado y almacenamiento de los alimentos, a fin de garantizar una óptima calidad nutricional y sensorial (Ferrari, Maresca, & Ciccarone, 2010). Por otro lado, los arilos de granada, al igual que otras frutas, son susceptibles a la alteración microbiana, la que puede reducir su vida útil.

Para conservar las propiedades nutracéuticas y extender la vida útil de los alimentos funcionales se ha sugerido la utilización de tecnologías innovadoras de naturaleza no térmicas. Entre estas tecnologías, la alta presión hidrostática (APH), tiene un gran potencial para extender la vida útil y producir alimentos de alta calidad, que mantengan las

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Effect of high hydrostatic pressure (HHP) processing on physicochemical properties, bioactive compounds and shelf-life of pomegranate juice

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abstract

The aim of the present study was to evaluate the effect high hydrostatic pressure (HHP) processing (350–550 MPa for 30, 90 and 150 s) on microbial quality as well as physico-chemical and bioactive compounds of pomegranate juices during 35 days of storage at 4 °C. Antioxidant activity, phenolic content and color values (L*, a* and ΔE) were determined. The microbiological results showed that HHP-treatment at or over 350 MPa for 150 s resulted in a reduction of the microbial load around 4.0 log cycles, and were sufficient to keep microbial populations investigated below the detection limit during the whole storage period. Therefore, these treatments were able to extend the microbiological shelf-life of pomegranate juice stored at 4 °C for more than 35 days. All HHP-treated samples showed a slight reduction in antioxidant capacity during storage time. Phenolic content increased significantly (pb 0.05) between 3.38% and 11.99% for treated samples with 350 MPa and 550 MPa at day 0. The ΔE values, which are an indicator of total color difference, showed that there were significant differences (pb 0.05) in color between untreated and treated samples and showed a significant decrease (pb 0.05) in ΔE values during storage time. The highest color difference was obtained at day 35 for 550 MPa for 90 s. These results clearly demonstrate that the color stability of pomegranate juice depends on the processing conditions. During the first 15 days, the pH, °Brix and titratable acid were not significantly affected by high pressure processing.

Industrial relevance: This paper provides information of storage stability of pomegranate juice after pressure treatments which is quite scarce. In database collected, criteria for commercial production of high quality pomegranate juice with safety requirements could be established.

1. Introduction

Pomegranate (*Punica granatum*, Punicaceae) is highly valued mainly due to its exceptional and unique sensory and nutritional properties (López-Rubira, Conesa, Allende, & Artés, 2005). Polyphenols are the major class of pomegranate phytochemicals, including flavonoids (anthocyanins), condensed tannins (proanthocyanidins) and hydrolysable tannins (ellagitannins and gallotannins) (Jaiswal, DerMarderosian, & Porter, 2009). It has been reported that consumption of pomegranate fruits has nutritional and medical benefits, including reduced oxidative stress, atherogenic modifications to LDL, and platelet aggregation, as well as anticancer, antibacterial, and antiviral activities (Qu, Pan, & Ma, 2010). Therefore, there is a need for alternative methods of processing which can increase microbiological stability and preserve nutritional and bioactive characteristics (Patras, Brunton, Da Pieve, & Butler, 2009). Consumer demand for freshly squeezed fruit juices is increasing, but such products are susceptible to spoilage and thus have a limited shelf-life (Buzrul, Hami, Largeteau, & Demazeau, 2008). Thermal processing (pasteurization) is the most commonly used preservation technique to extend the shelf life of juices. However, this process may have adverse effects on sensory and nutritional values of juices (Plaza et al., 2006). Therefore, color quality of anthocyanin containing juices is undesirably lost during thermal process (Patras, Brunton, O'Donnell, & Tiwari, 2010). Food scientists and the food industry are therefore searching for novel methods, which can destroy undesirable microorganisms with less adverse effects on product quality. Several methods have been investigated for extending the shelf life of food. Non-thermal processing technologies for food preservation and safety are gaining widespread acceptance throughout the food industry. An example is high hydrostatic pressure (HHP) technology, which has been identified as a method for inactivating microorganisms (Patterson, 2005) and the processing temperature does not increase beyond 40 °C (Welti-Chanes, Ochoa-Velasco, & Guerrero-Beltrán, 2009). This technology transmits isostatic pressure instantly to the product,

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Mixing and tempering effect on the rheological and particle size properties of dark chocolate coatings

Efecto del mezclado y temperado sobre las propiedades reológicas y de tamaño de partícula de coberturas de chocolate oscuro

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Chocolate coatings are semisolid suspensions of fine particles from sugar, cocoa, non fat milk solids in an oily phase. Processing steps of chocolate include mixing, refining, conching, tempering, molding, and packing. Tempering is a directed pre-crystallization that consists of shearing chocolate mass at controlled temperatures. The effect of mixing and tempering process on the particle size distribution and rheological behavior of dark chocolate coatings were evaluated. Each sample was melted (65 °C, 15 min) and tempered following three different procedures usually recommended for chocolate. Proximate composition analysis, specific surface area, mean particle diameter, consistency index (*K*), flow index (*n*), G', G'' and electron micrographs (4000×) were obtained. All samples followed Casson flow model and (*n*) showed a pseudoplastic behavior. Higher values of *K* were shown by tempering process 3. Shear increased chocolate storage module (G') and its stability. Samples without tempering and shearing have shown higher values of particle size.

Keywords: chocolate coatings; mixing; particle size; rheology; tempering

Las coberturas de chocolate son suspensiones semi-sólidas de partículas pequeñas de azúcar, cacao, sólidos no grasos de leche en una fase oleosa. Los pasos del procesamiento de chocolate incluyen mezclado, refinación, conchado, temperado, moldeo y empacado. El temperado es una pre-cristalización directa que consiste en cizallar la masa de chocolate a temperaturas controladas. Se evaluó el efecto del mezclado y del temperado sobre la distribución del tamaño de partícula y el comportamiento reológico de coberturas de chocolate obscuro. Las muestras fueron fundidas (65 °C, 15 min) y temperadas siguiendo tres procedimientos recomendados. Se determinaron el análisis proximal, área superficial específica, diámetro medio de partícula, índice de consistencia (*K*), índice de flujo (*n*), módulos viscoelásticos (G' y G''), y se usó micrografía electrónica, SEM (4000×). Todas las muestras presentaron un comportamiento al flujo ajustado al modelo de *Casson*. Los cambios de K estuvieron en función del proceso de temperado usado, pero (*n*) mostró cambios en su comportamiento pseudoplástico. Los mayores valores de K se obtuvieron para el temperado 3 y los menores para el temperado 1. El corte incrementó el módulo de almacenamiento (G') y en consecuencia su estabilidad. Las muestras sin temperado y corte mostraron el mayor tamaño de partícula (9.17 μm).

Palabras clave: cobertura de chocolate; mezclado; tamaño de partícula; temperado; reología

Introduction

Chocolate is a dispersion that during consumption activates the pleasure centers of the human brain (Afoakwa, Paterson, & Fowler, 2007). The quality of chocolate confectionary products is related to the appropriate melting behavior, because the products are solid at room temperature and melted on the tongue surface and ingested undergoing dissolution. Particle size distribution and ingredient composition play important roles in shaping its rheological behavior.

Chocolate coatings are semisolid suspensions of fine particles from sugar, cocoa and non fat milk solids in an oily continuous phase. Critical to physical properties is the continuous oil phase composition, which influences mouth feel and melting properties.

According to Attaie, Breischuh, Braun, & Windhab (2003), processing steps of chocolate include mixing, refining, conching, tempering, molding and packing. Tempering involves pre-crystallization of a small proportion of triacylglicerides with crystal forming nuclei.

Tempering has four key steps: melting to completion (usually at 50 °C), cooling to a point of crystallization (at 32–34 °C), crystallization (25–27 °C) and

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Effect of Sourdough on Quality and Acceptability of Wheat Flour Tortillas

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Abstract: As an alternative on the search for functional food products, this study evaluated the use of sourdough in the preparation of wheat flour tortillas. The sourdough was elaborated with *Lactobacillus sanfranciscensis* and the wheat flour tortillas were prepared with different concentrations of mother sponge (5%, 15%, and 25%) and fermentation times (1 and 3 h) at room temperature (25 ± 2 °C). Quality (diameter, height, color, pH, stretchability scores, and Kramer shear cell results) of wheat tortillas was evaluated after 24 h of preparation. The mother sponge concentration and fermentation time affected some quality parameters and acceptability properties (taste, aroma, color, opacity, and rollability). In addition, the sourdough tortillas had higher stretchability values than control tortillas. Since most of the prepared sourdough tortillas had acceptability values similar to those of tortilla controls, the introduction of sourdough is a viable means to incorporate additional nutritional and nutraceutical value into wheat tortillas.

Keywords: mother sponge, sourdough, wheat flour tortillas

Introduction

Polysaccharides from plant material are important additives for bread production, since they improve the textural properties and shelf life of bread (Korakli and others 2001). Microbial polysaccharides such as exopolysaccharides (EPS) produced by lactic acid bacteria (LAB) can replace those additives. The food industry is looking for multifunctional additives that not only provide an improvement in texture, but also have additional nutritional properties. Thus, the search for polysaccharides with prebiotic attributes is under way. The use of sourdough in the traditional bread production process, using biological dough fermentation, has maintained its importance, since it improves bread quality through the inhibition of spoilage microorganisms that extends shelf life, increases loaf volume, delays staling, improves bread flavor, and improves nutritional quality based on a lowered glycemic index (Gibson and others 1995; Kadizky and Vogel 2008; Korakli and others 2001; Thiele and others 2004). The main microorganisms involved in sourdough, are LAB and/or yeast (Ha¨ggman and Salovaara 2008; Ha¨nsen and Ha¨nsen 1994).

Different publications have shown evidence that LAB sourdough related species, *Lactobacillus sanfranciscensis* and *Lactobacillus reuteri*, contain strains that produce homo-polysaccharides of the fructan type, such as levan, inulin, and the corresponding fructo-oligosaccarides (Kaditzky and Vogel 2008), which are metabolized by bifidobacteria. Thus, they are considered as probiotic since they selectively favor the growth of bifidobacteria in the human intestinal tract (Gibson and others 1995). In addition, *L. sanfranciscensis*, which belongs to the microbial flora of traditionally prepared wheat and rye sourdough, produces EPS from sucrose. The strain LTH2590 produces EPS with a high molecular mass fructan homopolymer of the levan type (Dal Bello and others 2001). Levans from *L. sanfranciscensis* positively affect the rheology and machinability of wheat doughs as well as bread volume and texture (Brandt and others 2003). *L. sanfranciscensis* is considered the most predominant microorganism of sourdough because it affects bread quality through the production of a metabolite and improves the taste and aroma (Di Cagno and others 2007) as well as the organoleptic properties (Paramithiotis and others 2005). Shelf life is also extended by means of antifungal compound production (Vermeulen and others 2006), and rheological properties of dough are modified through the production of exopolysacharides (levansucrase) (Tieking and others 2005).

Wheat tortillas are very popular in Mexico and their production is one of the industrial sectors growing in the United States (Waniska and others 2002), since American consumers prefer wheat flour tortillas 2 : 1 over corn tortillas (Serna- Saldivar and others 2004). The "Tortilla Industry Association" (www.tortilla-info.com) reported that in 2006 the flour tortilla industry in the United States was about $US 7 billion, which more than doubled during the last decade. The wheat flour tortilla production process involves chemically leavened fermentation using sodium bicarbonate (Heidolph 1996) to form round, flat bread produced from gluten-structured dough (Serna-Saldivar and others 2004).

To evaluate the quality of flour tortillas, parameters such as weight, diameter, height, texture properties, color, opacity, and pH (Mao and Flores 2001; Waniska and others 2002), and sensorial properties such as taste, aroma, and rollability (Serna-Saldivar and others 2004) are used. Consumers actually prefer food products with demonstrated physiological benefits, known as functional foods, in addition to high nutritional value with equal or better appearance (Hernández-Nava and others 2009).

Given the trend toward natural food fermentation, the idea of using sourdough for wheat tortilla fermentation to optimize the technological and nutritional properties emerges as a new alternative. Since there are no known studies regarding the use of

MS 20110522 Submitted 4/25/2011, Accepted 8/30/2011. *Authors Ontiveros-Mart´ınez, Ochoa-Mart´ınez, Gonza´lez-Herrera, Delgado-Licon, and Morales-Castro are with Doctorado en Ing. Bioqu´ımica. UPIDET. Inst. Tecnolo´gico de Durango, Durango, Dgo. Me´xico. Author Bello-Pe´rez is with Centro de Desarrollo de Productos Bio´ticos del IPN, Yautepec, Morelos, Me´xico. Direct inquiries to author Morales-Castro (E-mail: juliana@itdposgrado-bioquimica.com.mx).*

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