INNOVACIÓN DE PROYECTOS DE INVESTIGACIÓN EN EL ÁREA ALIMENTARIA Y BIOTECNOLOGÍA (IPAAB)

El objetivo de la línea de investigación es promover programas de vinculación industrial para resolver problemas a través de la aplicación del conocimiento, que permita a su vez generar un conocimiento científico para su publicación, desarrollando en los estudiantes, así mismo, habilidades para la creación de negocios.

Los esfuerzos de la línea de investigación se han centrado en la formación de recursos humanos con habilidades científicas y en la resolución de problemas relacionados con actividades de importancia en el Estado. Del año 2013 a la fecha se han generado un total de 20 artículos, sin embargo es importante mencionar que en el periodo un profesor adscrito a dicha línea se jubiló, (Dr Aquiles Soto Solís), así mismo, en el año 2012, otro integrante de dicha línea (Dr Efrén Delgado Licón) dejó de laborar en la institucionm es solo hasta inicio del año 2017 cuando se integra el Dr Walfred Rosas Flores a ésta LGAC, por lo que la producción deberá mostrar en los próximos años una tendencia a el incremento

PRODUCTIVIDAD ASOCIADA A LOS PTC-ESTUDIANTES DE LA LÍNEA: INNOVACIÓN DE PROYECTOS DE INVESTIGACIÓN EN EL ÁREA ALIMENTARIA Y BIOTECNOLOGÍA.

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Review of Molecular Techniques for the Identification of Bacterial Communities in Biological Effluent Treatment Facilities at Pulp and Paper Mills

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One of the processes most used in biotechnology today for handling industrial liquid wastes is biological wastewater treatment. The efficiency and quality of its operation depends on the composition and activity of the microbial community that is present. The application of traditional and molecular techniques has provided a glimpse into the "black box" and has given information to improve the wastewater treatment process. However, bleach pulp and paper mill effluents require a better understanding of the active bacterial population. For the study of these microorganisms, molecular techniques have been used for more than 15 years. However, there has been a lack of knowledge of the physiological requirements and relations with the environment, which seems to be very difficult to obtain involving profile on the diversity. Nowadays, high-throughput sequencing technology is a promising method that makes it possible to identify the entire profile of microbial communities. In combination with fingerprint methods, this approach allows the identification and analysis of the whole biodiversity of microbial communities. In this review, several identification techniques will be discussed.

Keywords: Microbial characterization; Pulp and paper; Biological treatment; Molecular techniques; Bacterial communities

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EFFECT OF SPRAY DRYING OF AGAVE FRUCTANS, NOPAL MUCILAGE AND ALOE VERA JUICE

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ABSTRACT

The effect of inlet air temperature on the physicochemical properties and stability of agave fructans, mucilage of cactus and aloe juice were evaluated. Temperatures employed for inlet air was 70–110C in 10C increments. The best temperature for the inlet air and agave fructans cactus mucilage, where yields obtained were 40–93%, moisture content 1.71–4.10% and bulk density 0.40–0.58 g/mL, was 100 and 110C, respectively. For aloe juice, the inlet air temperature showed no significant effect on yield, water activity and bulk density, but it did for moisture content, hygroscopicity index, glass transition temperature and solubility time in the powder. Agave fructans presented desirable physicochemical stability characteristics with potential use as the carrier agent.

PRACTICAL APPLICATIONS

Agave fructans, nopal mucilage and aloe vera juice can be considered as food ingredients from natural sources. These ingredients can help to thicken various types of food. The ingredients from natural sources in powders improve the stability and transportation characteristics of the ingredients in juices or extracts. Finding the better spray drying conditions provides better physicochemical, stability, chemical and microbiological quality in the powder. Agave fructan, nopal mucilage and aloe vera powders have beneficial properties for health and present a potential use as nutraceutical food.

INTRODUCTION

Carbohydrates are an integral part of food; they are cost-effective and are present in a variety of sizes (polymers). This diversity of polymeric structures confers special physicochemical characteristics as thickeners, sweeteners, gelling agents, soluble and insoluble fibers. The main sources of carbohydrates are corn and potatoes for the production of starches and maltodextrins; chicory for inulin, gums plants (acacia), and seaweed for alginate. However, other potential sources have not been exploited industrially as sources of fructans and mucilage from agavaceae and cactaceae, respectively. Agave fructans are polymers of fructose of low molecular weight, few calories and prebiotic properties such as dietary fiber (Barclay *et al.* 2012). In addition, the agave fructans can be used as carriers in the microencapsulation agents (Chávez *et al.* 2004). Another important carbohydrate is nopal mucilage with high capacity to absorb water and can be used as thickener, emulsifier, water purifier, adhesive, plasticizer and foodstuff (Torres and Cano 2007; Miller *et al.* 2008; León *et al.* 2010). Finally, aloe vera juice composed of carbohydrates such as glucose and mannose (Nema *et al.* 2012). The aloe vera is used extensively in the pharmaceutical, food and cosmetics industry as functional ingredient (Min-Cheol *et al.* 2014). This functional ingredient has hepatoprotective properties, an immune effect and an effect against diabetes and obesity (Yagi *et al.* 2009; Saki *et al.* 2011; Nandal and Bhardwaj 2012). An alternative to industrial production of these products as food additives (agave fructans, nopal mucilage and aloe vera juice) is spray drying. The spray drying is an appropriate process for heat-

Optimization of a Microbial Formulation Acclimated for Pilot-Scale Biodegradation of Paper Mill Effluent

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A pilot-scale aerated lagoon was used for the aerobic treatment of pulp and paper mill effluent from September 1 to December 1, 2014. The aerated lagoon was installed at the chemistry laboratory in the Chemical Engineering Department at the Durango Institute of Technology and was fed with real pulp and paper mill effluent. The experimental work was run under various operating conditions. The operating parameters (total and volatile suspended solids (VSS) and dissolved oxygen concentration (DO)) and environmental variables (temperature, pH, COD, and BOD_5 of influent water) were monitored daily. In all the experiments conducted, the aerated lagoon generated an effluent of optimal quality complying with the requirements of SEMARNAT (2003) and CONAGUA (2003). A model that explains the behavior of the system under realistic operating conditions was obtained. The model indicated an optimal DO of approximately 4 mg/L for concentrations up to 1000 mg/L, showing variations in concentrations above this value. This data indicate that the flexibility of the bacterial formulation and its ability to adapt to environmental changes play an important role in the stability of an aerated lagoon.

Keywords: Optimization; Pilot scale; Model; Real conditions; Effluent; Pulp and paper; Microbial; Lagoon

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INTRODUCTION

Systems for treatment of industrial wastewater must meet two objectives. First, they must meet the increasingly rigid requirements of environmental laws. Second, they must reduce the operating costs and construction required for treatment, as this plays an important role in the economy of the industry. To satisfy these requirements, it is necessary, in addition to effective treatment processes, to have effective control strategies.

In the treatment of industrial wastewater containing toxic compounds, few systems operate successfully. The greatest difficulties arise because of the variability of residual water with respect to both its composition and its flow, because such substances (COD, BOD, turbidity, color, chloride, and organochloride compounds) show inhibitory activity.

Large aerated lagoons are commonly used in the pulp and paper industry for biological wastewater treatment. Atmospheric oxygen transferred at the water surface is not sufficient for the aerobic bacterial process, so treatment has to be supplemented by mechanical aeration. Mixing is necessary to maintain partial suspension of bacterial solids and to ensure the bacteria has adequate contact with organic pollutants (Pougatch *et al.* 2007).

Quantification of Endoglucanase Activity based on Carboxymethyl Cellulose in Four Fungi Isolated from an Aerated Lagoon in a Pulp and Paper Mill

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The aim of this study was to identify cellulolytic fungal strains capable of degrading cellulose from an aerated lagoon in a pulp and paper mill. Four fungal strains that were found to be highly active were isolated on carboxymethyl cellulose (CMC) and suggested to be CMCase/endoglucanase. The identified strains were *Aspergillus niger*, *Penicillium* sp., *Aspergillus fumigatus*, and *Mucor* sp. All the strains were studied in terms of cultural morphological characteristics and microscopic examinations. The endoglucanase with the highest isolate production was *Penicillium* sp., which also showed the highest qualitative endoglucanase activity (1.3 cm), in addition to the main activity of endoglucanase with 297 mmol/mg.min after 116 h. The results indicated that CMC is able to induce endoglucanase enzyme production and that the fungal isolates showed significant cellulose degradation properties.

Keywords: Quantification; CMC; Activity endoglucanase; Cellulose; Pulp and paper; Aerated lagoon

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INTRODUCTION

The bioprospecting of microorganisms, enzymes, and genes involved in cellulose degradation is still cutting-edge research in applied microbiology and biotechnology. The quantification of cellulolytic activity is a challenge in enzymology because of the complexity of the enzyme system involved and the heterogeneity of the techniques and units used to report it by different laboratories (Ohmiya *et al.* 2003; Aro *et al.* 2005).

The degradative system comprises several cellulolytic enzymes including endoglucanases, exoglucanases (cellobiohydrolases), and glycosidases (Diorio *et al.* 2003). Endoglucanases are widely used, and one of the most important components of the cellulolytic enzyme system is the endo1,4-β glucanase enzyme, which hydrolyzes the cellulose chains at random. This enzyme is found in a wide range of organisms, from bacteria to cellulolytic fungi. Among the substrates that have been evaluated are carboxymethylcellulose (CMC), cellulose pretreated with alkali or acid, and crystalline cellulose (Avicel or cotton fiber) (Aro *et al.* 2005).

The qualitative technique used was that reported by Tanaka *et al.* (2005), which is based on the association of Congo red and CMC generating a strong color that fades with

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Chemical and surface analysis during evolution of arsenopyrite oxidation by *Acidithiobacillus thiooxidans* in the presence and absence of supplementary arsenic

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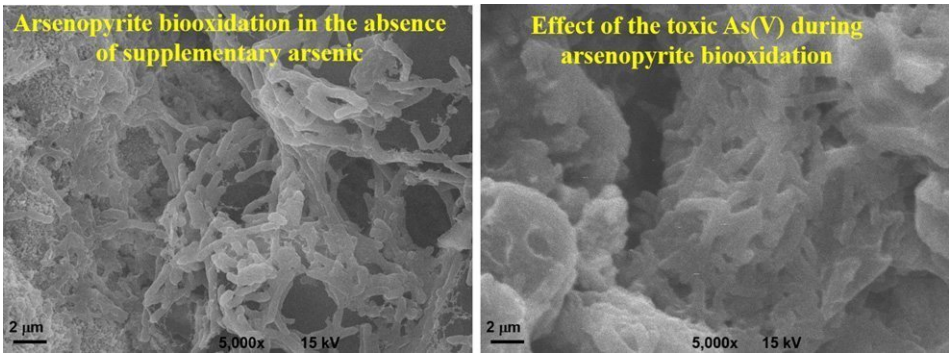
HIGHLIGHTS

- Biofilm structures occur as compact micro-colonies.
- Surface transformation reactions control arsenopyrite and cell interactions.
- Toxic arsenic does not limit biofilm formation but damage its evolution.
- Biofilm adhesion forces are lowered in the presence of supplementary arsenic.
- Synthesis of protein is mitigated in the presence of supplementary arsenic.

GRAPHICAL ABSTRACT



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ABSTRACT

Bioleaching of arsenopyrite presents a great interest due to recovery of valuable metals and environmental issues. The current study aims to evaluate the arsenopyrite oxidation by *Acidithiobacillus thiooxidans* during 240 h at different time intervals, in the presence and absence of supplementary arsenic. Chemical and electrochemical characterizations are carried out using Raman, AFM, SEM-EDS, Cyclic Voltammetry, EIS, electrophoretic and adhesion forces to comprehensively assess the surface behavior and biooxidation mechanism of this mineral. These analyses evidence the formation of pyrite-like secondary phase on abiotic control surfaces, which contrast with the formation of pyrite (FeS_2)-like, orpiment (As_2S_3)-like and elementary sulfur and polysulfide (S_n^{2-}/S^0) phases found on biooxidized surfaces. Voltammetric results indicate a significant alteration of arsenopyrite due to (bio)oxidation. Resistive processes determined with EIS are associated with chemical and electrochemical

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AEROBIC DEGRADATION OF DIESEL BY A PURE CULTURE OF *Aspergillus terreus* KP862582

DEGRADACIÓN AERÓBICA DE DIESEL POR UN CULTIVO PURO DE *Aspergillus terreus* KP862582

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Stephen Whitaker

Abstract

This study was conducted with a fungal strain isolated from a mining soil contaminated with total petroleum hydrocarbons (TPH) and properly identified by polymerase chain reaction (PCR) technique as *Aspergillus terreus* KP862582. The biodegradation potential of this pure culture was evaluated at laboratory scale; a wide diesel concentration range, from 10,000 to 50,000 mg diesel/kg soil (ppm), was tested using sterile soil microcosm over a 90-day period. Aerobic biodegradation of diesel by *Aspergillus terreus* KP862582 was significantly greater ($p < 0.05$) for 10,000, 20,000, and 30,000 ppm, with rate constant values of 0.025, 0.023, and 0.012 1/day, respectively. Cell viability at these concentrations was favored because it showed a significant increase during the first period of biodegradation (0-30 days), from this time onwards efficiency removal and cell viability decreased considerably. This pattern was observed as concentration of diesel increased, resulting in a much lower biodegradation rate for 40,000 ppm (0.005 1/day) and 50,000 ppm (0.002 1/day). Based on the results of this study it is concluded that the strain of *Aspergillus terreus* KP862582 can be used in the bioremediation of soils contaminated with petroleum hydrocarbons at concentrations of 10,000 and 20,000 ppm, and comply with the MPL established by the Mexican regulation.

Keywords: aerobic degradation, TPH contaminated soils, kinetics, mining industry.

Resumen

Este estudio se realizó con una cepa fúngica aislada de un suelo minero, contaminado con hidrocarburos totales de petróleo (HTP), e identificada como *Aspergillus terreus* KP862582 mediante la técnica de reacción en cadena de la polimerasa. El potencial de biodegradación de este cultivo puro se evaluó a nivel laboratorio a concentraciones de 10,000 a 50,000 mg de diésel/kg de suelo (ppm), usando microcosmos con suelo estéril durante 90 días. La capacidad de biodegradación aeróbica del *Aspergillus terreus* KP862582 fue significativamente mayor ($p < 0.05$) para 10,000, 20,000 y 30,000 ppm, con constantes de velocidad de biodegradación del diésel de 0.025, 0.023 y 0.012 1/día, respectivamente. La viabilidad celular del *Aspergillus terreus* KP862582 en estas concentraciones mostró un incremento significativo durante los primeros 30 días, a partir de este tiempo la eficiencia de remoción y la viabilidad celular disminuyeron considerablemente. Este comportamiento se observó a medida que aumentó la concentración del diésel, resultando en una menor tasa de degradación para 40,000 ppm (0.005 1/día) y 50,000 ppm (0.002 1/día). Con base en los resultados se concluye que la cepa de *Aspergillus terreus* KP862582 puede ser usada en la biorremediación de suelos contaminados con HTP, con concentraciones de 10,000 y 20,000 ppm, y cumplir con el LMP establecido por la regulación Mexicana.

Palabras clave: cinética, degradación aeróbica, industria minera, suelos contaminados con HTP.

1 Introduction

Diesel oil spills have increased considerably and they are one the main problems of environmental pollution. The main causes of these spills in soil and groundwater are due to their massive production as fuels for transportation, accidental spills while transported, and by leakage of pipeline and underground storage tanks (UST) (Lee *et al.,* 2006; Zanaroli *et al.,* 2010). Diesel oil is a medium

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EFFECT OF SPRAY DRYING OF AGAVE FRUCTANS, NOPAL MUCILAGE AND ALOE VERA JUICE

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ABSTRACT

The effect of inlet air temperature on the physicochemical properties and stability of agave fructans, mucilage of cactus and aloe juice were evaluated. Temperatures employed for inlet air was 70–110C in 10C increments. The best temperature for the inlet air and agave fructans cactus mucilage, where yields obtained were 40–93%, moisture content 1.71–4.10% and bulk density 0.40–0.58 g/mL, was 100 and 110C, respectively. For aloe juice, the inlet air temperature showed no significant effect on yield, water activity and bulk density, but it did for moisture content, hygroscopicity index, glass transition temperature and solubility time in the powder. Agave fructans presented desirable physicochemical stability characteristics with potential use as the carrier agent.

PRACTICAL APPLICATIONS

Agave fructans, nopal mucilage and aloe vera juice can be considered as food ingredients from natural sources. These ingredients can help to thicken various types of food. The ingredients from natural sources in powders improve the stability and transportation characteristics of the ingredients in juices or extracts. Finding the better spray drying conditions provides better physicochemical, stability, chemical and microbiological quality in the powder. Agave fructan, nopal mucilage and aloe vera powders have beneficial properties for health and present a potential use as nutraceutical food.

INTRODUCTION

Carbohydrates are an integral part of food; they are cost-effective and are present in a variety of sizes (polymers). This diversity of polymeric structures confers special physicochemical characteristics as thickeners, sweeteners, gelling agents, soluble and insoluble fibers. The main sources of carbohydrates are corn and potatoes for the production of starches and maltodextrins; chicory for inulin, gums plants (acacia), and seaweed for alginate. However, other potential sources have not been exploited industrially as sources of fructans and mucilage from agavaceae and cactaceae, respectively. Agave fructans are polymers of fructose of low molecular weight, few calories and prebiotic properties such as dietary fiber (Barclay *et al.* 2012). In addition, the agave fructans can be used as carriers in the microencapsulation agents (Chávez *et al.* 2004). Another important carbohydrate is nopal mucilage with high capacity to absorb water and can be used as thickener, emulsifier, water purifier, adhesive, plasticizer and foodstuff (Torres and Cano 2007; Miller *et al.* 2008; León *et al.* 2010). Finally, aloe vera juice composed of carbohydrates such as glucose and mannose (Nema *et al.* 2012). The aloe vera is used extensively in the pharmaceutical, food and cosmetics industry as functional ingredient (Min-Cheol *et al.* 2014). This functional ingredient has hepatoprotective properties, an immune effect and an effect against diabetes and obesity (Yagi *et al.* 2009; Saki *et al.* 2011; Nandal and Bhardwaj 2012). An alternative to industrial production of these products as food additives (agave fructans, nopal mucilage and aloe vera juice) is spray drying. The spray drying is an appropriate process for heat-

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Effect of Spray Drying Temperature and Agave Fructans Concentration as Carrier Agent on the Quality Properties of Blackberry Powder

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Abstract: The agave fructans as carrier agent can be an alternative to increase quality properties of blackberry. The aim of this study was to evaluate the effect of agave fructans concentration and inlet air temperature on quality properties of blackberry powder. Agave fructans concentrations were 50, 75 and 100 % (in base the total soluble solids percentage of blackberry extract), and the inlet air temperatures were 70–110 °C. A pilot-scale spray dryer was employed. Drying yield ranged from 58 to 94 % dry base. Encapsulation efficiency values varied between 48 and 100 % of anthocyanin concentration. The lower agave fructans concentration showed the best quality characteristics as lower water activity of 0.28, high anthocyanin retention of 98 %, high bulk density of 0.80 g/ml and the higher agave fructans concentrations showed the best stability properties as lower hygroscopicity of 0.013 g_{H2O}/g_{solids} and low particle temperature of 38 °C. The agave fructans improves good physicochemical and stability characteristics in blackberry powders.

Keywords: blackberry, agave fructans, microencapsulation, spray drying

1 Introduction

Blackberries are a rich source of anthocyanin and others polyphenolic antioxidants [1]. The main role of antioxidant compounds is to reduce the risk of many chronic diseases, such as cancer, coronary heart diseases, and immune system decline, among others [2]. Several studies have demonstrated a relationship between fruits consumption and a lower incidence of degenerative diseases such as heart disease, arthritis and aging [3]. However, the concentration of antioxidants compounds is affected by several factors, such as climate, harvesting period, and postharvest processing, such as drying and storage conditions, especially temperature, pH, light, and oxygen.

Spray drying refers to the removal of moisture from fluid materials (solution, dispersion or paste) by breaking it into small droplets in the presence of hot air to obtain a dry powder. In the spray drying process, the liquid is pumped into the drying chamber through an atomizing system [4]. Microencapsulation is a technique that has been around for decades in diverse industrial processes to obtain dehydrated materials in the form of fine powders and is the most used method in the food industry [5]. Quek et al.[6], Goula et al. [7] and Youssefi et al. [8] have observed that the quality of microencapsulation by spray drying depends on control parameters such as rotation speed, feed flow, inlet air temperature, and properties of the emulsion: composition, concentration, and type of carrier agent. Carrier agent usually used in spray drying of fruit juices are carbohydrate based, such as maltodextrins and gums, mainly due to their high solubility, low viscosity, which are important conditions for the spray-drying process [6]. Oligosaccharides as agave fructans have an immense potential not only for improving the quality of foods but also for improving functional and sensorial characteristics. These may also have a positive role in improving gut health, increasing mineral absorption, and other physiological benefits for the host [9]. Fructans are rich in fructose polymers with a terminal glucose and are composed of fructose units and terminal glucose unit linked by β- (2 → 1) -and β- (2 → 6) [10]. They are widely distributed in plants. They perform similar functions as dietary fiber and indigestible in the gastro-intestinal tract. For that reason, these are effective

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Partial substitution of bean (*Phaseolus vulgaris*) flour for fishmeal in extruded diets for rainbow trout (*Oncorhynchus mykiss*): Effects on yield parameters

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Abstract

The objective of this research was to evaluate yield parameters (gained weight, weight percentage, survival, feed conversion factor (FCR), feed conversion efficiency (FCE), condition factor (K), specific growth rate (SGR) and hepatosomatic index (HSI) of trouts fed with experimental diets elaborated with bean (*Phaseolus vulgaris* L.) flour instead of fishmeal with 15, 30 and 45% (BF15, BF30 and BF45, respectively) for 32 days, as well as a control diet (CD). The greatest weight gain was presented by fish fed with BF15 and BF30 (14.48 and 14.14 g, respectively) with no significant differences (p>0.05) and an approximate increase of 50% of their initial weight. FCR did not show significant differences (p>0.05) among CD, BF15 and BF30 diets with an average value of 2.05. FCE did not show significant differences (p>0.05) between diets BF15 and BF30 with an average value of 46.70%. SGR did not show significant differences (p>0.05) between BF15 and BF30 diets with an average value of 1.25. It is concluded that 30% is the maximum substitution without causing a decrease in yield and nutritional parameters in rainbow trout under the experiment conditions, although further research is suggested.

Keywords: Extruded diets, Fishmeal, *Oncorhynchus mykiss*, Specific growth rate.

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Blue corn (*Zea mays* L.) with added orange (*Citrus sinensis*) fruit bagasse: novel ingredients for extruded snacks

Maiz azul (*Zea mays* L.) con adición de bagazo de naranja (*Citrus sinensis*): ingredientes novedosos para botanas extrudidas

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Physicochemical and structural analyses were done of extruded snacks produced with two types of blue corn (hard and soft endosperm) combined with orange bagasse. Chemical composition, expansion index (EI), penetration force, water absorption index, and water solubility index values were calculated for all treatments. They were also analyzed with scanning electron microscopy, X-ray diffraction, and Fourier transform infrared spectroscopy. Addition of bagasse increased crude fiber content and hardness in the extrudates. It also lowered the EI, resulting in harder products with higher numbers of pores per area but of smaller sizes than in the extrudates without bagasse. Both the X-ray diffraction patterns and infrared spectra showed the starch to lose its semicrystalline structure due to mechanical shearing and high temperature. Orange bagasse was successfully incorporated into extrudated snacks made with blue corn of different endosperm hardnesses. Blue corn is a viable base for extruded snacks, and orange bagasse is a potential source of low cost, natural source fiber.

Keywords: fiber; specific mechanical energy; X-ray diffraction; scanning electron microscopy; Fourier transform infrared spectroscopy (FTIR)

Análisis fisicoquímicos y estructurales se realizaron en botanas extrudidas elaboradas con maíz azul de endospermo suave y duro combinados con bagazo de naranja. La composición química, el índice de expansión, la fuerza de penetración, el índice de absorción de agua e índice de solubilidad en agua, microscopía electrónica de barrido, difracción de rayos X y espectroscopia de infrarrojo fueron determinados para todos los tratamientos. La adición de bagazo de naranja en los productos incrementa el contenido de fibra cruda, pero disminuye el índice de expansión, dando como resultado productos duros con mayor número de poros por área pero de menor tamaño que los productos sin bagazo. Los patrones de difracción de rayos X y los espectros de infrarrojo muestran que el almidón pierde su estructura semicristalina debido al corte mecánico y a temperaturas elevadas. El maíz azul es una base viable para elaborar botanas extrudidas, mientras que el bagazo de naranja es una fuente potencial de fibra natural de bajo costo.

Palabras Clave: Fibra; Energía Mecánica Específica; Difracción de Rayos X; Microscopía Electrónica de Barrido; FTIR

1. Introduction

Maize (*Zea mays* L.) was domesticated thousands of years ago and is currently cultivated worldwide. Different varieties of corn produce grains ranging in color from red to purple to blue and black. With 59-recorded varieties, Mexico has the largest diversity of corn varieties in the world (Vielle-Calzada & Padilla, 2009). Among these is blue corn, originally from Peru and cultivated by ancient civilizations such as the Inca, Maya, and Aztec. This variety's blue color is due to the presence of anthocyanins, mainly in the aleuron and pericarp (Salinas-Moreno, Soto-Hernández, Martínez-Bustos, González-Hernández, & Ortega-Packza, 1999). Higher phenolic compound content has also been reported in the colored versus white and yellow varieties (Aguayo-Rojas et al., 2012; Mora-Rochin et al., 2010).

Blue corn products such as tortillas and chips are usually produced with the nixtamalization process (Serna-Saldivar, Gómez, & Rooney, 1990). Very few studies have been done on producing foods with blue corn using processes other than nixtamalization (Camacho-Hernández et al., 2014; Navarro-Cortez et al., 2014; Zazueta-Morales, Martínez-Bustos, Jacobo-Valenzuela, Ordorica-Falomir, & Paredes-López, 2001). Cereal-based foods have high glycemic content (Brennan, 2005). Glycemic index values can be lowered by incorporating dietary fiber into this type of food (Frost, Brynes, Dhillo, Bloom, & McBurney, 2003; Gualberto, Bergman, Kazemzadeh, & Weber, 1997; Symons & Brennan, 2004). However, inclusion of fiber in extruded products changes their physical characteristics, resulting in less expanded, harder products (Altan, McCarthy & Maskan, 2008). Fiber added to

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CALIDAD FERMENTATIVA Y NUTRICIONAL DE ENSILADOS DE MAÍZ COMPLEMENTADOS CON MANZANA Y MELAZA

Fermentative and nutritional quality of maize silages complemented with apple and molasses

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RESUMEN. Se evaluó la adición de manzana de desecho y melaza sobre la calidad fermentativa y composición nutricional del ensilado de maíz, utilizando cuatro combinaciones de maíz y manzana (100-0, 75-25, 50-50, 25-75) y tres niveles de melaza (0, 5 y 10 %) para obtener 12 tratamientos (100-0-0; 100-0-5; 100-0-10; 75-25-0; 75-25-5; 75-25-10; 50-50-0; 50-50-5; 50-50-10; 25-75-0; 25-75-5 y 25-75-10). El pH disminuyó con manzana a menos de 3.60, pero incrementó con melaza de 0.03 a 0.07 unidades. El nitrógeno amoniacal incrementó (0.59 a 2.44 %), aunque los AGVs se mantuvieron en rangos aceptables (acético de 0.04 a 0.73 %, propiónico de 0.02 a 0.70 %, y butírico de 0.0 a 0.58 %); incrementándose con la melaza y reduciéndose con la manzana. Frente al ensilado control (100-0-0), la MS y las cenizas disminuyeron con la adición de manzana e incrementaron con la melaza ($p < 0.001$), la PC incrementó en la formulación 100-0-5 (5.9 vs 7.5 %), mientras que los carbohidratos no estructurales (CNE) incrementaron en el tratamiento 25-75-10. La manzana incrementó la FDN y FDA, pero a 75 % de manzana ambos disminuyeron, mientras que la melaza redujo la FDN y la FDA. El costo de la MS digestible disminuyó en el tratamiento 75-25-10, el valor relativo calculado por el método de Petersen incrementó de 96.7 a 115.3 %. Dependiendo del precio y disponibilidad, la manzana de desecho y la melaza pueden mejorar la calidad y costo del ensilado de maíz.
Palabras clave: Ensilaje, *Malus domestica*, método Petersen, minisilos, pH, *Zea mays*

ABSTRACT. The addition of rejected apples and molasses to corn silage was evaluated on fermentation quality and nutritional composition using four combinations of corn silage and apples (100-0, 75-25, 50-50, 25-75) and three levels of molasses (0, 5 y 10 %) to obtain twelve treatments (100-0-0, 100-0-5, 100-0-10, 75-25-0, 75-25-5, 75-25-10, 50-50-0, 50-50-5, 50-50-10, 25-75-0, 25-75-5 and 25-75-10) using 36minisilos. The pH was reduced with the addition of apples ($pH < 3.6$), while molasses increased pH by 0.03 - 0.07 units. Ammonia nitrogen was increased (0.59 % to 2.44 %) while VFAs maintained acceptable levels (acetic acid: 0.04 - 0.73 %, propionic: 0.02 - 0.70 %; butyric: 0.0 - 0.58 %), increasing slightly with molasses and decreasing with apples. In comparison to control silage (100-0-0) dry matter and ashes were reduced with the addition of apples and increased with molasses ($p < 0.001$). Crude protein increased only in mixture 100-0-5 (5.9 vs. 7.5 %). Non-structural carbohydrates increased only with the highest level of apples and molasses (61.3 vs. 66 %). Apples increased NDF (59.5 vs. 63.1 %) and ADF (30.7 vs. 35.6 %), but at 75 % inclusion, both decreased; molasses reduced NDF and ADF always. The cost of digestible dry matter decreased

ESTABILIDAD Y TEXTURA DE REESTRUCTURADOS DE CARNE DE CABRA ADICIONADOS CON INULINA GELIFICADOS EN FRIO

Karla Ortega Valdez, Juan Ramón Esparza-Rivera, Marcela Ibarra Alvarado, Hiram Medrano Roldán, Efren Delgado Licon y Aquiles Solís Soto

RESUMEN

La elaboración de reestructurados cárnicos (REC) de cabra representa una alternativa recomendable para aprovechar los atributos nutricionales de este tipo de carne. Por otra parte, factores diversos como la temperatura de gelificación durante la elaboración del producto y la adición de compuestos nutracéuticos en la formulación, pueden afectar las propiedades funcionales de los REC. El objetivo de este estudio fue evaluar el efecto de la gelificación en frío y la adición de inulina sobre la estabilidad y textura de reestructurados de carne de cabra elaborados con transglutaminasa (TGM) microbiana. Dos formulaciones fueron utilizadas en el presente estudio: REC formulado con inulina o sin inulina, y los REC fueron elaborados usando gelificación térmica tradicional (a 50ºC) o en frío (a 2.6ºC). Las variables evaluadas fueron: estabilidad (pérdida por exudado en REC no cocido, y pérdida por cocción) y textura de los REC (evaluación instrumental de firmeza). Los reestructurados cárnicos de cabra gelificados en frío tuvieron menores pérdidas por exudado que los REC elaborados con gelificación térmica. Sin embargo las pérdidas por cocción fueron similares en productos gelificados en frio o en forma tradicional. Por otra parte, la gelificación en frío no afectó la firmeza de los REC sin inulina. No obstante, con respecto a los productos adicionados con inulina se observó que los REC gelificados en frío fueron más firmes que los elaborados con gelificación térmica. La gelificación en frío es recomendable para la elaboración de reestructurados con carne de cabra, y la adición de la inulina en la formulación de este tipo de productos es una opción viable para aumentar su calidad nutracéutica.

Introducción

La elaboración de reestructurados cárnicos (REC) consiste en la obtención de geles proteicos utilizando agentes ligantes tales como sales, fosfatos, aislados proteicos y enzimas como la transglutaminasa (TGM) (Llorente-Bousquets *et al.,* 2010; Talukder *et al.,* 2013). La acción ligante de la TGM está basada en la formación de un enlace cruzado ϵ-(λ-glutamil) lisina [ϵ-(λ-Glu) Lis] entre los grupos ε-amino de la lisina y γ-carboxamida de la glutamina de proteínas adyacentes (Uresti *et al*., 2006), lo cual le confiere cohesividad y elasticidad a los productos cárnicos elaborados (Sun, 2009). Esta enzima ha sido utilizada para la elaboración de diversos productos cárnicos, incluyendo piezas completas de musculo libres de grasa y tejido conectivo (Kolle y Savell, 2003), salchichas de pollo (Muguruma *et al*., 2003), *döner kebab* de pollo (Kilic, 2003), y albóndigas bajas o libres de sal (Tseng *et al*., 2000). La tecnología de reestructuración ha hecho posible controlar características finales de los productos cárnicos elaborados, incluyendo su forma, color, textura y contenido de grasa y humedad (Raharjo *et al*., 1995). Sin embargo, no se tienen reportes del uso de TGM en la elaboración de reestructurados de carne de cabra, lo cual representa una alternativa recomendable para aprovechar los atributos nutricionales de este tipo de carne, destacando su menor contenido de grasa saturada y colesterol en comparación a otros tipos de carne de mayor consumo, tales como res y puerco (USDA, 2009). Además, la carne de cabra contiene ácidos grasos insaturados benéficos para la salud, tales como ácido oleico, linoleico conjugado o CLA, linolenico y araquidónico (Webb *et al.,* 2005; USDA, 2009).

Entre las propiedades más importantes que determinan la aceptabilidad de los REC se encuentran su estabilidad, textura y apariencia (Jena y Bhattacharya, 2003). La estabilidad de los REC es afectada por la adición de compuestos funcionales a la formulación del producto (Weiss *et al*., 2010), así como por la temperatura de gelificación a la que se elabora el reestructurado (Ahhmed *et al.,* 2007). Dentro de los aditivos funcionales utilizados para aumentar la calidad nutracéutica de los productos alimenticios se encuentra la inulina, que es un polisacárido con propiedades benéficas para la salud (Siro *et al.,* 2008). Por otra parte, la actividad enzimática ligante de la TGM es óptima a 50ºC (Uresti *et al*., 2004; Ramírez *et al*., 2006); sin embargo a

PALABRAS CLAVE / Carne de Cabra / Fructo Oligosacáridos / Reestructurados / Transglutaminasa /

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Microorganism Degradation Efficiency in BOD Analysis Formulating a Specific Microbial Consortium in a Pulp and Paper Mill Effluent

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Pulp and paper mills are a major source of pollution, generating huge amounts of intensely colored effluent that goes to the receiving end of a wastewater treatment plant. The biochemical oxygen demand test (BOD_5) relies heavily on the microorganism metabolic capability added to the test as seeding material. The seeding material in the testing is obtained from sewage sampling or from commercial sources. Specific organic pollutants that are present in paper and pulp mill effluent can only be degraded by specific microbes; therefore, common sewage or synthetic seed may lead to erroneous BOD_5 estimations. In this study, specific microbial species were selected to evaluate their degradation efficiency, both individually and in combination. The microorganisms selected in the formulated seed exhibit BOD_5 in a reproducible and synergistic manner. The formulation of this specific microbial consortium can be used to develop bioremediation strategies.

Keywords: Paper and pulp; BOD_5; COD; Degradation; Formulation

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INTRODUCTION

The pulp and paper industry contributes heavily to water pollution, which generally arises from the industrial use of fiber, cellulose, and lignin; these components can impart high COD (chemical oxygen demand), color, and BOD to the effluent (Singh *et al*. 2008). The BOD_5 testing is not specific to any pollutant, but can be used as an aggregated water quality parameter indicating the amount of biodegradable organic materials in terms of oxygen consumption (Pepper *et al*. 1996).

Most of the industrial effluents have the necessary microorganisms to realize the BOD_5 test without adding a microbial seed to increase its efficiency. The oxygen used by the microorganism to degrade the organic matter is measured by the BOD_5 and changes with time and concentration. Using microorganisms obtained directly from the process *via* isolation and acclimation improves the treatment (Kumar *et al*. 2010).

Prabu and Udayasoorian (2005) reported that white rot fungus that was isolated from soil samples, enriched by continuous pulp and paper mill effluent irrigation, and identified as *P. chrysosporium*, was capable of 79% COD reduction. De Olivera *et al.* (2009) evaluated the ability of *Bacillus pumilus* CBMAI0008 to produce alkaline enzymes


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EFECTO DE LA CONCENTRACIÓN DE HARINA DE FRIJOL (*Phaseolus vulgaris* L.), CONTENIDO DE HUMEDAD Y TEMPERATURA DE EXTRUSIÓN SOBRE LAS PROPIEDADES FUNCIONALES DE ALIMENTOS ACUÍCOLAS

EFFECT OF BEAN FLOUR CONCENTRATION (*Phaseolus vulgaris* L.), MOISTURE CONTENT AND EXTRUSION TEMPERATURE ON THE FUNCTIONAL PROPERTIES OF AQUAFEEDS

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Resumen

Se evaluó el efecto de la concentración de harina de frijol (*Phaseolus vulgaris* L.), contenido de humedad y temperatura de extrusión sobre las propiedades funcionales de alimentos acuícolas. Se elaboraron dietas con sustitución de harina de pescado por harina de frijol (15, 30 y 45%) y un control. El incremento de la harina de frijol en las dietas tiene efecto ($p < 0.05$), sobre el índice de expansión (IE), densidad aparente (DA), índice de absorción de agua (IAA), índice de solubilidad en agua (ISA) y velocidad de hundimiento (VH). El aumento de la humedad de alimentación, disminuye ($p < 0.05$), el IE, ISA, L* y b*, pero incrementa ($p < 0.05$), la DA, VH, IAA, y a*. El incremento de temperatura de extrusión disminuyó ($p < 0.05$), el IE, DA, ISA, VH, color y aumentó ($p < 0.05$), el IAA. El IE más alto ($p < 0.05$), se encontró en la concentración del 15% de harina de frijol, 18% de humedad y a 120 ºC, comparados con las demás concentraciones. La menor VH se encuentra en concentraciones de frijol menores al 30% y humedades de 18%. Se recomienda elaborar alimentos balanceados acuicolas con 15% de harina de frijol extrudidos a 18% de humedad y a 120 ºC.

Palabras clave: acuacultura, harina de frijol, propiedades funcionales, extrusión.

Abstract

The effect of bean (*Phaseolus vulgaris* L.) flour content, moisture content and extrusion temperature on the functional properties of fish feed was evaluated. Diets with fish meal and different bean flour concentrations (15, 30 and 45%) and control diet were developed. The results show that the bean flour present in the diets has an effect ($p < 0.05$) on expansion index (EI), bulk density (BD), water absorption index (WAI), water solubility index (WSI) and sinking velocity (SV). Extrusion moisture decreased ($p < 0.05$), EI, WSI and the color parameters L* and b*, but increased (p ¡0.05), BD, SV, WAI, and the color parameter a*. The results also showed that an increase on extrusion temperature decreased ($p < 0.05$), EI, BD, WSI, SV, color and increased ($p < 0.05$), WAI. The highest ($p < 0.05$) EI was found in the extruded diet containing 15% of bean flour, 18% extrusion moisture and extruded at 120 °C, compared to other diets. The lowest ($p < 0.05$) SV was determined in the extruded diets with less than 30% bean flour and an extrusion moisture of 18%. The optimum extrusion conditions were found with diets containing 15% of bean flour and extruded with 18% moisture at 120 °C.

Keywords: aquaculture, bean flour, functional properties, extrusion.

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REGULAR ARTICLE

Effect of extrusion temperature, moisture content and screw speed on the functional properties of aquaculture balanced feed

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Abstract

The aim of this study is to analyze the effect of feed moisture content, temperature, and screw velocity on the functional properties of extruded feeds for aquaculture with a bean flour and soy protein base. Fishmeal was substituted at different concentrations of bean flour or soy protein. Later, the diets were extruded and the expansion index, apparent density, and the extrusion sinking velocity were analyzed and an optimization of the process was carried out. The extrusion moisture content has an effect ($p < 0.05$) on the extrusion expansion index. The extrusion conditions were optimized with 93, 186 and 279 g/kg of bean flour or soy protein. The diets with soy protein require a higher amount of moisture, higher temperature, and a higher screw velocity than diets with bean flour, to obtain diets that are within range of the physical characteristics similar to commercial diets.

Key words: Functional properties, Legumes, Extruded feed, Rainbow trout, Sinking velocity

Introduction

Over the last few years, aquaculture has experienced a great development with the aim of supplying a continuously growing population, with ever higher demands for fish. Fishmeal is one of the most important products in aquaculture feeding, however, the worldwide production of fishmeal has decreased in recent years. There is a search for fishmeal substitutes that use vegetable protein (De la Higuera and Cardente, 1993; Tacon, 1994; Guilluame and Metailler, 1999), with the protein content being an important factor to evaluate a potential inclusion in foods (Jobling, 1993; NRC, 1993; Bureau and Cho, 1996). Diets for rainbow trout (*Oncorhynchus mykiss*), require protein contents of 290 to 500 g/Kg and low starch levels of 10-20 g/kg (Dabrowski, 1984; Uys and Hecht, 1985; Charlon and Bergot, 1986; Kaushik and Médale, 1994). Due to its high protein level, grain legumes are used extensively as a replacement for fishmeal in fish diets (Allan, 1997). The replacement of fishmeal for bean flour (*Phaseolus vulgaris* L.) in diets for species carnivorous have not reported investigations in this regard, however this represents a good source of protein representing an economic advantage on the use of other vegetable flours such as soy bean, which turns it into a highly attractive alternative replacement source (Hughes, 1988). The extrusions with a high content of vegetable protein should contain the same nutritional and functional quality, as well as palatability and physical properties, as the fishmeal based extrusions (FAO, 2000). For this reason, aquaculture is experiencing a series of

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EFFECT OF GLANDLESS COTTONSEED MEAL CONTENT ON THE MICROSTRUCTURE OF EXTRUDED CORN-BASED SNACKS

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ABSTRACT

Knowledge of the microstructure of food materials can be used to improve their processing, as well as optimizing their physical and chemical properties to enhance benefits and characteristics sought by consumers, such as nutritional value, homogeneity and crunchiness, which ultimately would result in product acceptance. The objective of this research was to evaluate the effects on microstructure of corn-based extruded snacks using glandless cottonseed meal (CSM) and corn flour (0:98, 5:93, 10:88, 25:73 and 98:0 %, respectively). The following conditions for the extrusion process were used: exit die temperature: 120 °C, screw speed: 180 rpm, and, moisture content: 17%. Scanning electron microscoping (SEM), confocal microscoping and lambda scan were performed on the extruded samples. Cottonseed meal content influences extrudates` structure due to high lipids and protein content, since they form compact complexes with starch. SEM revealed that the basic structural components of textured proteins (strands, rivulets, layers) are present in glandless cottonseed meal extruded products. Confocal microscoping images agree with the conclusions obtained from SEM; presenting a more irregular and fluorescent structure as CSM content increased in the extruded product. Lambda scan showed a very similar fluorochrome content for all the treatments. It is concluded that as CSM content increases, extrudates' surfaces become rougher, lumpier and more pitted with a more disrupted structure, which could affect consumers' perception of the product.

KEYWORDS:
Cottonseed meal, extrusion, snack texture, microstructure

1. INTRODUCTION

Upward trending world population and increasing costs for traditional food proteins provide many incentives for the utilization of oilseed proteins directly in human diets [1]. Cotton, as one of the world's major oilseed crops, represents a potential source of food protein. Acceptability of oilseed protein products in terms of functional properties in food systems and nutritional value will largely determine the extent of their utilization by the food industry [2]. Cooking processes are essential to allow starch to be metabolized by humans; they involve heat, moisture and often mechanical action, and are a subset of the group of actions termed starch conversion [3]. Conversion involves the destruction of starch structure, starting from the highly ordered native granules, finishing with depolymerization of individual amylose and amylopectin molecules, and molecular degradation of glucose monomers [4]. A feasible option to process oilseed protein products (cottonseed meal, among others) is cooking extrusion, which has many benefits, such as protein denaturalization, starch gelatinization, deactivation of anti-nutritional factors and reduction of microorganisms [5]. During this treatment, starches go through gelatinization and retrogradation [6]. Gelatinization is an irreversible thermal transition caused by molecular disorganization of amylopectin (crystal fusion) in which amylose leaches out of the starch granules. Retrogradation is a reorganization process of amylose molecules (crystallization) into a double helix configuration, in other words, is the molecular reorganization (recrystallization) which occurs after cooling [7]. Monitoring morphological and microstructure view of extruded products under the microscope is used for characterization of the cell structure of food components; since it is helpful in controlling the extrusion process, obtaining desired and uniform extrudates, affecting directly the consumers' perception and acceptance of the product. The aim of this study was to evaluate the effect on the microstructure of

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Abstract

In this research, a diesel-degrading bacterium (strain KJ629314) was isolated from a mining soil contaminated with total petroleum hydrocarbons (TPH), and properly characterized using the polymerase chain reaction (PCR) molecular technique. The 16s rDNA sequence analysis allowed to identify KJ629314 as a strain of *Bacillus sp*. Experimental phase was conducted to assess the aerobic biodegradation of diesel; to determine the removal efficiency and the corresponding microbial growth; diesel was used as a substrate - electron donor - carbon source; and oxygen (via aeration) as the electron acceptor. Tests were conducted in microcosms with sterile sand with nutrients according to the Nitrogen:Phosphorus ratio of 15:1 at different diesel concentrations (10,000; 20,000; 30,000; 40,000 and 50,000 mg/kg soil). Results showed that the strain of *Bacillus sp* KJ629314 has a high potential in the biodegradation of diesel at the evaluated concentrations, and it was demonstrated that the removal efficiency was greater at low concentrations of diesel obtaining higher values for the microbial growth and diesel biodegradation rate constants. These promising results support the fact that *Bacillus sp* KJ629314 may be used as a novel biological resource to develop a bioprocess for the bioremediation of diesel-contaminated soil.

Keywords: aerobic degradation, *Bacillus sp* KJ629314, bioremediation, contaminated soils, mining industry, TPH.

Resumen

En esta investigación, una bacteria degradadora de diesel (cepa KJ629314) fue aislada de un suelo minero contaminado con hidrocarburos totales de petróleo (HTP) y debidamente caracterizada utilizando la técnica molecular de la reacción en cadena de la polimerasa (RCP). El análisis de la secuencia de 16s rDNA permitió identificar KJ629314 como una cepa de *Bacillus sp*. La fase experimental se llevó a cabo para evaluar la biodegradación aeróbica del diésel; para determinar la eficiencia de remoción y el crecimiento microbiano correspondiente; el diésel se utilizó como sustrato - donador de electrones - fuente de carbono, y el oxígeno (a través de la aireación) como aceptor de electrones. Las pruebas se realizaron en microcosmos empleando arena estéril con nutrientes de acuerdo con la relación Nitrógeno:Fósforo de 15:1 a diferentes concentraciones de diésel (10,000; 20,000; 30,000; 40,000 y 50,000 mg/kg de suelo). Los resultados mostraron que la cepa de *Bacillus sp* KJ629314 tiene un alto potencial en la biodegradación del diésel en las concentraciones evaluadas, y se demostró que la eficiencia de degradación fue mayor a bajas concentraciones de diésel; obteniéndose valores más altos para el crecimiento microbiano así como para las constantes de velocidad de degradación. Estos prometedores resultados apoyan el hecho de que el *Bacillus sp* KJ629314 puede ser utilizado como un recurso biológico novedoso para desarrollar un bioproceso para la biorremediación de suelos contaminados con diésel.

Palabras clave: *Bacillus sp* KJ629314, biorremediación, degradación aeróbica, HTP, industria minera, suelos contaminados.

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The Effect of Glandless Cottonseed Meal Content and Process Parameters on the Functional Properties of Snacks during Extrusion Cooking

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ABSTRACT

The results of the present study indicate that glandless cottonseed meal (CSM) can be incorporated in extruded corn flour snacks at a 10% content level, which increases snack protein content to 12.8% and reduce fat content to 6.2%. To improve snacks' nutritional quality, CSM and corn flour were extruded using a simple screw extruder. An expansion index (EI) ranging of 1.2 - 4.7 was obtained. Penetration force (PF) was 7 - 9 times harder than other extruded products. High extrusion temperature and high CSM concentrations decreased ($p < 0.05$) EI, water activity, and water absorption index. Higher CSM concentrations can be incorporated into extrudates if snacks are processed at higher extrusion moistures. CSM increased ($p < 0.05$) extrudates' PF giving them a unique crunchy texture. CSM decreased ($p < 0.05$) extrudates' water solubility index. Extrusion conditions used showed a 68.5% starch gelatinization, and a starch availability of more than 97%, which explains the high expansion index obtained.

Keywords: Cottonseed Meal; Extruded Snack; Functional Properties

1. Introduction

It is generally accepted today that, in order to adequately feed the world's rapidly expanding population, increasing amounts of plant proteins should be directly used in human diets. A feasible option is to use protein obtained from the cotton plant. Cotton should rank high among crop production priorities since it provides fiber, a renewable resource for garment manufacturing, as well as edible oil and protein for human consumption and animal feed [1]. However, it contains gossypol, a natural phenollic aldehyde that permeates cells and acts as an inhibitor for several dehydrogenase enzymes [2], it can cause negative effects on growth and reproductive performance, and it can also result in intestinal and internal organ abnormalities [3-5]. Glandless cottonseed flour could potentially be used as raw material for the production of texturized protein products. This is achieved by genetically eliminating the toxic compound gossypol from the cottonseed [6]. Cottonseed meal (CSM) is obtained by grinding the flakes once most of the cottonseed oil has been removed.

Hominy is obtained through a process called nixtamalization, which is a traditional alkali treatment in which corn is precooked with $Ca(OH)_2$, conditioned for 6 - 18 h, and ground to produce corn flour (Gomez *et al.*, 1991). Tortilla and other corn products are made from corn flour [7-10]. During nixtamalization, partial starch gelatinization and retrogradation take place, while starch birefringence decreases [8-12]. Nixtamalization increases Lys/Iso ratio, Ca content, and protein digestibility and decreases aflatoxin contamination [13-17].

Extrusion is inexpensive, productive and requires low levels of energy [18]. Snacks can be extruded products [17]. Because starch gelatinization provides texture and structure to the end-product [19,20], it is possible to produce extrudates from pure starch or high starch content cereals. Because of cottonseed meal's relatively high protein and fat content and its low starch content, extrusion of cottonseed meal is complicated. Other results show that high protein legumes can be extruded, obtaining an expansion index ranging between 1.5 and 2 at 18% of moisture [21]. Expansion, in general, increases with higher extrusion moisture, pressure and temperature [22]. Al-

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Original Article

The Effect of Pregelatinized Potato Starch on the Functional Properties of an Extruded Aquafeed

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Abstract

The most important physical properties affecting quality in aquaculture feeds are floatability, hardness, stability and sinking velocity. An evaluation was done of the effect of different concentrations (25, 50, 75 and 100 g Kg^{-1}) of native potato starch (PSt) and pregelatinized potato starch (PPSt) on functional properties in an extruded aquafeed. Maximum bulk density values were observed in the PPSt treatments, with a high value of 1.06 g cm^{-3} in the 25 g Kg^{-1}PPSt treatment. Hardness increased from 1.63 to 5.11 N in the PPSt treatments. Sinking velocity also increased, from 5.84 to 7.47 cm s^{-1}, while water solubility index values decreased from 12.8 to 7.9%. Use of PPSt did not affect ($P > 0.05$) the expansion index, the water absorption index (g Kg^{-1}) or color (L*, a* and b*). Addition of PPSt improved aquafeed pellet hardness without affecting the expansion index, preventing pellet disintegration and lixiviation of hydrosoluble nutrients. Of the tested concentrations, the optimum PPSt level was 100 g Kg^{-1} in fish meal (60%) based formulas.

Keywords:Aquafeed, potato starch, functional properties.

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The Effect of Glandless Cottonseed Meal Content and Process Parameters on the Functional Properties of Snacks during Extrusion Cooking

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ABSTRACT

The results of the present study indicate that glandless cottonseed meal (CSM) can be incorporated in extruded corn flour snacks at a 10% content level, which increases snack protein content to 12.8% and reduce fat content to 6.2%. To improve snacks' nutritional quality, CSM and corn flour were extruded using a simple screw extruder. An expansion index (EI) ranging of 1.2 - 4.7 was obtained. Penetration force (PF) was 7 - 9 times harder than other extruded products. High extrusion temperature and high CSM concentrations decreased ($p < 0.05$) EI, water activity, and water absorption index. Higher CSM concentrations can be incorporated into extrudates if snacks are processed at higher extrusion moistures. CSM increased ($p < 0.05$) extrudates' PF giving them a unique crunchy texture. CSM decreased ($p < 0.05$) extrudates' water solubility index. Extrusion conditions used showed a 68.5% starch gelatinization, and a starch availability of more than 97%, which explains the high expansion index obtained.

Keywords: Cottonseed Meal; Extruded Snack; Functional Properties

1. Introduction

It is generally accepted today that, in order to adequately feed the world's rapidly expanding population, increasing amounts of plant proteins should be directly used in human diets. A feasible option is to use protein obtained from the cotton plant. Cotton should rank high among crop production priorities since it provides fiber, a renewable resource for garment manufacturing, as well as edible oil and protein for human consumption and animal feed [1]. However, it contains gossypol, a natural phenollic aldehyde that permeates cells and acts as an inhibitor for several dehydrogenase enzymes [2], it can cause negative effects on growth and reproductive performance, and it can also result in intestinal and internal organ abnormalities [3-5]. Glandless cottonseed flour could potentially be used as raw material for the production of texturized protein products. This is achieved by genetically eliminating the toxic compound gossypol from the cottonseed [6]. Cottonseed meal (CSM) is obtained by grinding the flakes once most of the cottonseed oil has been removed.

Hominy is obtained through a process called nixtamalization, which is a traditional alkali treatment in which corn is precooked with $Ca(OH)_2$, conditioned for 6 - 18 h, and ground to produce corn flour (Gomez *et al.*, 1991). Tortilla and other corn products are made from corn flour [7-10]. During nixtamalization, partial starch gelatinization and retrogradation take place, while starch birefringence decreases [8-12]. Nixtamalization increases Lys/Iso ratio, Ca content, and protein digestibility and decreases aflatoxin contamination [13-17].

Extrusion is inexpensive, productive and requires low levels of energy [18]. Snacks can be extruded products [17]. Because starch gelatinization provides texture and structure to the end-product [19,20], it is possible to produce extrudates from pure starch or high starch content cereals. Because of cottonseed meal's relatively high protein and fat content and its low starch content, extrusion of cottonseed meal is complicated. Other results show that high protein legumes can be extruded, obtaining an expansion index ranging between 1.5 and 2 at 18% of moisture [21]. Expansion, in general, increases with higher extrusion moisture, pressure and temperature [22]. Al-

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Degradabilidad ruminal *in situ* y digestibilidad *in vitro* de diferentes formulaciones de ensilados de maíz-manzana adicionados con melaza

In situ ruminal degradability and *in vitro* digestibility of silages of maize and apple waste added with molasses

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Resumen

Se evaluó el efecto de la adición de manzana de desecho (ripio) y melaza en ensilados de maíz sobre las características nutricionales y de digestibilidad *in vitro* (digestibilidad verdadera *in vitro*, IVTD) e *in situ* (DISMS), de acuerdo a un arreglo de tratamientos factorial (4x3), con cuatro niveles de manzana (0, 25, 50, y 75%) y tres niveles de melaza (0, 5, y 10%). Se determinó el contenido de MS, PC, EE, FC, Cenizas, ELN, FDN, FDA y se calculó el TND, ED y EM de las mezclas. IVTD consistió en la incubación de las muestras con líquido ruminal durante 48 h, seguida del tratamiento del residuo con una solución neutro-detergente. DISMS se realizó en dos vacas fistuladas con tiempos de incubación de 0, 3, 6,

Abstract

The effect of different apple and molasses concentrations on maize silage was tested on its nutritional characteristics and *in vitro* true digestibility (IVTD) and *in situ* dry matter digestibility (ISDMD) according to a factorial arrangement (4x3), with four apple (0, 25, 50 and 75%) and three molasses levels (0, 5 and 10%). Nutritional characteristics included DM, CP, EE, CF, NFE, NDF, ADF and TDN, DE and ME calculations. The *IVTD* method consisted in the incubation of samples with ruminal liquid for 48 h, followed by the residue treatment with a neutral-detergent solution. ISDMD was performed using two rumen fistulated cows at incubation times of 0, 3, 6, 12, 18, 24, 35, 48, 72, 96 and 144 h.

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ANIMAL SCIENCE

Inhibition of the growth of rats by extruded snacks from bean (*Phaseolus vulgaris*) and corn (*Zea mays*)

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Abstract

There is a need to develop new food products with high protein quality and a high caloric value, high acceptability and low costs for low income families. The aim of this investigation was to evaluate in vivo an extruded bean–corn product, supplemented with Ca and Zn, as a potential nutritional snack. Extruded and non-extruded bean-corn flours were fed to rats. Antinutritional factors, rat weight and length, femur weight and heart weight and volume were determined. Microscopy pictures of rat liver were taken. The antinutritional factors present in the studied bean variety did not affect rat growth or internal organ characteristics. Bean-corn diets affected ($p<0.05$) rat weight and produced liver alterations, probably because of interference by bean protein with intestinal or systemic metabolism. Ca and Zn supplementation is not necessary in a bean-corn extruded snack for rats.

Key words: Bean flour, Extrusion, Maize flour, Mineral supplementation, Steatosis

Introduction

Malnutrition is common among neonates and infants in developing countries. There is a need to develop new food products with high protein quality and a high caloric value, high acceptability and low costs for low income families (Kannan et al., 2001; Hussain et al., 2010; Atienzo-Lazos, 2011; Rodriguez-Miranda et al., 2011, 2012).

Legumes play an important role in the diet of many people throughout the world. They are drough resistant and salt-tolkerant (Messina, 1999; Sagarpa, 2004; Akhtar et al., 2010; Rao and Shahid, 2011). Beans are rich in lysine but deficient in sulfur amino acids. On the other hand, corn contains high amounts of sulfur amino acids, but is poor in lysine. A combination of legumes and cereals can result in a product with high protein quality, even comparable to casein (Gujska and Khan, 1990; Stoecker et al., 2006; Dhingra and Jood, 2007; Hussain et al., 2010; Giwa and Ikujenlola-Abiodun, 2010; Atienzo-Lazos, 2011; Rodriguez-Miranda, 2012).

Beans and corn, as well as other plants, have antinutritional factors that affect growth, nitrogen balance, intestinal sugar and amino acid absorption, and the immune system, and reduce the bioavailability of cations (Mamiro et al., 2001; Manary et al., 2002; Devine 2002; Marzo et al., 2002; Nestares et al., 2003; Boccio and Monteiro, 2004; Dhingra and Jood, 2007; Martinez et al., 2012). Phytic and oxalic acid, which are present in cereals and legumes, can bind minerals such as Ca, Fe and Zn, reducing the availability of these minerals in cereal foods (Ockenden, 1997; Zhou and Erdman 1995; Adams et al., 2002; Lönnerdal et al., 2011). Phosphate can cause significant zinc loss and influence its bioavailability. Dehulling can reduce phytic acid content by 60 – 90% in cereals, since phytic acid is located principally in the germ and aluerone layer (Hatzack et al., 2000; Linares et al., 2007; Lönnerdal et al., 2011). Although phytate is the principal chelating agent, water-soluble components are responsible for 39% of the binding power of whole bran (Linares et al., 2007). Other

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Original Article

Effect of Moisture, Extrusion Temperature and Screw Speed on Residence Time, Specific Mechanical Energy and Psychochemical Properties of Bean Four and Soy Protein Aquaculture Feeds

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Abstract

The aim of this study was to evaluate the effect of moisture supply, temperature and screw speed on specific mechanical energy and functional properties of extruded feed for aquaculture bean flour and soy protein. Fishmeal was replaced by different concentrations of bean flour or soy protein. Subsequently, the diets were extruded and residence time, specific mechanical energy, absorption rate and solubility in water were analyzed. Temperature and screw speed had a significant effect (P <0.05) on the residence time and specific mechanical energy of extruded diets replaced with bean flour and soy protein. The initial moisture content only affected (P <0.05) the control diet (without vegetable protein). Therefore, we can conclude that the temperature and screw speed are the most important factors in the extrusion of diets replaced with bean flour and soy protein in a range of 15 to 45% for bean flour and 15 to 45% for soy protein.

Key words: Oncorhynchus mykiss, aquaculture feeds, bean four, extrusion

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Original Article

Effect of Sodium Alginate on Functional Properties of Extruded Feed for Fish for Human Consumption

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Abstract

Agglutinating compounds are commonly used to improve the physical quality of aquafeeds. An evaluation was done of the effect of the agglutinating compound sodium alginate on the functional properties of aquaculture fish feed produced by extrusion. Meals containing one of four sodium alginate concentrations (0, 0.5, 1.5 and 2%) were extruded in a simple-screw extruder at 120 °C, 20% moisture content and a 1:1 compression ratio, extruding each treatment in duplicate. Expansion index values ranged from 1.11 to 1.12 with no differences ($P > 0.05$) between the diets containing sodium alginate. In contrast, the different sodium alginate levels had positive ($P < 0.05$) effects on water absorption index values (2.24 to 2.79 g/g), water solubility index values (10 to 12.94%), sinking velocity (6 to 8.56 cm/s) and hardness (1.98 to 3.31 N). Maximum hardness (3.31 N) was produced in the 2% sodium alginate diet. The highest sodium alginate level tested (2%) had the most appropriate physical and functional properties for an extruded fish meal-based (62%) aquaculture fish feed.

Key words: Aquaculture, sodium alginate, hardness, functional properties, extruded feed

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Study of the Rheological Properties of a Fermentation Broth of the Fungus *Beauveria bassiana* in a Bioreactor Under Different Hydrodynamic Conditions

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Fermentation with filamentous fungi in a bioreactor is a complex dynamic process that is affected by flow conditions and the evolution of the rheological properties of the medium. These properties are mainly affected by the biomass concentration and the morphology of the fungus. In this work, the rheological properties of a fermentation with the fungus *Beauveria bassiana* under different hydrodynamic conditions were studied and the rheological behavior of this broth was simulated through a mixture of carboxymethyl cellulose sodium and cellulose fibers (CMCNa-SF). The bioreactor was a 10 L CSTR tank operated at different stir velocities. Rheological results were similar at 100 and 300 rpm for both systems. However, there was a significant increase in the viscosity accompanied by a change in the consistence index, calculated according to the power law model, for both systems at 800 rpm. The systems exhibited shear-thinning behavior at all stir velocities, which was determined with the power law model. The mixing time was observed to increase as the cellulose content in the system increased and, consequently, the efficiency of mixing diminished. These results are thought to be due to the rheological and morphological similarities of the two fungal systems. These results will help in the optimization of scale-up production of these fungi.

Keywords: Rheology, hydrodynamics, filamentous fungus, simulation bioprocess

The fermentation broth of microorganisms, especially filamentous fungi, is a complex rheological system where the accumulation of biomass or biosynthesized product leads to the continuous modification of the rheological properties of the medium produced in a bioreactor. Moreover, this medium is heterogeneous owing to cavern formation and recirculation. Under these conditions, one of the most important problems to be solved is to establish an adequate flow regime and processing parameters to carry out an optimal fermentation. Another problem arises when microorganisms such as filamentous fungi produced in the fermentation are sensitive to high shear stress [5]. The thread-like form of these fungi creates tridimensional network systems that produce highly viscous and non-Newtonian fermentation soups where mass transfer and homogenization are restrained. The implementation of high stir velocities is a common approach to overcoming these problems. However, high mechanical stress can result in cellular damage, leading to fungal cell differentiation [16, 17]. In recent years, there has been an increasing interest in the study of the optimization of the CSTR process conditions in terms of mixing times [5, 8, 14, 15, 18], power consumption [4], rheological behavior [1, 6], and chemical and morphological analyses [2, 9, 15]. On the other hand, given the complex morphology of the fungi involved, it is clear that monitoring is required at the macro and microscopic levels (evolution of the flow properties and image analysis) of the broth for proper control of the filamentous solution fermentation process. The optimization of this process is necessary since these types of fungi are of great importance owing to their insecticidal activity, which controls a variety of insect pests. The disadvantage of working with these microbial systems is a high risk of contamination, excessive costs, time constraints, and also the fact that the biomass concentration and morphology of these broths contribute significantly to modification of the rheological behavior of these systems; high viscosity and

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Original Article

Effect of Moisture and Temperature on the Functional Properties of Composite Flour Extrudates from Beans (*Phaseolus vulgaris*) and Nixtamalized Corn (*Zea mays*)

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Abstract

Beans have high protein content. Bean and corn flours can complement each other with essential amino acids. There has been little research on the production of snacks or extruded feed with bean–corn composite flours. The aim of this study was to obtain a bean–corn snack with high protein content for low-income families in the world. Bean–corn composite flours (60/40) were extruded. The effect of temperature and moisture during extrusion on the end quality of the product was analyzed. The expansion index, apparent density, water solubility index, water absorption index and the initial viscosity were measured and were significantly ($p < 0.05$) higher when bean–corn flour was extruded in high temperature and low moisture conditions. The best bean–corn extrudates was obtained in extrusion conditions of 190 ºC and 14.5% moisture. The results show that bean proteins can be complemented by corn proteins to obtain highly valuable protein flour. Extrusion is an alternative processing method for obtaining extruded products with high protein content for human or animal consumption.

Key words: Bean flour, nixtamalized corn flour, extrusion, functional properties

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Original Article

Optimization of the Extrusion Process Temperature and Moisture Content on the Functional Properties and *in vitro* Digestibility of Bovine Cattle Feed Made out of Waste Bean Flour

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Abstract

The main purpose of this research was to evaluate and optimize the effect of the extrusion temperature and moisture content on the functional properties of a bovine cattle feed made out of waste bean flour. In order to do so the methodology of response surface with a central composed design with star points was used, in which the independent variables were the temperature of extrusion and the moisture content; the response variables evaluated were the expansion index, bulk density, hardness, water absorption index, water solubility index and *In Vitro* digestibility. The diets were extruded on a simple screw extruder. On the statistical analysis of the most important response variables that influence the ruminal digestibility of the elaborated feed are water absorption index (WAI) and water solubility index (WSI), they presented a non-significant quadratic model and a significant model (0.5428 and 0.0202, respectively). In these models, it was observed that the linear term of the extrusion temperature was not significant in both cases, while for the WSI, the moisture content on its linear term did show a significant effect on the whole model on this response variable. In the WSI case, it was observed that the quadratic term of the temperature and its interaction with the moisture content presented a statistically significant effect. Under the experimental design evaluated it is concluded that it is possible to elaborate an extruded feed for bovine cattle with high values of solubility.Temperature and moisture content showed significative effect ($p < 0.05$) on WAI, WSI and BD.

Key words: Bovine cattle feed, digestibility, extruded

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Development of extruded snacks using taro (*Colocasia esculenta*) and nixtamalized maize (*Zea mays*) flour blends

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ABSTRACT

Extruded snacks were prepared from flour blends made with taro and nixtamalized (TF–NMF) or non-nixtamalized maize (TF–MF) using a single-screw extruder. A central composite design was used to investigate the effects of taro flour proportion in formulations (0–100 g/100 g) and extrusion temperatures (140–180 °C) on the following indices: expansion (EI), water solubility (WSI), water absorption (WAI) and fat absorption (FAI). Moreover, selected TF–NMF and TF–MF extruded products were partially characterized through proximate chemical analysis, resistant starch, color, pH, water activity, apparent density, hardness, and sensory analysis. Results indicated that EI and WSI of both TF–MF and TF–NMF extrudates were significantly increased by the use of higher proportions of taro flour, while the opposite behavior was observed for the FAI ($p < 0.05$). Taro flour at higher proportions in both extrudates did not produce a significant change of WAI, while the use of higher extrusion temperatures only caused a significant increase of FAI in TF–MF extrudates ($p < 0.05$). This study showed that flour mixtures made from taro and nixtamalized maize flour produced puffed extruded snacks with good consumer acceptance.

1. Introduction

Taro (*Colocasia esculenta* (L.) Schott) is an edible starchy tuber belonging to the *Araceae* family. Nowadays, this tuber is one of the most widely cultivated edible aroids in the tropical and subtropical regions of the world including West Africa and Indies, Asia, Caribbean, Pacific and Polynesian Islands and South America (FAO, 2008; Onwueme, 1999). Taro tuber crop cultivation in developing countries has taken importance in recent years due to its high fibre content (0.6–0.8 g/100 g), proteins (2–6 g/100 g), mucilage, vitamins, phosphorous, calcium and starch content (70–80 g/100 g d b), with small granules (1–4 μm) which are highly digestible in the gastrointestinal human tract (Sefa-Dedeh & Agyir-Sackey, 2002; Sefa-Dedeh & Agyr-Sackey, 2004). Despite their nutritional and health values, the use and consumption of taro tubers are generally limited by the fact that they are subjected to extensive post harvest losses as a consequence of their high moisture content, sustained metabolism, and microbial attack, leading to damage during harvest and storage (Agbor-Egbe & Rickard, 1991). These problems could be solved by converting the tubers from perishable to non-perishable products through food processing operations in order to manufacture new food products such as snack foods. These products have become a part of the feeding habits of the majority of the world population because they provide convenient portions and fulfill short-term hunger (Kuntz, 1996). One of the most important technologies which has shown great potential for the development of new snack products is extrusion cooking. Extrusion is a continuous food processing technique classified as a high temperature-short time operation in which raw food materials are thermo-mechanically cooked in a screw-barrel assembly by a combination of moisture, pressure and temperature in order to be mechanically sheared and shaped (Riaz, 2001). Product quality can vary considerably depending on the extrusion variables such as screw speed, feed moisture, temperature profile in the barrel, feed rate and die geometry. Extruder type and chemical composition of raw materials also affect product characteristics (Guy, 2001; Riaz, 2001).

Cereal grains are the commonest raw materials employed in the manufacture of extruded products (Ding, Ainsworth, Plunkett,

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Research Article

Mixing Analysis for a Fermentation Broth of the Fungus *Beauveria bassiana* under Different Hydrodynamic Conditions in a Bioreactor

The performances of radial-axial flow (Rushton-Maxflo impellers) and axial-radial flow (Maxflo-Rushton impellers) mixers in the laminar-transitional flow regime were experimentally and numerically investigated with Newtonian and non-Newtonian fluids. The rheological properties for a fermentation broth consisting of the fungus *Beauveria bassiana* were studied under different hydrodynamic conditions in these systems. The bioreactor was a continuous stirred-tank reactor (CSTR), set at different stirring velocities. The rheology of the systems exhibited shear-thinning behavior which was modeled with the power law model. The experimental hydrodynamics and configuration modes were compared and simulated with a model fluid system and by numerical criteria (computational fluid dynamics). The R-M mode was found to be more efficient than the M-R rotating mode in terms of energy and homogenization time. The results will help in the optimization of scale-up production of these fungi.

Keywords: Bioreactor, Filamentous fungus, Hydrodynamics, Numerical simulation, Rheology

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1 Introduction

The characteristics of a mixer are particularly critical for the economical aspects and quality of the end product. Typically, the design is based on process objectives, taking many variables into account. For example, the high viscosity of the phases usually restricts the mixing process to the laminar-transitional regime due the inefficiencies involved in generating turbulent instabilities under such conditions. Nowadays, the industry demands impellers that can work in laminar, transitional, or turbulent regimes with minimum modifications, particularly in biological systems where the preferred regimes are laminar and transitional. On the other hand, open impellers such as the Rushton (R) and Maxflo (M) are known to be highly efficient at high Reynolds numbers, but in a laminar regime, segregated zones are produced [1]. The situation becomes critical if during the process time the phases to be mixed develop high viscosity and non-Newtonian behavior such as shear-thinning, as reported for fungal fermentation broths [2–5], affecting the bioreactor hydrodynamic properties. Filamentous fungi are widely used in various pharmaceutical, food, and enzyme-producing processes [6–8]. The filamentous fungi generate 3D networks, causing the formation of highly viscous and non-Newtonian broths, where mass transfer and homogenization of a culture broth are drastically limited. Another problem arises when microorganisms produced during fermentation are sensitive to high shear stress (filamentous fungi). The implementation of high stir velocities is a common practice to overcome these problems. However, high mechanical stress can produce fungi cellular damage leading to fungal cell differentiation [9, 10]. It is common to evaluate these systems through master curves of dimensionless numbers such as the power number (P_o) and the Reynolds number (Re), which characterize phenomenological hydrodynamics of a mixing system [11]. Foucault et al. [12] reported that by using dimensionless analysis, a slight modification in the Re number definition can be meaningful to correlate experimental data (i.e., generalized master curves). In this manner, it was possible to build power consumption and homogenizing time master curves, valid for both Newtonian and non-Newtonian fluids [12]. Both experimental and numerical studies have been reported on the hydrodynamics of complex mixing systems involving multiple and independent impellers [13–15]. The

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Zinc bioleaching from an iron concentrate using *Acidithiobacillus ferrooxidans* strain from Hercules Mine of Coahuila, Mexico

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Abstract: The iron concentrate from Hercules Mine of Coahuila, Mexico, which mainly contained pyrite and pyrrhotite, was treated by the bioleaching process using native strain *Acidithiobacillus ferrooxidans* (*A. ferrooxidans*) to determine the ability of these bacteria on the leaching of zinc. The native bacteria were isolated from the iron concentrate of the mine. The bioleaching experiments were carried out in shake flasks to analyze the effects of pH values, pulp density, and the ferrous sulfate concentration on the bioleaching process. The results obtained by microbial kinetic analyses for the evaluation of some aspects of zinc leaching show that the native bacteria *A. ferrooxidans*, which is enriched with a 9K Silverman medium under the optimum conditions of pH 2.0, 20 g/L pulp density, and 40 g/L $FeSO_4$, increases the zinc extraction considerably observed by monitoring during15 d, *i.e.*, the zinc concentration has a decrease of about 95% in the iron concentrate.

Keywords: pyrite; pyrrhotite; bioleaching; zinc

1. Introduction

Conventional smelting methods require high-grade concentrates, while hydrometallurgical methods are less sensitive to the grade, which implies that priority can be given to recovery rather than grade in the flotation process. Currently, many researches by major mining companies are focused on bioleaching processes for the recovery of base metals, such as copper, nickel, and zinc [1-2]. Traditional extractions involve many expensive steps, such as roasting and smelting, which require sufficient concentrations of elements in ores. Low concentrations are not a problem for bacteria because they simply ignore the waste which surrounds the metals, attaining extraction yields over 90% in some cases. These microorganisms actually gain energy by breaking down minerals into their constituent elements [3-4].

Bioleaching is the extraction of specific metals from their ores by the use of bacteria through either direct or indirect mechanism. In the direct mechanism, metal sulfides are directly oxidized by *Acidithiobacillus ferrooxidans* (*A. ferrooxidans*) to soluble metal sulfates. In the indirect mechanism, ferric ions produced from the bacterial oxidation of ferrous ions react with metal sulfides chemically to produce Fe(II). Element sulfur which is naturally present or forms during the indirect oxidation of metal sulfides can be oxidized to sulfuric acid, leading to metal dissolution [5].

The habitats of *A. ferrooxidans* strains are geographically extremely diverse and vary in their physico-chemical conditions such as the presence of particular sulfide minerals and their ratio, pH values, temperature, and the content of toxic compounds in the liquid phase [6-7]. The aim of this investigation was to analyze a hydrometallurgical process, which is considered an efficient bioleaching zinc removal process and applied to mineral iron concentrates containing mainly pyrite and pyrrhotite from Hercules Mine of Coahuila, Mexico, using the native strain of *A. ferrooxidans*, and the

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Distribución de intrones en cepas de *Bacillus thuringiensis*

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Los intrones se encuentran presentes en los tres dominios de la vida, y se cree que están relacionados al origen evolutivo de las especies, ya que muchas veces su transferencia es horizontal, a través de genomas de especies estrechamente relacionadas.[1] Dentro de los organismos procariotas, los intrones del grupo I y II de bacterias son de gran importancia, ya que además de actuar como ribozimas (RNA catalíticos) contienen marcos de lectura abiertos (ORF) que codifican enzimas de gran potencial biotecnológico. Tal es el caso de las Homing Endonucleasas (HE), un tipo de enzima de restricción muy selectiva codificada en intrones del grupo I, encargada de copiar el intrón en secuencias homólogas del DNA.[2]

Los intrones II, por su parte, pueden codificar para enzimas con actividad de Transcriptasa Reversas (RT), estas enzimas son únicas, ya que sintetizan cDNA a partir de RNA[3] y han sido empleadas ampliamente en el análisis del transcriptoma de organismos por la técnica de RT-PCR.

Así pues, la identificación de los intrones en bacterias como *Bacillus thuringiensis*, importante desde el punto de vista de la genómica básica, da un panorama de la transferencia horizontal y vertical de material genético entre las cepas de esta especie.

Además, es aplicable para el manejo de enzimas que puedan ser empleadas en estudios de biología molecular y el estudio de la eficiencia catalítica de nuevas ribozimas, que puedan ser probadas en tratamientos para el silenciamiento de genes, en patologías oncogénicas o virales.

Materiales y métodos

Cepas y conservación

En este estudio fueron analizadas 50 cepas de *Bacillus thuringiensis*. La conservación y activación fue seguida con base en el protocolo descrito por Sambrook *et al.*[4]

☐ El presente artículo está basado en la investigación "Distribución de intrones en cepas de *Bacillus thuringiensis*", galardonada con el Premio de Investigación UANL 2011, en la categoría de Ciencias de la Tierra y Agropecuarias, otorgado en sesión solemne del Consejo Universitario, en septiembre de 2011.

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