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Meeting of Food Engineering

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V Jornada de Ingeniería en Alimentos
Tuxtepec, Oax
Oct 16, 2018
Extended Abstract

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Welcome

We welcome all the participants. We appreciate the support given to the call for Meeting of Food Engineering 2018 by social networks: Rerearchgate, Facebook, Twitter, Linked in, Whatsapp, CONACYT press, Tab UNAM, email and <http://www.bio.edu.mx>

The areas for submitting extender abstract were classified as follows

Num	*Area categories/Division*	*Example:*
I.	*Education, Extension, Teaching & Learning*	*Education from elementary school to adulthood. Research opportunities, innovative teaching methods & learning techniques, effective methods for serving your clientele and examples of successful outreach. General teaching and learning strategies, improving students critical thinking, TICs, simulation, WHO, Codex*
II.	*Food Chemistry*	*Chemistry and analysis of foods, bulking agents, carbohydrates (cereals, grains, seeds, legumes, pulses)*
III.	*Food Engineering*	*Measurement, modeling, optimization and control of food processing systems. (Distillation, fermentation, nanotechnology. drying, transport processes, (bio) chemical reactors, extraction, dehydration, crystallization, food frying, nonlinear systems, cost of production and transportation, instrumentation of processes, techniques of optimization and decision applied to food processes and impact of automation in food engineering).*
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XII.	*Public Policy, Food Laws And Regulations*	*Practical, real world implication for food and feed industry of legislative, regulatory, and judicial developments in Mexico and global scale. Non GMO, Organic, etc.*
XIII.	*Quality Assurance*	*Quality assurance, quality control, and food wholesomeness*
XIV.	*Refrigerated & Frozen Foods*	*Preservation of foods employing refrigeration or freezing technology*
XV.	*Sensory Science*	*Advancements in the science of sensory and consumer research, for product development and marketing research*
XVI.	*Sustainability*	*Biotechnology, Food Security, Food Waste, Life Cycle Analysis, Water, Management & Energy Management*
XVII.	*Toxicology & Safety Evaluation*	*Science and technology of toxicology and safety evaluation relevant to foods or food components.*

We invite you to be part of Mexican Society of Biotechnology and Bioengineering Oaxaca Delegation.

The International Biotechnology Foundation is a nonprofit, international association dedicated to dissemination of Biotechnology in an inclusive way.

The next Meeting of Food Engineering Conference / VI Jornada de Ingeniería de Alimentos on Tuxtepec Oaxaca will be held next October 16, 2019, at Universidad del Papaloapan to continue its legacy of providing a vital forum for the food research community. It will present the latest advances in food engineering as a multidisciplinary field.

Sincerely

Susana Lozano Muñiz
Universidad el Papaloapan
Sociedad Mexicana de Biotecnología y Bioingeniería Delegación Oaxaca
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Content

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Speaker Session

Title of Speech:

Enzymatic Hydrolysis of Starch for the Food and Fermentation Industries

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Starchy materials have high impact on the economy of the countries, not only on food and fermentation industries but also others such chemistry industry. New technologies for farming have increased the productivity of the crops, then, it is possible to harvest more tons of crops per hectare of land to produce starch. Starches are very important in the diet of human being. The hydrolysis of starch generates products such maltodextrins, maltose, high syrup fructose and glucose. Upon the conversion of starch for instance to glucose, the possibilities to expand the use of the starches is very huge. Food industry use the products of the hydrolysis of starch for modifying texture, enhance flavors, improve shelf life, etc. Moreover, glucose can be used for fermentation industry which represent a very profitable industry by adding economic value to the starchy materials. Here we highlight the enzyme hydrolysis of starch for the food and fermentation industries and some discoveries by the authors.

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Keywords: Starchy materials, enzymatic hydrolysis, fermentation industry, glucose.

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International consultant for the United Nations Organization for Industrial Development.

Business consultant in Japan, Malaysia, Singapore, Indonesia and Thailand.

He has published more than 50 international articles.

Extended abstract

AREA I *Education, Extension, Teaching & Learning*

Food Engineering in University System of the state of OAXACA

Susana Lozano Muñiz[1,2,3] , María del Carmen Urzúa Hernández[4]

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Abstract: An analysis of the Database web site available about Careers and Bachelor's degrees in Food Engineering and System of the state of Oaxaca (SUNEO) was carried out, comparing it with biotechnology. Higher education constitutes the most important gateway to the knowledge about society, since it represents the ideal means for enhancement of human capital and its individual and collective intelligence: World Conference on Higher Education organized by the UNESCO, (1998). It is required to make a great effort to promote the career as the Meeting of Food Engineering 2018 <www.bio.edu.mx/mfe>, and spread the advantages of studying this career and maintain a direct relationship with the productive sector in order to understand its correlation between what is produced in higher education and what the productive sector requires.

Key words: Education, food, Universities in Mexico

Introduction: to avoid hunger in world we need to study food and try to spread this knowledge, about diverse needs of the agri-food sector helped and several career options that impact on food production. Food Engineering bachelor at SUNEO is a low number of applicants, to pursue the career of food engineering, It is required to implement strategies to increase the number of applicants and graduates.

Materials and methods: An exhaustive search was carried out for data analysis and comparative graphs in several databases such as google, SUNEO, and SEP.

Results and discussion: Engineering in Food is one of the university careers that places its studies in the bromatological field. It is responsible for analyzing the transformations and

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processes suffered by raw materials for human consumption, also responsible for innovation and improvement of edible products. The objectives of this branch of study are linked to the development of food conservation for as long as possible, avoiding losing food nutrients, reducing resources in the creation of food and achieving maximum use of raw materials. Those interested in studying this type of program should be oriented to bromatological research, to biology, to work with systematized information and to innovation. The occupational land that occurs in this area, is located in food industries, in research and development, in the import or export of food, in the control and supervision of industries of this nature, in the packaging industry, in the manufacture of raw materials and in teaching.

Figure 1. Adult education level OECD Bellow upper secondary / Tertiary/ Upper secondary % of 25- 64 years old 2016.

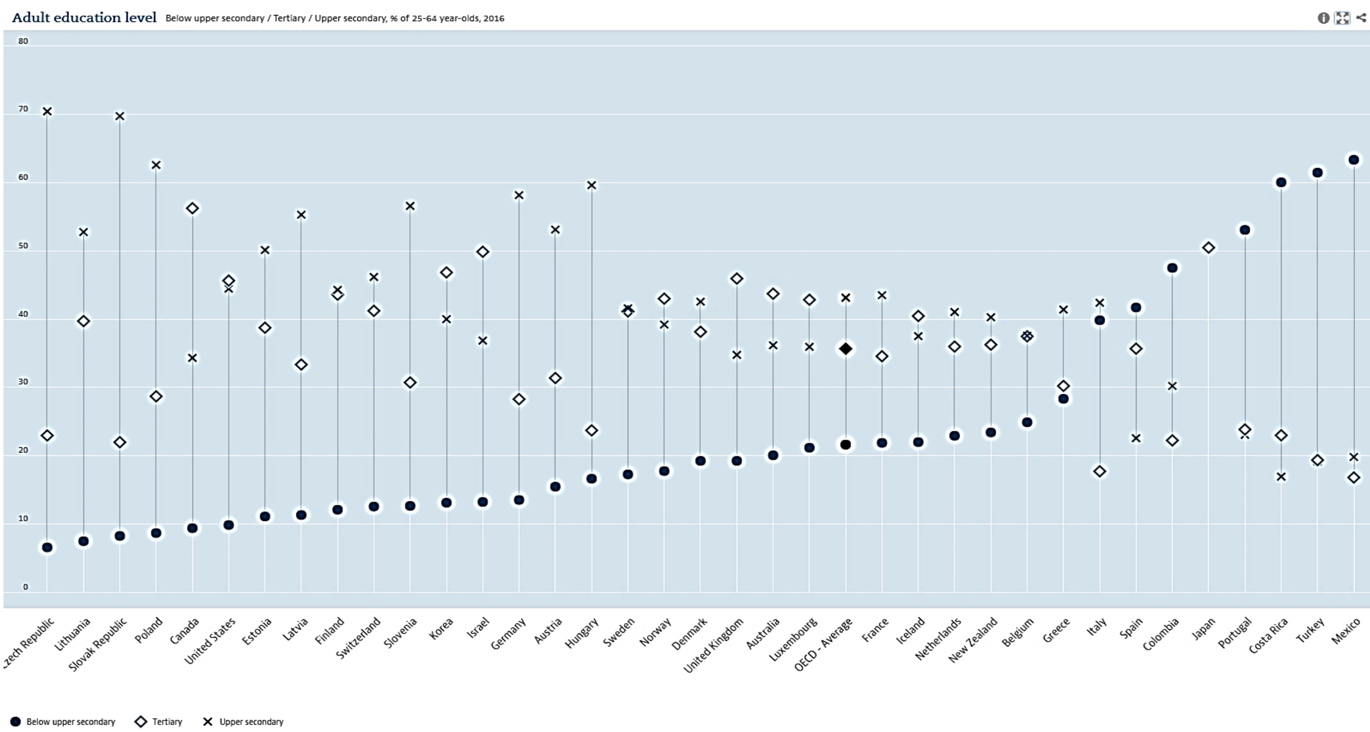

Figure 1 shows a map indicating the academic life expectancy after high school with gender parity, the last place is for Mexico and the first place is for Czech Republic.

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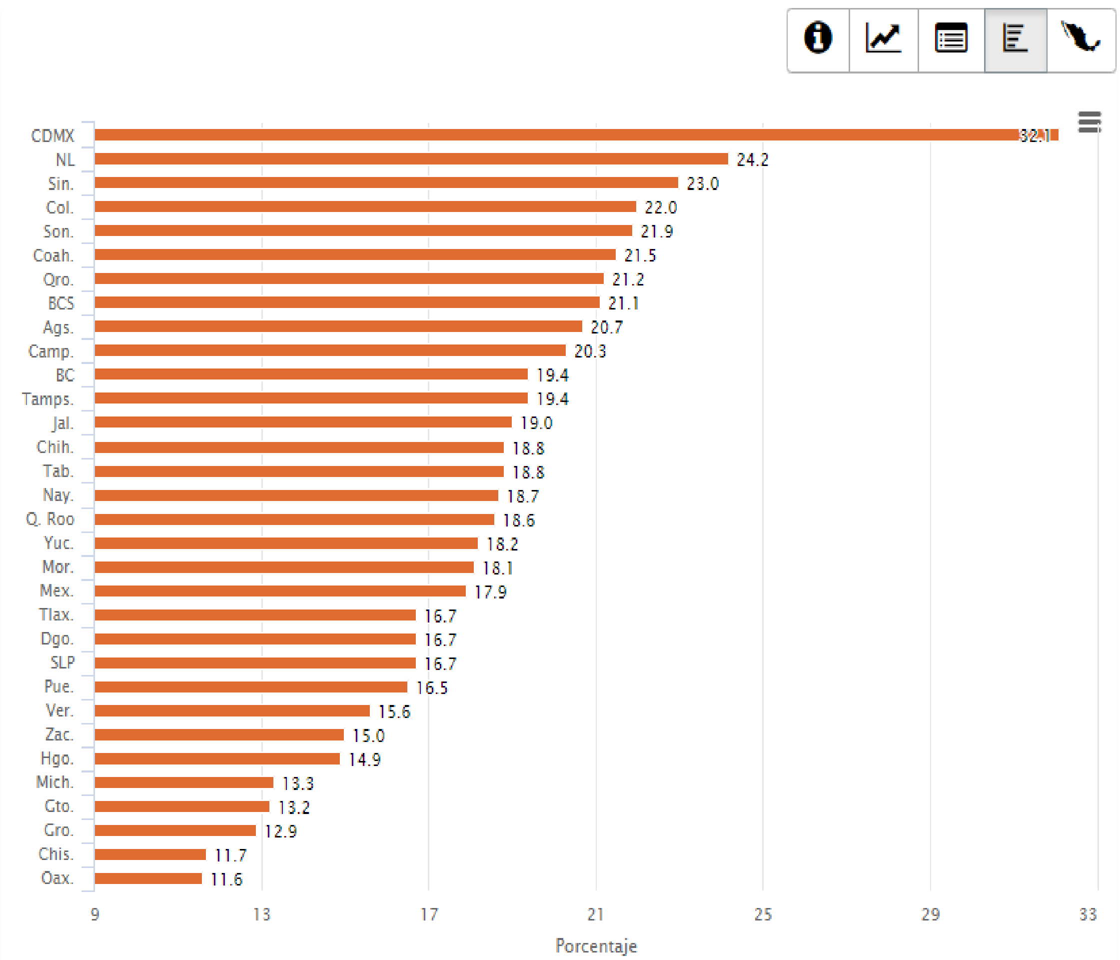
Figure 2. Percentage of the population aged 15 and over with higher education 2015. INEGI.



In Figure 2 we can observe data from INEGI about the number of persons in Mexico with higher education 2015, Oaxaca have the last place in the table with an 11.6%.

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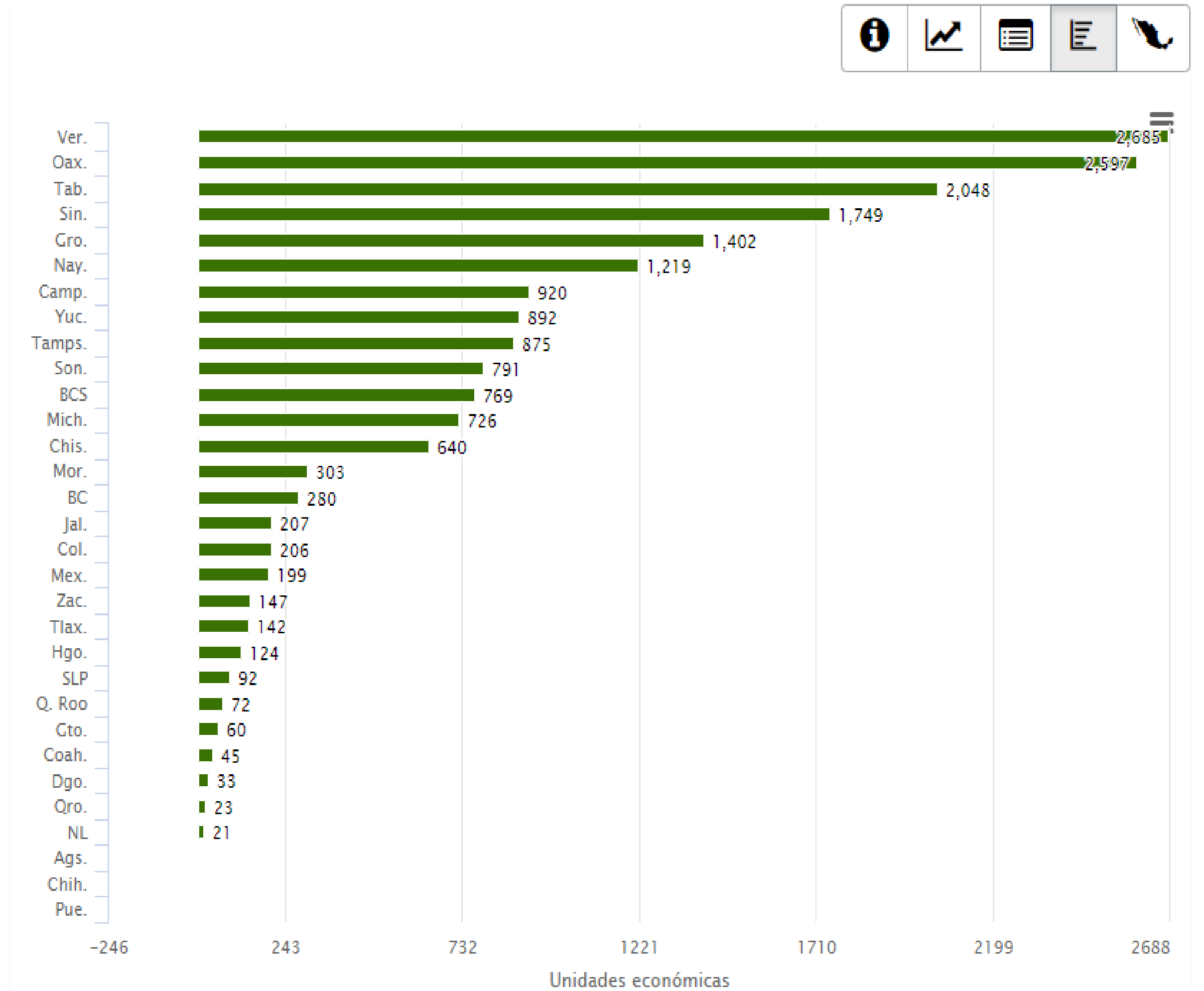
Figure 3. Economic units' sector 11 fishing and aquaculture (economic units) 2015. INEGI.



In Figure 3 We can see the production in the area of agriculture, cattle raising and fishing, specifically, fishing and aquaculture production in Mexico by state of Mexico, and the states with less infrastructure of education have more production of this area. This states produce a lot of food but they can´t obtain the infrastructure for education. The second one is Oaxaca.

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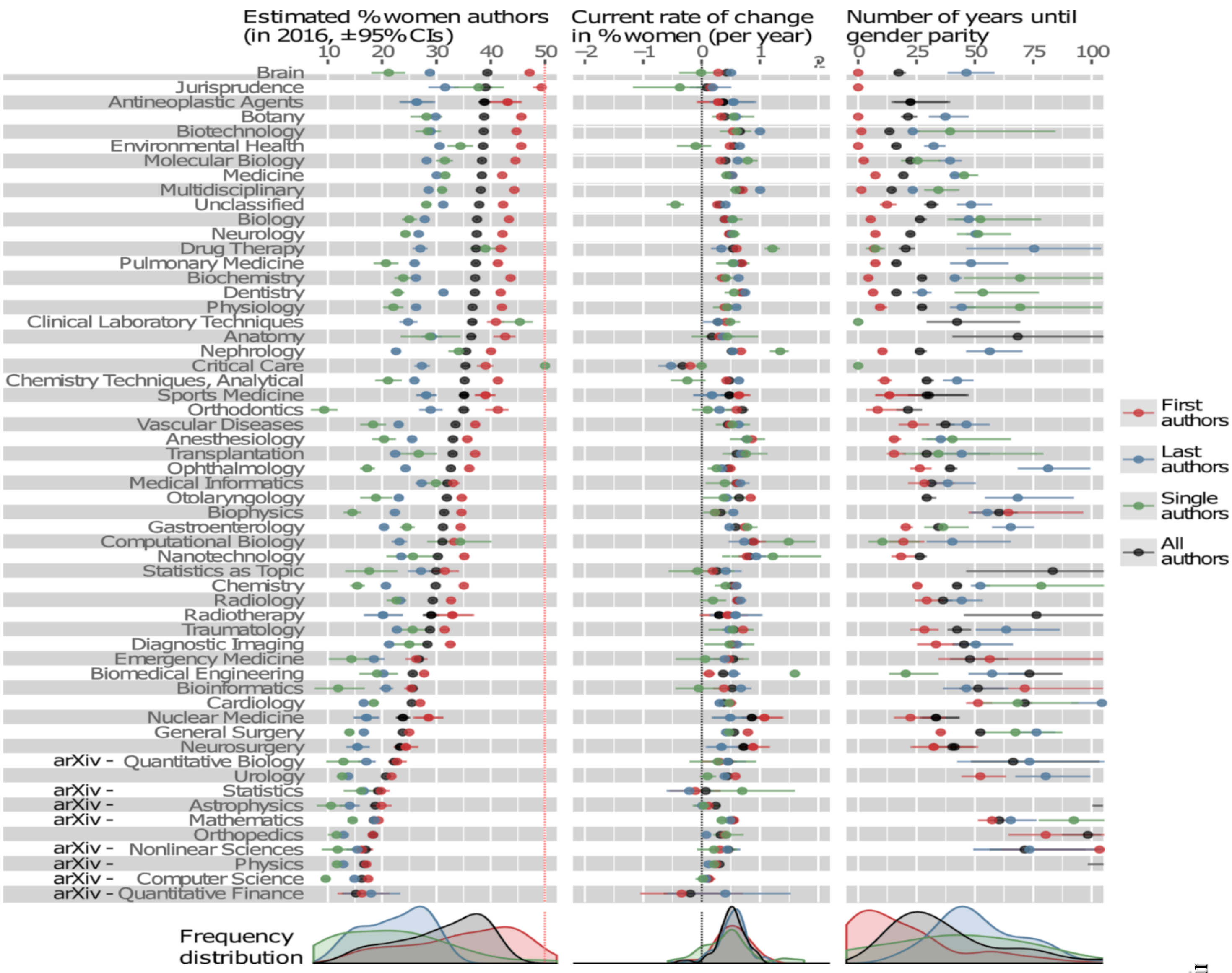
Figure 4. This figure is obtained from the article: The gender gap in science: How long until women are equally represented? Luke Holman Devi Stuart-Fox Cindy E. Hauser.



In Figure 4: The panels show the current author gender ratio, its rate of change per year, and the estimated number of years until the gender ratio comes within 5% of parity

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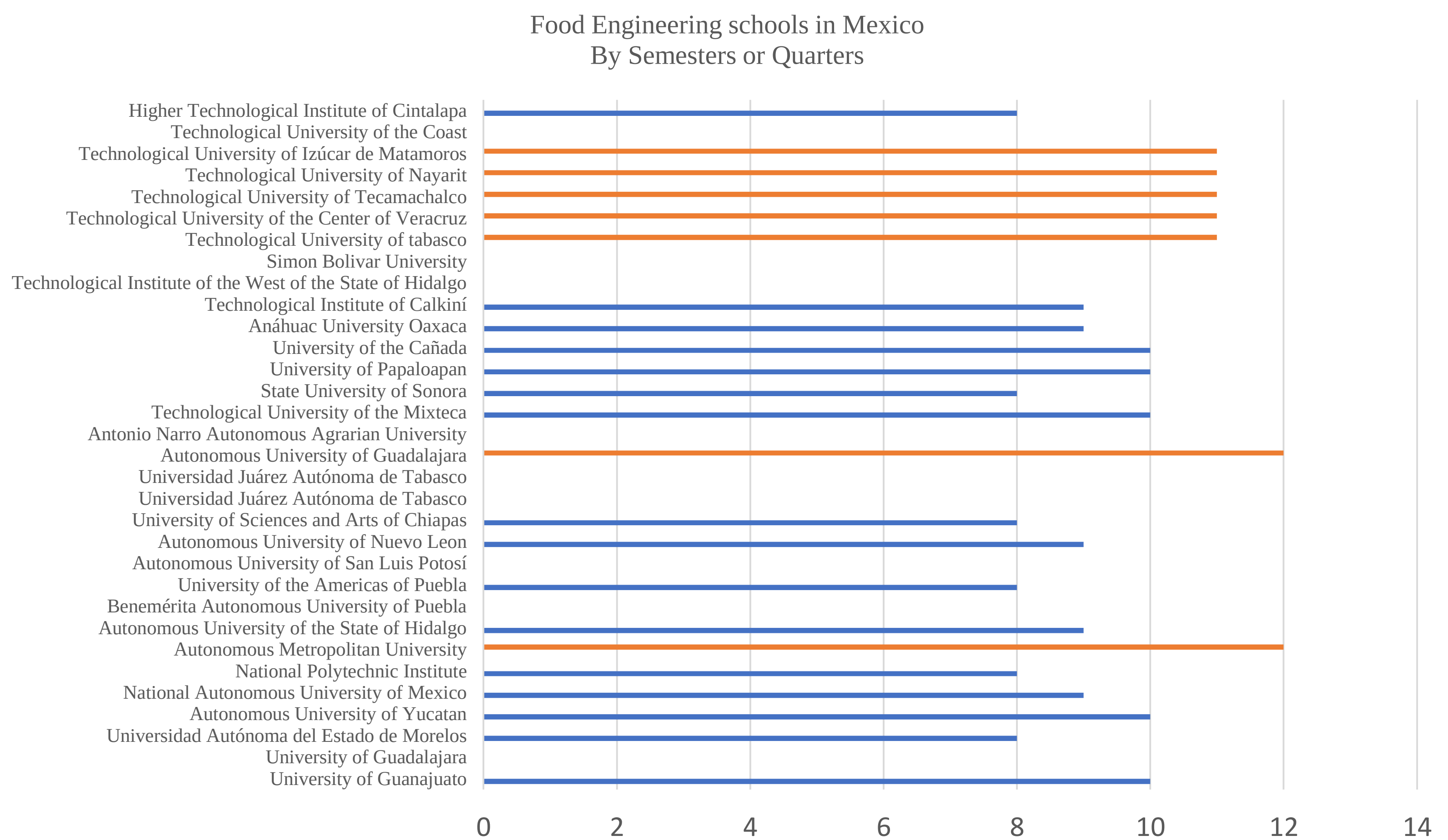
Figure 5: Food Engineering schools in Mexico by semesters or quarters. https://universidadesdemexico.mx/carreras/ingenieria-en-alimentos



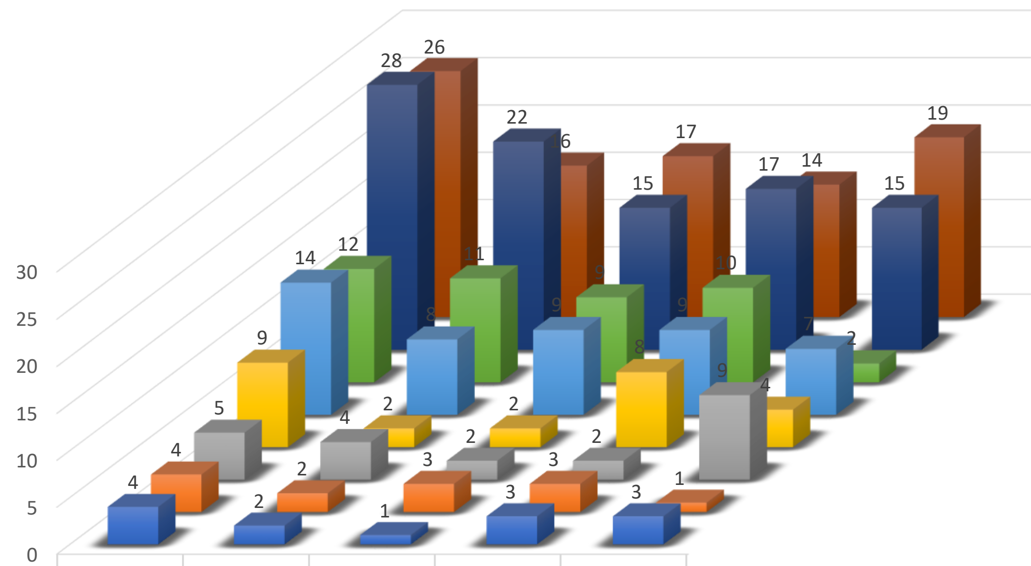
	University of Guanajuato	University of Guadalajara	Universidad Autónoma del Estado de Morelos	Autonomous University of Yucatan	National Autonomous University of Mexico	National Polytechnic Institute	Autonomous Metropolitan University	Autonomous University of the State of Hidalgo	Benemérita Autonomous University of Puebla	University of the Americas of Puebla	Autonomous University of San Luis Potosí	Autonomous University of Nuevo Leon	University of Sciences and Arts of Chiapas	Universidad Juárez Autónoma de Tabasco	Universidad Juárez Autónoma de Tabasco	Autonomous University of Guadalajara	Antonio Narro Autonomous Agrarian University	Technological University of the Mixteca	State University of Sonora	University of Papaloapan	University of the Cañada	Anáhuac University Oaxaca	Technological Institute of Calkiní	Technological Institute of the West of the State of Hidalgo	Simon Bolivar University	Technological University of tabasco	Technological University of the Center of Veracruz	Technological University of Tecamachalco	Technological University of Nayarit	Technological University of Izúcar de Matamoros	Technological University of the Coast	Higher Technological Institute of Cintalapa
Quarters	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	11	11	11	11	11	0	0
Semester	10	0	8	10	9	8	0	9	0	8	0	9	8	0	0	0	0	10	8	10	10	9	9	0	0	0	0	0	0	0	0	8

Quarters Semester

Proceed

In Figure 5 we can see different kind of schools, with a bachelor about food engineering.

Figure 6: Data of number of students who study Food Engineering bachelors at SUNEO in the website of Sistema Nacional de Información de Escuelas. http://snie.sep.gob.mx/SNIESC/



	1st Grade	2nd Grade	3rd Grade	4rd Grade	5ve Grade
FOOD ENGINEERING UNCA 16-17	4	2	1	3	3
FOOD ENGINEERING UNCA 15-16	4	2	3	3	1
ING EN ALIMENTOS UNPA 16-17	5	4	2	2	9
FOOD ENGINEERING UNPA 15-16	9	2	2	8	4
ING DE LOS ALIMENTOS UTM 16-17	14	8	9	9	7
FOOD ENGINEERING UTM 15-16	12	11	9	10	2
BIOTECH ENGINEERING UNPA 16-17	28	22	15	17	15
BIOTECH ENGINEERING UNPA 15-16	26	16	17	14	19

Conclusion: We need to make some strategy to obtain resources for support students so they can finish high education. The students frequently have economic, health and family problems that impact their permanence. Oaxaca is a state with production of food as an example aquaculture production but this don't impact on improve infrastructure of education.

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4. Ingeniería en Alimentos - Carreras Universitarias y Licenciaturas https://universidadesdemexico.mx/carreras/ingenieria-en-alimentos Accessed october 2018
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AREA II *Chemistry and analysis of foods, bulking agents, carbohydrates*

Implementation of the optimal conditions of acid hydrolysis of mucilage powder and identification of different residues through thin plate chromatography

Becerril-Álvarez Doris Paola[1], Carpintero-Tepole Violeta[1], Vázquez-León Lucio Abel[1], Blancas-Cabrera Abel[2], Córdova-Aguilar María Soledad[1*].

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Abstract

Nopal mucilage is a complex heteropolysaccharide with alternating residues of rhamnose and galacturonic acid, and branches of arabinose and xylose in the galactose side chains. Severe hydrolysis conditions are reported with degradation of rhamnose and galacturonic acid. The mucilage used in these researches is obtained by precipitation with organic solvents. The main objective of this work is standardizer the hydrolysis technique and thin layer chromatography (TLC) for the characterization chemical of nopal mucilage powder (*Opuntia ficus-indica)* obtained by mechanical extraction (free of organic solvents) and spray drying. Proximal chemical and minerals analysis were carried out according to the official methods of the AOAC (1990) to know the mucilage composition. During the acid hydrolysis, 3 variables (temperature, time and acid concentration) are been studied to establish the adequate conditions to hydrolyze the mucilage without galacturonic acid degradation. Thin layer chromatography (TLC) is been stablished (mobile phase relation) to identify the monosaccharides (rhamnose, xylose, arabinose, galactose and galacturonic acid) that are present in the nopal mucilage powder. Nopal mucilage is formed by nitrogen-free extract (62%), ash (26%) and crude proteins (7%). Besides, mucilage powder is a source of potassium (68%), calcium (12%) and sodium (10%) and other minerals in lower concentration. TLC of hydrolyzed samples (8 h and strong acid) showed the presence of rhamnose and xylose but not galacturonic acid, galactose and arabinose. This can be attributed to that the monosaccharides are not being hydrolyzed for the short hydrolysis time

(8 h) it is necessary to continue studying the variables to establish under what conditions the presence of the 4 monosaccharides and galacturonic acid are obtained.

Keywords: nopal mucilage • hydrolysis • thin layer chromatography.

1 Introduction

Nopal mucilage is a heteropolysaccharide with a molecular weight from $2.3x10^4$ to $4.3x10^6$ *Da* and a sugar residues content of up to 30,000 (Sáenz *et al.*, 2004). Chemical structure characterization and sugars composition of nopal mucilage has been carried out by chromatographic techniques (Trachtenberg and Mayer, 1981). Most of these authors describe the mucilage is chemical structure as a complex chain, with alternating residues of rhamnose and galacturonic acid, where the sugars of arabinose and xylose are branches of the galactose side chains. There are differences in the chemical profile and carbohydrate content of the mucilage (Sepúlveda *et al.*, 2017). These variations are attributed to the extraction conditions, agroclimatic conditions and stage of maturity of the cladodes. However, other authors reported that mucilage hydrolysis and purification, extraction methods are not ideal (Sáenz *et al.*, 2004). Severe hydrolysis conditions (time, temperature and acid type) can degrade the rhamnose and galacturonic acid of the polysaccharide. Some investigations analyze cactus mucilage obtained by precipitation with organic solvents (ethanol and isopropanol). The objective of this work is to standardizer the thin layer chromatography (TLC) and hydrolysis techniques for the characterization chemical of nopal mucilage powder (*Opuntia ficus-indica)* obtained by mechanical extraction and spray drying. This work involves proximal chemical analysis and minerals analysis of mucilage to know it´s composition. An acid hydrolysis (weak and strong) considering 3 variables (temperature, time and acid type) to establish the adequate conditions to hydrolyze the mucilage without degradation of galacturonic acid. The hydrolyzed samples are then eluted on thin layer chromatography plates to identify the monosaccharides (rhamnose, xylose, arabinose, galactose and galacturonic acid) presents in the mucilage (Trachtenberg and Mayer, 1981; Salazar-Ramírez, 2018).

2 Materials and methods

2.1 Nopal mucilage extraction and spray drying process

A series of mechanical separation processes were used to obtain nopal extract according to Guzmán-Huerta (2018): milling of whole cladodes, centrifugation, sedimentation, decantation and vacuum filtration. Mucilage extract was dried using a Niro Atomizer spray dryer.

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2.1.1 Proximal chemical and minerals analysis

Proximal chemical analysis was carried out according to official methods of the AOAC (1990). The analyzes were humidity (drying in the oven), ethereal extract (Soxhlet method), ashes (incineration), raw fiber (acid and alkaline digestion) and crude protein (Kjeldahl method). Atomic absorption spectrometry was carried out to the determination of the minerals content (AOAC 927.02 method).

2.1.2 Acid hydrolysis of the mucilage

Dried mucilage (1 g) was resuspended in tridestilated water until a concentration of 2% (w/w). A 3^3 factorial design was used to evaluate the effect of acid hydrolysis on the monosaccharide separation. Independent variables were acid concentrations (10, 20 and 30% v/v), hydrolysis time (4, 6 and 8 h) and temperature (50, 80 and 95 ºC). The acidified samples with HCl (3 mL) at different concentrations were kept under reflux conditions at the temperature evaluated. The hydrolysis was stopped with the addition of $Ca(OH)_2$.

2.1.3 Thin layer chromatography (TLC)

Both "n-butanol:ethanol:tridestilated water" (5:4:2 v:v:v; solution-1) and "n-butanol:methanol:tridestilated water" (6:3:1 v:v:v; solution-2) were used as the mobile phase. The stationary phase was silica gel dispersed in glass plate (Macherey-Nagel GmbH. SIL G-25). The developer was a 10% (v/v) H_2SO_4 solution in methanol. The standards used were: arabinose, galactose, rhamnose, xylose and galacturonic acid. The samples were eluted and then were dried at 50 °C for 15 min in an oven. The plates were sprinkled with the developer solution and then dried at 100 °C for 15 minutes. The retention factor (Rf) was calculated according to Eq. (2.1).

$$Rf = \frac{Distance\ traveled\ by\ the\ sample\ (cm)}{Distance\ traveled\ by\ the\ solvent\ (cm)} \quad (2.1)$$

It should be noted that the application line of samples was not drawn on TLC plates. A rule on glass was used as support and apply the samples (1 cm separation).

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3 Results and discussion

3.1 Proximal chemical and minerals analysis

Proximal chemical composition and minerals content of the mucilage powder are shown in Table 1. Nitrogen-free extract (62.40%) was the highest fraction of the dry matter, which is similar to the reported by Abraján-Villaseñor (2008) (~70%) and Salazar-Ramírez (2018) (~62.68%). Crude protein (7.03%) was higher than reported by Abraján-Villaseñor (2008) (3-4%) and similar than obtained by Sepúlveda *et al.*, (2007) (6.1-7.9%) and Salazar-Ramírez (2018) (7.65%). Protein values from 4.0 to 10.0% have been reported for cactus flours, depending on the age of the cladode (Sepúlveda *et al*., 2007).

Table 1. Proximal chemical composition and minerals content of the cactus mucilage powder (*Opuntia ficus-indica)*.

Analysis	%	Mineral	g/100 g powder
Dry matter	96.16	Sodium	0.2590
Humidity	3.84	Calcium	0.3500
Crude protein	7.03	Potassium	1.8269
Lipids	0.75	Coober	0.0004
Ashes	25.97	Zinc	0.0100
Raw fiber	0.01		
Nitrogen-free extract	62.40		

Raw fiber content (0.01%) was lower than the results reported by Abraján-Villaseñor (2008) (0.1-1.3%) and similar to Salazar-Ramírez (2018) (0.02%). Ash content (25.97%) was similar to that reported by Abraján-Villaseñor (2008) (20.5-25.9%) and Salazar-Ramírez (2018) (25.93%). Ashes value obtained indicates a high mineral content in the mucilage powder (Table 2). The mucilage powder obtained in the present work is a source of potassium, calcium and sodium: 68, 12 and 10%, respectively. These values are similar to those reported in the literature for cactus *Opuntia ficus-indica* (Stintzing and Carle, 2005;

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Sepúlveda *et al.*, 2007). The composition of minerals depends on the type of species, place of harvest and physiological state of the cladode tissue.

Variations with respect to other authors (Sepúlveda *et al.*, 2007, Abraján-Villaseñor, 2008, Salazar-Ramírez, 2018) in the results obtained from proximal chemical composition and minerals content, are attributed that the mechanical extraction process does not contemplate the use of organic solvents. Most of the researches treated the cactus cladodes by long periods (8 to 24 h) at high extraction temperatures (100 ° C) and they carried out mucilage precipitation with organic solvents (Medina-Torres *et al.*, 2000, Sepúlveda *et al.*, 2007). The differences in chemical composition are also attributed to the agro-environmental conditions, such as: climatic conditions, soil type and age of the cactus (Stintzing and Carle, 2005).

3.2 Acid hydrolysis and thin layer chromatography (TLC)

Standards eluted with solution-1 needed 9 h for their separation, while that with the solution-2 was necessary only 5 h. Therefore solution-2 (n-butanol:methanol:tridestilated water, 6:3:1 v:v:v) was selected as mobile phase inTLC.

The polysaccharide separation in monosaccharides was not feasible at low concentrations of HCl (10% v/v), times (4 h) and temperatures (50 and 80 C). Hydrolysis at 95 ºC with 20 and 30% HCl allowed the monosaccharides separation. Thin layer chromatography of hydrolyzed samples with 20 and 30% HCl at times 6 and 8 h are shown in Figure 1. The separated carbohydrates of hydrolyzed samples under strong acid (20 and 30% HCl) at 95 ºC in both times (6 and 8 h), were xylose (standard and sample Rf: 0.58 and 0.59) and rhamnose (standard and sample Rf: 0.72 and 0.76).

In the mucilage hydrolyzed samples there was no presence of galactose and arabinose, this can be attributed to that the monosaccharides are not being hydrolyzed. There was no presence of galacturonic acid in hydrolyzed samples. Which agrees with the results of Salazar-Ramírez (2018). This can be attributed to the decarboxylation of galacturonic acid during hydrolysis whit strong acid (Trachtenberg and Mayer, 1981). Several researchers have studied different *Opuntias* varieties, however there are several contradictions in the results of TLC. For some authors, the mucilage is composed of D-galactose and L-arabinose residues (Harlay, 1902). Sands and Klaas, (1929) reported the presence of L-arabinose, D-galactose, L-rhamnose and D-galacturonic acid. While Ribeiro *et al.*, (2010) reported four monosaccharides except rhamnose.

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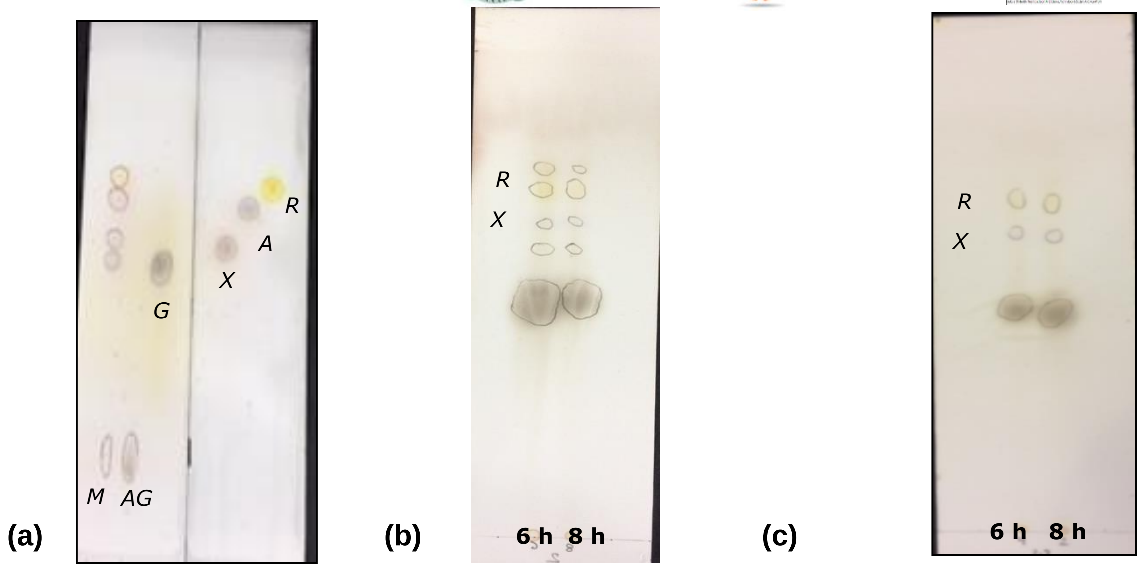

Figure 1. Thin layer chromatography of the standard samples (a) and hydrolyzed samples with 20% HCl (b) and 30% HCl (c). Standards: standards mixture (M), galacturonic acid (AG), galactose (G), xylose (X), arabinose (A) and rhamnose (R).

4 Conclusions

Proximal chemical composition of mucilage was similar to the reported by several authors, differing in the crude protein and fiber content. These differences are attributed to the mucilage extraction method and to the agro-environmental conditions, in which nopal cladodes were developed. From the TLC results is inferred that must continue working on the following: sample preparation and hydrolysis (time, acid type and/or acid concentration).

Acknowledgements

The research group acknowledges the financial support of the Secretariat of Science, Technology and Innovation of Mexico City, project SECITI / 097/2017 CDMX for the development of this project. Authors acknowledges to the ICAT and IIBO of the UNAM for the support and facilities to carry out this project.

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AREA III *Food Engineering*

Use of mucilage of *Opuntia Ficus Indica* as dispersing agent for vegetable protein suspensions

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The aim of this work is to evaluate the use of the cactus mucilage of *Opuntia ficus indica* as a dispersing agent of flours of vegetable source. These flours are used for the formulation of protein supplements which are resuspended in liquid such as water or milk, for nutritional support of patients with malnutrition. For the study of the effects and interactions between the mucilage and the components of the supplement, it was proposed a multifactorial design considering as factors, the type of flours (cereal or legume), flour concentrations, presence or absence of mucilage as a dispersing agent and the liquid media (water and skimmed milk). It was found that mucilage 10% could be used as dispersing agent for both 10 and 20%of vegetable flour. All control suspensions (without mucilage), promptly sediment while in the suspensions with 10% w/w of mucilage no settling was observed, even after 7 days of storage at 4°C. The suspensions with mucilage present a shear thinning behavior as well as they formed soft but strong gels, which are characteristics of baby food.

Keywords: gel characteristics, cohesiveness, homogeneity, cereal and legume suspensions.

1 Introduction

Food supplements from animal sources such as milk and egg protein have a high cost and unpleasant taste (Sanvicente, 2018). An alternative is the use of supplements based on flours of vegetable origin, such as protein content from cereals (8-12%) and legumes (11-34%) (Belitz and Grosch, 2009). They are familiar seeds for the Mexican consumer so they could be more accessible and transform into greater acceptance of the supplements (Varella and Fiszman, 2013). Consecutively, if the supplement is in a ready-to-eat presentation such as a milk-type beverage, the probability of assimilation in the market could increase. It should be noted that vegetable proteins to be well dispersed in the liquid matrix, need a particle size and solubility over and above the use a dispersing agent to stabilize the mixture. In this work

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mucilage from *Opuntia Ficus Indica* was used as dispersing agent. However, it must important the knowledge of the interactions that may be between the cereal/legume flour, mucilage and the liquid in which powders would be resuspended.

2 Materials and methods

The multifactorial design of four factors: type of flours (oats, quinoa and amaranth or chickpea, lentils, beans and broad beans), flour concentrations (10% or 20%), presence or absence of mucilage as a dispersing agent, in two liquid media (water and skimmed milk) is shown in table 1.

Table 1. Design of experiments

Factor	**Mucilage**	**Flour**	**% flour**	**liquid**
levels	Sin/con	Cereal/Legume	10/20	skimmed milk /water

Legumes were subjected to a thermal process, which ensured the decrease of trypsin inhibitors; subsequently they were dried in a solar dryer. Cereals and legumes were ground and sieved.

Mucilage from Opuntia ficus-indica

Fresh cladodes of *Opuntia ficus-indica* from Milpa Alta, México, were washed, chopped into small slices and milled. The extract then was centrifugated and vacuum filtrated. Finally, the mucilage solution was dried by a Niro Atomizaer® spray dryer to obtain mucilage powder.

Water activity Aw

Mucilage and flours samples were placed in a water activity equipment per dew point at 25° C (Meter Aqua Lab 4TE). The determinations were made by triplicate.

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Humidity %

Moisture content of mucilage and flours was determined in triplicate using a balance for measuring humidity content at 135 °C (Sartorius MA37-1).

Sedimentation

Sedimentation tests were used to demonstrate that the mucilage could be used as dispersing agent in vegetal protein suspensions. The test is carried out by centrifugation at 100 rpm (Power-Spin LX Centrifuge, Unico) at 25 ° C and the supernatant is vacuum filtered.

Rheological measurements

The dynamic and shear viscosity characterization was performed in a rotational controlled stress rheometer (Anton-Para-Physica Austria MCR101) at 25 °C equipped with a plate and plate geometry (50 mm diameter, 1 mm gap) and a concentric-cylinder measuring system. The data were analyzed with the software Rheopus 3.5.

3 Results and discussion

The 10% mucilage added to 10 and 20% vegetable flours suspended in both liquids tested allows having homogeneous and stable systems during formulation and storage for up to 7 days. The mucilage reduced or avoided the sedimentation of the flours (Figure 1). It is appreciated that the absence of mucilage forms precipitates regardless of the type or concentration to which the vegetable flour is, due to the higher solids content. Dispersions made with mucilage form stable networks, however at higher protein concentrations although a lower protein content makes the system less stable.

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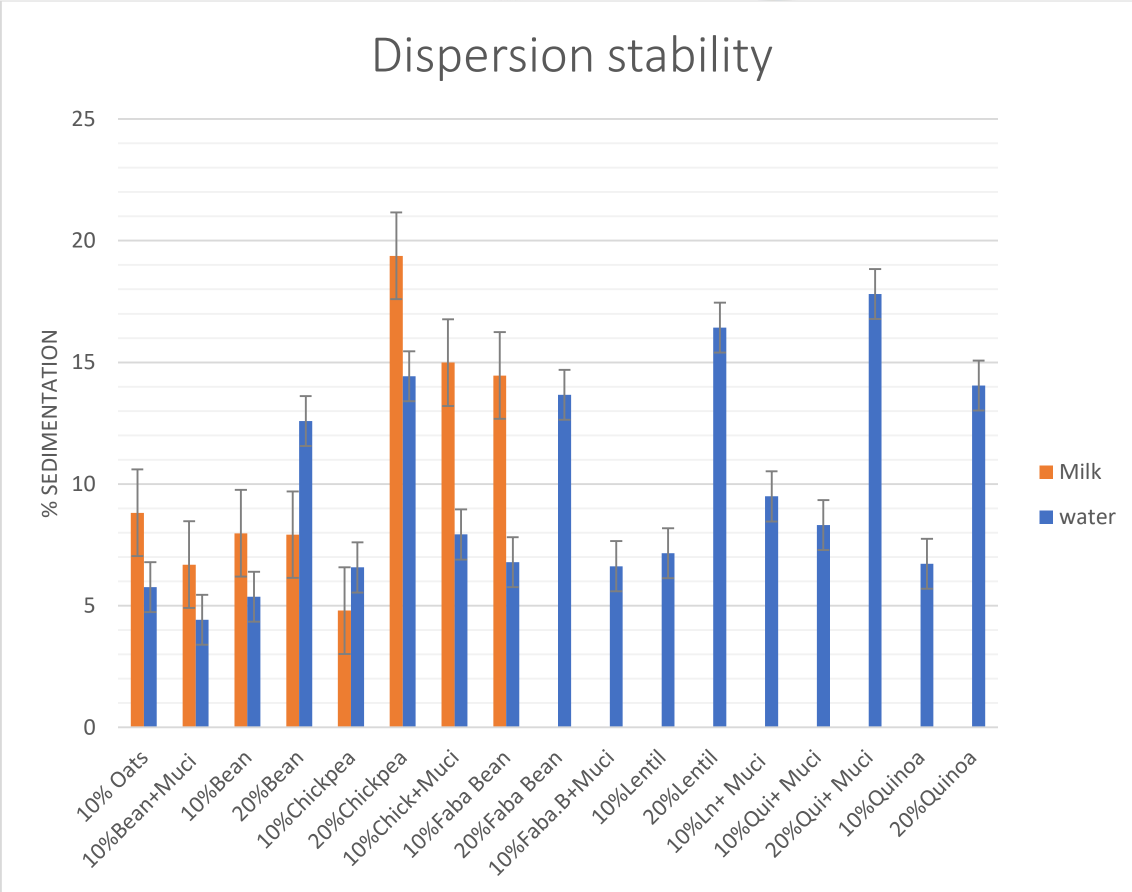

Figure 1. Sedimentation of 10 and 20 % of vegetable flours resuspended in water or milk with or not mucilage 10% as dispersing agent.

The dispersions in presence of mucilage showed a shear thinning behavior (Figure 2 and 3) while samples at 10% without mucilage have a Newtonian behavior.

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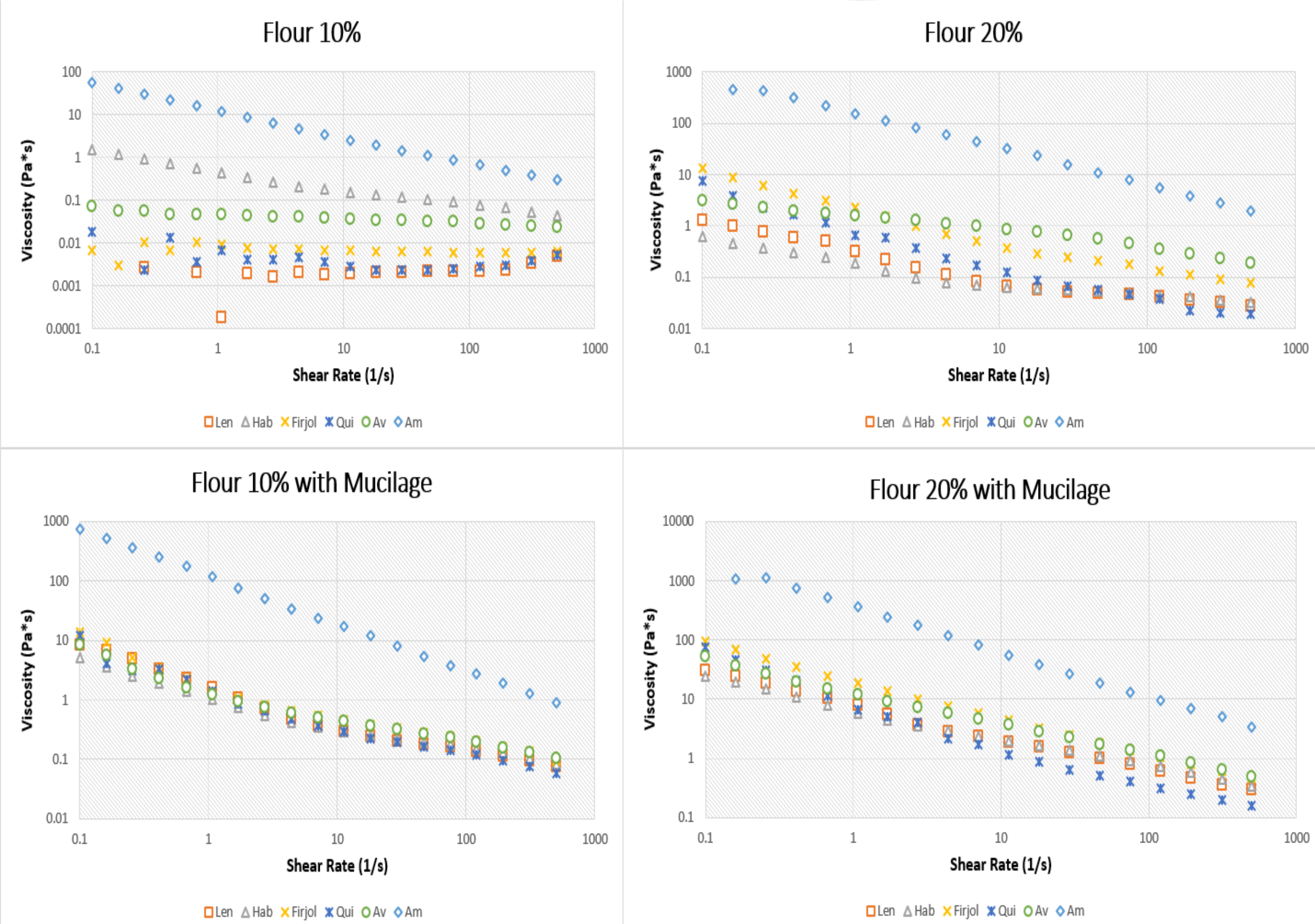

Figure 2. Shear viscosity of suspensions at 10 and 20 % of flour with or not 10% mucilage using water as liquid media.

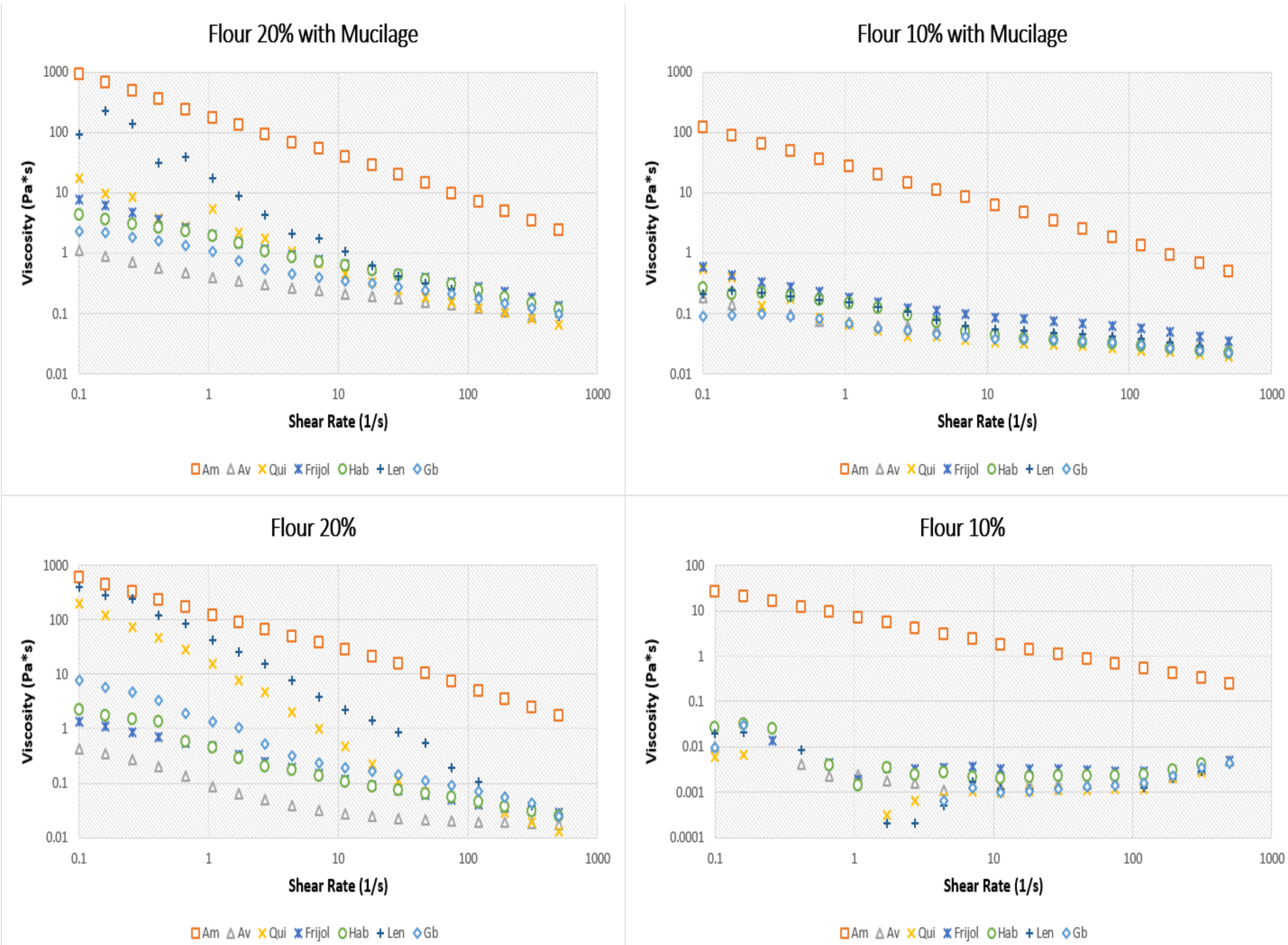

Figure 3. Shear viscosity of suspensions at 10 and 20 % of flour with or not 10% mucilage using skimmilk as liquid media.

It is important to point out that at low shear rates the viscosity varied too much, which could be associated with the instability of the dispersions regardless of the liquid matrix. Samples without mucilage and 20% flour showed also a non-Newtonian behavior of the reofluidizing type. Amaranth dispersions are shear thinning type fluids regardless of the concentration of the flour or whether presence or not of mucilage; In this case, the liquid matrix does not affect the stability of the suspension since amaranth albumins could improve stability of the systems in addition to the formation of soft and firm gels, which are characteristic of baby food.

4 Conclusions

The mucilage could be used as a dispersing agent in vegetable protein suspensions at the concentration of 10% w/w. It avoids sedimentation even for dense mixtures, so mucilage could stabilize suspensions based on vegetable flours up to 10%.

Understanding the behavior of dispersions of vegetable flours in water and milk and the presence a dispersing agent such as cactus mucilage, can formulate different mixtures and develop more stable systems, with high consumer acceptance.

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Spray drying of nopal mucilage (*Opuntia ficus indica*) obtained by mechanical extraction

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Nopal mucilage has potential application in food and pharmaceutical industries, due to its properties of forming gels, as emulsifier, viscosity modifier or suspension stabilizer. Mucilage in form of dry particles facilitates its handling, storage and dosage. In this work, mucilage obtained by free organic solvents extraction was recovered as dry particles by spray drying with the objective to evaluate the effect of both inlet (T_{in}) and outlet (T_{out}) temperatures of the drying air as well as the presence of a carrier material on the yield, and physicochemical characteristics of the mucilage powders. At T_{in} -1 and T_{out} 1 the higher yield (77-82%) was obtained, independently of the added carrier material concentration. The a_w values ranged from 0.1847-0.3412. There were no significant differences ($p < 0.05$) in the flow rheological behavior of the reconstituted mucilage. Functional groups such as galacturonic acid, rhamnose, xylose, arabinose and galactose were identified by infrared spectroscopy (FTIR-ATR).

Keywords: spray drying • nopal mucilage • spectroscopy • functional groups.

5 INTRODUCCIÓN

Nopal mucilage (*Opuntia ficus indica*) is a complex carbohydrate, with capacity to absorb water (León-Martínez et al., 2010). This polysaccharide has multiple applications, such as a food thickener, food emulsifier, as a water purifier, as an adhesive for lime ($Ca(OH)_2$), as a natural plasticizer and as a viscosity modifier in food products (Medina-Torres et al., 2000). Due to its composition and high-water activity (>0.8), fresh mucilage is susceptible to microbial attack (León-Martínez et al., 2010). Spray drying (SD) of nopal mucilage to obtain dry particles is an option to extend its shelf life and facilitate its handling, storage and dosage. Nopal mucilage and materials with similar composition have been spray-dried without carrier

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materials (León-Martínez et al., 2010; Cervantes-Martínez et al., 2014) and evaluated merely the physical and rheological properties. Spectroscopic techniques are tools that offer information about the energy levels of atoms and molecules, which allow the structural chemical characterization (Dupont, 1985). Therefore, evaluating the spectroscopic characteristics of dry mucilage particles provide information of the chemical composition of the product dried in different conditions. In the present work, nopal mucilage obtained by mechanical extraction was evaluated in terms of process yield, physicochemical and rheological characteristics and functional groups at different inlet and outlet temperatures of the drying air, considering the presence of different concentrations of carrier material (maltodextrin).

6 Materials and methods

6.1 Mechanical extraction of nopal mucilage

Cladodes (*Opuntia ficus indica)* were obtained from a local market at Milpa Alta, Ciudad de México, México. Nopal mucilage is obtained from fresh cladodes without addition of water and organic solvents, following the proposed process of 5 stages (Guzmán-Huerta, 2018): milling whole cladodes, centrifugation, sedimentation, decantation and vacuum filtration. The extracted mucilage with 4 ºBrix was stored at 4 ºC until spray drying.

6.2 Spray drying process

Maltodextrin was added directly to the fresh mucilage extracted. The resulting mixture was homogenized in an orbital shaker. A laboratory-scale spray dryer was used (Büchi, model B-290) for the spray drying process. The powders were packed in polyurethane bags sealed under vacuum and stored at 25 ºC. Process yield was calculated as the relation between the total recovered product mass and the total solids of the feed mixture.

6.3 Experimental design and statistical analysis

A 2^3 factorial design was proposed to evaluate the effect of different spray drying conditions on final characteristics of the dry mucilage extract. All experiments were carried out in duplicate. The response variables fitted to the following model, which included linear and interaction terms:

$$y_i = \beta_{i0} + \beta_{i1}x_{i1} + \beta_{i2}x_{i2} + \beta_{i3}x_{i3} + \beta_{i12}x_{i1}x_{i2} + \beta_{i13}x_{i1}x_{i3} + \beta_{i23}x_{i2}x_{i3} \quad (2.1)$$

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where β_{ij} are the regression coefficients; x_1, x_2 and x_3 are the independent coded variables; y_i is the response variable i. β_{ij} were calculated by multivariate linear regression. The independent variables were inlet air temperature (Tin, x_1: -1 y 1), outlet air temperature (Tout, x_2: -1 y 1) and g of carrier material (CM) per each g of fed extract solids (g CM/g ES; x_3: -1 y 1). Significant terms ($p < 0.05$) in the model for each response variable determined by multivariate analysis of variance (MANOVA). Minitab 16 Statistical Software (2010) was used to statistical analysis.

6.4 Water activity of mucilage powders

Water activity (a_w) of spray-dried powders was determined using an AquaLab 4TE apparatus (METER Group; Pullman, WA, USA) at 25 ºC.

6.5 Rheological behavior of reconstituted mucilage

Mucilage powders were reconstituted with tri-distilled water for measurement of rheological behavior; solutions were prepared at initial concentrations of feed mixtures. A stress-controlled rheometer (Anton Paar GmbH, model Physica MCR101) with concentric cylinder geometry (CC27/T200) was used to determine rheological characterization at 25 ºC.

6.6 Spectroscopic characterization of mucilage powders

An infrared spectrometer by Fourier transform (FT-IR) in option attenuated total reflection (ATR) was used (Thermo Scientific Nicolet FT-IR, model iS50R). Smart iTX-Diamond was used to obtain the spectra at a resolution of 4 cm^{-1} (interval: 4000-525 cm^{-1}). An UV-Vis-NIR Spectrophotometer (model Cary 5000) at 800-200 nm with quartz cells for liquids was used.

7 Results and discussion

7.1 Spray drying of nopal mucilage obtained by mechanical extraction

In this work, spray drying (SD) was studied to obtain nopal mucilage powders. Regression coefficients (β_{ij}) for the proposed model (Eq. 2.1) were calculated for each response variable (y_i): process yield (Eq. 2.2), a_w (Eq. 2.3) and viscosity at shear rate $(\gamma) = 100\ s^{-1}$ (Eq. 2.4). Studied SD conditions that significantly affected (p < 0.05) the response variables were determined (Table 1).

$$y_1 = 77.253 - 1.203x_1 + 2.464x_2 + 0.613x_3 + 1.343x_1x_2 - 0.717x_1x_3 + 1.119x_2x_3 \quad (2.2)$$

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$y_2 = 0.2789 - 0.0015x_1 - 0.0189x_2 + 0.0432x_3 - 0.0015x_1x_2 - 0.007x_1x_3 + 0.0089x_2x_3$ (2.3)

$y_3 = 0.0048 + 0.0019x_1 - 0.0019x_2 - 0.0019x_3 - 0.0019x_1x_2 - 0.0020x_1x_3 + 0.0019x_2x_3$ (2.4)

Table 1. *p*-values for the variables evaluated during spray drying of nopal mucilage

Independent variables	Process yield	a_w	Viscosity at $\gamma = 100s^{-1}$
g CM / g ES	0.10046	0.00008	0.39201
Tin (°C)	0.02704	0.74932	0.37538
Tout (°C)	0.00171	0.00294	0.39545

The terms were considered statistically significant at the *p*-values less than 5% ($p < 0.05$).

Both carrier material concentration and Tout showed an effect significant ($p < 0.05$) on the a_w (Table 1). A further increase in the amount of added carrier material decreased the a_w of the powders obtained. The a_w values of the mucilage powders were in the interval 0.1847-0.3412. Spray-dried powders obtained in this work can be considered safe because a_w values < 0.5 are desired to avoid microbial growth (Cortés-Rojas and Oliveira, 2012).

Both Tin and Tout showed an effect significant ($p < 0.05$) on the process yield (Table 1). The highest yields were obtained in treatments with lower Tin (-1) and higher Tout (1) (Fig. 1A). A partial sticking of the insufficiently dry particles on the dryer walls at higher Tin and lower Tout can be carried out, due to the increased feed rate for fixing the Tout. Moreover, high temperatures promote changes in the thermoplastic behavior, increasing the deposits on the walls of the dryer, and yield decreases (Cervantes-Martínez et al., 2014). Process yield was not affected ($p > 0.05$) by the carrier material concentration, this can be attributed to high molecular weight of nopal mucilage (2.3×10^4 - 3×10^6 g·mol^{-1}) (León-Martínez et al., 2010).

The viscous response ($\gamma = 100s^{-1}$) of reconstituted mucilage was not affected ($p > 0.05$) by the SD process parameters evaluated (Table 1 and Fig. 1B). These results could indicate that the molecular structure of the nopal mucilage was not affected by a thermal degradation, at least in the evaluated region. For confirm this, spectroscopic analyses of mucilage powders were carried out.

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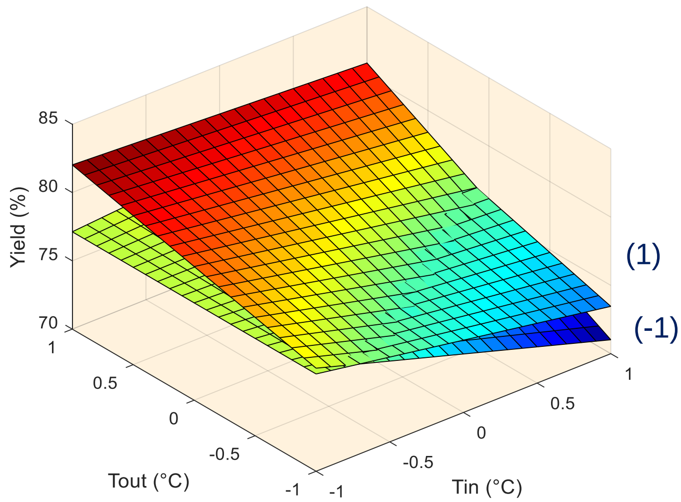
(A)



(B)

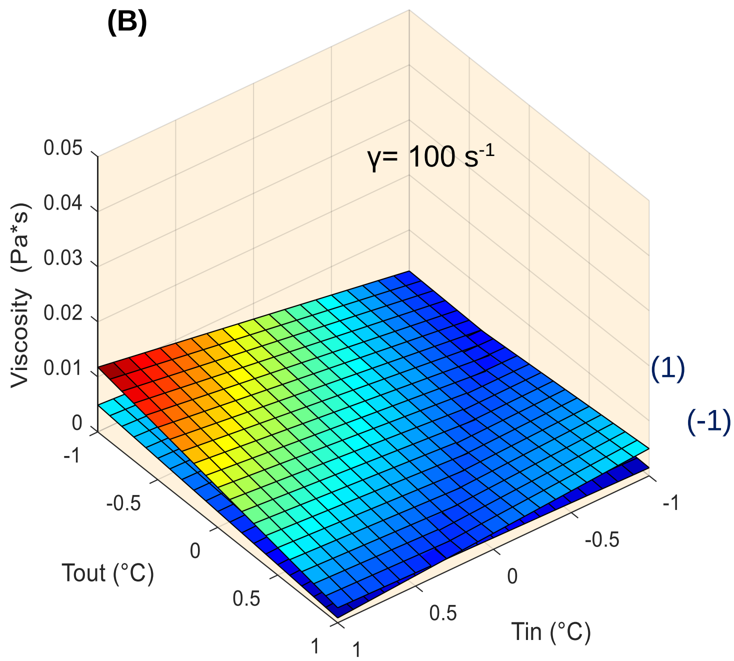


Figure.1 Spray drying process of nopal mucilage: effect of process variables on process yield (A) and viscosity (B). Carrier material concentrations: 1 y -1.

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7.2 Spectroscopic analyses of mucilage powders

Infrared spectrum by ATR of dried nopal mucilage (Fig. 2) show the characteristic bands of groups OH^- and H_2O (3249 cm^{-1}) (Hesse, 2005); -COOH groups of lignin (1715 cm^{-1}); N-H bonds of amide groups (1515 cm^{-1}); C-C, C-H, C-O and C-O-C bonds of carbohydrate molecules (1000-1080 cm^{-1}) (Hesse, 2005). The bands observed between 1150-825 cm^{-1} are characteristics of powder polysaccharides (Mondragón, 2017).

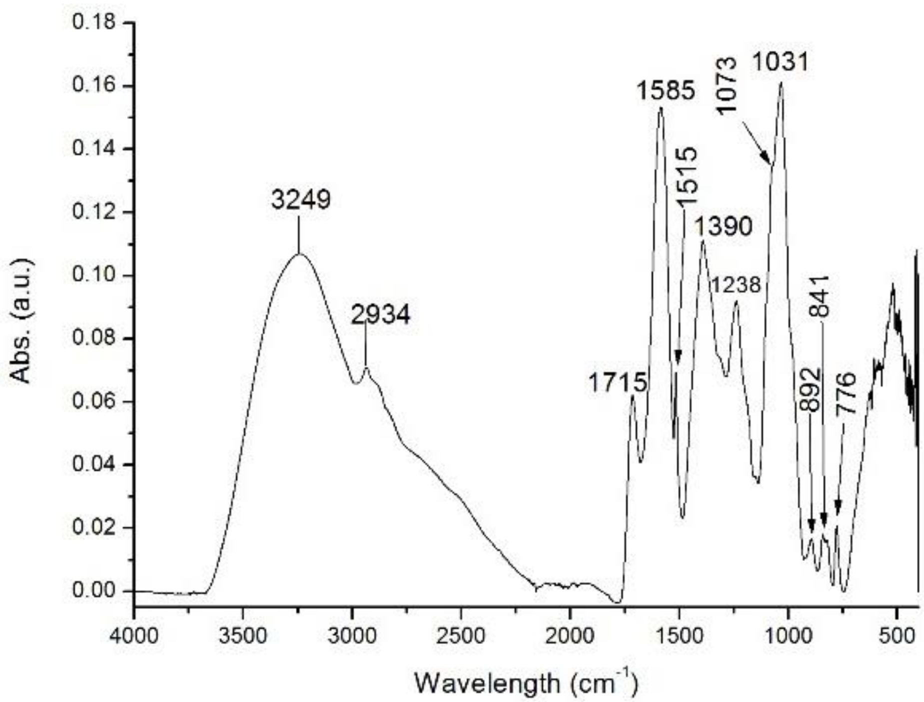

Fig. 2 Infrared spectra of nopal mucilage characteristic.

The spectra of the mucilage powders obtained at different conditions of SD, showed the same characteristic bands (Fig. 3A). This indicates that the mucilage structure not modified during the SD process. Figure 3B shows the spectra of mucilage powders with maltodextrin at different conditions of SD. The presence of maltodextrin only modifies the absorption band located at 1038 cm^{-1}, due to the contribution of the very intense absorption band of maltodextrin molecule located near the same position (1021 cm^{-1}).

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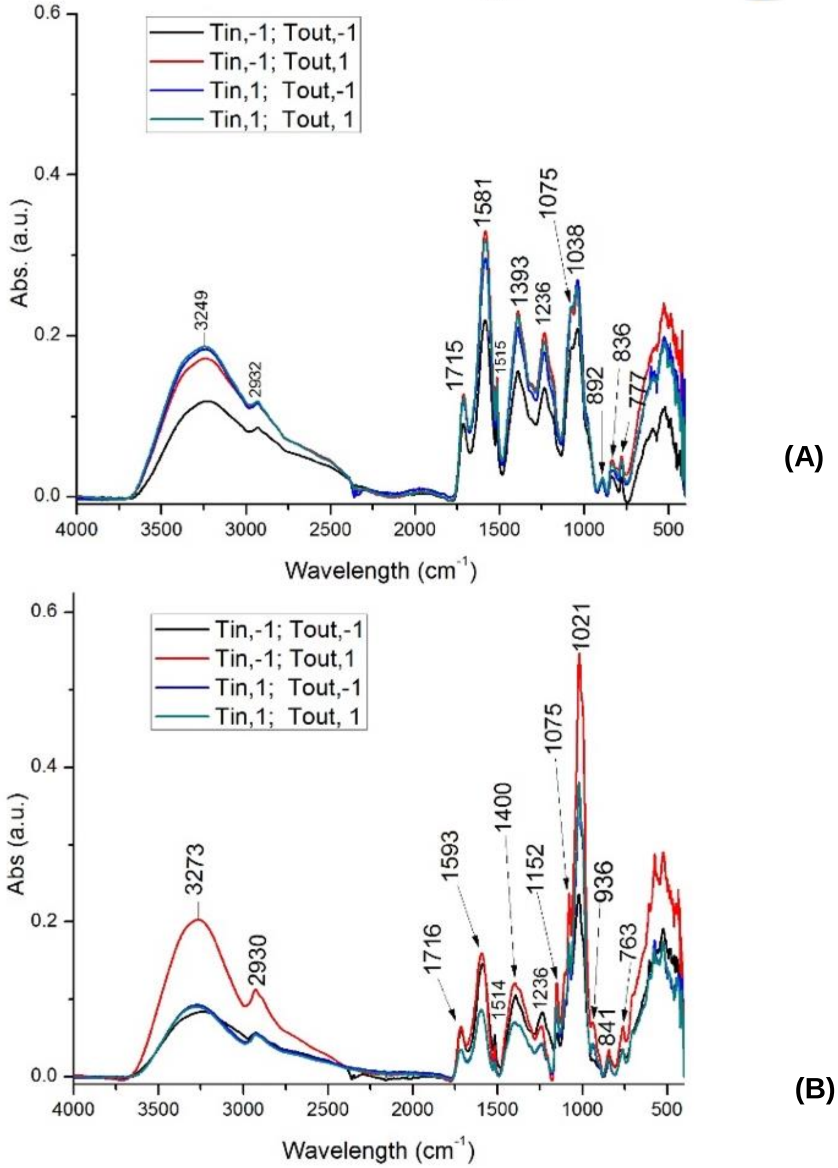

Fig. 3. Infrared spectra by Attenuated Total Reflectance (ATR) of dried nopal mucilage obtained at different spray drying conditions and carrier material concentrations: 1 (A) and -1 (B).

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In UV-vis spectrum of reconstituted mucilage at different amount of water (Fig. 4) were identified the tyrosine (273 nm) and tryptophan (280 nm) amino acids (Bello, 2000).

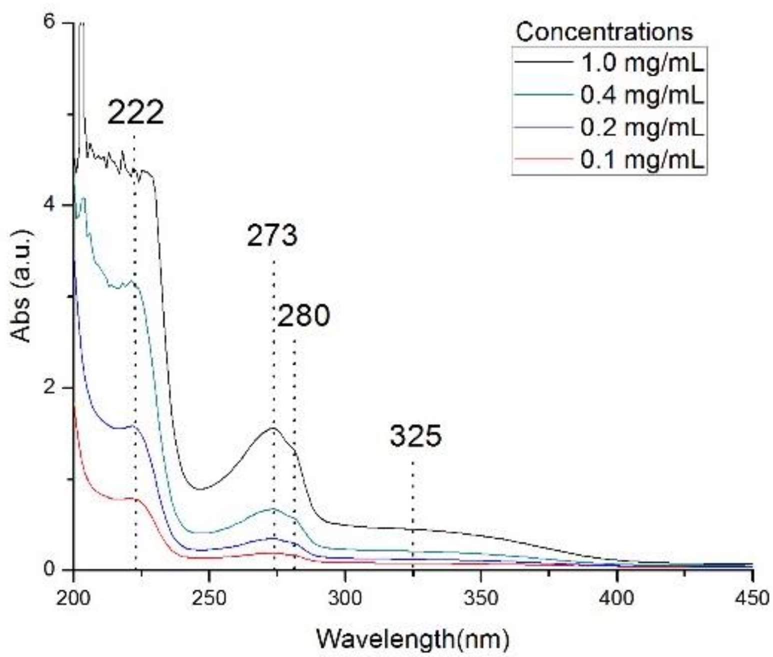

Fig. 4 UV-vis spectra of mucilage reconstituted at different amounts of water. SD conditions: Tin, -1; Tout, 1; g CM/g ES, -1.

8 Conclusions

The process spray drying allows obtaining mucilage powders without compromising their rheological properties, chemical profile and molecular structure.

Acknowledgements

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Concentration of *Opuntia ficus indica* mucilage and its application as edible coating films

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Abstract

Opuntia ficus indica is an important source of mucilage which is of interest for the food and pharmaceutical industries. Several authors have focused their studies on the extraction and concentration of cactus-mucilage. However, they report high consumption of organic solvents, long extraction times and low extraction efficiencies. The aims of this work were the use of the cross-flow ultrafiltration (UF) as concentration method for the mucilage obtained by a process free of organic solvents and, mucilage application as edible coating for cactus ("nopalitos"). Cladodes without thorns from Milpa Alta, CDMX were subjected to mechanical extraction. UF experiments were carried out in a pilot cross-flow system (Millipore®, Pellicon) at 25 °C considering the pore size of polyethersulfone membranes, transmembrane pressure and cross flow velocity on the UF performance. Physicochemical properties of the concentrated samples such as solids content, °Brix, a_w, the presence of mucilage, pH, zeta potential and rheological behavior were determined. Finally, the concentrated mucilage was used as edible coatings evaluating the addition or not of a plasticizer to increase the shelf life of "nopalitos at 5 and 25 °C. The 1 *kDa* membrane generated the highest percentage of solids (6.92 ± 0.12 %) mucilage with the lowest hydraulic resistance (0.15×10^{15} m^{-1}) as well as enhanced properties of zeta potential and viscosity. No significant difference was observed on color and firmness of "nopalitos" while consumers preferred the concentrated extract with plasticizer.

Key words: Ultrafiltration, mucilage, edible coatings.

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1. Introduction

Fresh cactus pads, commonly known as "nopales" or "nopalitos", are important in the Mexican diet included as green vegetable in salads, sauces, soups, stews, snacks, beverages and some desserts as well as characterized by their mucilage production (Contreras-Padilla *et al.*, 2016). Several authors have focused their studies on the extraction and concentration of mucilage from fresh nopal (Goldstein and Nobel, 1991, Sepúlveda *et al.*, 2007). These studies are associated with high solvent consumption, long operation time, high temperatures and low recovery yields (in a range of 0.07 to 4.53 %, based on fresh weight) (Sáenz *et al.*, 2004). Evaporation is one of the most used methods for concentration of mucilage, however it can produce color changes and flavour in the fruit juices (Cassano *et al.*, 2007). Membrane processes offer particular advantages in terms of absence of phase transition, mild operating conditions, separation efficiency, nonuse of additional aqueous phases, and easy scaling up when compared with conventional methods (Conidi *et al.*, 2014). Ultrafiltration is a viable option to concentrate cactus mucilage for its wide range in pore size. In the present work, cactus extracts were obtained by mechanical processes. The UF experiments were carried out in a pilot cross-flow system (Millipore®, Pellicon) at 25 °C. The effect of the pore size (d_p = 1, 10 and 50 kDa), transmembrane pressure (TMP = 1.0 and 2.0 bar) and cross flow velocity (V_x = 9.68x10^{-5} and 1.33x10^{-4} m/s) on the UF performance were studied. Physicochemical properties of the concentrated samples were determined (solids content, °Brix, a_w, the presence of mucilage, pH, zeta potential and rheological behavior) to evaluate the UF effect on these. In the present work, mucilage concentrated was proposed to prepare edible coating from cactus mucilage, in order to increase the shelf life of Mexican cactus. The treatments evaluated were 5: distilled water (T), unconcentrated extract (M), unconcentrated extract with plasticizer (MP), concentrated extract (MC) and concentrated extract with plasticizer (MCP). They were stored at 5/25 °C and 75% relative humidity by 11 days and their physicochemical properties (firmness, thickness, weight loss, titratable acidity, °Brix, pH and color) were monitored every 48-72 hours. The results of this research shown that a 1 *kDa* membrane generated the lowest hydraulic resistance (0.15x10^{15} m^{-1}), the highest percentage of solids (6.92 ± 0.12 %) and improved the physicochemical properties of mucilage (zeta potential -17.5 ± 1.0 mV and viscosity 0.5 Pa·s a 10 s^{-1}). There was not significantly difference on the physicochemical properties of "nopalitos" to the different formulations analyzed (pH, °Brix, color and firmness). According to the sensorial analysis, the treatment most and least liked by the consumers was the MC and MCP, respectively.

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2. Methodology

2.1 Cladodes: characterization

Opuntia ficus-indica young cladodes or ''nopalitos'' were obtained from Milpa Alta (Mexico). The cladodes were characterized in terms of water fraction, extractable solids fraction and non-extractable solids fraction according to Castillo-Santos *et al.*, (2016).

2.1.1 Water determination in cladodes

Water determination was carried out using a thermo balance aeADAM® (PMB 202, max 200 g and d=0.01 g). The water content was expressed as water mass fraction in feed (x_{F_3}) according to the next equation:

$$x_{F_3} = \frac{w_0 - w_I}{w_0} \quad (1)$$

Where w_0 is the initial weight and w_I is the final weight, the analysis was done in triplicate.

2.1.2 Non-extractable and extractable solids in cladodes

Exhaustive extraction was performed to determinate the non-extractable and extractable solids fraction from "nopal" cladodes, according to Castillo-Santos *et al.*, (2016). The refined phase (cladodes with extract) was separated from the extract (extractable material and distilled water as solvent) by decantation. Then the refined was put in vacuum oven (GCA Corporation, Mod. 28AE-5) at 70 ºC and 6.4×10^4 Pa until reach constant weight. The remains solids are the non-extractable material in cladodes and were expressed in mass fraction (x_{F_1}):

$$x_{F_1} = \frac{w_0\,(1 - x_{F_3}) - w_I}{w_0} \quad (2)$$

Then the extractable mass fraction(x_{F_2}) was estimated by difference:

$$x_{F_2} = 1 - x_{F_1} - x_{F_3} \quad (3)$$

2.2 Mucilage extract

A series of mechanical separation processes were used to obtain cactus extract according to Salazar-Ramírez (2018). The solids content of the obtained extracts during each mechanic process was determined by triplicate in a vacuum oven (GCA Corporation, Mod. 28AE-5) at 70 °C and 6.4x10^4 Pa until constant weight was reached. At the end of the mechanic

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processes, the mucilage extraction yield was determined in function to extractable solids from cladodes.

2.3 Filtration system: membranes, hydraulic permeability and flux recovernopal

Fresh extract was concentrated in a cross-flow pilot ultrafiltration system (Millipore®, Mod. Pellicon) using Cassette Pellicon® membranes of polyethersulfone (PS). The tests were carried out using a feed volume of 10 L at 25 ± 2.0 °C. The effect of the pore size (d_p = 1, 10 and 50 kDa), transmembrane pressure (TMP = 1.0 and 2.0 bar) and cross-flow velocity (Vx = 9.68x10^{-5} $m \cdot s^{-1}$ and 1.33x10^{-4} $m \cdot s^{-1}$) were evaluated on the UF performance (permeate flux, membrane permeability and mucilage recovery yield). The filtration test was over when the concentration of the fresh extract reached a volumetric reduction factor (VRF) of 10. The feed pressure ($P1$), retentate pressure ($P2$) and permeate pressure ($P3$) were adjusted until obtaining the TMP value desired (Equation 4).

$$TMP = \frac{P1 + P2}{2} - P3 \quad (4)$$

2.4 Physicochemical properties of nopal extracts after ultrafiltration

The rheological behavior was determined in a rheometer MCR101 (Anton Paar Physica, Austria) using a geometry of concentric cylinders (CC27/T200) over a shear rate of 0.1-100 s^{-1} at 25 °C. The pH was measured in a Science MED potentiometer (SM-3BW Microprocessor pH/Meter) at 25 ± 1 °C. The a_w measurements were made in an AQUALAB (4TE) manufactured under ISO 9001:2015. The zeta potential was carried out in a Malvern analyzer (Zetasizer Nano ZS90) under a sample dilution at 2.5% with deionized water. The total soluble solids were measured using 5 µL of sample with a refractometer Reichert® (BRIX 35HP) at 25 ± 2.0 °C. Finally, an alcohol test (sample:isopropanol, 1:2 w/w) was applied to the concentrated and permeated samples to identify if there was presence of mucilage.

2.5 Edible coatings from mucilage

The “nopalitos” were submerged in chlorinated water and dried for 1 hour. Then the edible coatings (distilled water: T; unconcentrated extract: M; unconcentrated extract with plasticizer: MP; concentrated extract: MC and concentrated extract with plasticizer MCP) were applied on them. One group of nopales was stored at room temperature (25 °C) and the other in refrigeration (5 °C); with a 75% relative humidity by 11 days. The physicochemical properties (pH, °Brix, thickness, weight loss and texture) and sensorial analysis of the “nopalitos” were determined on days 2, 4, 6, 9 and 11 of storage.

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2.5.1 Physicochemical properties of edible coatings

The titratable acidity was performed using the AOAC method (2000). It was expressed in % (g malic acid per 100 g sample). The pH was measured with a potentiometer (Science MED, Mod. SM-3BW microprocessor pH/Meter) according to the NOM-F-317-S-1978 standard. The “nopalitos” were weighed on a digital scale (OHAUS, mod ScoutTM Pro) and the percentage of weight loss was determinate according to the Equation 5. The firmness of the “nopalitos” (expressed in N) was measured with a portable penetrometer (DeltaTrak®, mod GY-1/12226). Photographs of “nopalitos” were taken with a digital camera (CANON, mod EOS REBEL T3i). The color values were compared with CIELAB scale (L,*a y *b) through a digital colorimeter (version 5.11, Apple Inc., Copyright 2001-2017). Finally, a panel of 50 judges carried out a sensory analysis. First a questionnaire about “nopalitos” consumption, conservation method and place of purchase was applied. Subsequently, a test of preference level was applied; preference based on visual acceptability and resistance to cutting. The consumers rated the nopal of each treatment on a scale of 1 to 9. 1 represented "I really dislike" and 9 "I really like it". The resistance data obtained from the consumers were analyzed with the Friedman test.

$$Weight\ loss\ (\%) = \frac{P_0 - P_x}{P_0} * 100 \quad (5)$$

Where, P_0 is cactus weight on day zero and P_x is cactus weight on the corresponding day of the monitoring.

3. Results

3.1 Characterization of cladodes

Characterization of cactus cladodes in function of the water, no-extractable solids and extractable solids content was 94.00 ± 0.20 %, 1.79 ± 0.05 % and 4.21 ± 0.05 % respectively. The values obtained in this research are agree to the literature: 88-95% humidity, 3-7% carbohydrates (extractable solids) and 1-4% fiber and ash (non-extractable solids) (Stintzing and Carle, 2005).

The solids content of cactus extract was 3.55%. The yield of mucilage recuperated was 2.31% and 39.49% based on fresh weight and dry weight respectively. These yields were higher

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than those reported in the literature (Cárdenas *et al*., 1997; Sepúlveda *et al*., 2007; Contreras-Padilla, 2016).

3.2 Mucilage concentration by cross-flow ultrafiltration

The permeate flux decreased from 15 to 4 $Lm^{-2}h^{-1}$ with the decreasing in pore size from 50 to 1 kDa. An increasing in the permeate flux was observed when the TMP was increased from 1.0 to 2.0 bar for all membranes evaluated. However, the permeate flux was not affected byVx. The extracts obtained with a 1 kDa membrane (Figure 1.b) were those with the highest values of Brix grades, which is consistent with the highest percentages of solids in concentrated samples (≥ 6%). The lowest hydraulic resistances were obtained with this membrane, being a value of 0.15x10^{15} m^{-1}.

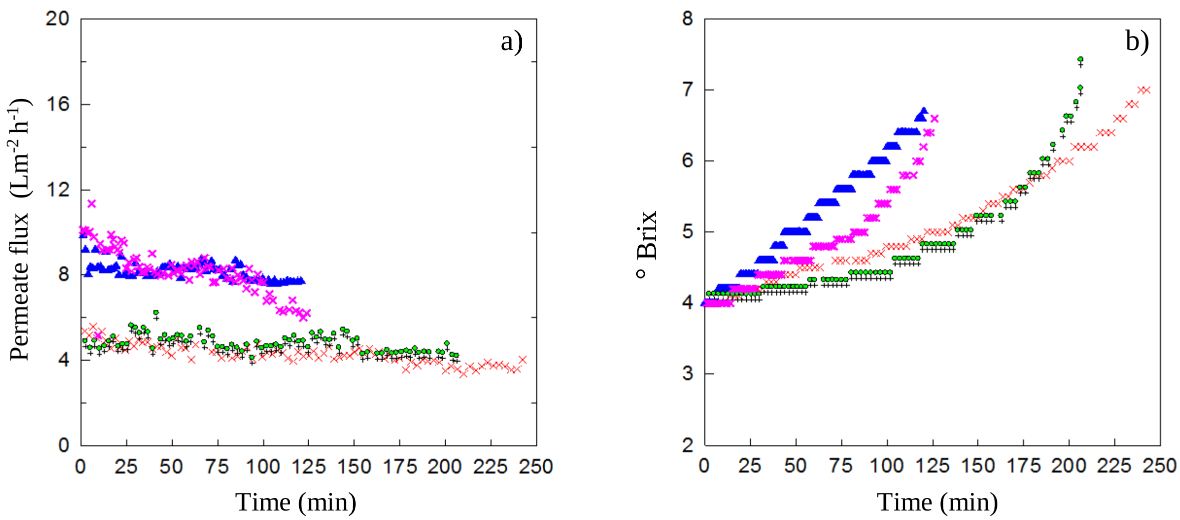

Figure 1. a) Evolution of the permeate flux and b) °Brix grades during the ultrafiltration of cactus extract with a polyethersulfone membranes of 1 kDa. TMP =1 bar - V_x = 9.68x10^{-5} ms^{-1} (×), TMP =1 bar - V_x = 1.33x10^{-4} ms^{-1} (•),TMP = 2 bar - V_x = 9.68x10^{-5} m·s^{-1} (×) and TMP = 2 bar - V_x = 1.33x10^{-4} m·s^{-1} (▲).

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3.3 Physicochemical properties of extracts after ultrafiltration

All the concentrated extracts obey the Carreau model, a Newtonian behavior at low share speeds (< 10 s^{-1}) and a pseudoplastic behavior at high share speeds (> 10 s^{-1}). A viscosity of 0.5 Pa·s a 10 s^{-1} was obtained with a 1 *kDa* membrane, being similar to that reported by Medina-Torres *et al*., (2003). The pH of the cactus extracts decreased significantly after ultrafiltration (from 5.10 ± 0.09 to 4.05 ± 0.07). It could be attributed to the retention of macromolecular components that affect the pH of the cactus extracts (minerals, vitamins, etc.). The negative charge was reduced when a 50 kDa membrane (-17.5 to -11 mV) was used. The a_w values of the powders obtained were in the range of 0.1937-0.2703. These results are similar to those reported for powders obtained by spray drying (Şahin *et al*., 2011). Formation of white precipitates was observed in the permeated sample with a 50 kDa membrane during the alcohol test, which explains a VRF equal to 2. Whereas that more concentrated extracts were obtained with 1 and 10 kDa membranes, being VRF equal to 10 with a filtration time of 125-250 min. Based on the results obtained, it was decided to concentrate mucilage with a 1 kDa membrane. Subsequently, the mucilage was spray dried, with a yield of 81.0%.

3.4 Edible coatings from mucilage

The shelf life of "nopalitos" stored at room temperature was 5 days lower compared to those stored in refrigeration. There was not significantly difference on the physicochemical properties of "nopalitos" to the different formulations analyzed (pH, °Brix, color, etc.). However the MP treatment showed greater weight loss (2-4%) while MC and MCP treatments showed a slight decrease in the first 4 days, with respect to the control treatment (Figure 2). Therefore, coatings formulated with concentrated mucilage function as regulators of gas exchange (water vapor, oxygen, carbon dioxide), decreasing the weight loss percentage of the cladode.

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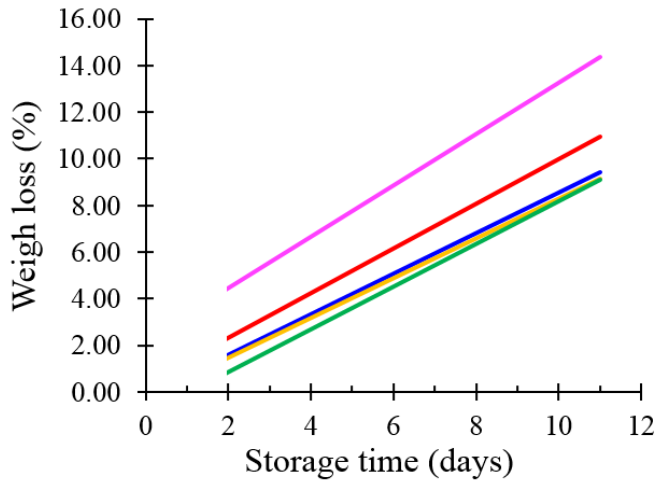

Figure 2 Effect of biodegradable coating treatments on weight loss of nopales during storage at 5 °C. Formulations: control: ▬ ; M: ▬ ; MP: ▬; MC: ▬ and MCP: ▬.

The luminosity of nopals decreased as the storage time increased, independently of the applied treatment. On the first day of storage, the best treatment in appearance was the MC followed by the MCP, M, T and finally MP. After the 3rd day, the best was the T, followed by M, MC, MCP and MP. There was no differences between the 5 treatments in terms of resistance to cutting in different days of storage.

4. Conclusion

The mucilage obtained in this work was free of organic solvents and was successfully applied as edible coating in nopal. A membrane of 1 *kDa* generated the highest percentage of solids with the lowest hydraulic resistances. The concentrated extract had a significant effect on weight loss of "nopalitos" and it was the most accepted by the consumers. It should be considered to testing "nopalitos" with thorns to prevent cactus transpiration and to control peeling cutting.

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Cooked and dried process standardization for legumes to obtain flours for nutritional supplements

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ABSTRACT

The health sector challenges in that we face today are considerable like malnutrition and obesity, resulting in the need for healthy food alternatives, such as supplements make from legumes flours. However, they have anti-nutritional factors which cause undesirable physiological effects. For that reason, they need cooking and drying process. Nevertheless, dried food production is expensive, consequently, emergent technologies as solar dryer or solar dryer with electric-energy. The aim of this job was the drying of *Lens-culinaris, Cicer-arietinum* and *Vicia-faba* using a solar dryer and forced convection solar dryer. Previously, they were soaked during 24 h. They were cooked at different times at 95°C. Finally, they were dried in both dryers. Trypsin inhibitor, water activity (*Aw)* and %moisture were measured. Trypsin inhibitor activity decreased from 61.83 TIU/mg (raw samples) to 25.06 TIU/mg (cooked samples). *Aw* was from 0.98 before dryer to 0.46 after dryer. Also, the diffusivity was a value of 2.59E-09. Finally, the forced convection solar dryer and solar dryer efficiency was 94.30% and 22.22%, respectively. The inclusion of forced convection dismissed the drying time by 1 day. Likewise, the physicochemical parameters were the same in both dryers.

Key words: diffusivity, forced convection solar dryer, legumes, solar dryer, trypsin inhibitor**.**

INTRODUCTION

Malnutrition and obesity were the next major epidemiologic challenge, with the annual allocation of healthcare resources for the disease and related comorbidities. Despite great efforts in the past decades, people undernutrition is still prevalent in developing countries.

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As a response, flour legume supplements were development. Dry legume is the seed dried with different color, size and shape (FAO, 2016).
Legumes had anti-nutritional factors which can be toxic or causes flatulence, bloating, stomach upset, pancreatic affectations, hematocrit clumping, dismissed nutrition assimilation and others (Elizalde et al., 2009). To reduce anti-nutritional factor content, conventional processing methods of legumes including soaking, cooking and drying have been investigated. However, production of dryer food has high cost, so, emergent technologies reduces it. Solar drying is a method for preservation of food and agriculture crops since the beginning of humanity. Consequently, it is a very useful device from the energy conservation point of view as it reduces the total amount of fuel energy required.
The aim of this job was drying of *Lens-culinaris*, *Cicer-arietinum* and *Vicia-faba* using a solar dryer and forced convection solar dryer. The dyers are different in time, temperature, environmental humidity but the heat inactivates trypsin inhibitor, chymotrypsin, lectins and lipooxygenase (De Schutter y Morris, 1990). Thus, there is need to understand this operation well (dryer kinetics and legumes diffusivity) and to ensure that it is carried out as efficiently as possible.

MATERIAL AND METHODS

Samples: *Lens-culinaris*, *Cicer-arietinum* and *Vicia-faba*
Receipt of raw materials: Parched seeds or extraneous materials are discarded.
Soak and cook: The legumes (200 g) were soaked during 24 h at room temperature. Then, they cooked in electric pot (not pressure system) at different times.
Trypsin inhibitor (technic miniaturization): Trypsin inhibitor was measured by Kakade (1973) and it was modified by Klomklao (2011). Therefore, the volume and time reaction was reduced. Raw and cooked legumes were tested.
Drying: The legumes were dryer in two equipment solar dryer (40 ± 5 °C) and forced convection solar dryer (46 ± 2 °C). They were designed and manufactured by Ingenieria de Proceso (ICAT, UNAM). The initial data of legumes as Aw and moisture was measured. The legumes mass was measured each hour, as well as, temperature and humidity for chamber dryer were measured. Finally, the solar irradiation was checked in weather station from UNAM.

RESULTS AND DISCUSION

Morphological characteristics. Table 1 shows the legumes morphological characteristics as appearance, color and size (length, width and thickness) before cooked. *Cicer-arietinum* was characterized by yellow-cream color and rounded appearance. *Lens-culinaris* was characterized by circular appearance and pale-gray-brown color. *Vicia-faba* was yellow-light green and kidney-shaped.

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Table 1. Morphological characteristics of raw and cooked legumes.

Legume	Appearance	Size	Color	Dimensions (mm)
Cicer-arietinum	Irregular round	Medium	yellow-light cream	12.1±0.5/ 9.0±0.2/ 9.1±0.4
Lens-culinaris	Circular shape	Small	gray	4.6±0.4/ 4.6±0.4/ 2.5±0.2
Vicia-faba	Kidney shape	Big	yellow-light green	25.6±1.2/ 17.5±2.2/ 6.2±0.7

Moisture and *Aw*. The values of raw samples moisture content were below standard required CODEX STAN 171-1989. Likewise, the cooked samples had a high value due to water absorbed and swelling cotyledons (Enjamio *et al*. 2017). The *Aw* value was between the interval 0.2 to 0.3 where the monolayer moisture (W_0) represented the content moisture that minimize biochemical reactions (Ramírez-Miranda *et al*., 2014).

The legumes have toxic factors as protease inhibitor, thus, they are considered “dangerous” plants if they have not been cooked (Badui, 2006). Figure 1 shows that *Lens-culinaris*, *Cicer-arietinum* and *Vicia-faba* trypsin inhibitors dismissed when cooked time increased. Lima (2018) said that trypsin inhibitor units (TIU) which intoxicated the rats were 30 TIU/ mg sample. Consequently, the samples had the minimum quantity of TIU to avoid malabsorption problems.

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Table 2. Moisture content for raw and cooked legumes.

Legume	Moisture (%)	*Aw* (24.94±0.15 °C)
Cicer-arietinum		
Raw	8.32±0.33^{b}	0.45±0.00^{c}
Coocked	47.97±1.64^{b}	0.98±0.01^{a}
Flour	3.66±0.15^{c}	0.35±0.04^{a}
Lens-culinaris		
Raw	9.89±0.22^{a}	0.49±0.00^{b}
Coocked	54.26±4.40^{a}	0.98±0.00^{a}
Flour	9.41±0.49^{a}	0.35±0.03^{a}
Vicia-faba		
Raw	9.85±0.73^{a}	0.56±0.01^{a}
Coocked	54.52±2.64^{a}	0.98±0.01^{a}
Flour	8.06±0.84^{b}	0.34±0.03^{a}

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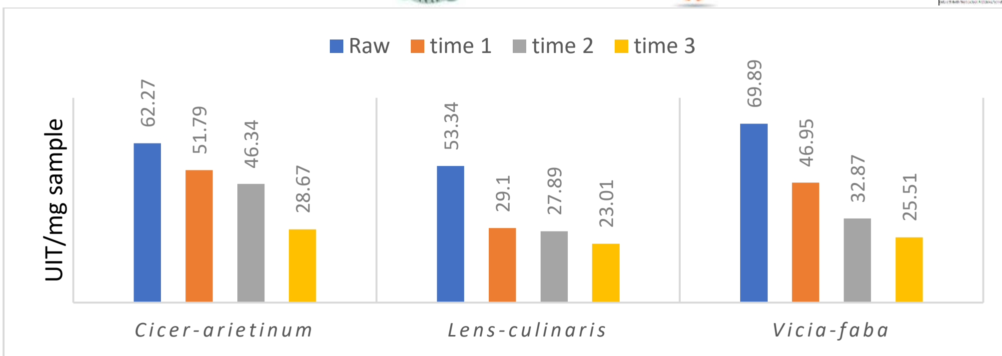

Figure 1. Effect of cooked treatment on legume trypsin inhibitor activity at different times.

Figure 2 shows the loss of moisture in solar dryer through the time. The significant moisture change was during the first two hours, then, the dryer velocity was persistent. Finally, the moisture content was constant and minimum (critical point). Likewise, figure 3 shows that dryer time in forced convection solar dryer was less than in solar dryer. Since, the conditions were beneficial for drying when resistances were used.

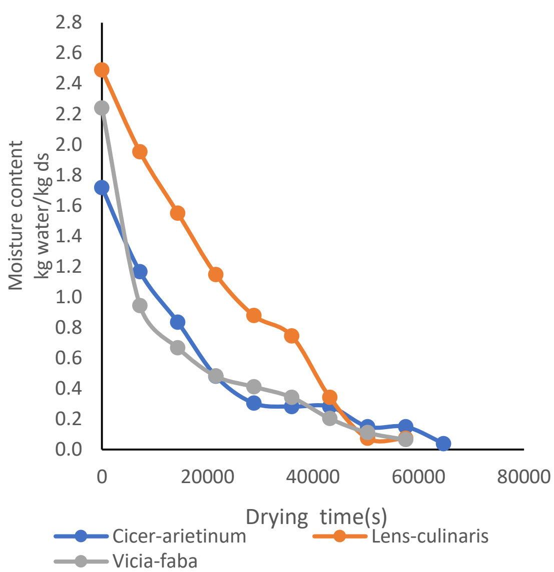

Figure 2. Drying curves of legumes by solar dryer.

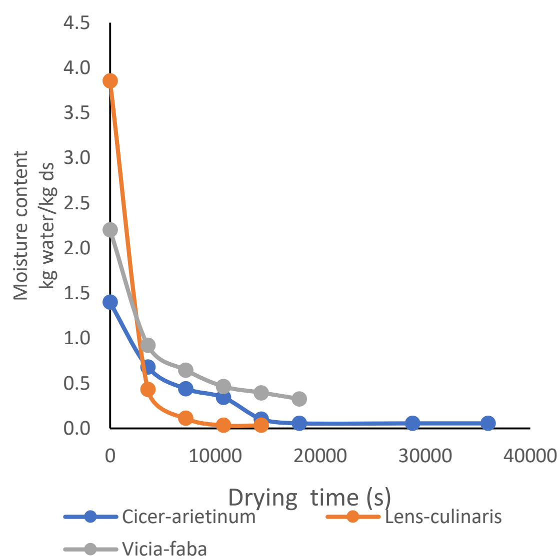

Figure 3. Drying curves of legumes by forced convection solar dryer.

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Similarly, diffusivity values are related with structure, composition and state of food. If the diffusivity value is high the dryer time will be low (Table 3).

Table 3. Diffusivity values of legumes by solar and forced convection dryer.

Legume	Diffusivity (m^2/s)	
	Solar Dryer	**Forced Convection Dryer**
Cicer-arietinum	2.79E-09	2.13E-09
Lens-culinaris	1.95E-10	3.88E-09
Vicia-faba	4.06E-10	6.14E-10

Efficiency. The system efficiency in dehydration chamber was estimated by Amer et al., (2009) model. The forced convection dryer had an efficiency value (94.31%) four times higher than solar dryer (22.16%).

The forced convection dryer had operating time of 5.5 h during experiments where four resistances were used. They had a power consumption of 1600 [W], therefore, the energy consume was of 35.20 [kW·h]. In this regard, the electricity cost was $24.00 MXN (Comisión Federal de Electricidad, CFE).

CONCLUSIONS

Cooked method was standardized for *Lens-culinaris*, *Cicer-arietinum* and *Vicia-faba* and anti-nutritional value was dismissed. Similarly, the legumes were dehydrated by both systems. The samples physicochemical characteristics (Aw, moisture) were similar. However, the time to had these characteristics was different due to the forced convection dryer had an efficiency four times higher.

ACKNOWLEDGEMENT

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Eating Disorders and Obesity

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Abstract. Culturally in Mexico we have a serious problem in the diet since much of the food consumed is rich in fats and carbohydrates, in addition to sedentary lifestyle, that is the case of people with purchasing power. But when money is a problem this is exacerbated because low-nutrient foods are consumed and lead to malnutrition. All civil society has a commitment to the information of good nutrition and exercise practices; as well as preventing the waste of food that they no longer occupy in homes with high purchasing power to take them to the neediest homes. **Objective:** Raise awareness about the food problem about obesity in Mexico and strengthen solidarity in the fight against hunger, malnutrition and poverty, as an opportunity to support sustainable development. **Methods:** Make an exhaustive search in the available web databases: OECD, WHO, INEGI, epidemiological bulletin of Mexico and analyze that data about obesity and malnutrition in Mexico from 2015-2018 week 39. **Results**: The OECD report countries with obesity rate in adults 2016: United States with 40%, Chile (34.4), Mexico (33.3) and the country with less obesity Japan 4.2% Figure 1. OECD in 2017 report United States (38.2%) and Mexico (32.4%) Figure 2. OECD present a graphic about rising overweight rates in adults aged 15-74 Mexico in first place Figure 3, and a projected rates obesity for 2030 as a second one after United States Figure 4. In the epidemiological bulletin of Mexico of the week 39 2018 the more cases presented about severe malnutrition was the state of Mexico (486), Veracruz/Mexico City (399), Chihuahua (258) and Chiapas (206); Moderate malnutrition: state of Mexico (1830), Mexico City (746), Veracruz (700) and Puebla (595). For Mild malnutrition state of Mexico (7813), Mexico City (3656), Veracruz (3650) and Puebla (3468) Figure 5. Anorexia Nervosa and Bulimia Nervosa: Jalisco (225), State of Mexico (175), Morelos (177) and Chihuahua (166) Figure 6. Obesity: Mexico City (56226), state of Mexico (53375), Jalisco (38778) and Baja California (25064) Figure 7. In Figure 8 and 9 present an example of aquaculture production and sales in Mexico, the first places of production are Veracruz, Tabasco and Oaxaca, but the largest

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sale is in the state of Mexico and Mexico City. **Conclusion**: It is important to manage food distribution services to the places in need when those with the greatest purchasing power no longer want or will not consume those foods.

Figure 1. Obesity rate in adults, 2016 late or latest year. OECD 2016

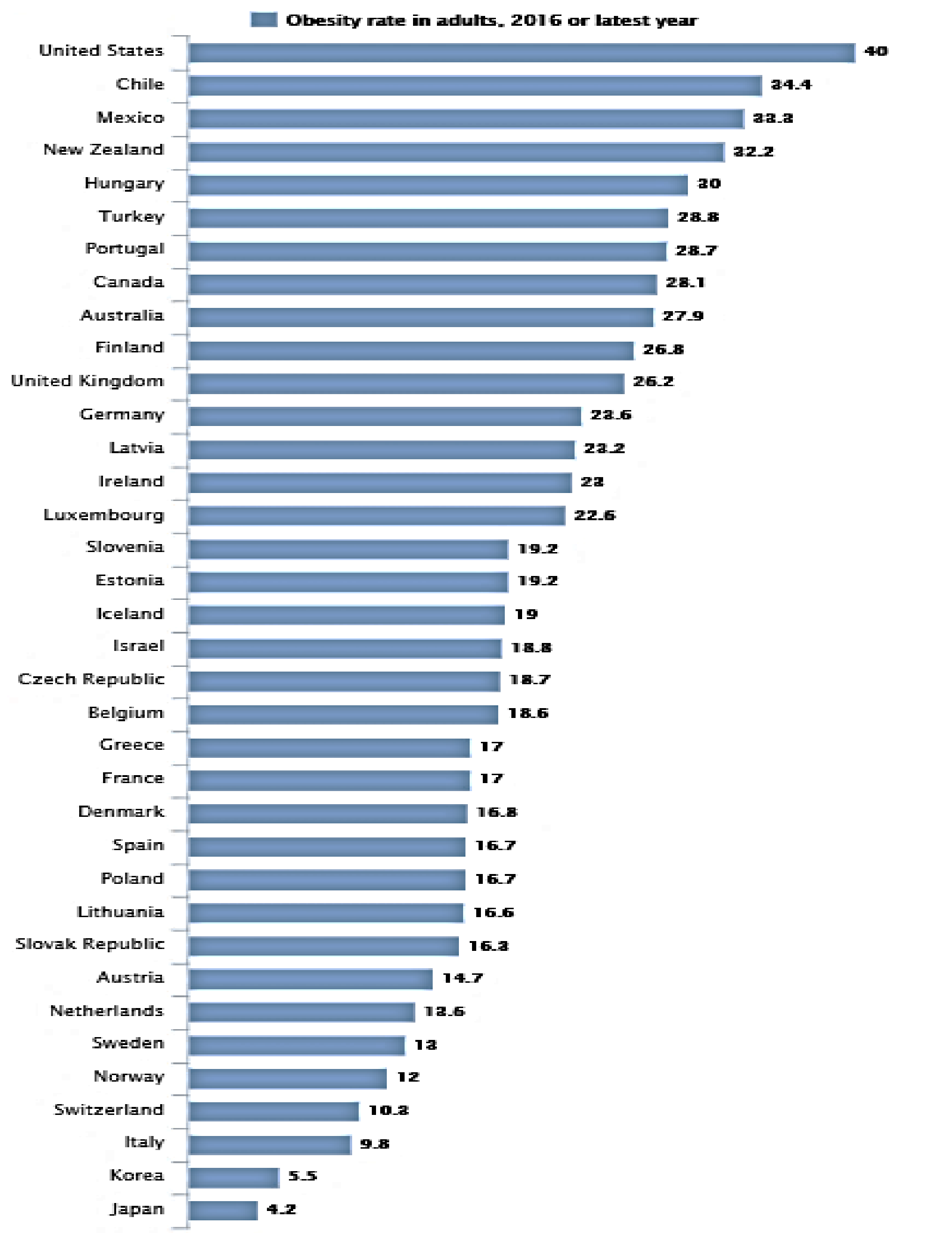

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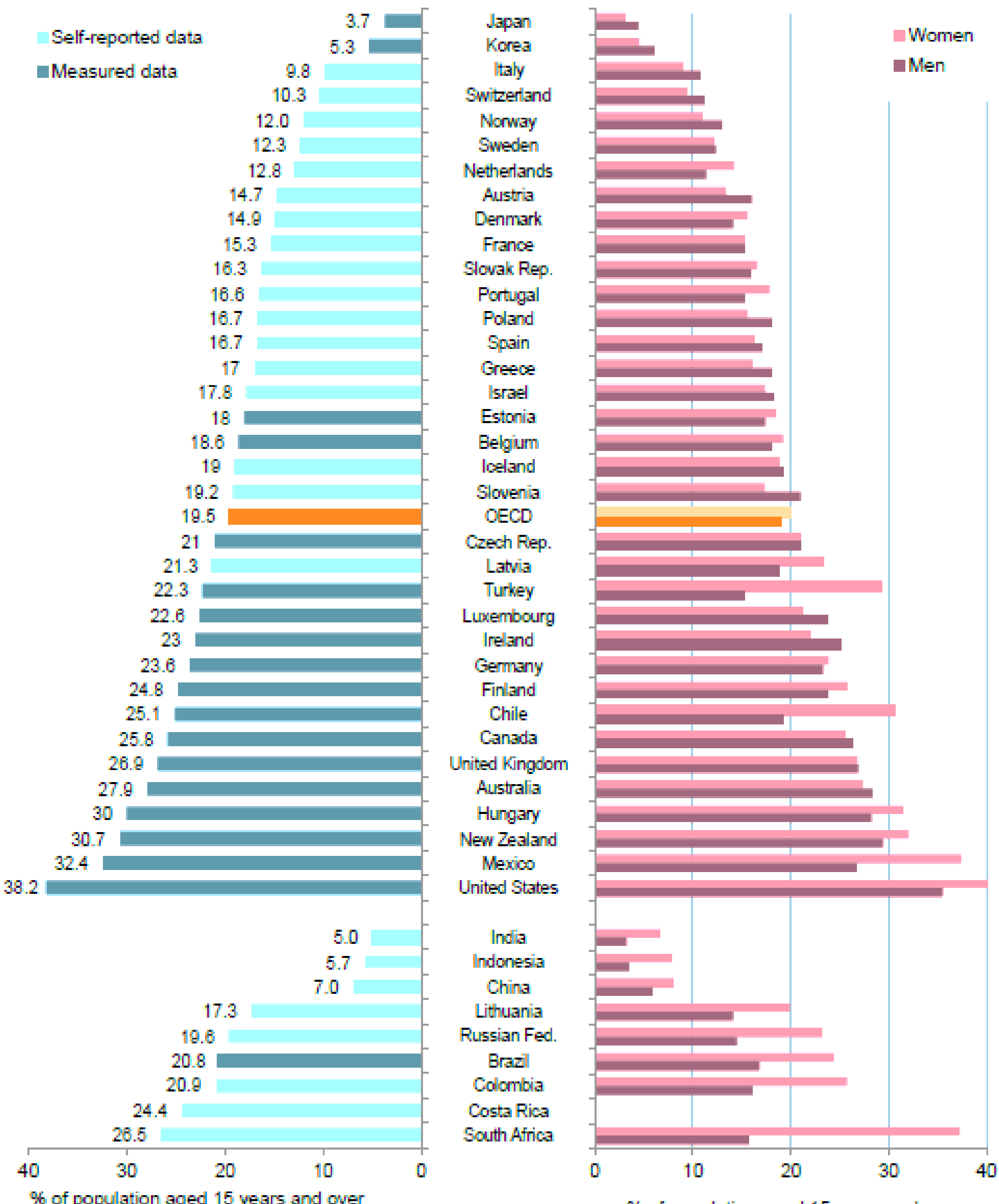
Figure. 2. Obesity among adults 2015 or nearest year. Source OECD 2017



Source: OECD (2017), OECD Health Statistics 2017 (Forthcoming in June 2017).
www.oecd.org/health/health-data.htm
Note: The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the

Figure 3. Rising overweight rates in adults aged 15-74
Source OECD 2017

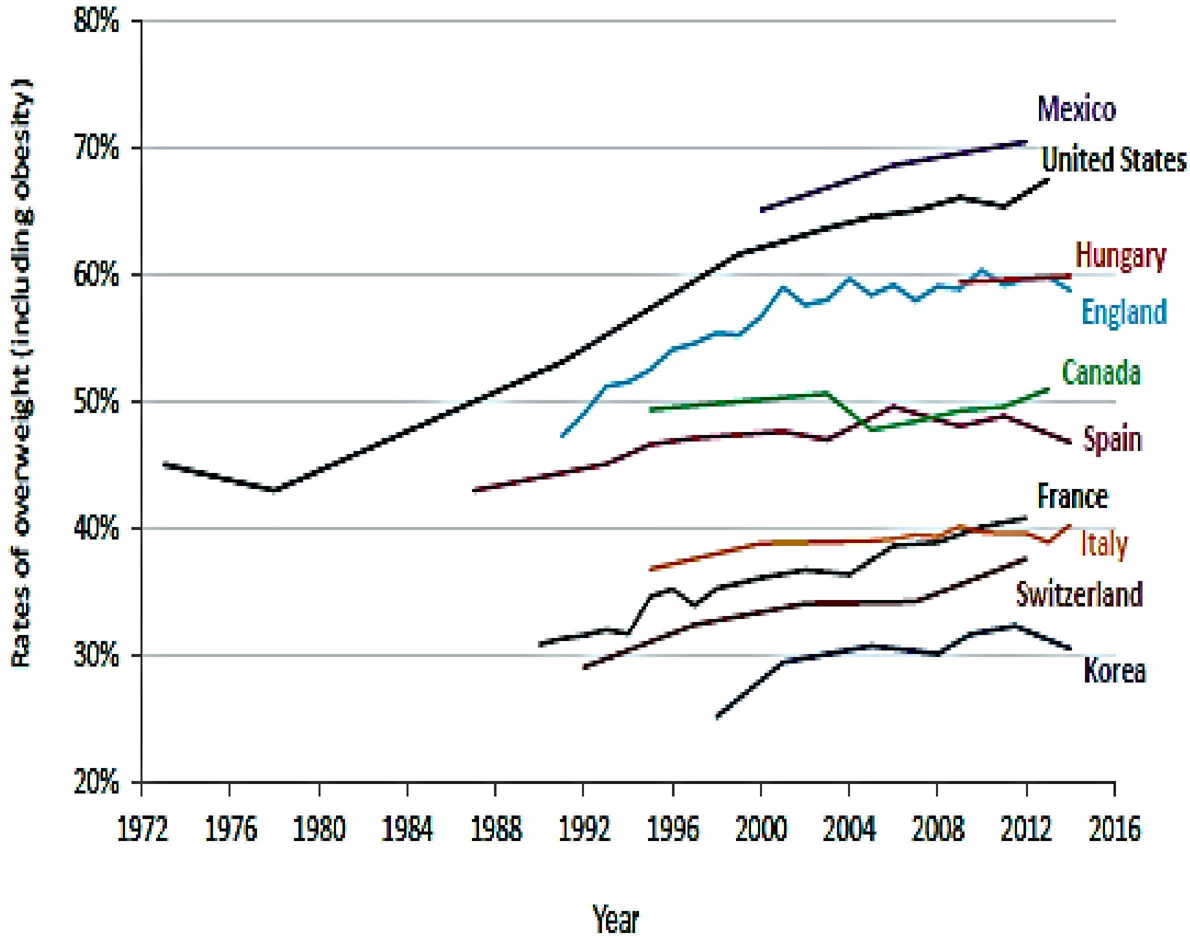


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Figure 4. Projected rates of obesity Source OECD 2017

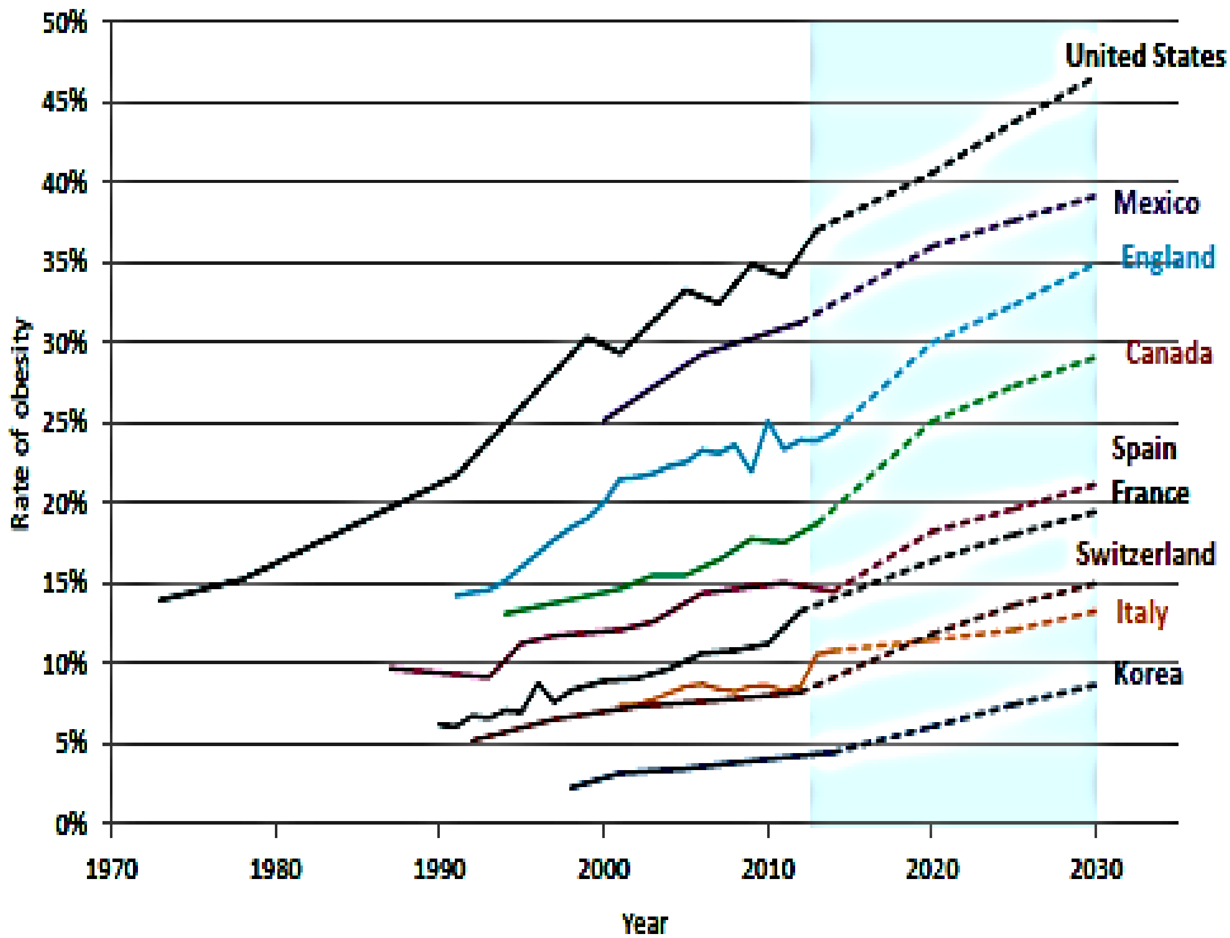

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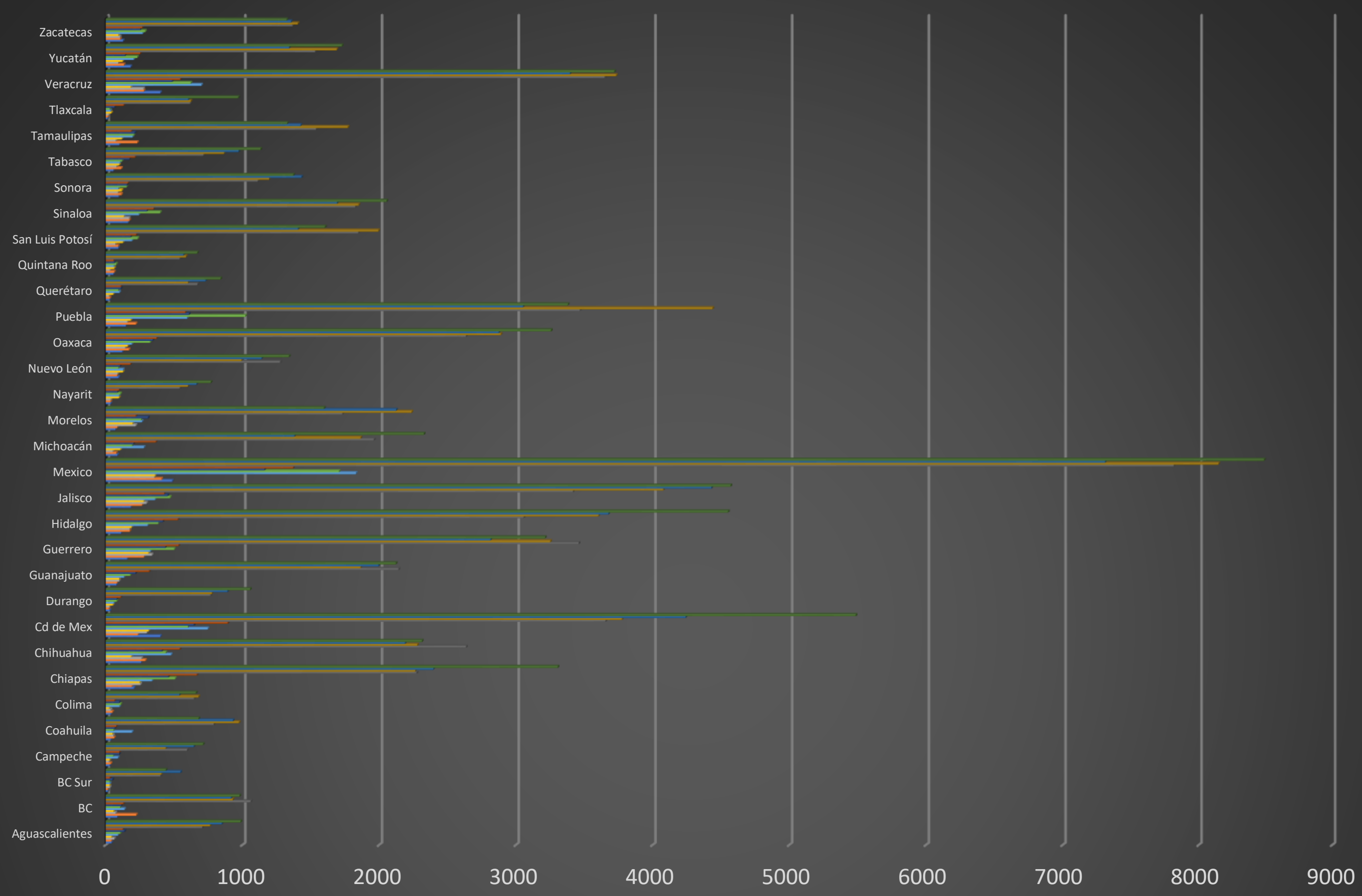
Figure 5. Severe, Moderate and Mild Malnutrition



	Aguascalientes	BC	BC Sur	Campeche	Coahuila	Colima	Chiapas	Chihuahua	Cd de Mex	Durango	Guanajuato	Guerrero	Hidalgo	Jalisco	Mexico
Mild 2015	987	978	439	711	680	660	3307	2313	5487	1056	2122	3213	4552	4571	8489
Mild 2016	849	917	547	644	930	538	2396	2189	4241	890	1995	2814	3677	4430	7309
Mild 2017	764	929	407	438	975	679	2263	2279	3776	777	1864	3252	3604	4078	8147
Mild 2018	706	1060	400	595	790	646	2274	2636	3656	766	2142	3460	3057	3418	7813
Moderate 2015	124	129	30	99	77	65	667	542	892	109	318	533	528	427	1371
Moderate 2016	136	113	48	98	66	97	458	410	645	81	218	435	417	452	1161
Moderate 2017	107	106	27	54	57	109	508	439	601	81	179	501	384	472	1707
Moderate 2018	89	137	31	89	192	101	339	478	746	60	134	326	306	361	1830
Severe 2015	41	58	27	29	49	26	248	186	313	53	98	312	189	277	361
Severe 2016	63	73	31	24	56	38	254	262	300	27	99	338	174	298	355
Severe 2017	40	223	16	37	62	49	191	290	235	24	82	279	176	265	408
Severe 2018	42	83	14	29	36	37	206	258	399	30	78	157	112	184	486

	Michoacán	Morelos	Nayarit	Nuevo León	Oaxaca	Puebla	Querétaro	Quintana Roo	San Luis Potosí	Sinaloa	Sonora	Tabasco	Tamaulipas	Tlaxcala	Veracruz	Yucatán	Zacatecas
Mild 2015	2327	1597	768	1340	3258	3380	840	669	1604	2054	1372	1132	1327	969	3720	1728	1324
Mild 2016	1379	2123	663	1140	2875	3052	730	568	1406	1691	1431	971	1425	603	3395	1341	1355
Mild 2017	1864	2238	600	993	2890	4439	602	587	1994	1849	1195	865	1771	621	3734	1689	1405
Mild 2018	1961	1730	542	1275	2635	3468	670	541	1847	1826	1113	715	1538	618	3650	1532	1366
Moderate 2015	367	220	96	180	372	582	109	57	222	349	163	214	186	130	544	252	267
Moderate 2016	202	309	85	103	344	608	110	62	181	300	155	173	212	64	485	141	252
Moderate 2017	193	258	108	93	325	1020	92	77	234	398	152	120	206	29	621	231	289
Moderate 2018	279	265	96	127	191	595	101	60	192	242	93	103	196	35	700	205	269
Severe 2015	108	196	96	125	160	184	54	62	125	132	116	99	117	40	183	123	93
Severe 2016	52	220	37	87	143	158	25	32	70	171	89	79	74	23	276	91	104
Severe 2017	76	83	36	82	170	221	31	62	90	173	115	114	231	16	279	133	106
Severe 2018	85	71	36	94	121	147	27	56	92	164	94	56	99	12	399	181	126

Mild 2015 Mild 2016 Mild 2017 Mild 2018 Moderate 2015 Moderate 2016
Moderate 2017 Moderate 2018 Severe 2015 Severe 2016 Severe 2017 Severe 2018

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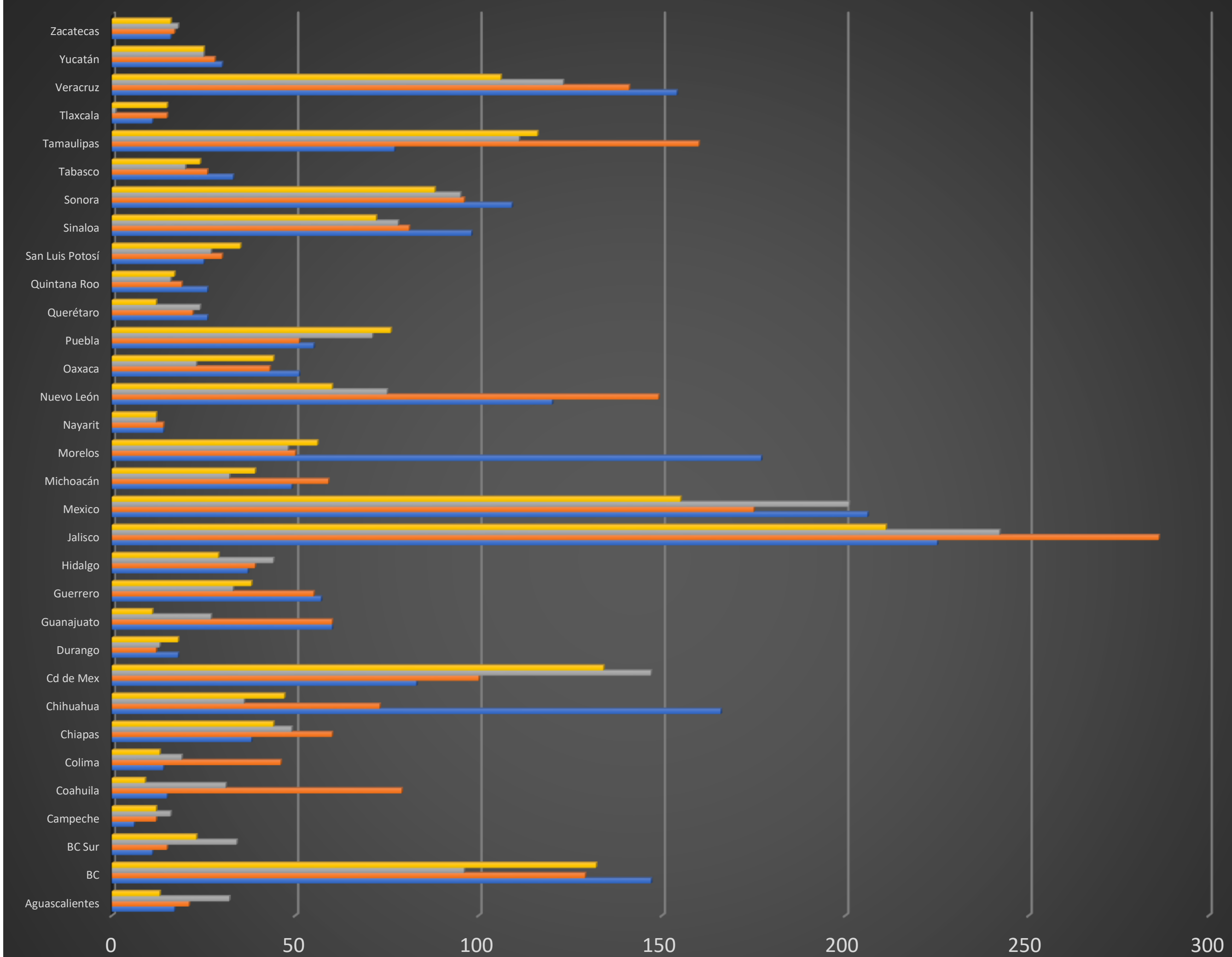
Figure 6. Anorexia Nervosa and Bulimia Nervosa

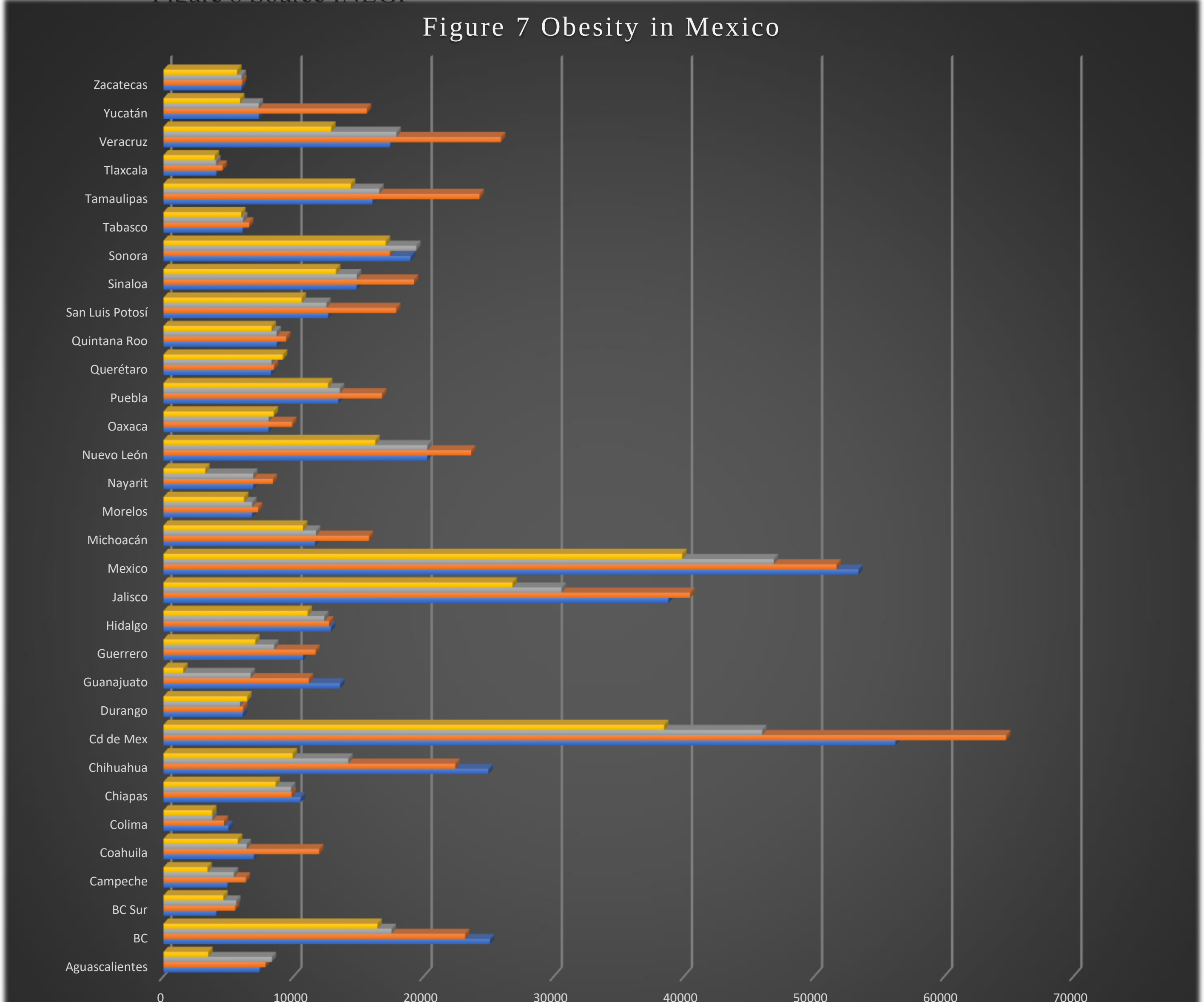


	Aguascalientes	BC	BC Sur	Campeche	Coahuila	Colima	Chiapas	Chihuahua	Cd de Mex	Durango	Guanajuato	Guerrero	Hidalgo	Jalisco	Mexico	Michoacán
Year 2015	13	132	23	12	9	13	44	47	134	18	11	38	29	211	155	39
Year 2016	32	96	34	16	31	19	49	36	147	13	27	33	44	242	201	32
Year 2017	21	129	15	12	79	46	60	73	100	12	60	55	39	286	175	59
Year 2018	17	147	11	6	15	14	38	166	83	18	60	57	37	225	206	49

	Morelos	Nayarit	Nuevo León	Oaxaca	Puebla	Querétaro	Quintana Roo	San Luis Potosí	Sinaloa	Sonora	Tabasco	Tamaulipas	Tlaxcala	Veracruz	Yucatán	Zacatecas
Year 2015	56	12	60	44	76	12	17	35	72	88	24	116	15	106	25	16
Year 2016	48	12	75	23	71	24	16	27	78	95	20	111	1	123	25	18
Year 2017	50	14	149	43	51	22	19	30	81	96	26	160	15	141	28	17
Year 2018	177	14	120	51	55	26	26	25	98	109	33	77	11	154	30	16

Year 2015 Year 2016 Year 2017 Year 2018

Figure 8 Source INEGI



	Aguascalientes	BC	BC Sur	Campeche	Coahuila	Colima	Chiapas	Chihuahua	Cd de Mex	Durango	Guanajuato	Guerrero	Hidalgo	Jalisco	Mexico	Michoacán
year 2015	3431	16438	4595	3375	5708	3732	8617	9926	38458	6423	1511	7047	11071	26811	39839	10709
year 2016	8314	17521	5580	5405	6380	3747	9792	14192	45984	5879	6690	8496	12346	30576	46878	11718
year 2017	7831	23167	5495	6315	11954	4634	9827	22408	64765	6106	11158	11677	12718	40455	51705	15780
year 2018	7377	25064	4037	4901	6934	4981	10527	24957	56226	6087	13551	10716	12844	38778	53375	11630

	Morelos	Nayarit	Nuevo León	Oaxaca	Puebla	Querétaro	Quintana Roo	San Luis Potosí	Sinaloa	Sonora	Tabasco	Tamaulipas	Tlaxcala	Veracruz	Yucatán	Zacatecas
year 2015	6188	3208	16264	8457	12636	9166	8299	10613	13251	17076	5960	14400	3928	12876	5877	5656
year 2016	6805	6888	20263	8071	13542	8300	8685	12509	14850	19413	6111	16573	4038	17891	7317	5987
year 2017	7259	8396	23632	9879	16790	8475	9416	17870	19241	17395	6567	24276	4532	25922	15613	6033
year 2018	6795	6885	20256	8060	13417	8252	8695	12642	14825	18973	6059	16046	4038	17413	7317	5978

year 2015 year 2016 year 2017 year 2018

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Figure 8. Data from INEGI about production in aquaculture.

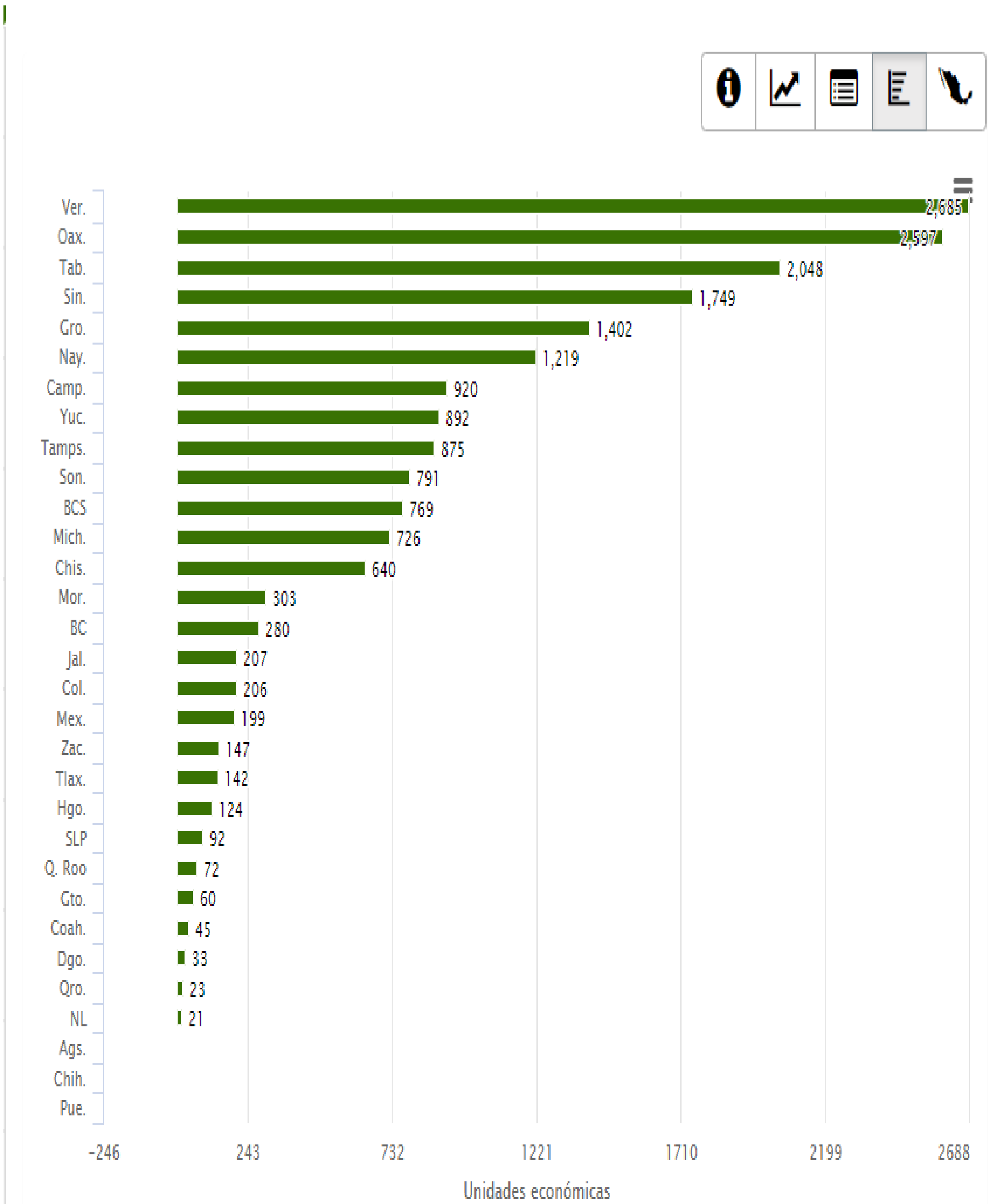

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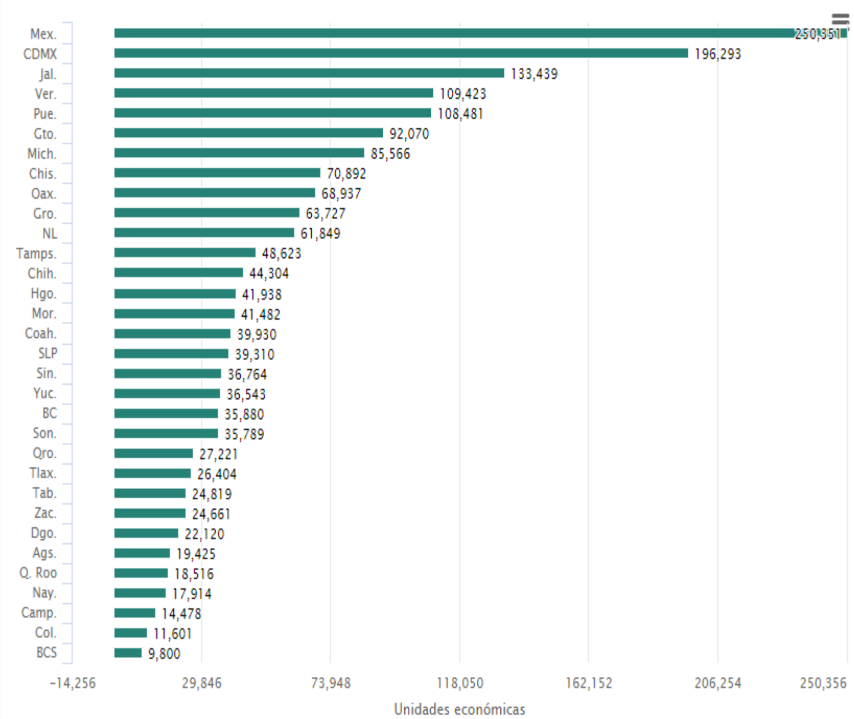
Figure 9. Economic Units, Source INEGI 2008



In Figure 1, we can observe Obesity rate in adults, 2016 late or latest year; the first place is United States, in second place Chile and third place Mexico but this data is from OECD 2016. And the last 5 place were for Norway, Switzerland, Italy, Korea and Japan. In Figure 2, we can observe Obesity among adults (2015 or nearest year, OECD 2017), the first place United States, second place Mexico, women won to men. The last 5 place Norway, Switzerland, Italy, Korea and Japan. Men won to women. And in population aged 15 years and over, the first place was for Sout Africa were women won to men and the last place was for India and women won to men. In Figure 3. We can observe the Rising overweight rates in adults aged 15-74 (Source OECD 2017) were Mexico won with more than 70%. In Figure 4, we can observe Projected rates of obesity Source OECD 2017 how United States win for 2030. In Figure 5 we can observe data from Mexico Epidemiological Bulletin about Severe, Moderate and Mild Malnutrition of 32 states from Mexico. the first place was for State of Mexico, followed by Mexico City, Puebla and Veracruz. In the Figure 6 we can observe data from Mexico Epidemiological Bulletin about Anorexia Nervosa and Bulimia Nervosa, were the first place is Jalisco. In the Figure 7 we can observe data from Mexico Epidemiological Bulletin about Obesity, were the first place was for Mexico City followed by state of Mexico, Jalisco, North BC, Nuevo León and Chihuahua. The last place was for Tlaxcala and South BC. In figure 8 we can observe data from

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INEGI about aquaculture production in the states of Mexico were Oaxaca has the first place. The last place was for Nuevo Leon. In the figure 9 about we can observe data from INEGI about economic units and the first place is the state of Mexico followed by Mexico City, Jalisco, Veracruz and Puebla.

Conclusion: In Oaxaca we have moderate malnutrition, not too much obesity, and we produce in second place aquiculture products but we don't have a lot of economic units. The most important issue about food is that in the state of Oaxaca as in the poor states of Mexico we do not have an adequate public health and assistance infrastructure, as well as, the government or private initiative infrastructure does not work properly. That is, epidemiological surveillance not working 100%, as in other states of the republic, where food is more expensive, as a result of whether epidemiological surveillance programs work, as is the case of a Nuevo Leon or Sinaloa. By not having an adequate health infrastructure, nutrition or malnutrition measures may be biased. Being the cheapest foods, we can have more access to food, whether or not we have the necessary nutritional characteristics and adequate health. So, we can observe malnourished people fat. We can produce many foods regionally, but if this production does not impact on improving the infrastructure of education, epidemiological surveillance and public health, it is an incongruity of the poor people's / states to vice versa of the rich.

Literature:
http://www.who.int/topics/obesity/en/ Accessed october 2018
http://www.who.int/mediacentre/factsheets/fs311/en/ Accessed october 2018
https://caloriebee.com/misc/International-Obesity-Facts-Highest-vs-Lowest-Worldwide-Obesity-Rates Accessed october 2018
https://www.shapefit.com/health/childhood-obesity.html Accessed october 2018
https://www.youtube.com/watch?v=IkoC3HZwe7Q Accessed october 2018
https://www.weforum.org/agenda/2016/04/is-the-world-getting-dangerously-fatter/ Accessed october 2018
https://www.worldobesity.org/data/ Accessed october 2018
Boletín Epidemiológico - Gobierno de México https://www.gob.mx/salud/acciones-y-programas/direccion-general-de-epidemiologia-boletin-epidemiologico Accessed october 2018
Instituto Nacional de Estadística y Geografía (INEGI) https://www.inegi.org.mx/ Accessed october 2018

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Elaboration of flour based on Roatan plantain *(Musa paradisiaca)* sweetened with stevia, low in gluten

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Participation Area: Food development

Abstract

A flour was prepared for hot cakes to base plantain Roatan (*Musa paradisiaca*) low in gluten, for the development of the flour the fruit was chopped into small slices which were immersed in a solution of citric acid to avoid enzymatic browning, the Equipment used for dehydration was a drying kiln at a functional temperature of 54-59 °c. The dehydrated product was ground and transformed into flour, which was stored in medium density polyethylene bags at room temperature. The obtained results showed that the temperature used is optimal for the dehydration of the plantain. According to the NOM-247-SSA1-2008 Official Mexican standard cereals, flours and Semolinas It was concluded that the plantain flour has the physical characteristics, chemical color, smell, flavor and texture of a flour which is suitable for the elaboration of a hot cake.

***Key words**: ·Gluten. ·Flour. ·Dehydration. ·Enzymatic Browning.*

Introduction

Approximately 100 million tons of plantains are produced annually worldwide, with African countries leading banana producers, most of this production is consumed locally (Arias, 2004). In Mexico, different varieties of bananas and plantains are cultivated in 15 states, Veracruz being the third place in plantain production (Saldívar Iglesias, 2017) In our state, there are about 3.361 producers who are concentrated in two geographical areas as the northern area: comprising the municipalities of Martínez de la Torre, San Rafael, Tlapacoyan, Nautla, Vega de Alatorre, Atzalan, Gutiérrez Zamora, Papanta and Misantla and the basin

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area of the Papaloapan: includes the municipalities of Otatitlán, Tlacojalpan, Tuxtilla, Chacaltianguis, Cosamaloapan and Tres Valles (Tepetlan-Juan, 2017).

Plantain (genus Musa sp) represents the fourth source of energy for developing countries after maize, rice and wheat. Due to the high concentration of starch, the processing of green plantain as flour and starch is of interest as a possible source of importance for food for industrial purposes (Pacheco-Delahaye E. &., 2005). In Mexico and other tropical countries, the wheat consumed is imported, but it can be mixed with other high-starch cereals and vegetables, which could be available locally and less expensive sources of nutrients (Torres E. , 2007), in particular it has studied the enrichment of bread with sources of dietary fiber (Torres E. , 2007) . The term "compound flour" refers to any mixture of two or more flours of cereals, legumes or tubers for different purposes. Among the products developed with these compound flours are the baked ones and especially the bread, where the function of the bakery is to present the flour of wheat in an attractive and palatable form (Pacheco-Delahaye E. &., 2005). The proteins of the wheat form a visco-elastic net, the gluten formed by the gliadins and Glutenins. The glutenins are high molecular weight proteins and contribute to the elasticity of the masses. The gliadins are proteins of lower molecular weight, responsible for the viscous masses (León., 2007). When the gluten is mixed with the water and enough energy, they provide the dough of the bread with visco-elastic characteristics.

Methodology

Materials

The Roatan plantains (*Mussa Paradiasiaca*) was used in the central zone of Veracruz and citric acid food grade (brand DROTASA; Mexico D.F.).

Methodology

For the flour elaboration process, the Roatan plantains pulp was used in the green state, it is sliced in 2 mm slices in a slicer (Torrey brand, model RB-300); slices were placed in a drying stove (riosa mark, model H-62) to a Temperature of 54-59 °c for 4 hours, subsequently the dehydrated slices were taken to a pulverizer to obtain the flour, a sifting

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was carried out in a sieve mesh no. 60. The flour was packed in a vacuum packer (Torrey brand, model EVD-20).

Formulation.

Three different formulations were made of plaint flour, wheat flour, baking powder and sweetener.

Analysis physicochemical

Acidity, PH and Brix degrees were performed using the methods of the AOAC, the equipment used were a potentiometer (brand HANNA), and a refractometer (brand ATAGO, model AT PAL 1); To determine the color was used a Colorimeter brand Konica Minolta model CR-400; Analyses were carried out in triplicate by taking representative samples of the raw material.

Statistical analysis

An analysis of variance (ANOVA) and tests were used with the Tukey test (confidence level = 95%), using the Minitab 16.0 software (Minitab, Inc., USA). The Excel software was used to analyze the results using statistical graphs.

Results and discussion

Physicochemical analysis

The results obtained from the physicochemical analyses in the unripe plantain are shown in table 1. The results obtained from pH were 6.17 and the acidity was reported as a percentage of malic acid contained in the sample having results of 0.02% acidity. Brix degrees had values of 1.57; these three parameters show that the plantain is still at an immature stage.

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Table 1. Physicochemical analysis results in unripe plantain.

Parameter	Fresh simple
pH	6.17± 0.53
Acidity (%)	0.02±0.01
Brix degrees	1.57±0.44

According to the results obtained in table 2, it can be observed that there were no significant differences (P < 0.05). The dehydrated sample has a luminosity of 77.168 ± 1.925, and the fresh 72.108 ± 1.295, as for the values in a* can be observed that the samples are between very low intervals of color that go green to a reddish hue according to the scale CIE L * a* b*; for the values in b* it was obtained for the fresh sample 20.090 ± 0.799 and in dehydrated sample 20.238 ± 0.35, because when obtaining the dehydrated sample, it is a slightly yellow hue.

Table 2. Results obtained of color analysis.

Color	Fresh sample	Dehydrated sample
L* (Luminosity)	77.168±1.925[B]	72.108±1.295[a]
a* (Chromatic parameter)	0.282±0.333[B]	1.038 ±0.244[a]
b* (Chromatic parameter)	20.090±0.799[B]	20.238±0.355[a]

The values reported for each case are the average (±) standard deviation.

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Sensory evaluation

The sensory evaluation was carried out on Thursday August 4, 2016 at the Universidad Tecnológica del Centro de Veracruz 30 untrained panelists, of which 18 were males and 12 women. The interpretation of the results was carried out through an analysis of variance (ANOVA). The results obtained as shown in Figure 1 showed that of the three formulations the third one had a greater acceptability on the part of the public, in the attributes evaluated of taste, smell, color and texture.

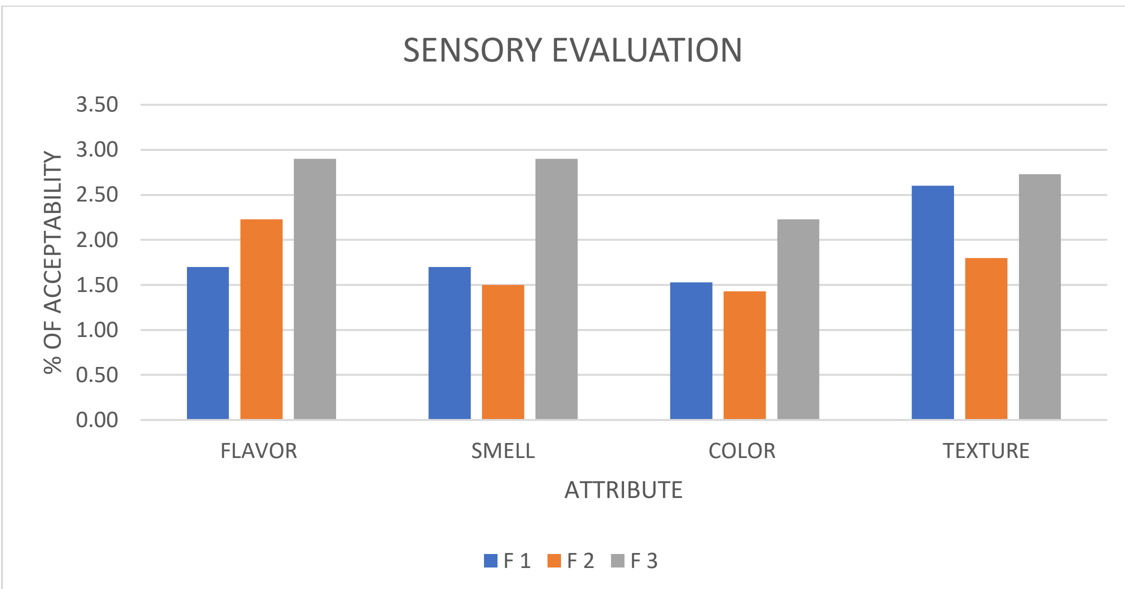

Figure 1. Results of sensory evaluation.

Conclusion

According to what was done, and the result of the sensory evaluation we conclude that the formulation three of plantain flour is the one that has the physical and chemical characteristics, according to the standard of cereals, flours of cereals, flours and Semolinas

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(official norm Mexican NOM-247-SSA1-2008 has color, smell, flavor and texture of a flour suitable for the elaboration of a hotcake with greater acceptability of the public.

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AREA V *Food Microbiology*

Study of the prevalence of *Salmonella enterica* in standard and refined sugar

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Abstract
Salmonella enterica is a Gram negative bacterium, short bacillus, not sporulated that produces gastrointestinal infections, has been found in low water activity foods (AW) as: dehydrated egg, milk powder and peanut butter. This research evaluated the prevalence of *Salmonella enterica* in standard and refined sugar. Samples were divided into 250g containing pouches, sterilized (121 °c/15min). Later they were contaminated with 20 glass beads containing 6, 7x105 CFU, and were incubated for 200 days at 25 and 35 °c, both at 60 and 80% relative humidity (HR), during storage The bacterial charge was evaluated weekly by the he results show that in standard sugar at 25 and 35 °c with 80% RH the same number of CFU/100 days prevailed, but with 60% RH, the prevalence time was higher (200 days) in incubated samples at 35 C, a similar behavior presented the refined sugar samples method of extension in plate and confirmation the presence of the biochemical organism. The maximum prevalence time of this microorganism was 200 days in both samples stored at 35 °c and 100 days stored at 25 °C.

Key words: *Salmonella enterica*, standard sugar, refined sugar, relative humidity

Introduction
Within the production of some foods of low (AW), there are unitary operations that are able to reduce the pathogens present in the raw materials, which makes a product safe. However, failures in sanitation programs have caused the finished product to be contaminated with pathogens present in equipment and/or facilities, coupled with inadequate manipulation and poor storage and marketing conditions of the Product. Salmonella is a enteropathogen bacterium whose natural habitat is the intestinal tract of mammals (domestic and wild), reptiles and insects [Brenes and Arias, 2006], [Brunett and Col., 2000], [Klerks and Col., 2007]. The majority of these microorganisms are associated with diseases in humans are: *S. Enteritidis, S. Typhimurium and S. enterica subsp. enterica*, the latter transmitted mainly by

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raw and precooked foods, vegetables, poultry, egg, raw milk, dairy products, shellfish, fruits, and other plant products, as well as by food handlers [Brendan and Col., 2013], [FDA, 1992], [Kataoka and Col., 2014].

Although the production of sugar involves stages of heat such as evaporation of the juice and crystallization where temperatures above 100 °c are used, the drying stage is the possible point of clear possibility of contamination. Despite improvements to sugar food safety programs, there is currently no data in literature regarding the survival of food-borne pathogens in table sugar [Brenes and Arias, 2006], [Burnett and Col., 2000]. This study will allow to know the prevalence of *Salmonella enterica* in table sugar after contaminating the product.

Methodology

It was used a strain lyophilised *Salmonella enterica subsp. Enterica*, resistant to rifampin gained in Scientific Senna, S.A de C.V. ECA was inoculated and enriched in broth soy tripticaseína (TSB), which is constituted by: 17 g of digestive pancreatic casein, 3 g of digestive pancreatic soy, 5 g of sodium chloride, 2.5 g of dipotassium hydrogen phosphate and 2.5 g dextrose for 1l of solution, which was incubated at 35 °c/24 ± 2h, subsequently inoculated in soy agar tripticaseina incorporating rifampicin (TSArif) to the solution, formed by casein peptone 15 g, soy peptone 5 G, sodium chloride 5 g and agar 15 g and finally incubated at 35 °c/24 ± 2h.

Biochemical confirmation and inoculation of samples

Took roasted TSArif and inoculated by striated and sting in three different media (1): Agar triple sugar iron (IST) formed by 10 g trypton casein, 10 g trypton meat, 5 g of sodium chloride, 10 g of lactose, 10 g of sucrose, 1 g of dextrose, 0.2 g of iron sulfate and ammonium, 0.2 g of sodium thiosulphate, 25 mg of phenol red and 13 g of agar, to form 1l of solution biochemistry and inoculation of the samples 2): lysine iron agar (LIA) containing 5 g of gelatin peptone, 3 g of yeast extract, 1 g of glucose, 10 g of lysine, 0.5 g of iron and ammonium citrate, 0.04 g of sodium thiosulfate, 0.02 g of Bromocresol Purpura and 15 g of agar per litre , (3): Xylose deoxycholate agar (XDA) composed of xylose 3.5 G, L-lysine 5 g, lactose 7.5 g, sucrose 7.5 g, sodium chloride 5 g, yeast extract 3 G, sodium deoxycholate 2.5 g, sodium thiosulfate 6.8 g, iron citrate and ammonium, 0.04 g of sodium thiosulfate, 0.02 g of Bromocresol Purpura and 15 g of agar per litre, (3): Xylose deoxycholate agar (XDA) composed of xylose 3.5 G, L-lysine 5 g, lactose 7.5 g, sucrose 7.5 g, sodium chloride 5 g, yeast extract 3 G , sodium deoxycholate 2.5 g, sodium thiosulfate 6.8 g, iron citrate and ammonium 0.8 g, red phenol 80 mg and agar 13.5 g, the media were incubated at the same

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temperature as TSArif. From the isolated strain in LIA, it was inoculated in test tube with TSArif by striation, it was innaved at 35 °c/24h ± 2h and was covered with mineral oil previously sterilized at 121 °c/15min and was stored at room temperature, the latter were taken roasted from the Microorganism and were taken to tubes with TSB which were incubated 35 °c/24 ± 2h.

From the TSB tubes, 1 ML was inoculated by extension in TSArif plates and incubated at 35 °c/24 ± 2h, each plate served to contaminate 20 sterile glass beads that were placed in different pouches which contained 250 g of refined sugar (Marien) and 250 g of AZ Standard Úcar (Marien) previously sterilized in autoclave (121 °c/15 min). Two temperatures were used for the storage of the samples; 35 and 25 °c Both 60 and 80% relative humidity reached with NaBr solution to 90.5% and (NH4) 2SO4 to 76% respectively.

Microbiological sampling and analysis.

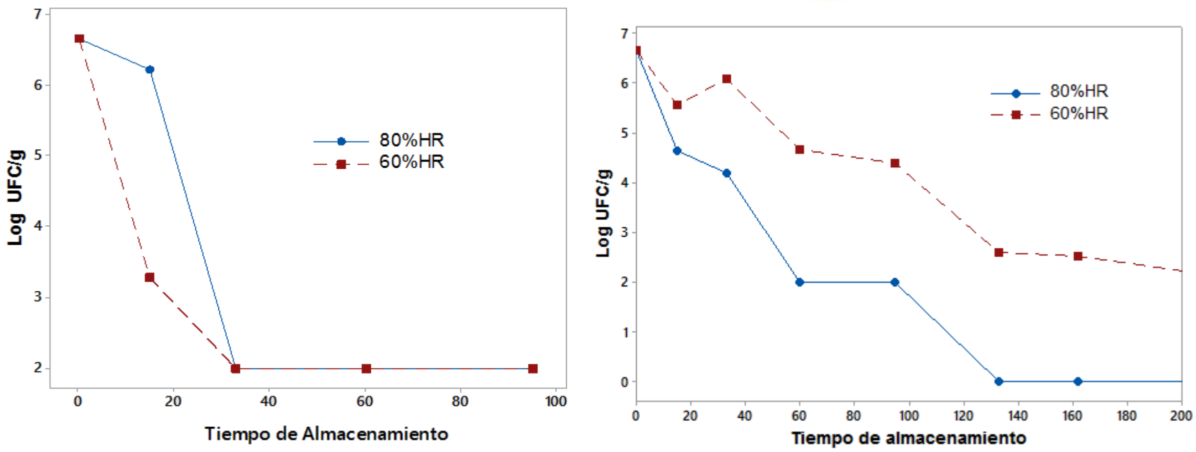
Immediately after inoculation of the samples, an initial sampling was carried out to evaluate the load of Salmonella contained in the contaminated samples, the count was performed with TSArif and it was inoculated by plaque extension and incubated at 35 °c/24 ± 2h. Confirmation of the survival of Salmonella was performed by Striation in TSArif Weekly and in triplicate in the samples stored.

The results of the bacterial population were analyzed with the statistical program Minitab 17, with test of comparison of Tukey measures ($\alpha = 0.05$).

Results and Discussion

Prevalence of *Salmonella enterica*

In Figure 1, it is observed the behavior that showed Salmonella inoculated in standard sugar stored at 25 and 35 °c, with a relative humidity of 60 and 80%



a) b)

Figure 1. Prevalence of *Salmonella enterica* in standard sugar a) 25 °c and B) 35 °c.

The concentration with which the samples were contaminated was 6.7 Log CFU/G. At 25 °c, the bacterial charge in both HR decreased considerably during the first 35 days of storage, reaching 2 CFU/g and remaining constant until the end of the study. While at 35 °c The samples also showed a decrease in both HR, but at a longer time, as a bacterial charge of 2UFC/G was presented up to 60 days for 80% RH and 135 days at approximately 60% RH, prevailing longer in the latter.

During the days 20-40, there is an increase in bacterial load of samples stored at 35 °c/60% RH, which may be originated biochemically by the ability of the microorganism to belong to the family of the Enterobacteriaceae of metabolize nutrients such as glucose by respiratory and fermentation, coupled with the relative humidity could generate hydrolysis in the sucrose and release other fermentable sugars such as glucose and fructose. *Salmonella* has an optimal temperature of growth between 34 and 42 °c, hence in this study the samples that showed greater prevalence of this microorganism were those stored at 35 °c/69% RH, even though there has been observed presence in food stored at temperatures of 2 °c [Ozioma and Col., 2015], this is why the importance of controlling factors such as temperature and HR during storage.

Recent research has demonstrated the survival capacity of *Salmonella* for more than a year in low water activity (AW) foods such as black pepper, chocolate, gelatin and has even survived for more than 4 years in dehydrated whole egg [S. J and P. R, 2017].

Kataoka and Col., 2014, observed the prevalence of *Salmonella* after one year of storage at 20 °c in peanut paste, with a fat content higher than 50% and low AW (0.3 and 0.6).

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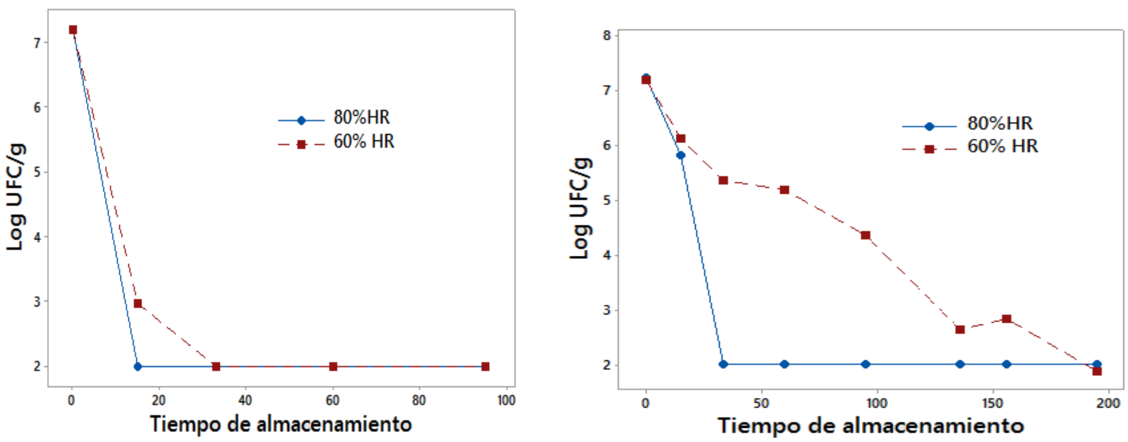
Therefore, the results obtained in this research confirm the prevalence of this bacterium in table sugar considered as low aw food and with zero fat content, since it has been observed that these microorganisms also grow in foods rich in fat as the peanut and some of its derivatives, as well as in food with a pH from 4 to 9, being the table sugar inside this interval [A.B and cabbage., 2017], [Kataoka and cabbage., 2014], [Ozioma and cabbage., 2015].

Figure 2 shows the prevalence of Salmonella inoculated in refined sugar.

In samples of sugar standard, the initial load of *S. enterica* was the same as that in samples of refined sugar, but the behavior shown during storage was different, in this last at 25°C in both HR the microorganism reached its phase of decline in a time less than stored at 35°C. The most important factors influencing the prevalence of pathogenic microorganisms in food are: pH, temperature and aw, in this study it was observed a higher prevalence of *S. enterica* in samples stored at 35°C.



a) b)

Figure 2. Prevalence of *Salmonella enterica* in refined sugar to) 25°C and b) 35°C.

The samples stored at 25°C/80%RH presented a load of <2 Log CFU/g at 35 days of storage, while at the same temperature and with a HR of 80% presented the same load but in a shorter time, these results are similar to those reported by Brenes and Arias, 2006, they inoculated and stored at 21°C *S. enteritidis* in commercial samples of peanut butter, noting that the organism was not able to survive beyond two weeks, reaching the samples values < 2.0Log CFU/g, which indicates that the moisture in the food is also an important factor to consider during the storage.

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An important stage in the sugar refining process is the wash with saturated hot syrup, which aims to loosen the molasses film for subsequent removal of the standard grain, this film still remaining in the standard sugar can be Source of nutrients for microorganisms [The Sugar Association, 2005], this could result in the refined sugar being observed a lesser prevalence of *S. Enteric* than in standard sugar. In addition to this, if in the packaging stage is packed hot and not at room temperature can occur condensation of water vapor in the walls of the gasket so that the water can concentrate on the surface of the product which favors its contamination and subsequent deter Parrot [Pujol & Col., 2007]. That is why this stage plays an important role in the sanitary quality of the product and hygienic conditions of the process, since this product is used as an ingredient in the food and pharmaceutical industry, to other is marketed also for direct consumption in the homes of almost all over the world and even recent investigations have demonstrated beneficial uses of the sugar in the treatment of ulcers diabetic [Biswas and col., 2010].

Conclusion

There are few studies that detail the survival of *Salmonella enterica* in table sugar, but the study performed in this research shows that the microorganism can adapt to relative humidity variables that include 60 to 80% and can survive in temperatures that vary from 25 to 35°C in table sugar, the prevalence of this microorganisms was greater in samples of sugar standard stored at 35°C with 60%RH.

The conditions during storage, are factors to consider very important to prevent a possible contamination by *Salmonella* and other pathogenic microorganisms in sugar. Therefore, the temperature and relative humidity can be considered as critical control points during the process of obtaining sugar, including storage.

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AREA XI *Product Development*

Standardization of the process of a dressing from the soybean extract *[Glycine max (L.) Merrill]*

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Participation Area: Food development

Soybean is a seed with diverse functional properties, it contains vitamins, minerals and protein. In Mexico, it is not exploited in its entirety. INEGI data show that 50% of the Mexican population suffers from lactose intolerance, which causes people to stop using milk products; since *soy Glycine max* has a high emulsifying power, a cream-like dressing with habanero chile flavor *(C. chinense Jacq.)* suitable for people suffering from these conditions was elaborated; a factorial 2^2 design was proposed to standardize the process and a sensorial analysis of paired preference, to evaluate the degree of acceptability on the part of the consumers, as well as the determination of physicochemical analysis (protein, fat, pH and ° Brix) the final formulation. It was concluded that, by eliminating the oligosaccharides by soaking the grain, the flavor of the soybean is not as strong and by adding citric acid the formation of the emulsion is favorable. The yield of the seed is of 80%, reason why the elaboration of a dressing is viable and opportune for the creation of new derived products of the soybean.

Key words: dressing • emulsifier • oligosaccharides • soy Glycine max.

Introduction

Data from INEGI show that 50% of the population in Mexico suffers from lactose intolerance, which becomes problematic when choosing foods free of this disaccharide, since most lactose-free products have a high cost. Due to the high emulsifying power of *soy Glycine max*, it was decided to standardize the process of making a cream-type dressing,

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using the habanero chile *C. chinense Jacq*. since it contains capsaicin, the main capsaicinoid that stimulates the mucous membrane of the stomach, increasing salivary secretion and peristalsis (contractions of the intestine that advance the food), which stimulates the appetite, likewise, capsaicin has an anti-inflammatory effect. (Ruiz, Lara, & Martínez, 2011). In addition, Soy is a seed with various functional properties, contains vitamins, minerals; This species is known for its high protein content and essential polyunsaturated fatty acids (linoleic and alpha-linolenic, together with vitamin E) those that occupy more than 60% of total fatty acids (Carrao et al.1995). Soybean production in Mexico is concentrated in the states of Tamaulipas (58%), mainly in the south of the state, San Luis Potosí (18%), Chiapas (8%), Veracruz (8%) and Campeche (5%) (SIAP-SAGARPA, 2012). This seed is not used in its entirety, since it is used mainly in cattle feed or vegetable oils. (Díaz, Torres, Gonzales, & Noda, 2003).

Materials and methods

Formulation

It began with the selection and washing of *soy Glycinen max*, which was obtained from a supermarket from the central area of Paso Del Macho, Veracruz. An immersion in drinking water was carried out during a period of 10 h with the purpose of eliminating the oligosaccharides present in the soybeans, which give a bitter taste. When the time elapsed, it was cooked for 30 minutes at a temperature of 95 ° C. Later, a first filtration was carried out with a mesh of number 18 and another filtration with mesh number 325 to separate most solids. Obtained the extract is mixed with the rest of the supplies. The process of transforming the raw material into finished product is observed in the Figure 1.

a) b) c) d)

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Figure 1 Transformation of soybean in dressing

a) Soaking the Grain B) Cooking C) Grinding D) Obtaining the Finished Product

Design of experiments

The design applied was the factorial design 2^2 (Pulido & Salazar, 2008) in which, the effect of the concentration of spicy and citric acid on the acceptability of the product was studied. The factors used were the following: concentration of lemon with two levels: 20-25 ml, concentration of habanero pepper with levels of 3,5-5 grams and the response variable the degree of consumer satisfaction, where a group of 25 people gave a score to the four formulations obtained in the design, for this a statistical package was used (Minitab Statistical Software 18).

Sensory evaluation and physicochemical analysis

Subsequently, a sensory analysis of paired preference was applied (Regueiro, Mauriz, Fero, & Plana, 2014) to the two formulations with the highest score by 50 untrained panelists, with an age range of 15 to 50 years; the two formulations that were evaluated were coded as M7396 which contained 46.9% soy extract, 46.9% soybean oil, 4.7% lemon, 0.9% salt and 0.7% habanero pepper and M4561 with 46.7% extract soy, 46.7% soybean oil, 4.6% lemon, 0.9% salt and 0.9% habanero pepper, randomly.
The analyzes that were made to the final formulation were protein determination by the digestion method; pH using the potentiometric method and fat by weight difference.

Results and Discussion

Sensory evaluation
A sensory test was developed paired preference, which consists in asking the panelist to test a couple of samples of a product and specify which of the two samples he prefers. (Hernandez et al. 2005).
The results of the sensory evaluation are shown in figure 2, where the percentages obtained from the formulations coded as M7396 and M4561 are randomly compared.

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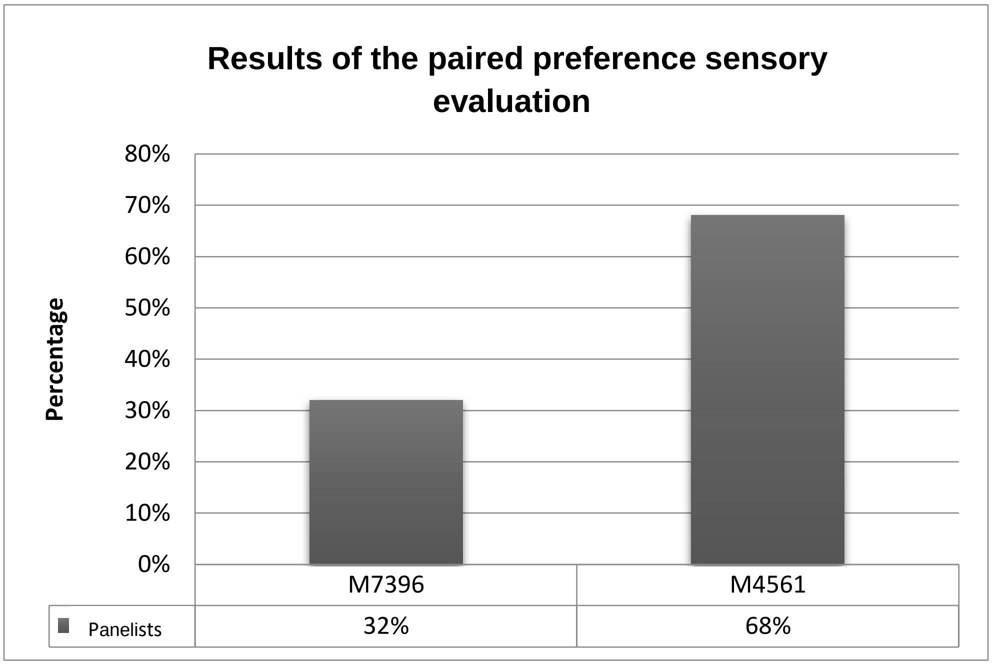

Figure 2 Results of the sensory evaluation

34 of the panelists opted for the sample coded as 4561 which is equivalent to 68%, the remaining 16 panelists opted for the sample coded as M7396. This means that the one that had the greatest impact was the sample with the largest amount of habanero pepper *(Capsicum chinense*).

Physicochemical analysis

In Table 1, the results of the physicochemical analyzes performed on the final formulation are shown. All the analyzes were carried out in triplicate, within the laboratory of the University**.**

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Table 1 Results of physicochemical analysis

Test	Method employee	Reference	Obtained
pH	potentiometric	de 3.5 - 3.8	2.77, 2.77 y 2.75
Protein	Digestion	2,27%	2%, 3.2775% y 2%
Grease	Gravimetric	33% by weight minimum	46.72% by weight minimum

The results of the physicochemical analysis show in the previous table were compared with the characteristics of a mayonnaise, it should be mentioned that for the determination of the fat, the method used for the dressing was by weight difference and the quantity was taken of soybean oil used, because it is what helps the formation of the emulsion. Soybean oil was used, as it is a vegetable oil that is not harmful to health and is derived from the seed used. All analyzes were performed in triplicate.

Conclusions

The yield of the seed is of 80%, reason why the elaboration of a dressing is viable and opportune for the creation of new derived products of the soya. The characteristic flavor of soy is improved during the elimination of the oligosaccharides.

It will work together to reduce the percentage of soybean oil used without breaking the emulsion. With the losses, a meat substitute can be created to make the process sustainable and avoid large losses.

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