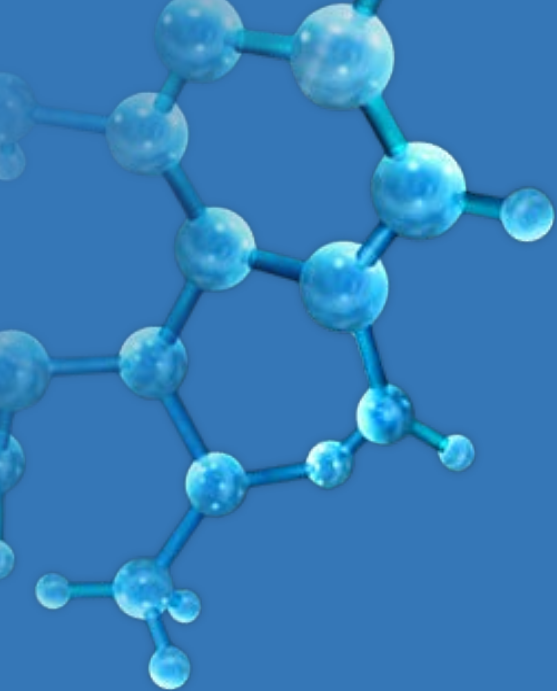




AGAVE: Phytochemistry, microbiota & sustainability

Dra. Janet A. Gutiérrez

GEE NutriOmics

Directora de Departamento de Bioingeniería y Ciencias

Zona Sur

Campus Puebla

Food Security Center

December 2017





El TEC en números

89,641 estudiantes

26,144 Preparatoria

55,565 Profesional

7,962 Posgrado

10,117 profesores

31 campus

18 Oficinas
internacionales



NUESTRA VISIÓN

**Educar líderes que
tengan un espíritu
emprendedor, una
perspectiva humanista y
que sean competitivos
internacionalmente**

Escuela de Ingeniería y Ciencias

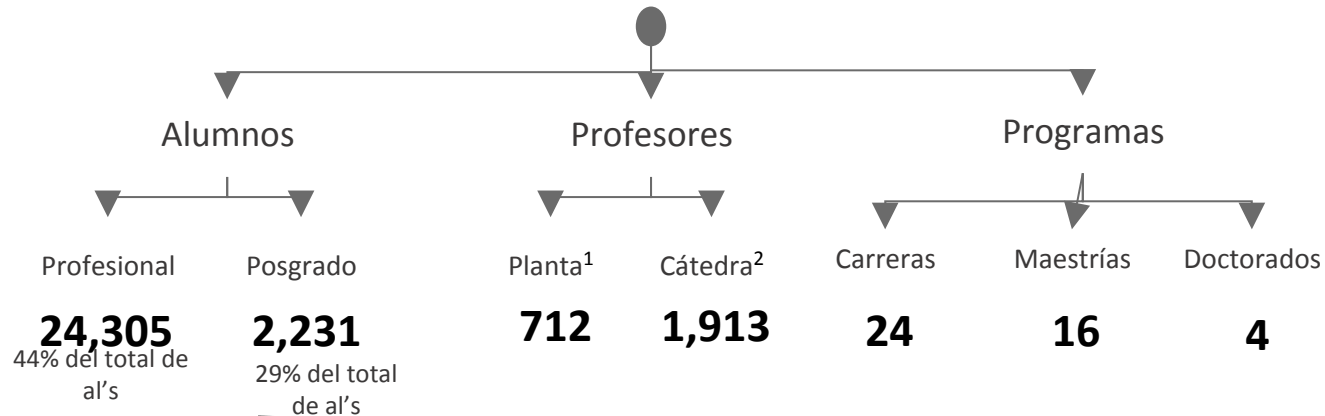


Tecnológico de Monterrey
Escuela de Ingeniería y Ciencias

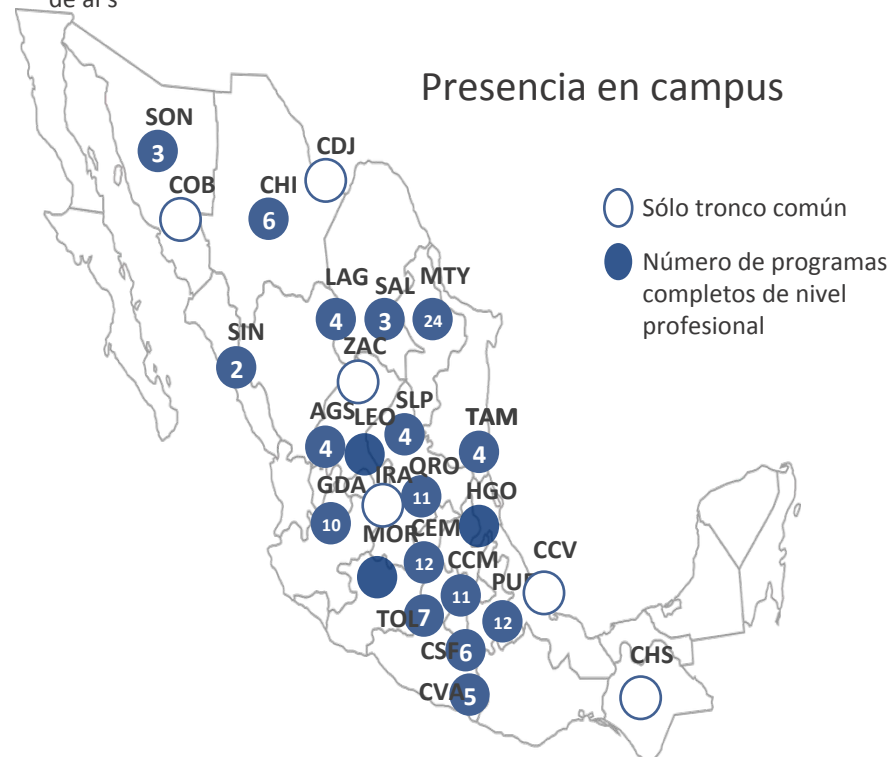


School of Engineering and Science

Información general



Presencia en campus



¹Incluye profesores investigadores

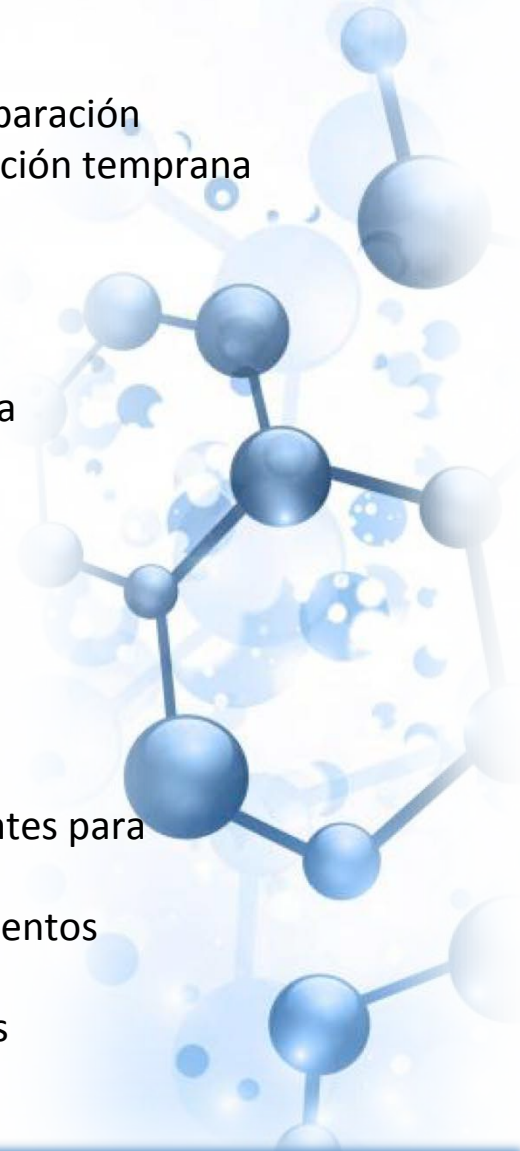
²Incluye profesores extranjeros visitantes

Programas de profesional

- Ingeniero Agrónomo
- Ingeniero Civil
- Ingeniero en Bionegocios
- Ingeniero en Biotecnología
- Ingeniero en Desarrollo Sustentable
- Ingeniero en Diseño Automotriz
- Ingeniero en Industrias Alimentarias
- Ingeniero en Innovación y Desarrollo
- Ingeniero en Mecatrónica
- Ingeniero en Negocios y Tecnologías de Información
- Ingeniero en Sistemas Computacionales
- Ingeniero en Sistemas Digitales y Robótica
- Ingeniero en Tecnologías Computacionales
- Ingeniero en Tecnologías de Información
- Ingeniero en Tecnologías Electrónicas
- Ingeniero en Telecomunicaciones y Sistemas Electrónicos
- Ingeniero Físico Industrial
- Ingeniero Industrial y de Sistemas
- Ingeniero Mecánico Administrador
- Ingeniero Mecánico Electricista
- Ingeniero Químico Administrador
- Ingeniero Químico en Procesos Sustentables
- Ingeniero en Nanotecnología y Ciencias Químicas
- Ingeniero Biomédico

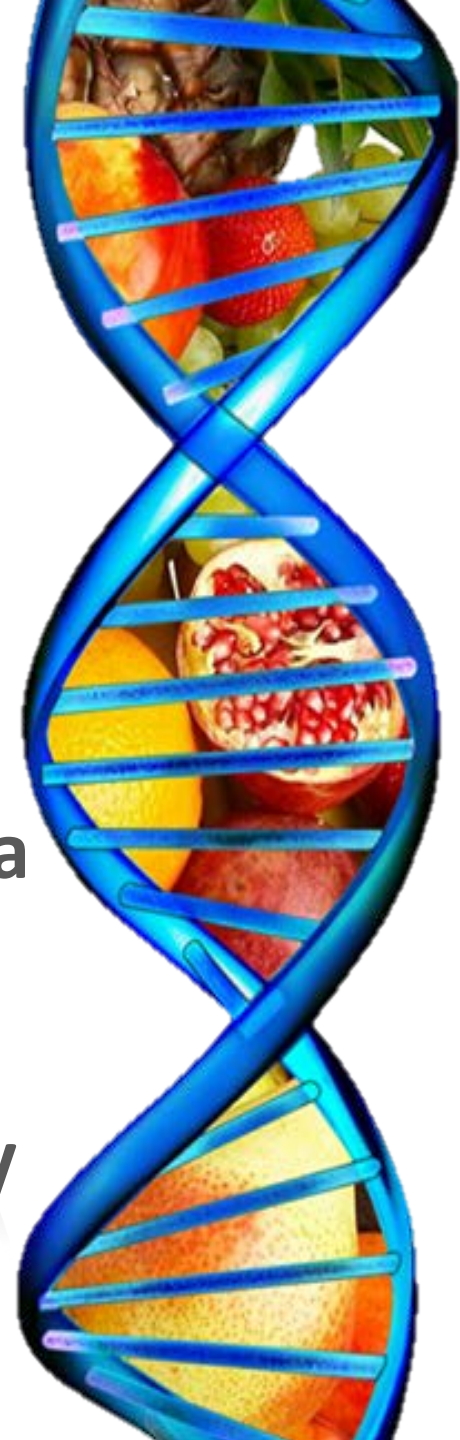
Grupos de Enfoque Estratégico (Biotecnología)

- **GEE: Bioprocesos y Biología Sintética**
 - Diseño de bioprocesos
 - Tecnologías novedosas de bioseparación
 - Tecnologías de medición y detección temprana
 - Biología sintética
- **GEE: NutriOmics**
 - Nutrigenómica
 - Desarrollo de proteínas vegetales para aplicación en alimentos
 - Fitoquímica y ensayos biológicos
- **GEE: Tecnologías Emergentes para la Estabilización de Nutrientes Esenciales: Diseño de alimentos Basados en Nutrigenética**
 - Tecnologías emergentes para la estabilización y conservación de alimentos
 - Nutrigenética
 - Nutrientes esenciales

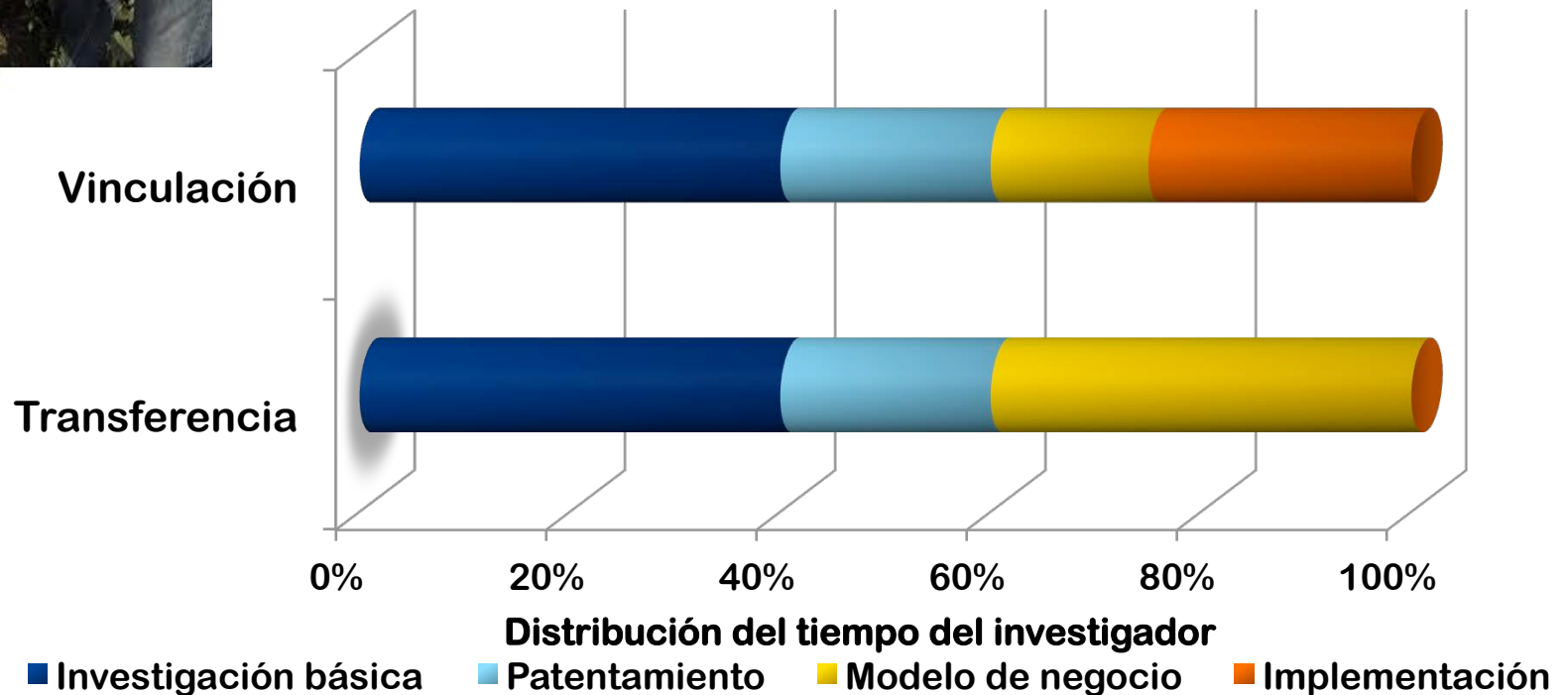


Grupo de enfoque en NUTRIOMICS

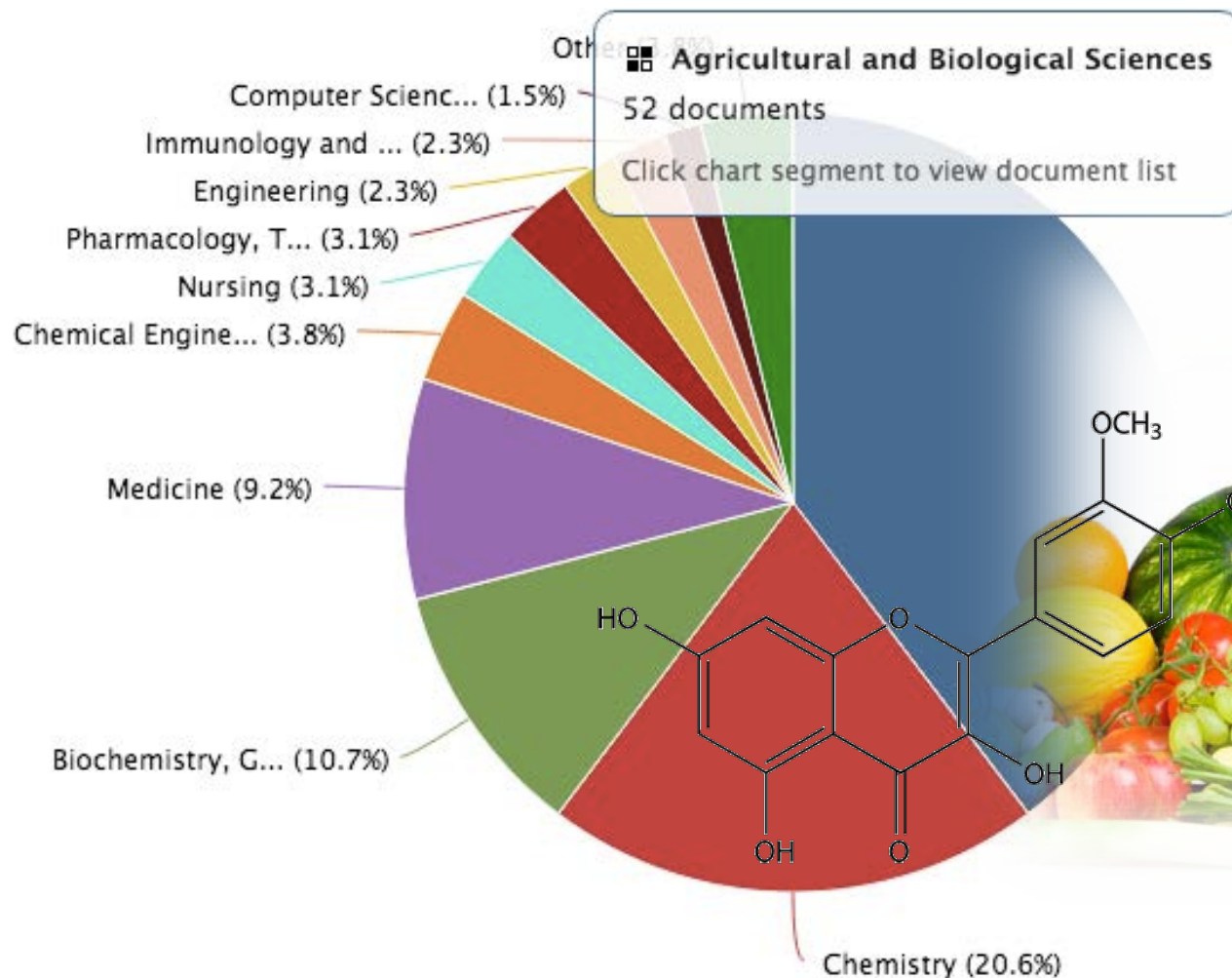
Generar una plataforma de conocimiento, tecnología y talento para proveer soluciones para la industria alimentaria en el esfuerzo de contrarrestar el síndrome metabólico y otras enfermedades crónico-degenerativas



Beyond research...

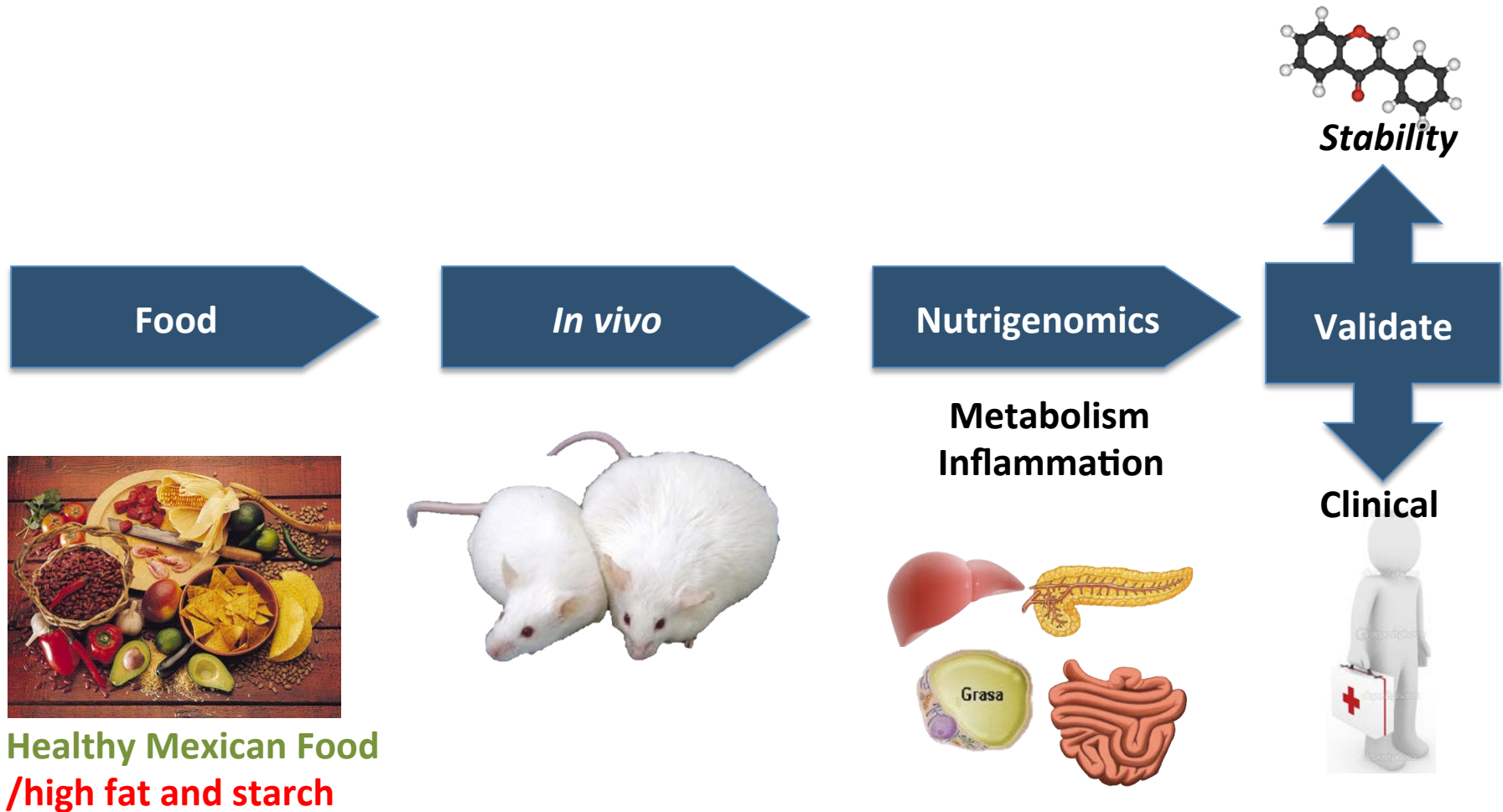


Identify, stabilize & validate

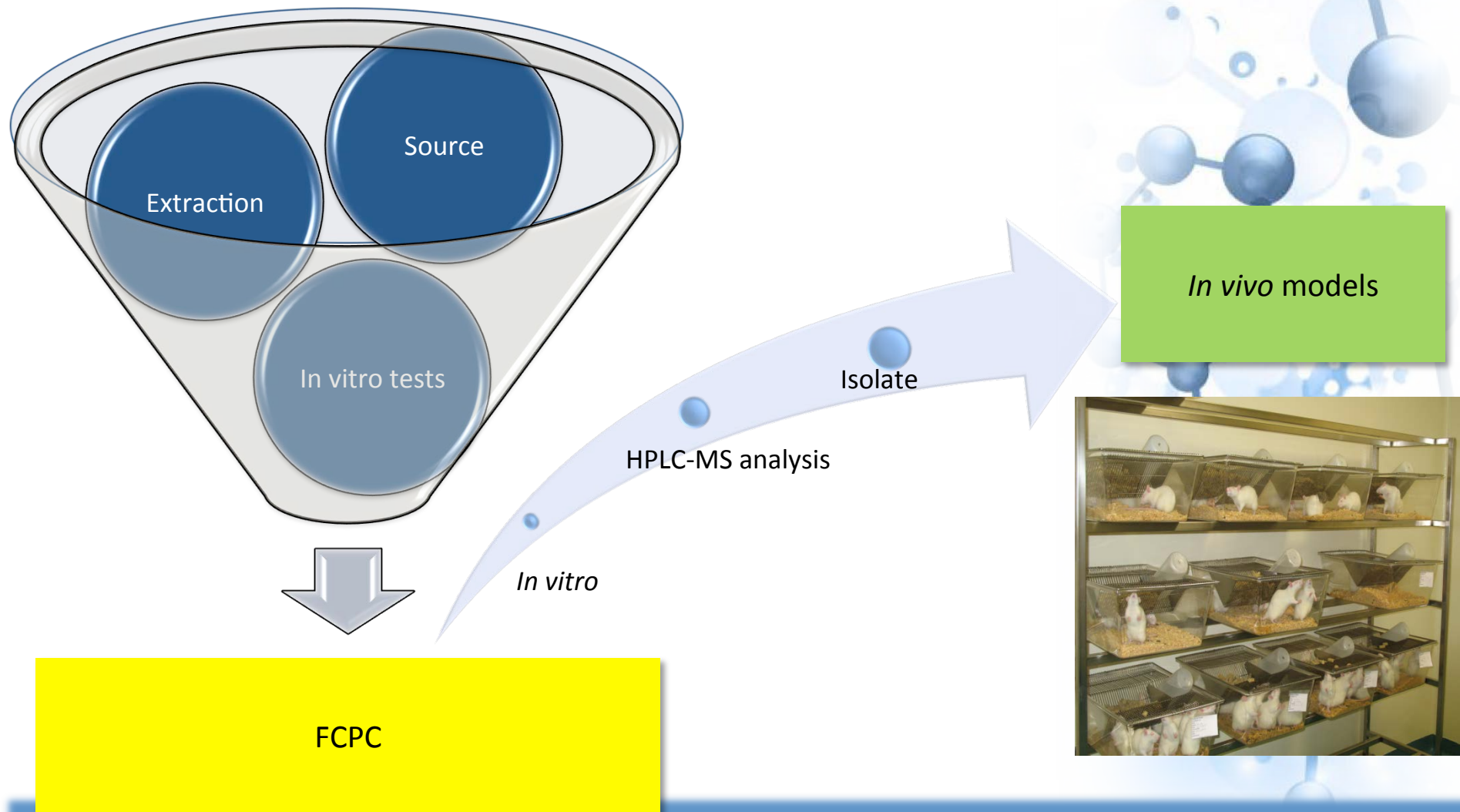


Food- Genome

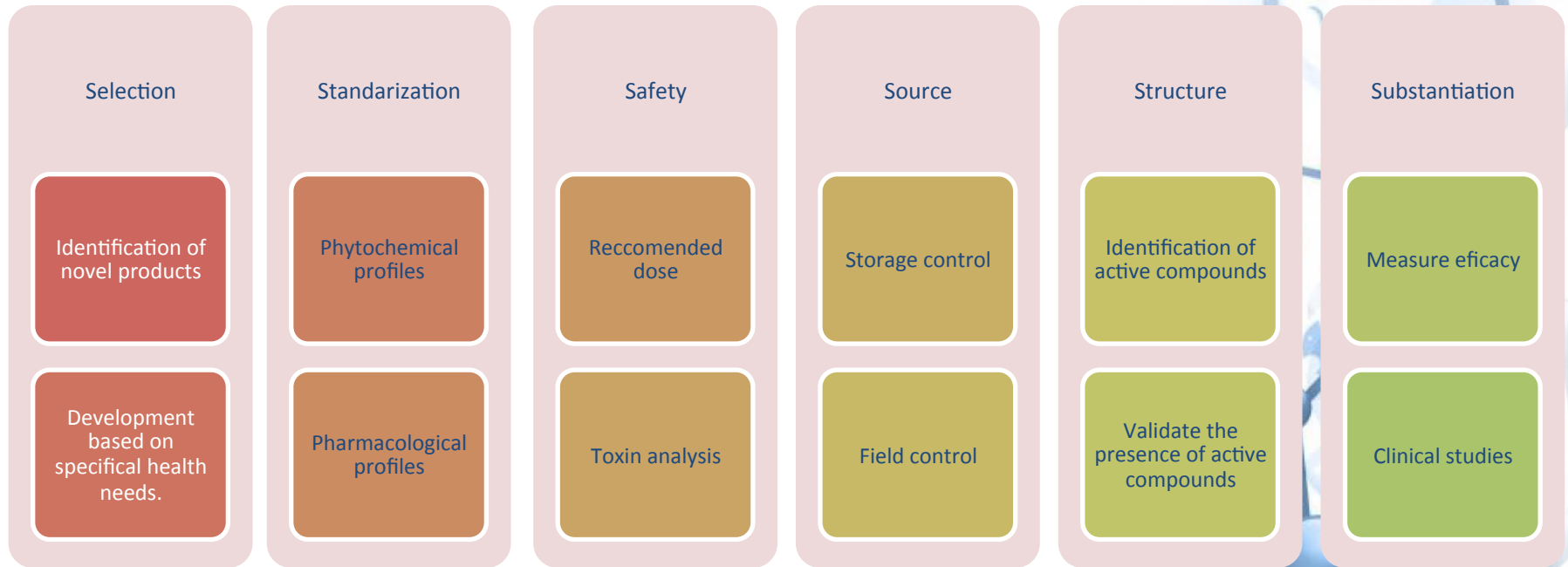
New uses of traditional Mexican foods as functional ingredients



Fast centrifugal partitioning chromatography for screening



6 “s” for nutraceuticals





EQUIPO
CIENTIFICO
(ITESM-CB)

**DIRECTOR
GENERAL**

EQUIPO DE
NEGOCIOEQUIPO
CAMPELINOSJOURNAL OF
AGRICULTURAL AND
FOOD CHEMISTRY

Effect of Agave (Agave) Content from Compound

Ara María Leal
Janet Alejandra

Santos-Zea Liliz
Janet Alejandra

Supporting Info

ABSTRACT: Short

Departamento de B
Monterrey, Av. Eug

Original Research
Characteriza

translucent liquid in times.⁶ Agammiel is fermented into the called pulque, or can High fructose agn its low glycemic ind substance produced exclusively.⁷ To scli leaves are removed, Agammiel concentr plant is not harveste by heat.⁷

The most suitable americana, *Agave sal* and *Agave foxt*.⁴ It is considered the most suitable in the area

lyzed eight varieties they can accumulate. Ortiz-Basurto *et al.* (FOS) content of 7.5%, therefore, this plant is a good candidate to be used as feedstock for ethanol currently used as a biofuel for production and as a source of essential oils. In the manufacturing process, the molecules may be extracted

Glucose (PubChem CID: 5642)
Sucrose (PubChem CID: 5743)

Keywords:
Agave sap
Storage
Superoxide
Browning
Antioxidant
Ruoxin
Agavefruit
Food analysis
Food composition

Mesoamerican medicinal purposes. Some presence of sapor

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 Monterrey-Campus Mo
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[http://dx.doi.org/10.1016/j.0000-1255\(0\)201511001](http://dx.doi.org/10.1016/j.0000-1255(0)201511001)

Current Bioactive Compounds 2012, 8, 000-000

Journal of Food Composition and Analysis 45 (2016) 112–120

Plant Foods Hum Nutr (2016) 71:57–63
DOI 10.1007/s11100-015-9525-2

ORIGINAL PAPER

Fast Centrifugal Partition Chromatography Fractionation of Concentrated Agave (*Agave salmiana*) Sap to Obtain Saponins with Apoptotic Effect on Colon Cancer Cells

Liliana Santos-Zea¹ · Oscar R. Fajardo-Ramírez² · Irasema Ramo-López¹ · Janet A. Gutiérrez-Urbe¹

Published online 23 December 2015
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Abstract Separation of potentially bioactive components from foods and plant extracts is one of the main challenges for their study. Centrifugal partition chromatography has been a successful technique for the screening and identification of molecules with bioactive potential, such as steroid saponins. Agarose is a source of steroid saponins with a saponin potential, though the activity of these compounds in concentrated agarose sap has not been yet explored. In this study, fast counter-current chromatography (FCCC) was used together with *in vitro* tests on HT-29 cells as a screening procedure to identify saponic compounds from an acetonic extract of concentrated agarose sap. The latter most bioactive fractions obtained by FCCP at partition coefficients between 0.23 and 0.4 contained steroid saponins, predominantly aglycoside **h**. Flow cytometry analysis determined that the fraction rich in kaempferol and isomeric glycosides induced apoptosis, but when genistein and isomeric glycosides were also found in the fraction, a synergistic effect was observed. In conclusion, the present study provides evidence that the active principle in concentrated agarose sap has potential inducers of apoptosis and that it was possible to separate them using fast centrifugal partition chromatography.

Keywords: Agarose gel · Antisense · Fast centrifugal partition chromatography · Saponins · Kammogenin · Manogenin · Gentogenin · Hecogenin

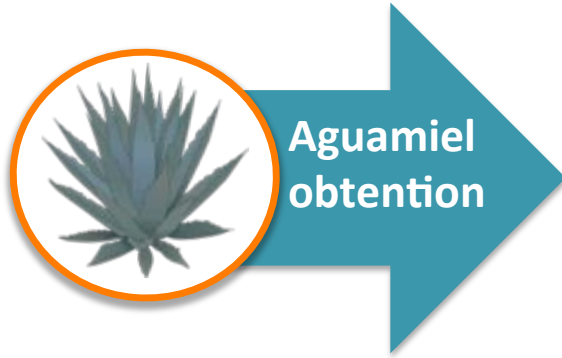
Introduction

One of the main challenges to validate natural products is the isolation of bioactive constituents that are commonly found in small quantities and often present synergistic action with other components [1]. Centrifugal partition chromatography (CPC) has been successfully used to screen for bioactive metabolites in plant extracts, such as antitubercular *M. tuberculosis* from



[13] J. McMillon and P. Rutenfranz, *On the composition of the human diet*, *Am. J. Hyg.* 1936, 23, 1-14.

AGAVE SAPONINS



- ↗ Coahuila (25° 22N, 101° 28W)
- ↗ 1,410 m above sea level
- ↗ n=8
- ↗ Voucher specimen in the UANL herbarium
 - ↗ No. 025618 for *A. americana*
 - ↗ No. 025619 for *A. salmiana*

A. americana

Vegetative Reproductive



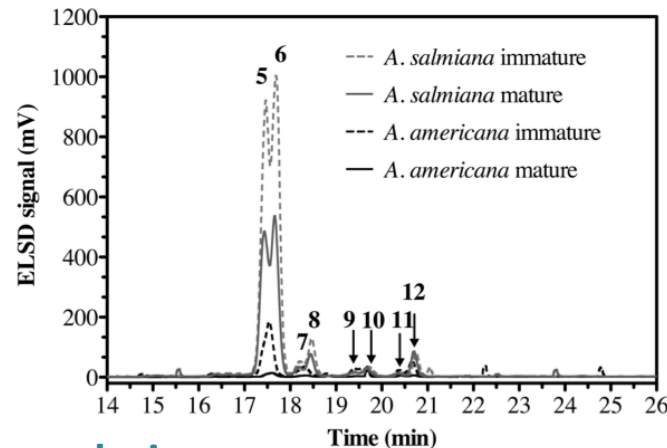
A. salmiana

Vegetative Reproductive



AGUAMIEL SAPONINS

HPLC-ELSD saponin chromatogram



Saponin quantitate analysis

Saponin ^a (PE μ g/g aguamiel DM) ^{b,c,d}	<i>A. salmiana</i>		<i>A. americana</i>	
	Immature	Mature	Immature	Mature
Kammogenin glycosides	321.9 $\pm$ 8.0 a	200.9 $\pm$ 11.8 b	97.9 $\pm$ 1.3 c	22.6 $\pm$ 0.8 d
Manogenin glycosides	55.7 $\pm$ 0.7 a	50.2 $\pm$ 3.0 a	23.2 $\pm$ 0.8 b	12.2 $\pm$ 0.2 c
Gentrogenin glycosides	51.4 $\pm$ 2.0 a	50.4 $\pm$ 0.9 a	29.5 $\pm$ 1.2 b	13.2 $\pm$ 0.2 c
Hecogenin glycosides	49.3 $\pm$ 1.2 a	24.1 $\pm$ 0.5 b	28.3 $\pm$ 1.2 a	12.8 $\pm$ 0.3 c
Total saponin content	478.4 $\pm$ 5.6 a	325.7 $\pm$ 15.7 b	179.0 $\pm$ 2.2 c	60.5 $\pm$ 1.1 d

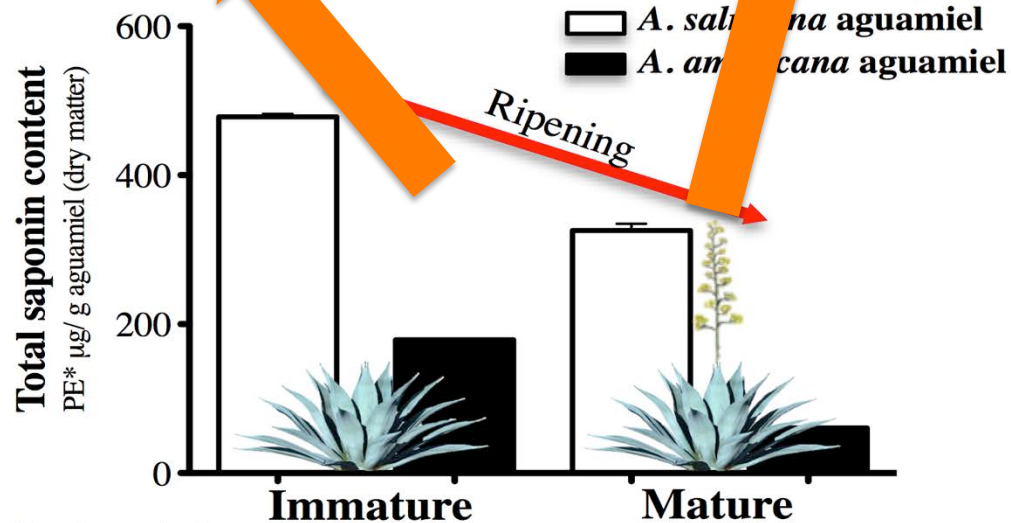
^a Saponins sharing the same aglycone were quantified together.

^b PE, protodioscin equivalents μ g/g aguamiel dry matter

^c Data are expressed as mean $\pm$ SD of three independent extractions.

^d Mean values in each row with different letter are significantly different ($p < 0.01$).

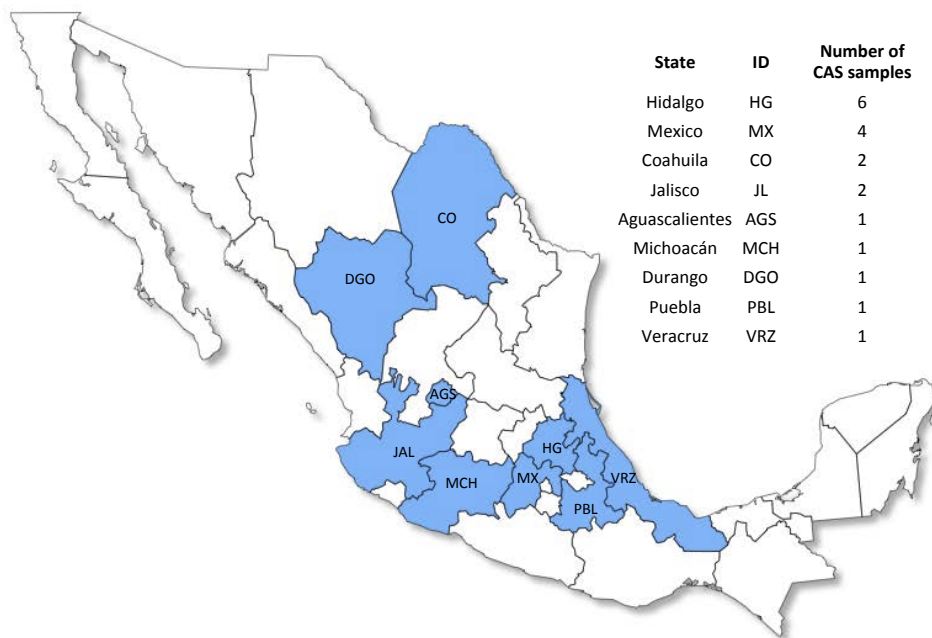
AGUAMIEL SAPONINS



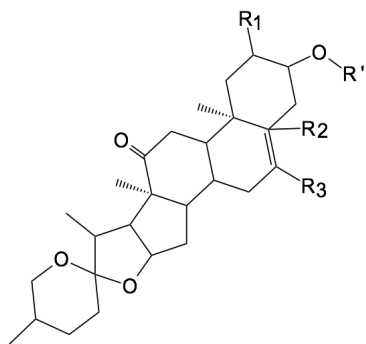
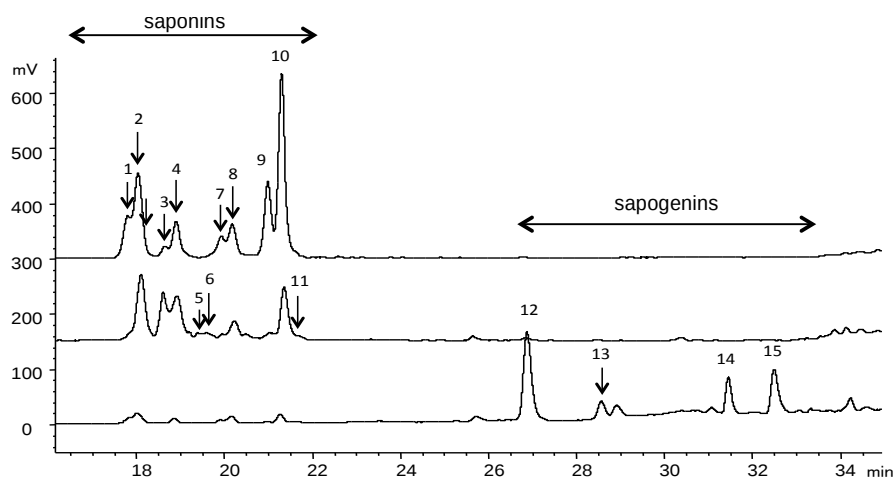
* Protodioscin equivalents

Sources (167) Szakeil et al. (2011) Phytochem. Rev.; (168) Ortuño et al. (1998) Food Chem; (169) Ndamba et al. (1994) Phytochemistry ;(58) Augutin et al. (2011) Phytochemistry: (56) Osbourn (1996) Trends Plant Sci; (57) Francis et al. (2002) Br. J. Nutr.

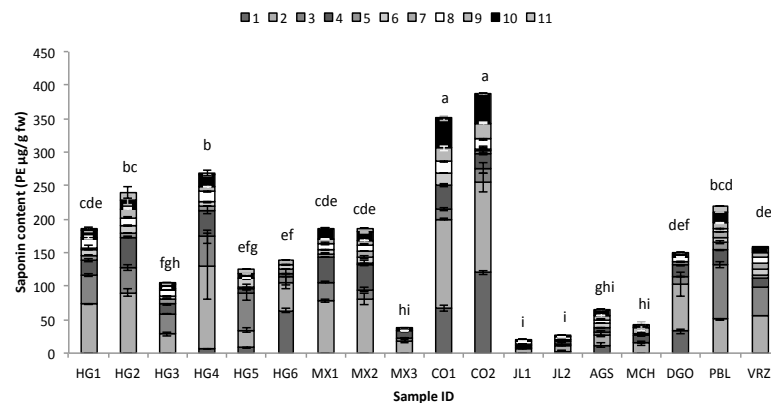
Towards product standarization



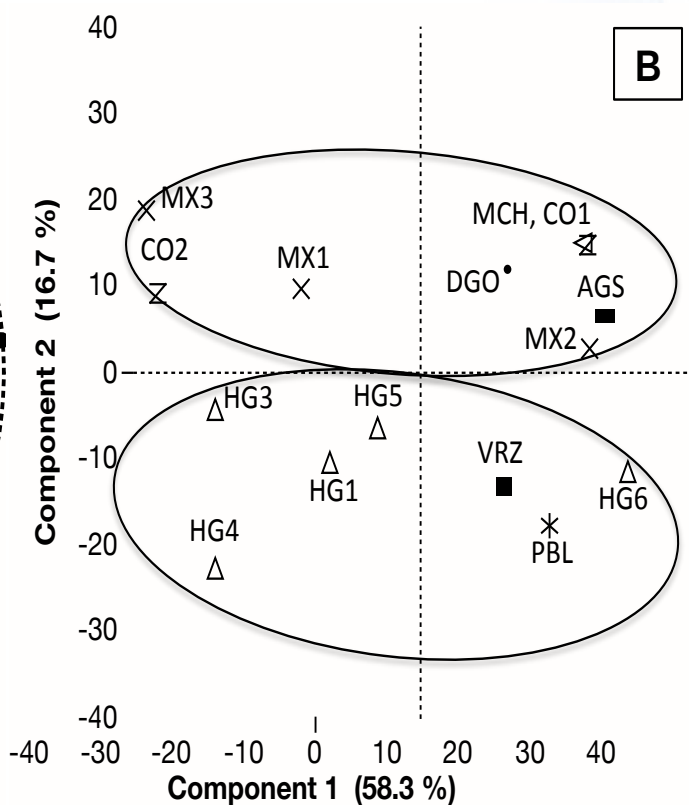
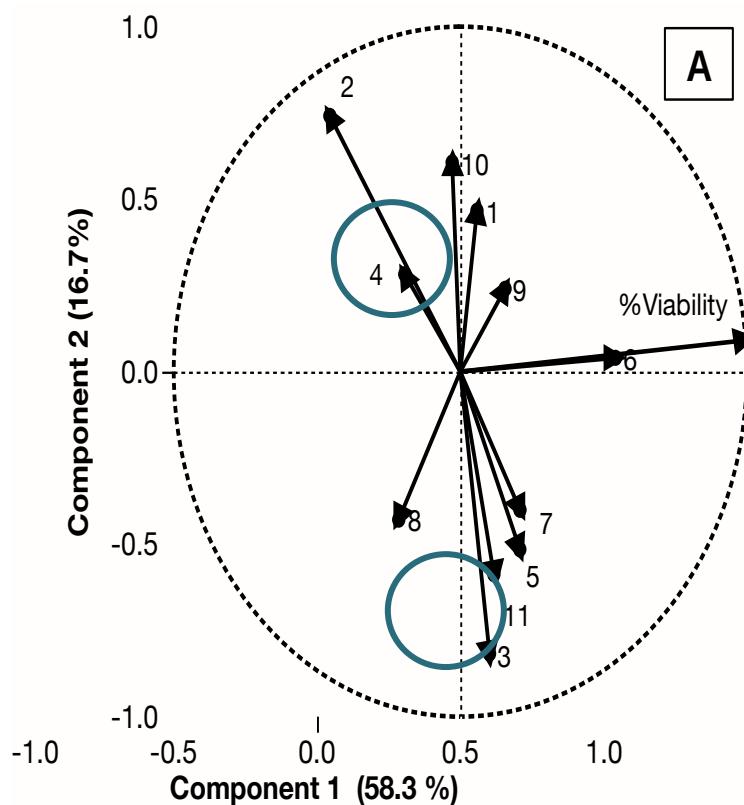
Differences in saponins content



	R1	R2	R3	R'	Compound
1	OH			4Hex+1Pen	Kammogenin pentaglycoside
2	OH			3Hex+1Pen	Magueyoside B
3	OH			2Hex+2Pen	Kammogenin tetraglycoside
4	OH	H	H	3Hex+1Pen	Magueyoside C
5	OH	H	H	2Hex+2Pen	Manogenin tetraglycoside
6	OH	H	H	2Hex+1Pen	Manogenin triglycoside
7	H			3Hex+2Pen	Magueyoside H
8	H			3Hex+1Pen	Gentrogenin tetraglycoside
9	H	H	H	3Hex+2Pen	Cantalasaponin-4
10	H	H	H	3Hex+1Pen	Agavoside C'
11	H	H	H	3Hex	Agavasaponin C



Effects on cancer cell viability



Bioactivity screening

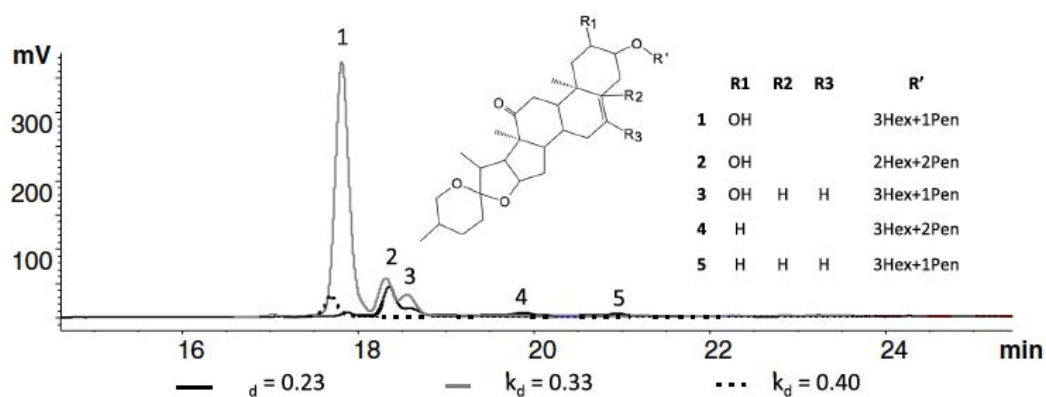
Plant Foods Hum Nutr (2016) 71:57–63
DOI 10.1007/s11130-015-0525-2



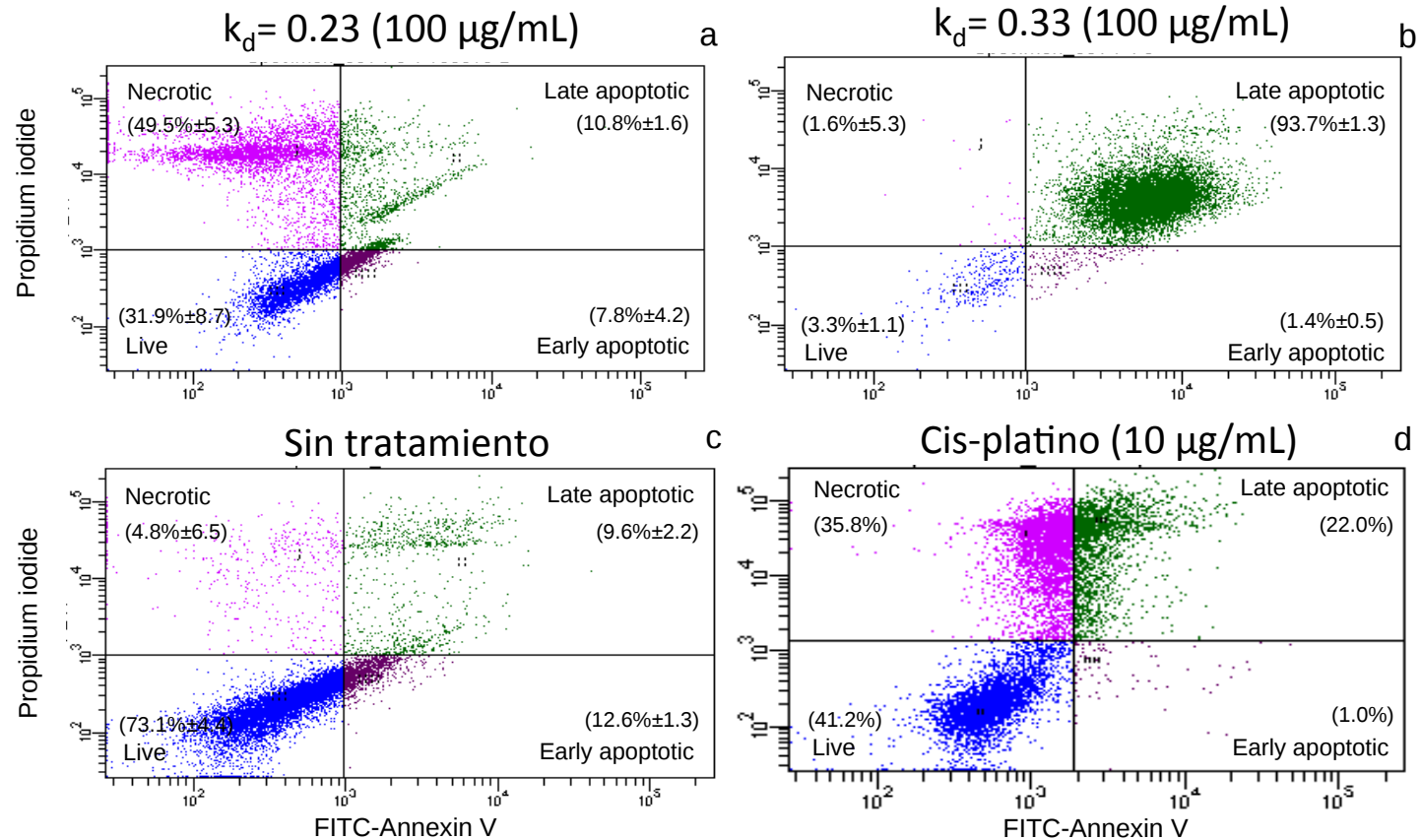
ORIGINAL PAPER

Fast Centrifugal Partition Chromatography Fractionation of Concentrated Agave (*Agave salmiana*) Sap to Obtain Saponins with Apoptotic Effect on Colon Cancer Cells

Liliana Santos-Zea¹ · Oscar R. Fajardo-Ramírez² · Irasema Romo-López¹ · Janet A. Gutiérrez-Urbe¹



Apoptotic effect



Effects on obesity

SCIENTIFIC REPORTS

OPEN

Aguamiel concentrate from *Agave salmiana* and its extracted saponins attenuated obesity and hepatic steatosis and increased *Akkermansia muciniphila* in C57BL/6 mice

Received: 29 December 2015
Accepted: 09 September 2016
Published: 20 September 2016

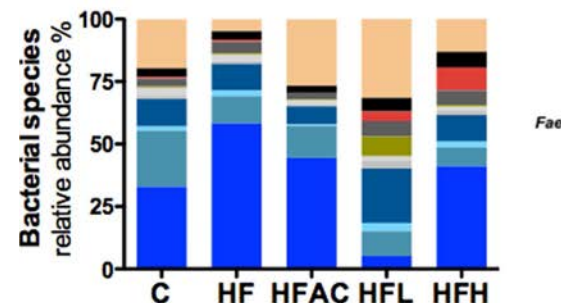
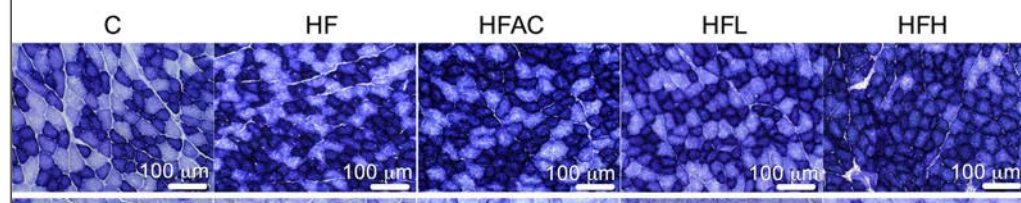
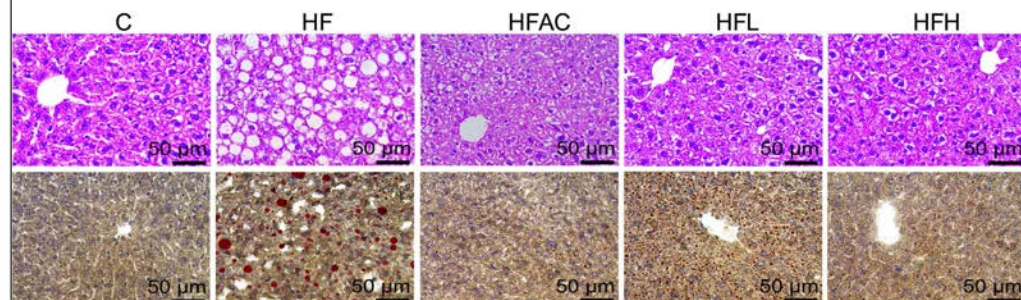
Ana María Leal-Díaz¹, Lilia G. Noriega², Ivan Torre-Villalaz³, Nimba Torres¹, Gabriela Alemán-Escondido¹, Patricia López-Romero¹, Mónica Sánchez-Tapia¹, Miriam Aguilar-López¹, Janette Furuzawa-Carballeda¹, Laura A. Vázquez-Villages¹, Azalia Avila-Nava¹, Guillermo Ordaz¹, Janet A. Gubínez-Uribe², Sergio O. Serna-Saldívar⁴ & Armando R. Tovar¹

Obesity and its comorbidities are a severe public health problem worldwide. The use of bioactive compounds found in some foods has been demonstrated to ameliorate the metabolic abnormalities associated with obesity. The purpose of this study was to assess whether the bioactive compounds present in aguamiel concentrate (AC) from *Agave salmiana* could attenuate glucose intolerance and hepatic steatosis in mice fed a high fat (HF) diet. HPLC-ELSD analysis showed that AC contained several saponins. The consumption of an AC extract rich in saponins reduced weight gain and fat mass and lowered serum glucose, insulin and LDL-cholesterol levels in mice fed a HF diet. Additionally, mice fed the saponin extract exhibited a reduced HOMA index and hepatic lipid levels and increased expression of genes involved in fatty acid oxidation. Saponins increased white adipose tissue browning, AMPK phosphorylation, fatty acid oxidation, and mitochondrial activity in skeletal muscle and energy expenditure in mice fed the HF diet. These metabolic changes were accompanied by an increase in the abundance of *Akkermansia muciniphila* in the gut microbiota. Therefore, *Agave salmiana* saponins can be an alternative to attenuate the metabolic changes that accompany obesity.

Since 1980, obesity prevalence has doubled worldwide. In 2014, overweight individuals represented 39% of the adult population, and 13% of these individuals were obese¹. Specific metabolic abnormalities develop in obese individuals, such as pro-inflammatory states, dyslipidemia, high blood pressure, insulin resistance, glucose intolerance and non-alcoholic fatty liver disease (NAFLD); these abnormalities are accompanied by gut microbiota dysbiosis²⁻⁴. Insulin resistance develops during obesity due to alterations in insulin signaling and increases in the systemic inflammatory response⁵. These alterations occur in part through a lipotoxic effect due to the accumulation of lipids in non-adipose tissue organs, particularly the liver and skeletal muscle⁶.

Recently, it has been established that dietary intervention must be included to prevent or ameliorate the biochemical abnormalities associated with obesity⁷. With this aim, extensive research on functional foods has recently been performed. These foods provide a health benefit in addition to their nutritional value⁸. Most

¹Instituto de Investigación en Alimentos, Centro de Biotecnología FEMSA, Escuela de Ingeniería y Ciencias, 64849, Monterrey, NL, México. ²Departamento de Fisiología de la Nutrición, Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán, 14080, México D.F., México. ³Departamento de Inmunología y Dermatología, Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán, 14080, México D.F., México. Correspondence and requests for materials should be addressed to A.R.T. (email: tovar.ar@gmail.com)

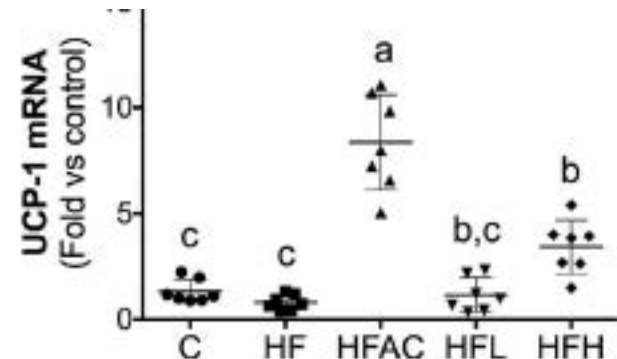
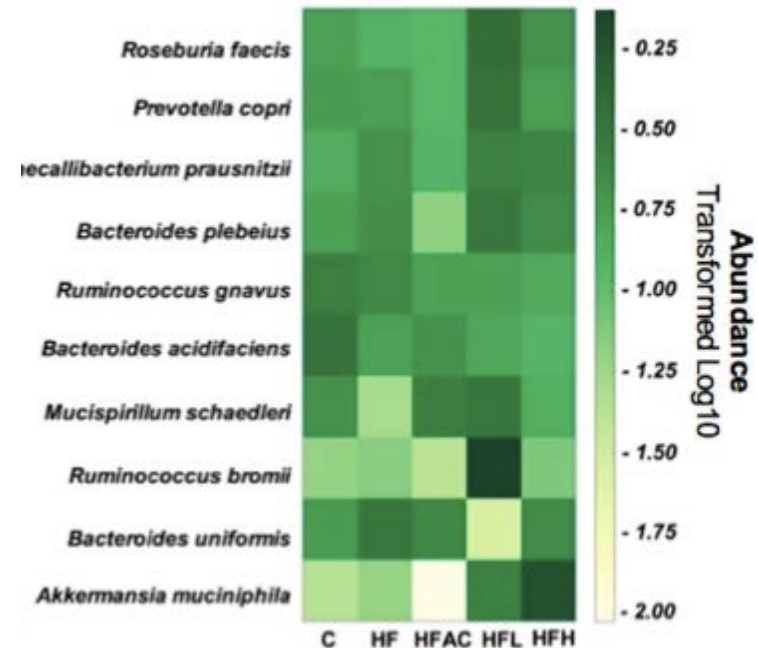
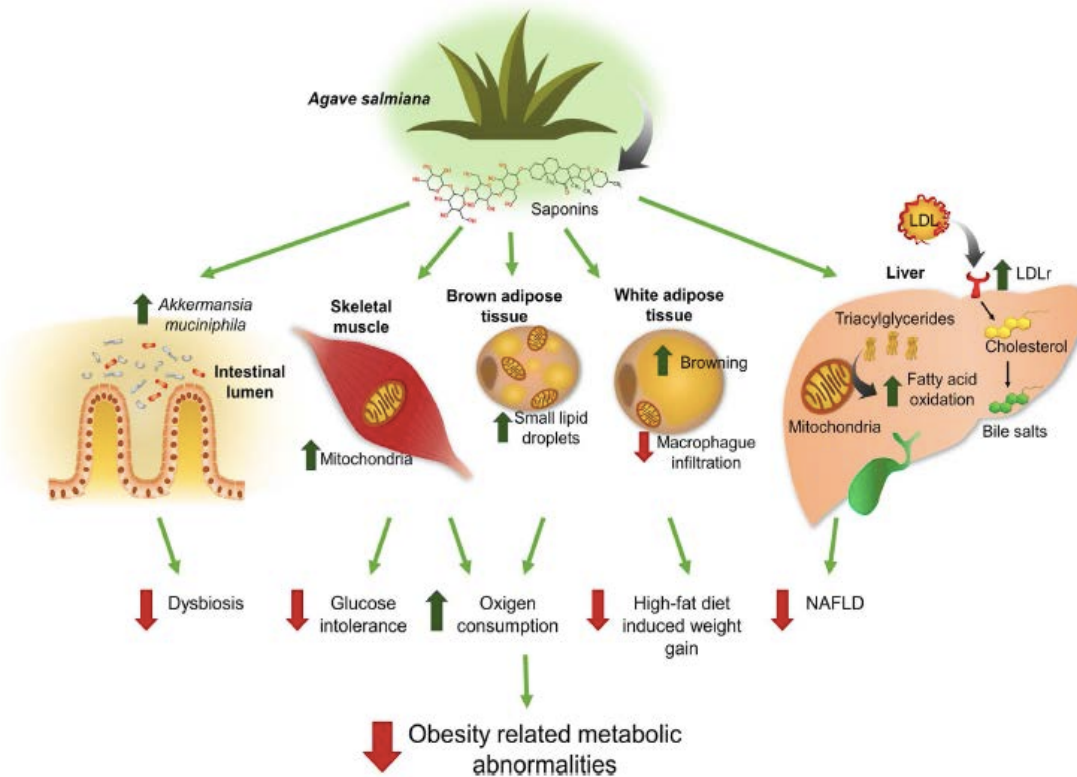


Bacteroidetes
■ *B. uniformis*
■ *B. acidifaciens*
■ *B. plebeius*
■ *P. copri*

Firmicutes
■ *R. faecis*
■ *R. bromii*
■ *R. gnavus*
■ *F. prausnitzii*

Other
■ **Deferribacteres**
■ *M. schaedleri*
■ **Verrucomicrobia**
■ *A. muciniphila*

Genes & microbiota



Microorganisms affect saponins glycosylation



Article

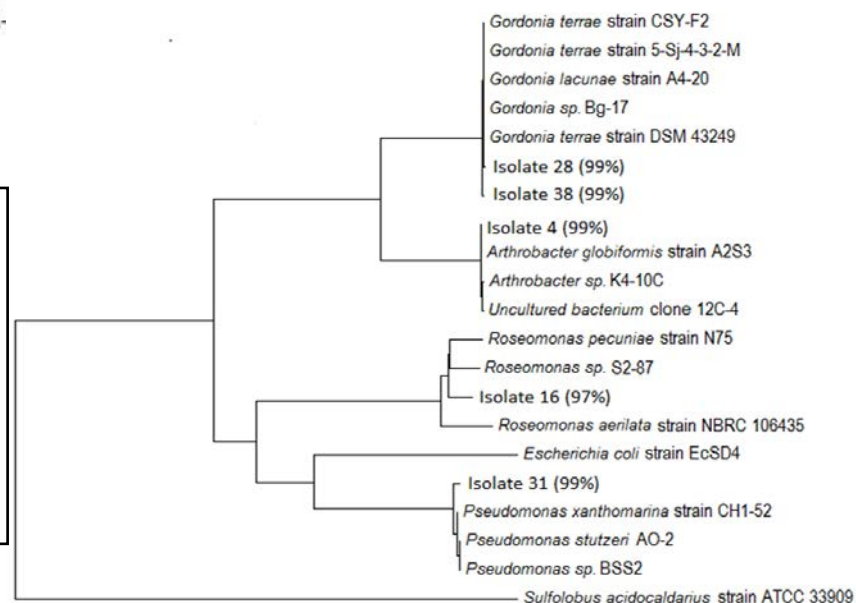
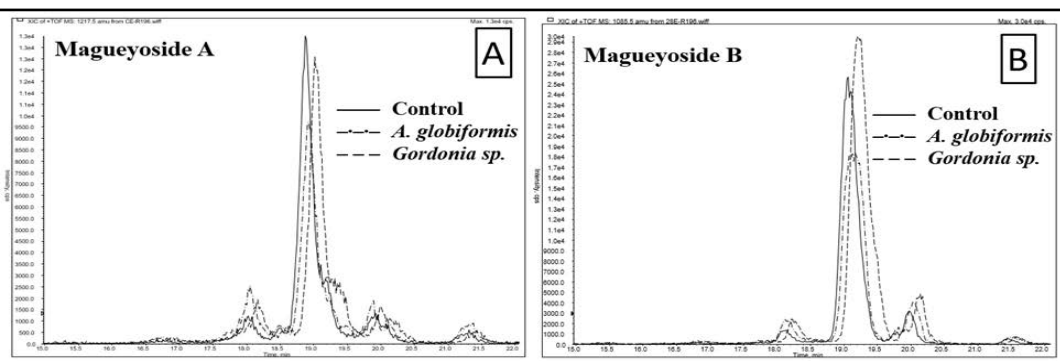
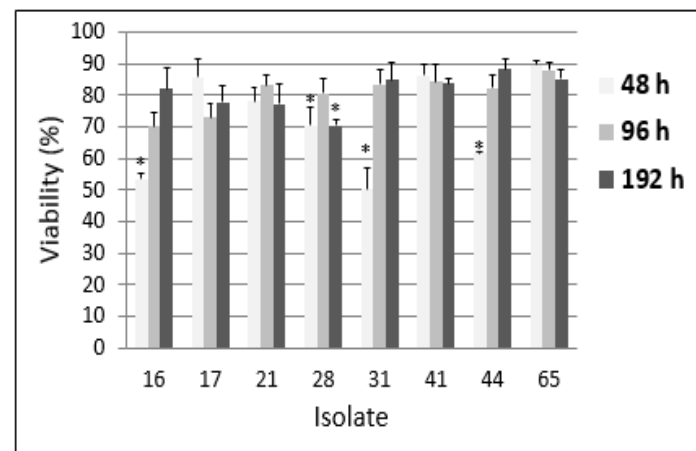
Mass Spectrometry-Based Metabolomics of Agave Sap (*Agave salmiana*) after Its Inoculation with Microorganisms Isolated from Agave Sap Concentrate Selected to Enhance Anticancer Activity

Luis M. Figueroa ¹, Liliana Santos-Zea ¹, Adelfo Escalante ² and Janet A. Gutiérrez-Urbe ^{1,*} 

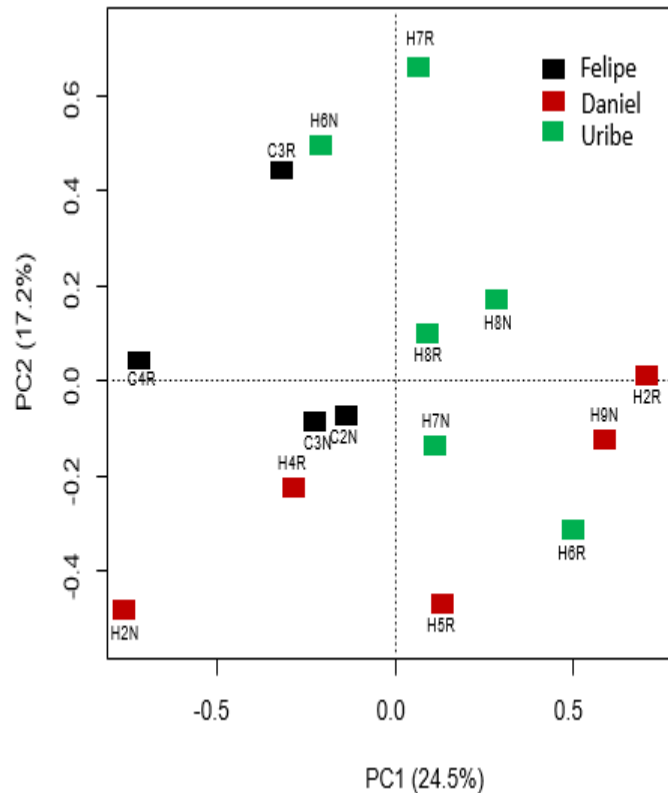
¹ Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. Eugenio Garza Sada 2501, Col. Tecnológico 64849 Monterrey, N.L., Mexico; luisfigueroa8605@gmail.com (L.M.F.); lilianasantos@itesm.mx (L.S.)

² Departamento de Ingeniería Celular y Biotecnología, Instituto de Biotecnología, Universidad Nacional Autónoma de México (UNAM), Av. Universidad 2001, Col. Chamilpa, 62210 Cuernavaca, Mor., Mexico; adelfo@ibt.unam.mx

* Correspondence: jagu@itesm.mx; Tel.: +52-81-8358-2000 (ext. 1802)



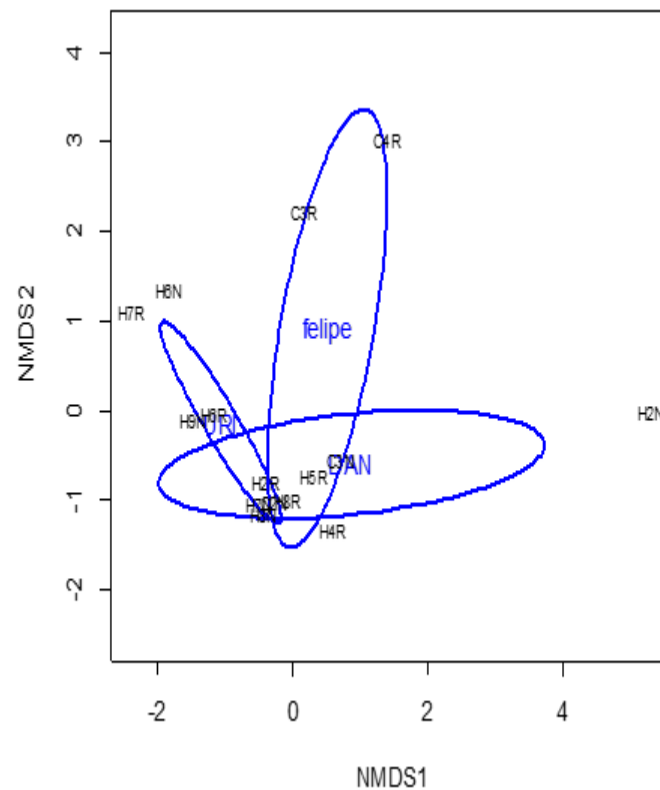
Preliminars on Food microbiota

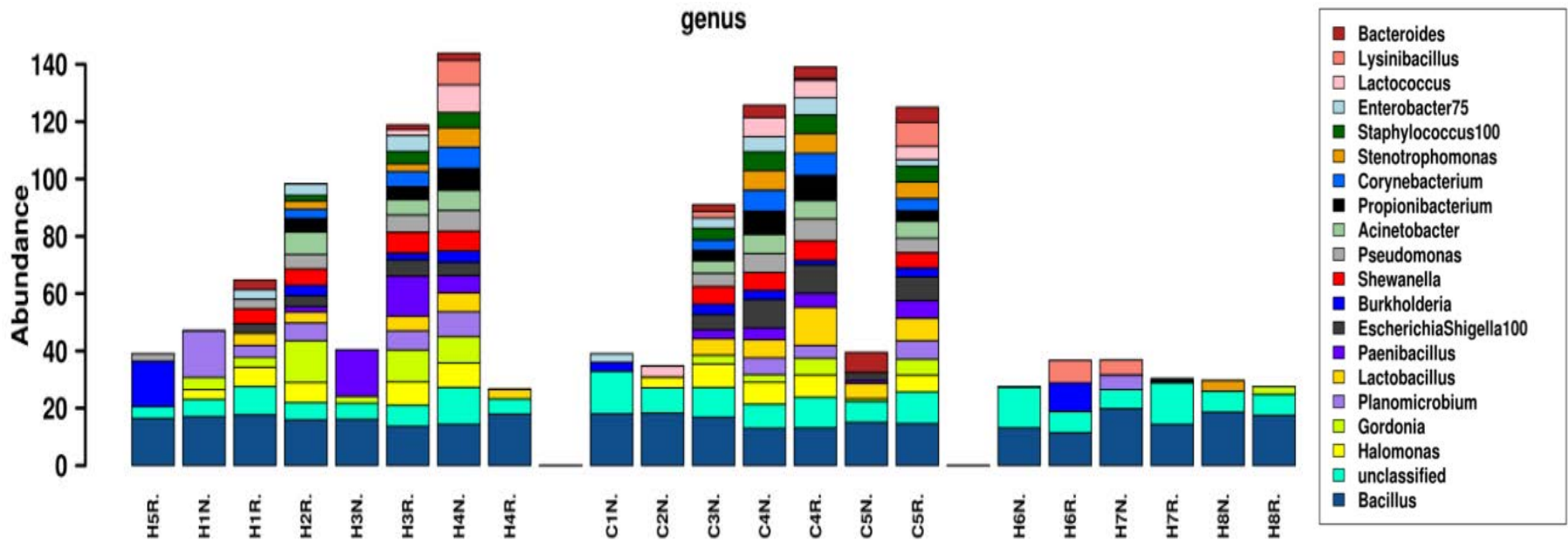


Goodness of fit:

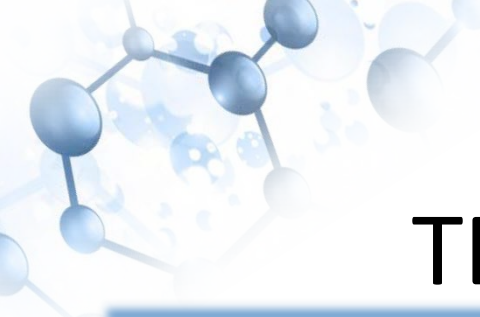
	r ²	Pr(>r)
Procedencia	0.0873	0.298
Recolector	0.2443	0.105
Medio	0.0546	0.501

Permutation: free
Number of permutations: 999





- Diversidad dominada por *Bacillus*
- Se encontraron diversas BAL:
Bifidobacterium, *Enterococcus*, *Lactobacillus*, *Lactococcus*, *Leuconostoc* y *Streptococcus*
- Se encontraron los géneros *Arthrobacter*, *Gordonia* y *Pseudomonas*



Y todavía más allá...

TEC 21 con sentido humano



The background image shows four people (three men and one woman) walking along a dirt path in a desert landscape. They are all smiling and appear to be part of a field trip or research team. The man on the far left is wearing a checkered shirt and jeans, waving. The woman next to him is wearing a blue polo shirt. The man in the center is wearing a blue polo shirt, jeans, and a hat. The woman on the far right is also wearing a blue polo shirt. The background features desert hills and a cloudy sky. Overlaid on the image are two molecular models: a large one in the top left corner and a smaller one in the bottom right corner.

Moléculas del millón en plantas del desierto

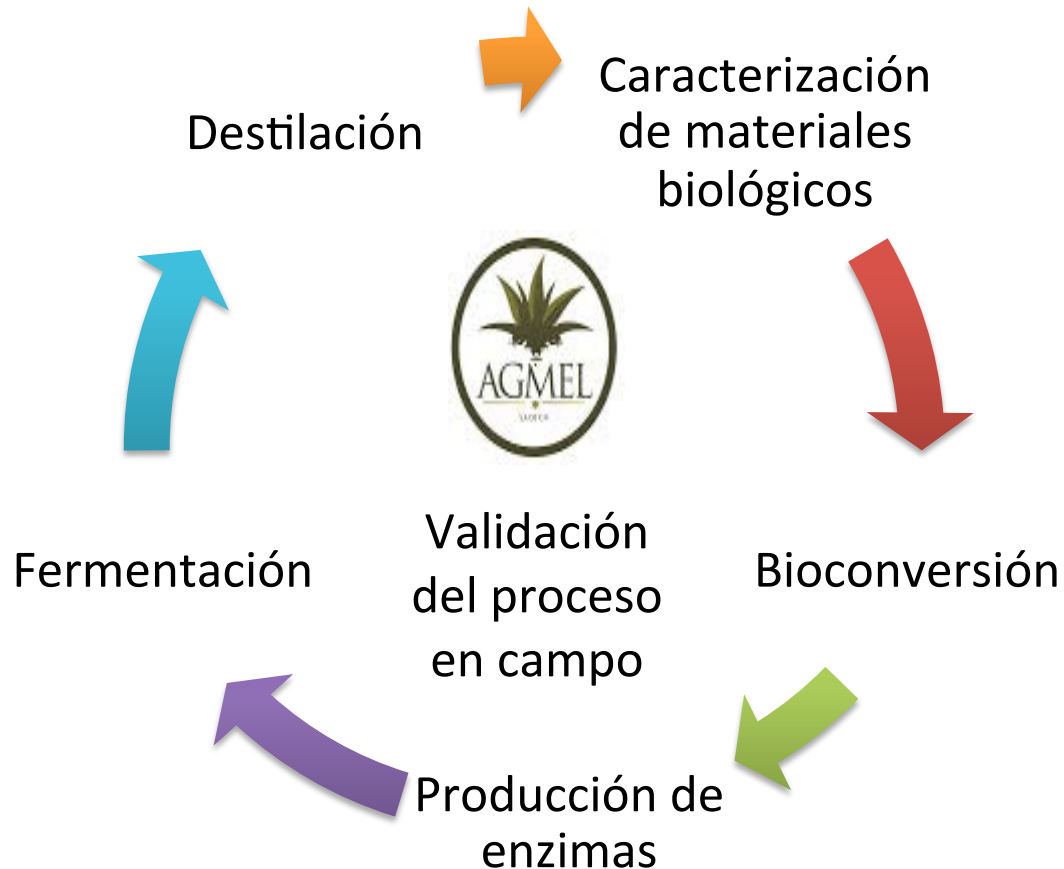
Validación tecnológica de procesos y productos

- Establecer pruebas piloto para aplicar la ciencia y la tecnología en el desarrollo de procesos biotecnológicos para aprovechar las plantas del desierto.

Semestre i 2017

Retos

RETO 1: Producción de etanol a partir de subproductos del agave



Retos

RETO 2: Desarrollo de nuevos productos biotecnológicos utilizando recursos del desierto.

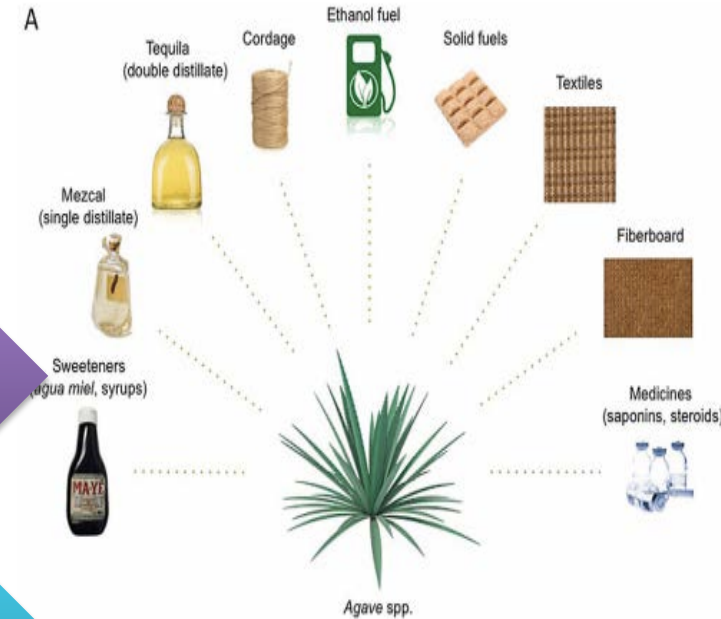
Recursos naturales

Nuevos productos

Propiedad intelectual

Restricción de agua

Control de calidad





Gracias

