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

Tecnológico de Monterrey

Tecnológico de Monterrey

Universidad privada fundada en 1943

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

Alumnos

Profesional	Posgrado
24,305	**2,231**
44% del total de al's	29% del total de al's

Profesores

Planta[1]	Cátedra[2]
712	**1,913**

Programas

Carreras	Maestrías	Doctorados
24	**16**	**4**

Presencia en campus

[1]Incluye profesores investigadores
[2]Incluye profesores extranjeros visitantes

Programas de profesional

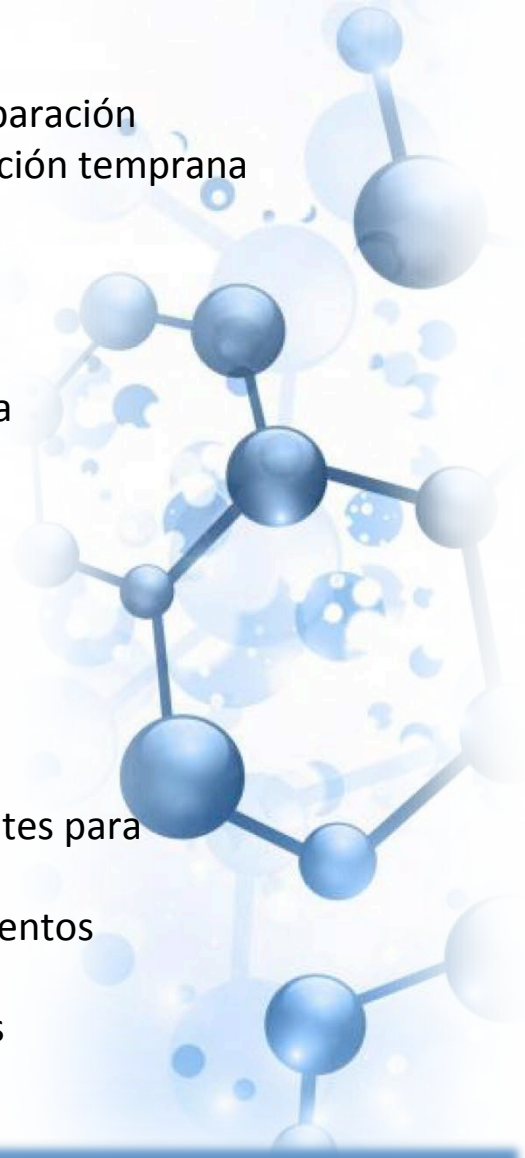
- Ingeniero Agrónomo
- Ingeniero Civil
- Ingeniero en Bionegocios
- Ingeniero en Biotecnología
- Ingeniero en Desarrollo Sustentable
- Ingeniero en Diseño Automotriz
- Ingeniero en Industrias Alimentarias
- Ingeniero en Innovación y Desarrollo
- Ingeniero en Mecatrónica
- Ingeniero en Negocios y Tecnologías 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

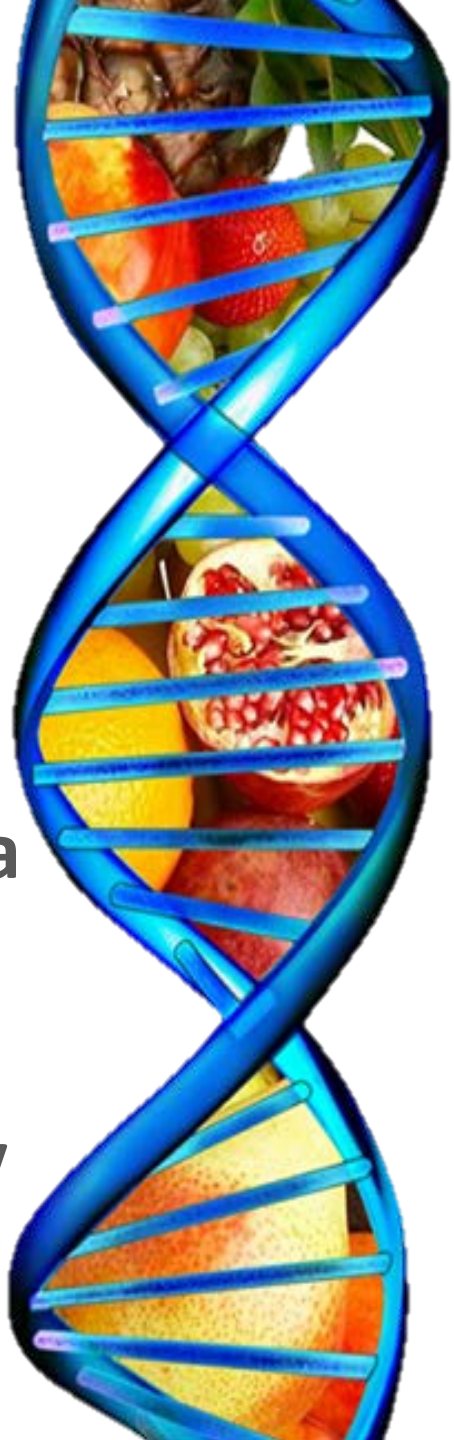
- **GEE: Tecnologías Emergentes para la Estabilización de Nutrientes Esenciales: Diseño de alimentos Basados en Nutrigenética**
  - Tecnologías emergentes para la estabilización y conservación de alimentos
  - Nutrigenética
  - Nutrientes esenciales



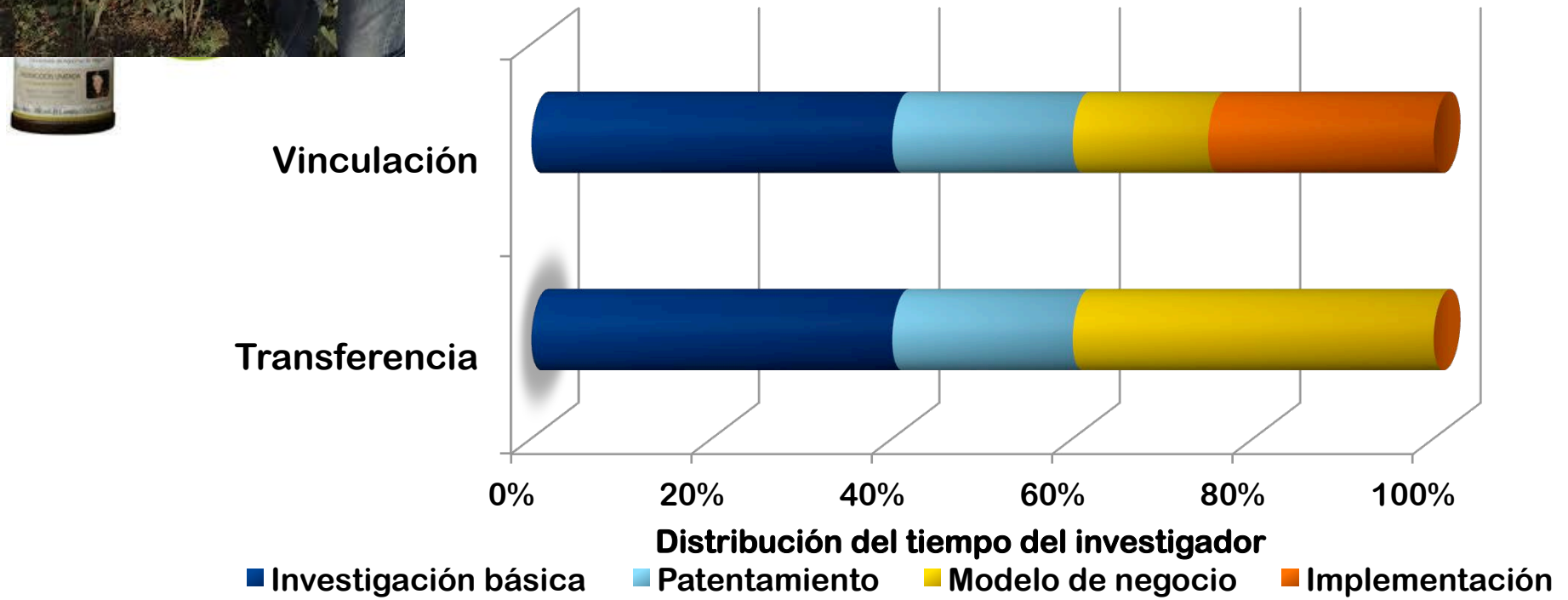
Centro de Biotecnología FEMSA

Grupo de enfoque en NUTRIOMICS

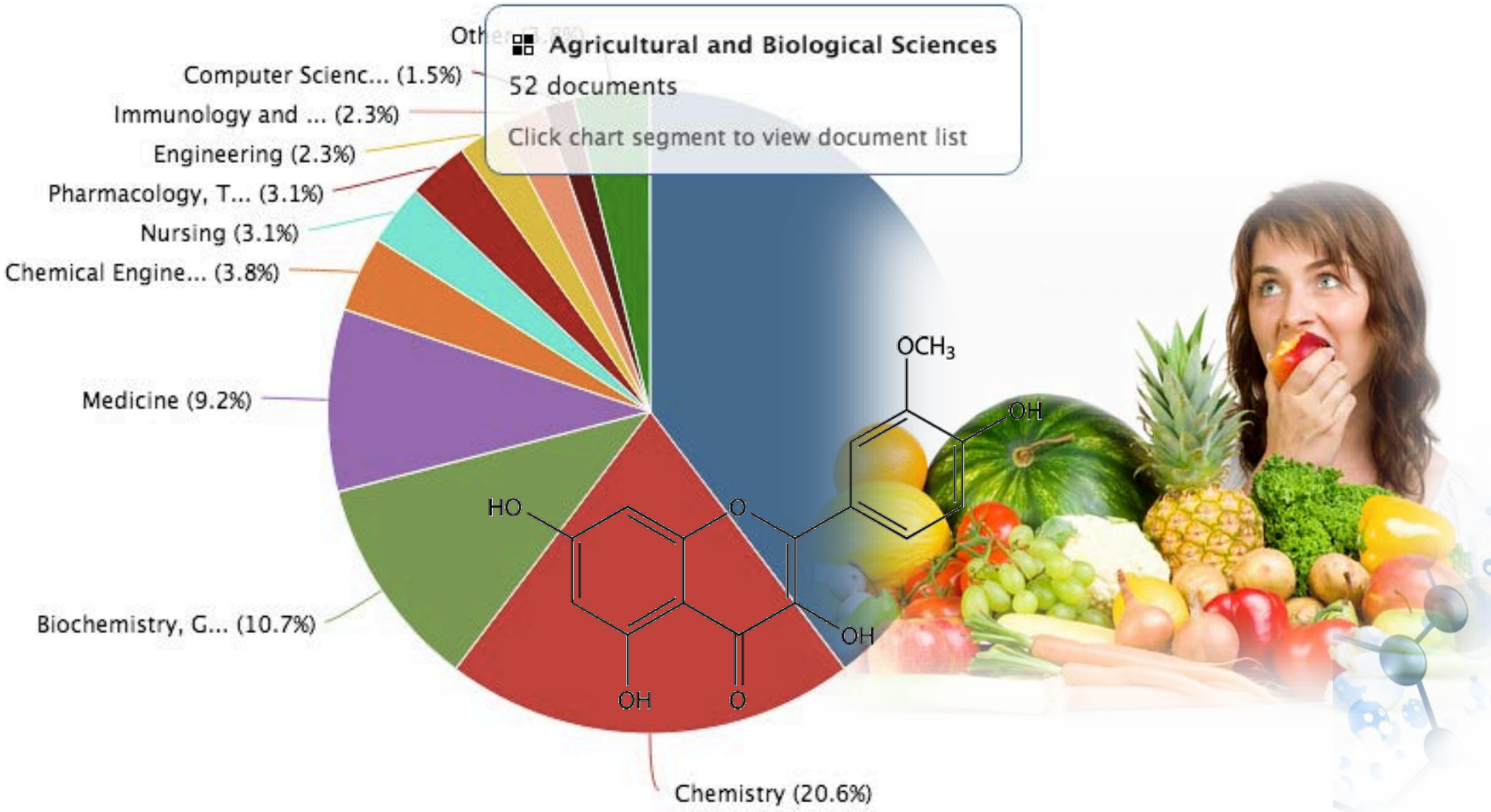
Generar una plataforma de conocimiento, tecnología y talento para proveer soluciones para la industria alimentaria en el esfuerzo de contrarrestar el síndrome metabólico y otras enfermedades crónico-degenerativas



Beyond research…

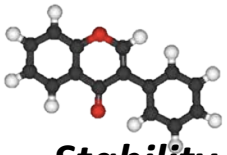


Identify, stabilize & validate



Food- Genome

New uses of traditional Mexican foods as functional ingredients

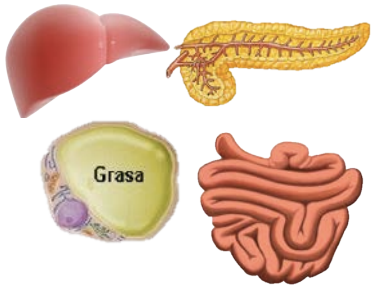


Stability

Food → ***In vivo*** → **Nutrigenomics** → **Validate**

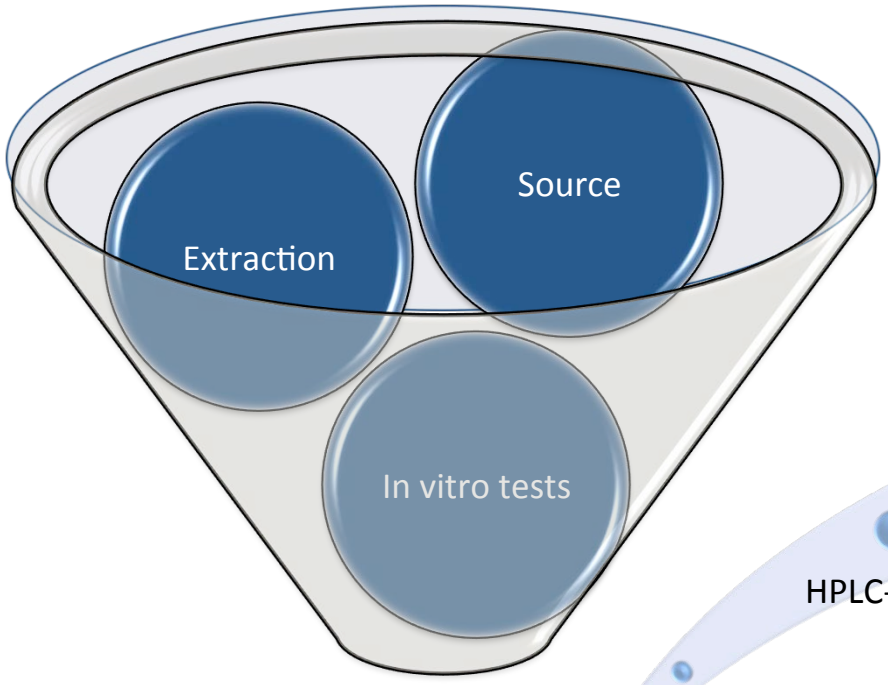
Healthy Mexican Food
/high fat and starch

Metabolism
Inflammation



Clinical

Fast centrifugal partitioning chromatography for screening



FCPC

In vitro

HPLC-MS analysis

Isolate

In vivo models

6 “s” for nutraceuticals

Selection	Standarization	Safety	Source	Structure	Substantiation
Identification of novel products	Phytochemical profiles	Reccomended dose	Storage control	Identification of active compounds	Measure eficacy
Development based on specifical health needs.	Pharmacological profiles	Toxin analysis	Field control	Validate the presence of active compounds	Clinical studies

Tecnológico de Monterrey

AGMEL

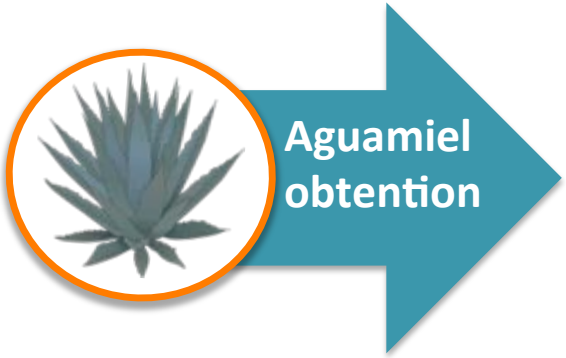
DIRECTOR GENERAL

EQUIPO CIENTIFICO (**ITESM-CB**)

EQUIPO DE NEGOCIO

EQUIPO CAMPESINOS

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

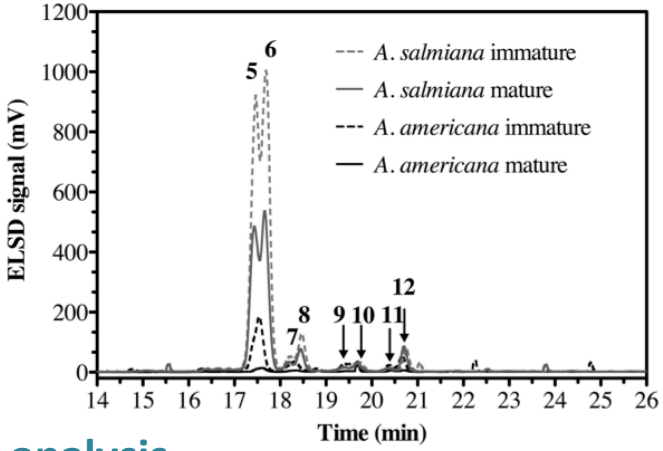
Vegetative Reproductive

A. salmiana

Vegetative Reproductive

AGUAMIEL SAPONINS

HPLC-ELSD saponin chromatogram



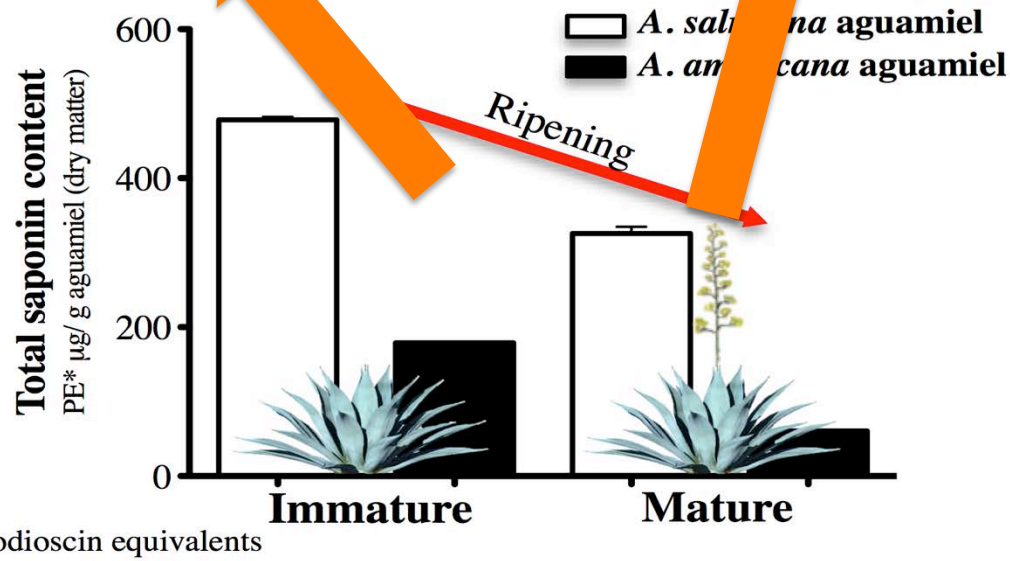
Saponin quantitate analysis

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

[a] Saponins sharing the same aglycone were quantified together.
[b] PE, protodioscin equivalents µg/g aguamiel dry matter
[c] Data are expressed as mean ± SD of three independent extractions.
[d] Mean values in each row with different letter are significantly different ($p < 0.01$).

(139) Ponos-Rodriguez et al. (2008) S. Afr. J. Anim. Sci.; **(2009)** Pinos-Rodriguez (2009) Anim. Feed Sci. Technol.

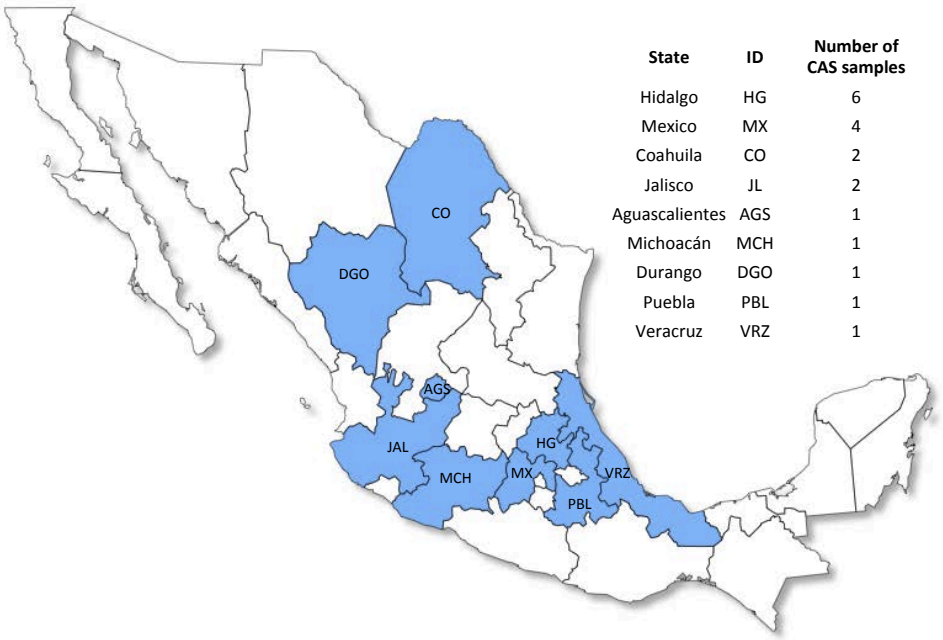
AGUAMIEL SAPONINS



* Protodioscin equivalents

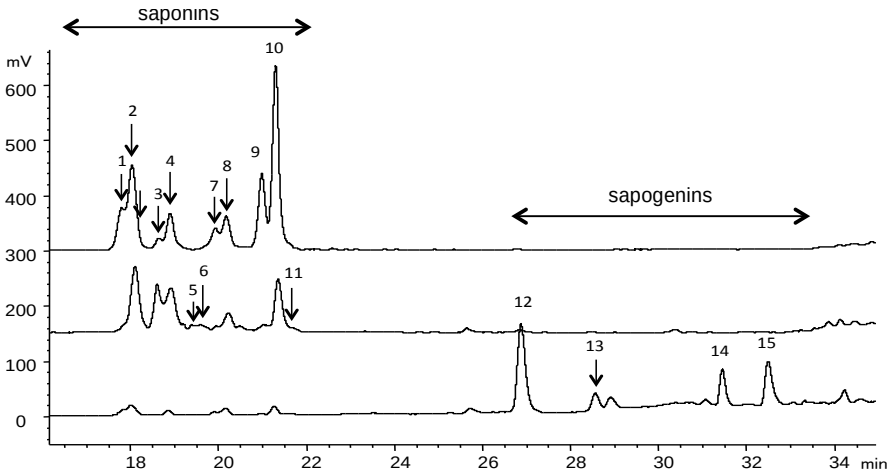
Sources (167) Szakeil et al. (2011) Phytochem. Rev.; (168) Ortuño et al. (1998) Food Chem; (169) Ndamba et al. (1994) Phytochemistry ;(58) Augutin et al. (2011) Phytochemistry: (56) Osbourn (1996) Trends Plant Sci; (57) Francis et al. (2002) Br. J. Nutr.

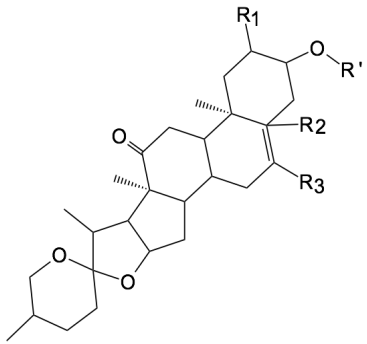
Towards product standarization



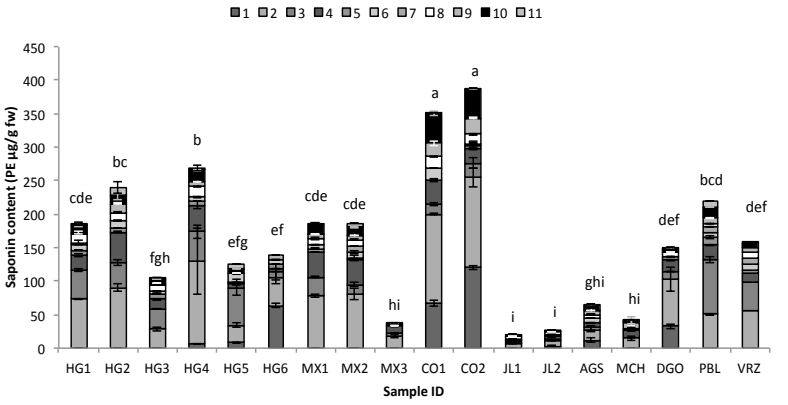
State	ID	Number of CAS samples
Hidalgo	HG	6
Mexico	MX	4
Coahuila	CO	2
Jalisco	JL	2
Aguascalientes	AGS	1
Michoacán	MCH	1
Durango	DGO	1
Puebla	PBL	1
Veracruz	VRZ	1

Differences in saponins content

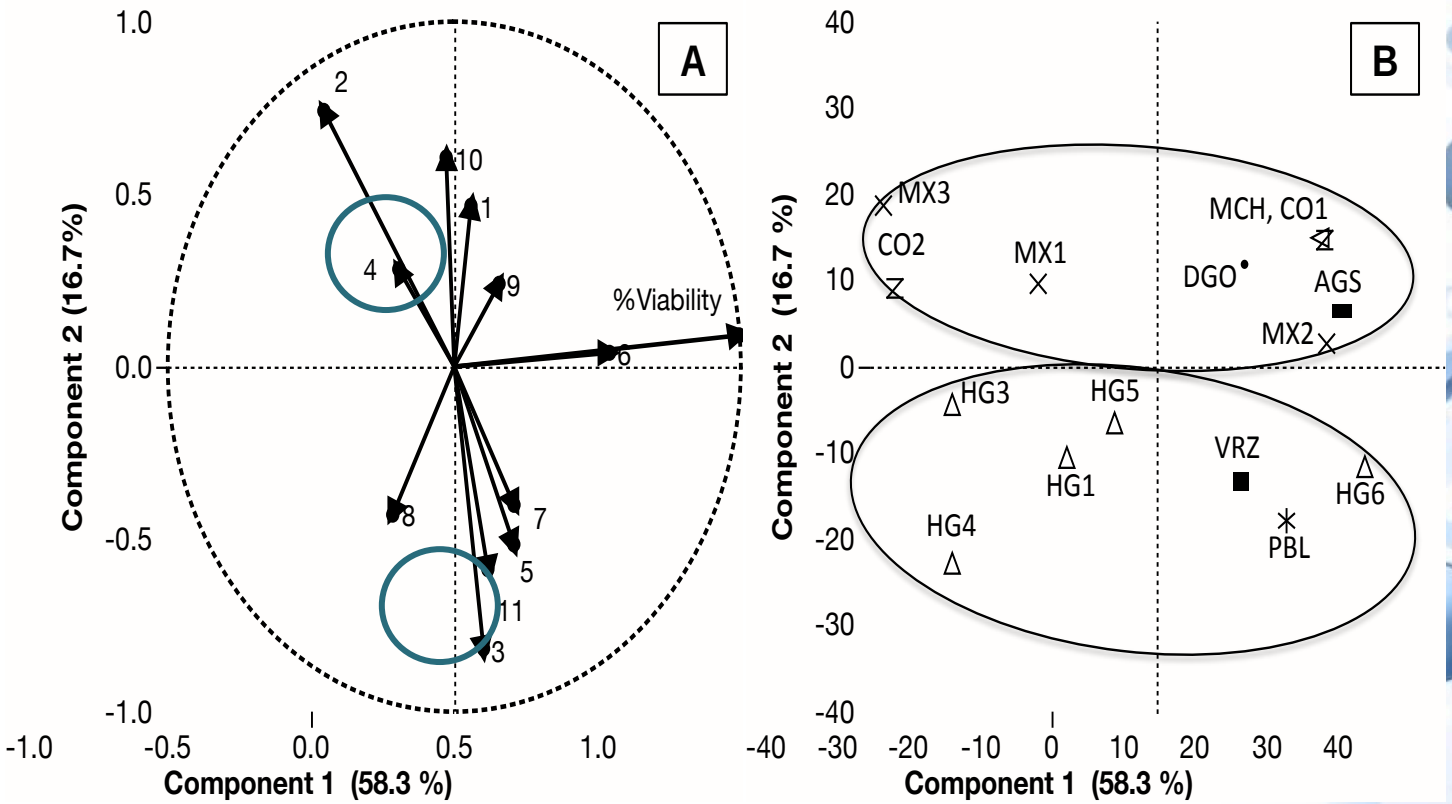




	R1	R2	R3	R'	Compound
1	OH			4Hex+1Pen	Kammogenin pentaglycoside
2	OH			3Hex+1Pen	Magueyoside B
3	OH			2Hex+2Pen	Kammogenin tetraglycoside
4	OH	H	H	3Hex+1Pen	Magueyoside C
5	OH	H	H	2Hex+2Pen	Manogenin tetraglycoside
6	OH	H	H	2Hex+1Pen	Manogenin triglycoside
7	H			3Hex+2Pen	Magueyoside H
8	H			3Hex+1Pen	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



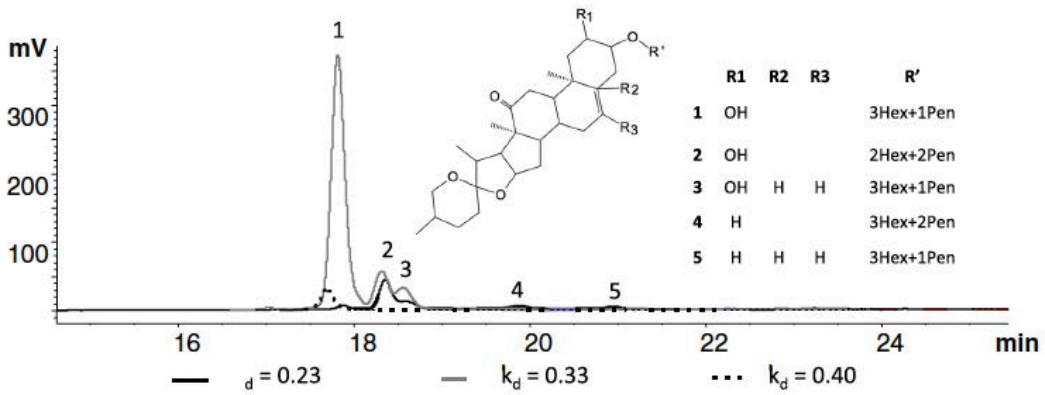
Bioactivity screening

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

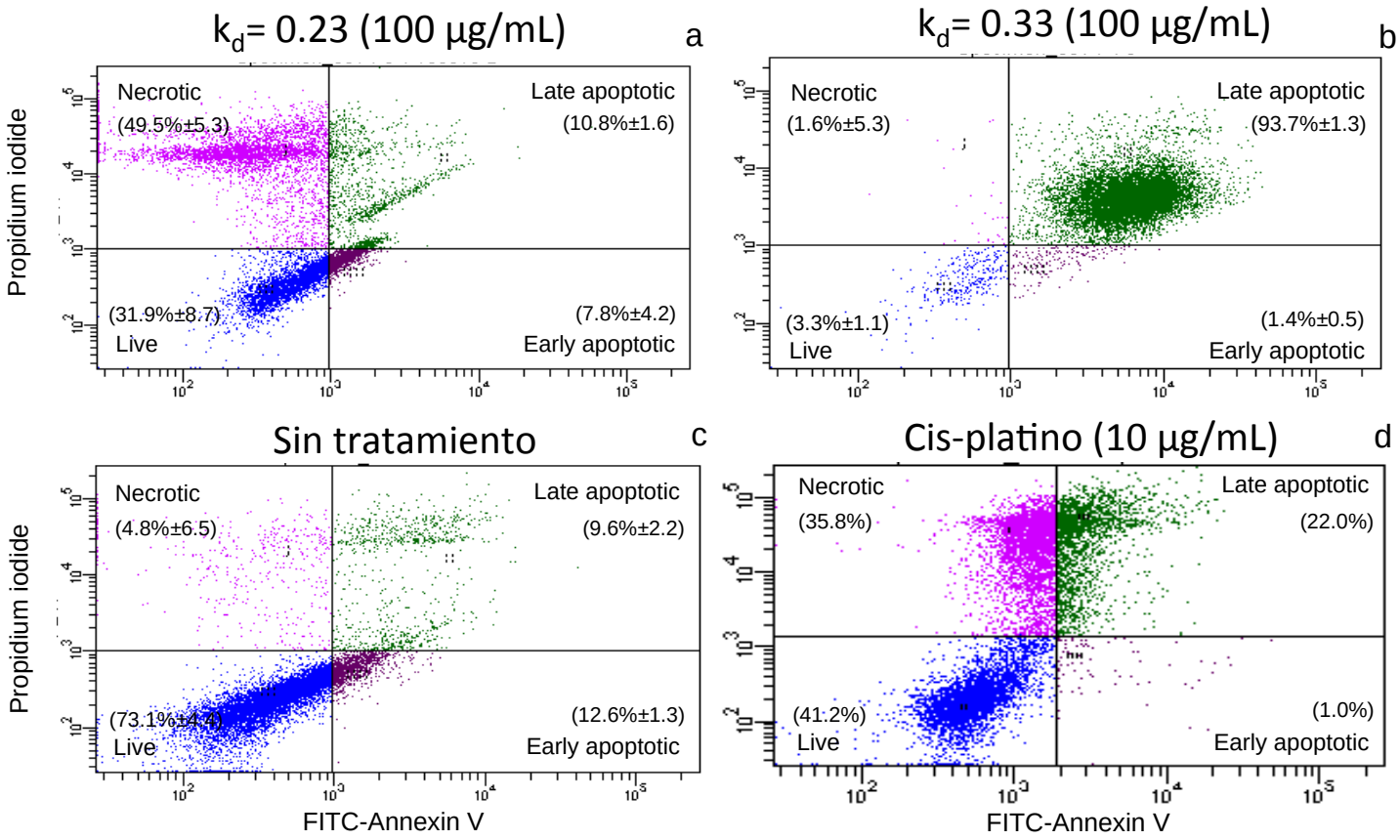
ORIGINAL PAPER

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

Liliana Santos-Zea[1] · Oscar R. Fajardo-Ramírez[2] · Irasema Rosa-López[1] · Janet A. Gutiérrez-Uribe[1]



Apoptotic effect



Effects on obesity

www.nature.com/scientificreports

SCIENTIFIC REPORTS

OPEN

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Aguamiel concentrate from *Agave salmiana* and its extracted saponins attenuated obesity and hepatic steatosis and increased *Akkermansia muciniphila* in C57BL6 mice

Ana María Leal-Díaz[1], Lilia G. Noriega[2], Ivan Torre-Villalvazo[2], Nimbe Torres[2], Gabriela Alemán-Escondrillas[2], Patricia López-Romero[2], Mónica Sánchez-Tapia[2], Miriam Aguilar-López[2], Janette Furuzawa-Carballeda[3], Laura A. Velázquez-Villegas[2], Azalia Avila-Nava[2], Guillermo Ordáz[3], Janet A. Gutiérrez-Uribe[1], Sergio O. Serna-Saldivar[1] & Armando R. Tovar[2]

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 obese[1]. 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 dysbiosis[2,3]. Insulin resistance develops during obesity due to alterations in insulin signaling and increases in the systemic inflammatory response[4]. 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 muscle[5].

Recently, it has been established that dietary intervention must be included to prevent or ameliorate the biochemical abnormalities associated with obesity[6]. With this aim, extensive research on functional foods has recently been performed. These foods provide a health benefit in addition to their nutritional value[7]. Most

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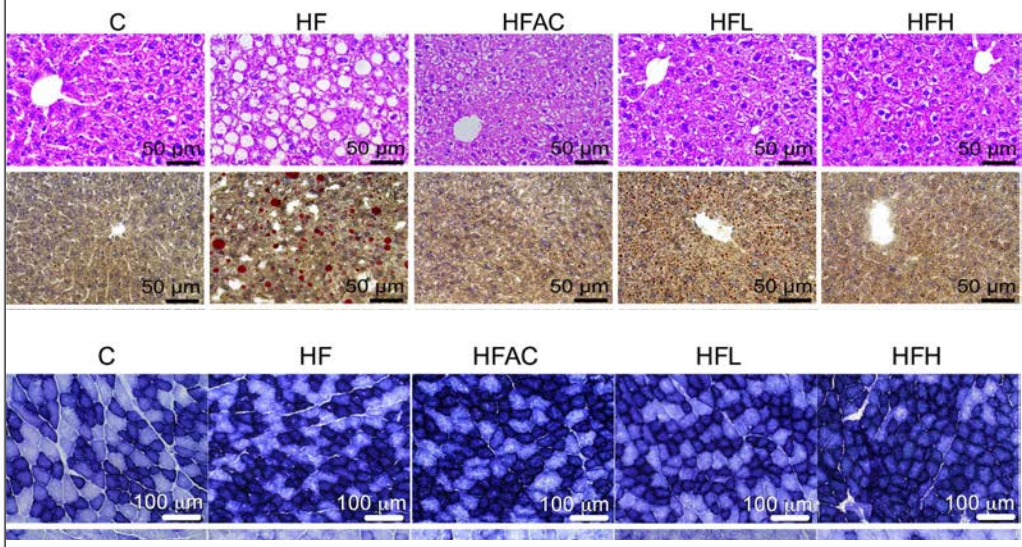
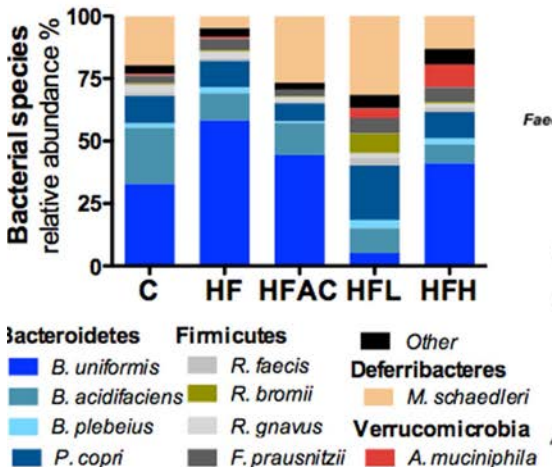
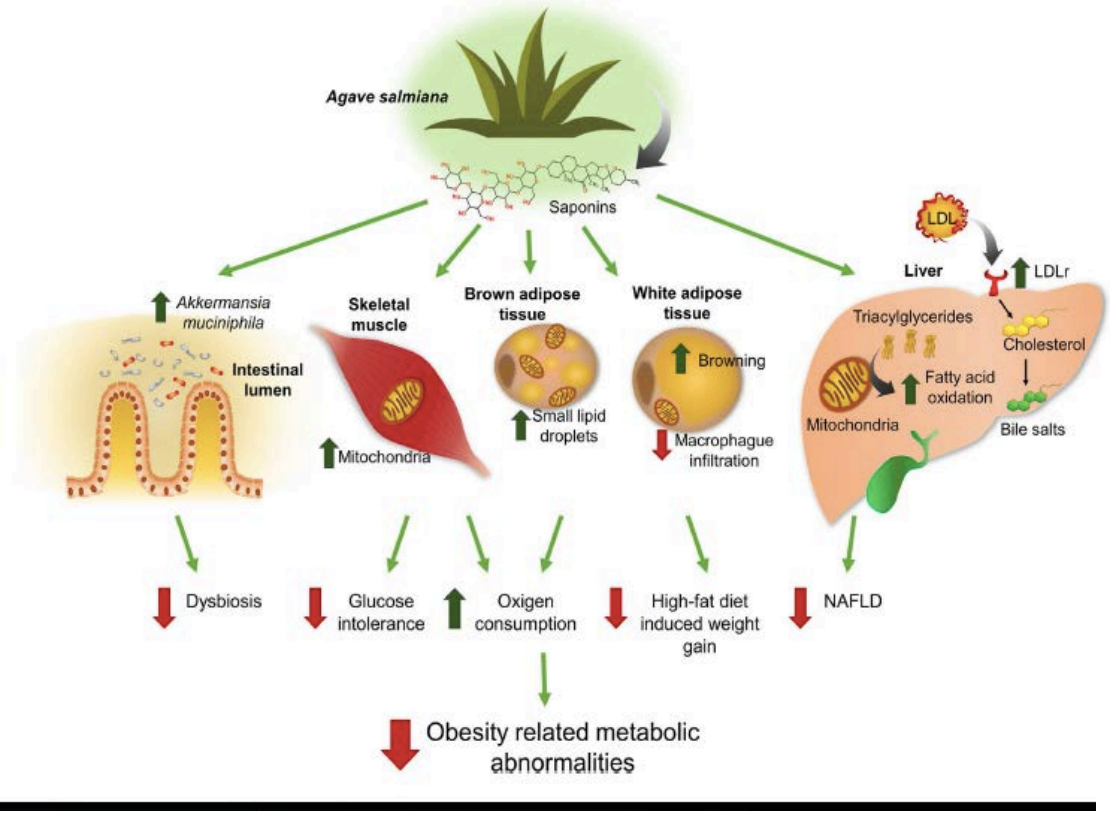
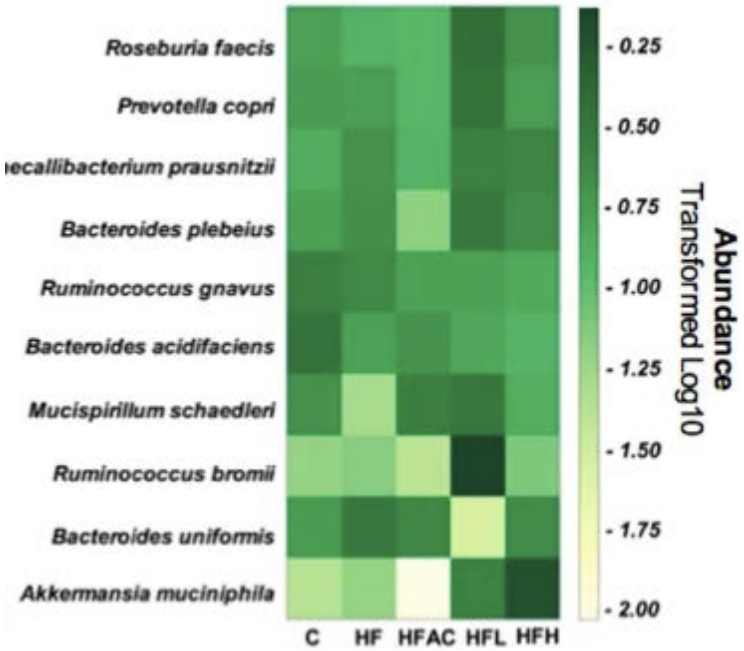
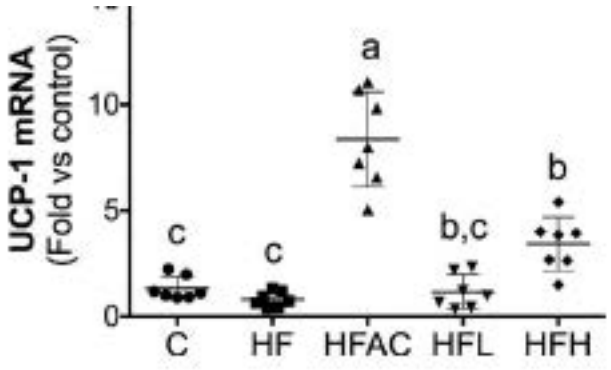




Genes & microbiota







Microorganisms affect saponins glycosylation

sustainability

MDPI

Article

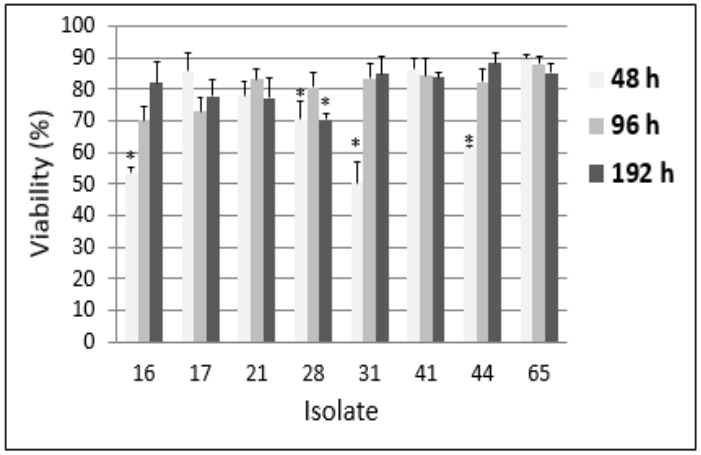
Mass Spectrometry-Based Metabolomics of Agave Sap (*Agave salmiana*) after Its Inoculation with Microorganisms Isolated from Agave Sap Concentrate Selected to Enhance Anticancer Activity

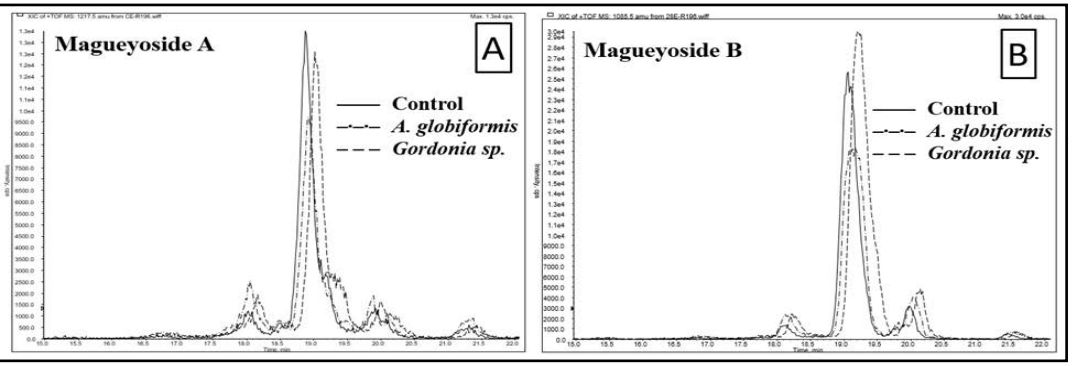
Luis M. Figueroa [1], Liliana Santos-Zea [1], Adelfo Escalante [2] and Janet A. Gutiérrez-Uribe [1,*]

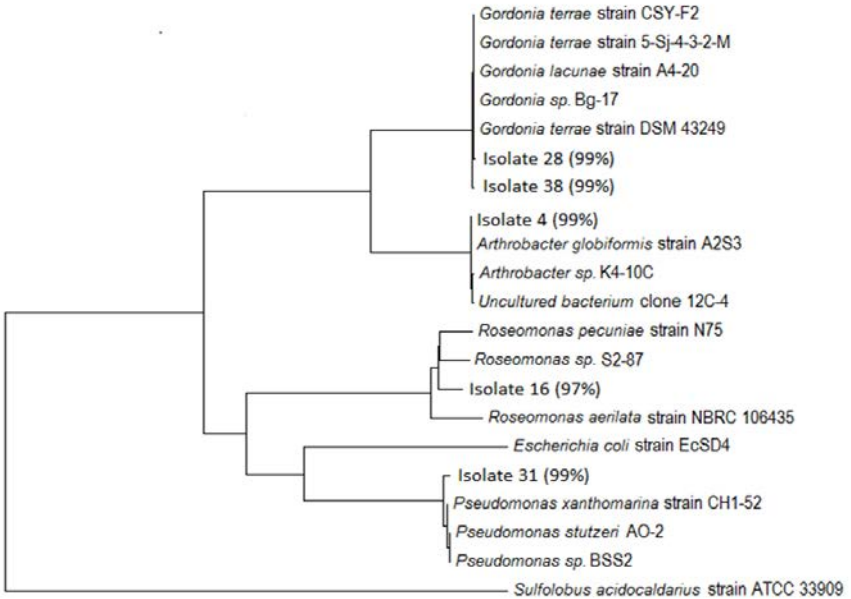
1 Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. Eugenio Garza Sada 2501, Col. Tecnológico 64849 Monterrey, N.L., Mexico; luisfigueroa8605@gmail.com (L.M.F.); lilianasantos@itesm.mx (L.S.-

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

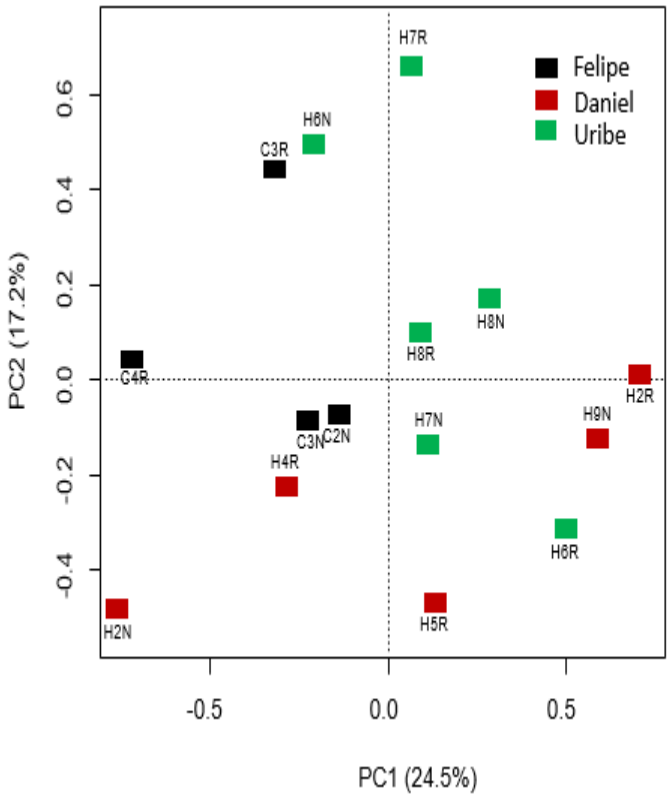
* Correspondence: jagu@itesm.mx; Tel.: +52-81-8358-2000 (ext. 1802)



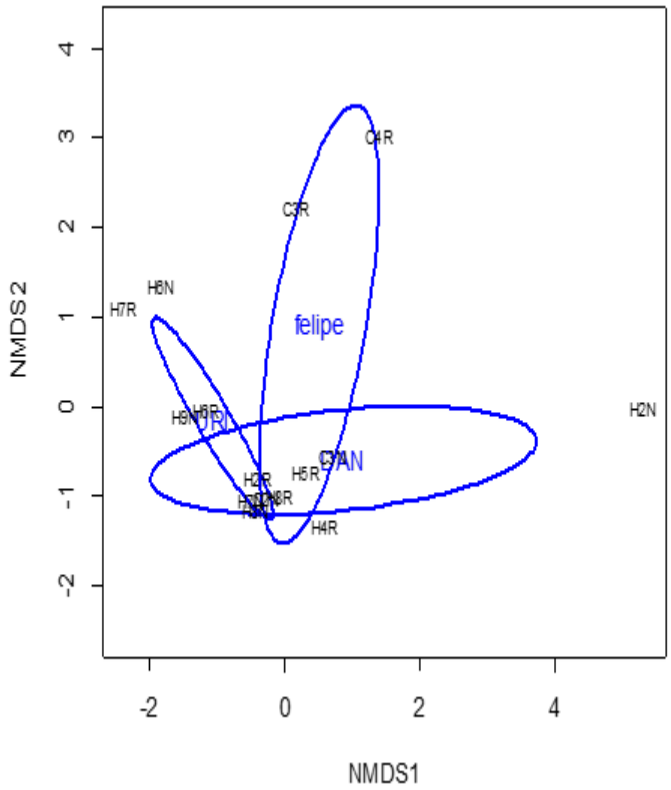


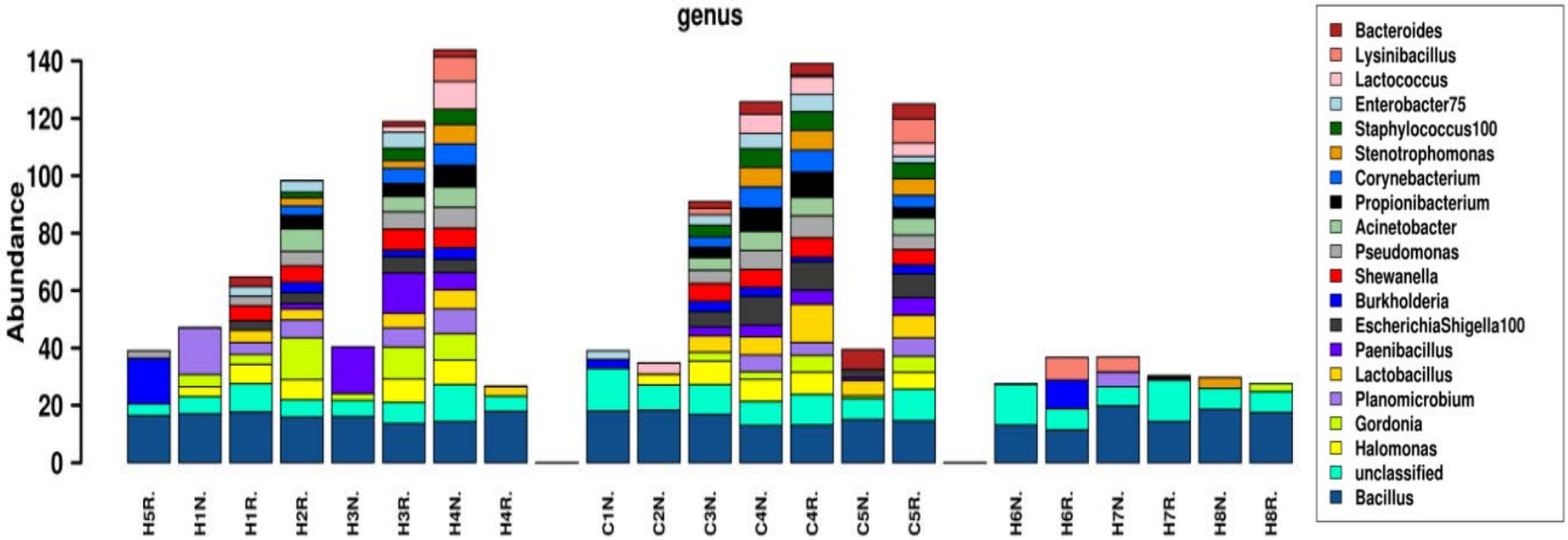


Preliminars on Food microbiota




```
Goodness of fit:
                r2 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

SEMANA i

Moléculas del millón en plantas del desierto

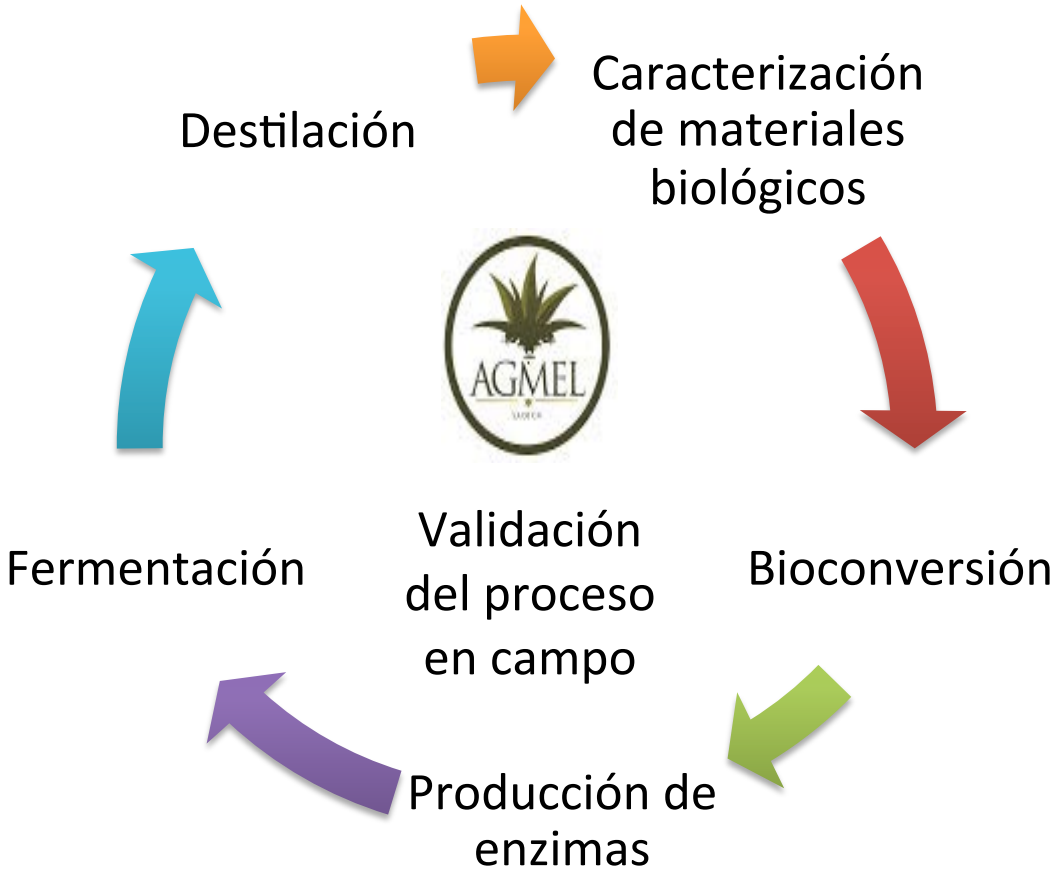
Validación tecnológica de procesos y productos

- 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

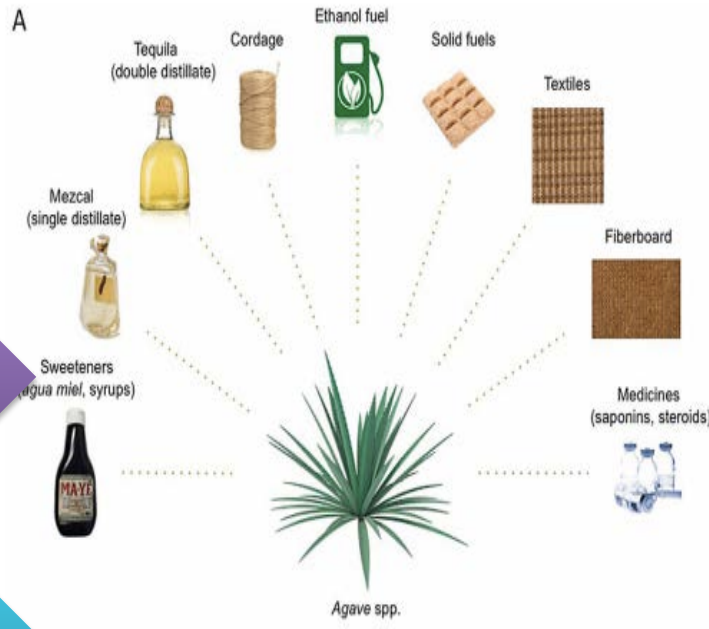
RETO 1: Producción de etanol a partir de subproductos del agave



Retos

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

- Recursos naturales
- Nuevos productos
- Propiedad intelectual
- Restricción de agua
- Control de calidad



Tecnológico de Monterrey

Gracias