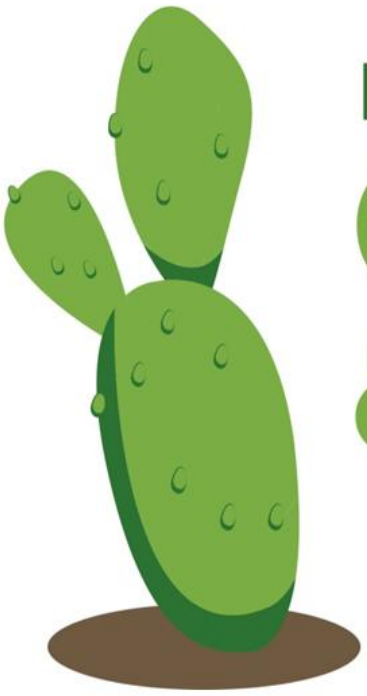

IX International Congress on Cactus Pear & Cochineal

"CAM crops for a hotter and drier world"

COQUIMBO - CHILE 2017

Book of Abstract and
Symposium Program

ISHS

FAO FIAT PANIS

ICARDA

CACTUSNET

FIA
Fundación para la Innovación Agraria

WELCOME

Dear colleagues, On behalf of the International Society for Horticultural Science (ISHS) and FAO-ICARDA International Technical Cooperation Network on Cactus, the University of Chile honored to receive you at the **IX INTERNATIONAL CONGRESS ON CACTUS PEAR AND COCHINEAL *"CAM crops for a hotter and drier world"*** and the **General Meeting of the FAO-ICARDA International Cooperation Network on Cactus Pear and cochineal (CACTUSNET)**, in **Coquimbo, Chile, March 26th - 30th, 2017.**

The University of Chile, with Dr. Fusa Sudzuki as convener, organized the II International Congress on Cactus pear and Cochineal which was hosted in Santiago in 1992. This special opportunity for hosting the IXth congress, allows us to bring back the congress to Chile, one of the few countries worldwide were cactus pear fruits ("tunas") are commonly consumed and form part of the traditional diet. Many things have changed during these 25 years: Chile has consolidated as one of the world leaders in the fresh fruit export industry and, regarding cacti, new CAM-crops (eg. "Copao" [*Eulychnia acida*], pitahaya) are being developed. And the use of *Opuntias* as a source of fodder and energy has grown in the country.

Now we have the opportunity to share these new developments with the international Cactus community in the beautiful city of Coquimbo, at the southern margin of the driest desert of the world (Atacama) along the Pacific coast and at the feet of the Andes mountain range. The city is surrounded by valley oases which host a third of the Chilean cactus pear growing area. It shall be our pleasure to welcome you back in Chile.

THE CONVENERS

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COMMITTEE

ORGANIZING COMMITTEE

Park Nobel	Honorary President
Nicolás Franck & Carmen Sáenz	Conveners
Paolo Inglese	General Coordinator Cactusnet-FAO-ICARDA
Makiko Taguchi	AGPM, FAO – Rome
Loreto Prat	University of Chile
Marcos Mora	University of Chile
Víctor Muñoz	University of Chile
Mariano López	Foundation for Agricultural Innovation (FIA, Chile)
Mounir Louhaichi	ICARDA

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Edition Book of Abstract

Universidad de Chile

Facultad de Ciencias Agronómicas (IHB)

Design of the Congress logo: Carmen Sáenz Escobar

Programme

Sunday 26 March

18:00-19:00	*Welcome and registration at Hotel de la Bahia*

Monday 27 March

8:00-9:00	*Registration and poster display*
9:00-9:45	*Opening ceremony: greetings from international and local authorities.*
9:45-10:15	*Opening lecture:* ***CAM metabolism: advantages for a hotter and drier world*** *Prof. Park Nobel - University of California Los Angeles.*

SESSION 1: Genetic resources and breeding of Opuntia

Chair: Paolo Inglese

10:15-10:45	*Invited speaker:* *Prof. Candelario Mondragón – Universidad Autónoma de Querétaro.* ***Functional properties: actual frontier of native and improved cactus pear germplasm***
10:45-10:55	***Assessment of genetic diversity of Brazilian and Mediterranean cactus cultivars by SSR markers and morphological traits.*** *Nefzaoui M, Lira MA, Udupa SM, Louhaichi M, Boujghagh M, Santos DC.*
10:55-11:05	***Assessment of four cactus (Opuntia ficus-indica (L.) Mill.) accessions for growth, yield and quality parameter under pot culture.*** *Kauthale VK, Punde KK.*
11:05-11:15	***Morphological characterization of Opuntia sps. accessions for potential use as a forage crop in dry areas of Bolivia.*** *Lazarte L, Ramirez K.*
11:15-12:00	***COFFEE BREAK***
12:00-12:10	***Genotype x environmental interactions of cactus pear (Opuntia ficus-indica) in the semi-arid regions of South Africa: cladode production.*** *Fouché HJ, Coetzer GM, Smith MF.*
12:10-12:20	***Genotype x environmental interactions of cactus pear (Opuntia ficus-indica) in the semi-arid regions of South Africa: fruit production.*** *Coetzer GM, Fouché HJ, Smith MF.*
12:20-12:30	***Screening of cladodes from 42 south African spineless cactus pear cultivars for human food applications.*** *De Wit M, Du Toit A, Fouché HJ, Hugo A, Venter SL.*

12:30-12:40 ***Evaluation of some morphological and chemical characteristics of 38 accessions of spineless cactus under Qatar environmental conditions.*** *Al Wawi HM, Al Yafei MS, Ouled Belgacem A.*

12:40-12:50 ***Nutritive characterization of the cladodes of sixteen cultivars of spineless cactus from different geographic origins.*** *Abidi S, Ben Salem H.*

12:50-13:00 ***Determination of apomixes and polyploidization in Opuntia ficus-indica.*** *Espinoza F, Muñoz C, Prat L.*

13:00-14:30 ***LUNCH***

SESSION 2: CAM plants as a source of forage and energy
Chair: José Dubeux

14:30-15:00 *Invited speaker:*
Dr. Ali Nefzaoui, International Center for Agricultural Research in the Dry Areas.
Cacti as an adaptation option for livestock feeding under changing climate in the dry areas

15:00-15:10 ***Nutritive value of 'Raketamena' (Opuntia stricta [Haw.] Haw.) as a fodder in Madagascar.*** *Dubeux J, Schroth W, Ruiz-Moreno M, Ferreira MA.*

15:10-15:20 ***Cactus pear's potential to sustain livestock production in drought stricken areas: a case study of Oppermans community in the Free State province of South Africa.*** *Fouché HJ, Coetzer G, de Wit M, Mavengahama S, Venter SL.*

15:20-15:30 ***Valorization of nopal cladodes and seeds.*** *Varnero MT, Homer I.*

15:30-15:40 ***Energy recovery from waste and by-products of the cactus produced in Italy: preliminary work.*** *Danzì C, Timpanaro G, Foti VT, La Malfa S, Testa G, Cosentino SL.*

POSTER SESSION 1: Genetic resources, CAM plants for forage and energy

15:40-16:40 *Poster viewing (coffee will be served)*

SESSION 3: Towards a hotter and drier world:
ecophysiological adaptations of Opuntia and new CAM crops
Chair: Giorgia Liguori

16:40-17:10 *Invited speaker:*
Prof. Ryan Stewart, Brigham Young University.
Exploring the possibility of photosynthetic plasticity in Agave sensu lato.

17:10-17:20 ***Soil volume: the effect of pot size on roots and canopy growth performance of cactus pear.*** *Hassan S, Liguori G, Sortino G, Louhaichi M, Inglese P.*

17:20-17:30 ***Cactus pear roots turnover and total carbon sequestration rate depends on soil volume availability.*** *Hassan S, Liguori G, Sortino G, Louhaichi M, Inglese P, Gristina L, Novara A.*

17:30-17:40 ***Water use efficiency of cactus pear and pitahaya as compared to other arid zone adapted fruit trees.*** *Muñoz-Aravena V, Talamilla M, Castro P, Faúndez C, Kremer C, Franck N.*

17:40-17:50 ***Regulation of stomatal opening via phototropins – blue light receptors – in the CAM plant Hylocereus undatus.*** *Sitrit Y, Bayramoğlu B, Tel-Zur N.*

17:50-18:00 ***Influence of the nurse plant effect of Prosopis flexuosa DC. on nutrient contents and productivity of Opuntia ellisiana Griffith.*** *Grünwaldt J, Guevara JC, Martínez Carretero E, Grünwaldt EG.*

Tuesday 28 March

SESSION 3: continued

Chair: Giorgia Liguori

9:00-9:30 *Invited speaker:*
Prof. Noemí Tel-Zur, Ben-Gurion University of the Negev.
Pitahayas – exotic species thriving in extreme desert conditions: challenges in developing a new crop.

9:30-9:40 ***Reproductive phenology of facheiro in Agreste of Paraíba, Brazil.*** *Barbosa A, Andrade AP, Souza VC, Aquino IS, Medeiros RLS, Barbosa Neto MA, Anjos F.*

9:40-9:50 ***Fruit quality and flower volatiles of the columnar cacti Cereus peruvianus and Cereus jamacaru.*** *Lewinsohn E, Bar E, Golan E, Ninio R, Mizrahi Y, Sitrit Y.*

9:50-10:00 ***Behavior of selections of Eulychnia acida Phil. under irrigation conditions, after 8 years.*** *Salvatierra GA, Martínez L.*

10:00-10:15 *Launching of the 2nd edition of the FAO technical paper "Agroecology, cultivation and uses of cactus pear (Opuntia sp. pl.)"*

10:15-10:40 *Tribute to Dr. Enza Chessa: Universidad de La Serena Chamber Ensemble*

POSTER SESSION 2: Ecophysiology and fruit production

10:40-11:20 *Poster viewing (Coffee will be served)*

SESSION 4: Fruit production: orchard and fruit management

Chair: Nicolás Franck

11:20-11:50 *Invited speaker:*
Prof. Paolo Inglese – Università degli Studi di Palermo.
Cactus fruit production: where are we and where are we going to?

11:50-12:00 ***Influence of age of cladode, growth, hormone and cladode pieces on propagation of cactus pear (Opuntis ficus-indica).*** *Kauthale VK, Punde KK.*

12:00-12:10 ***Supplemental irrigation improves water use efficiency, yield and fruit quality of ´Roja Dalia' cactus pear.*** *Zegbe JA, Serna-Pérez A, Maldonado-Rodríguez MR.*

12:10-12:20 ***Relationships between fruit attributes and fruiting cladode dry or fresh matter in Opuntia ficus-indica (L.) Miller variety 'Rojo Pelón'.*** *López-García R, Mata-González R, Blanco-Macías F, Méndez-Gallegos SJ, Valdez-Cepeda RD.*

12:20-12:30 ***Climatic influences on fruit yield, quality and sensory traits: a five-year evaluation.*** *Coetzer G, De Wit M, Fouché HJ, Venter SL.*

12:30-12:40 ***Effect of fruit ripening on morphological and chemical characteristics of Opuntia ficus-indica from Morocco.*** *Oumato J, Zrira S, Boujneh M, Saidi B.*

12:40-12:50 ***Effect of GA3 + Ethephon on glochid removal and cactus pear fruit quality.*** *Corrales-García J, Cardona-Vázquez J, Lira-Sandoval JA, Colinas-León MT.*

12:50-13:00 ***Preferences towards cactus pear in minimum process: an approach from the consumer through graphics stimulus.*** *Mora M, Esparza J.*

13:00-14:30 ***LUNCH***

WORKSHOP: Geographic distribution of Opuntia

Chair: Makiko Taguchi

14:30-15:30 *Use of GIS for zoning of Opuntia ficus-indica production areas*

15:30-17:30 *General Meeting of FAO-ICARDA International Cooperation Network on Cactus Pear and Cochineal (CACTUSNET)*

20:30 ***SOCIAL DINNER***

Wednesday 29 March

8:30-19:30 *Technical excursion (Valleys of Limarí and Elqui)*

Thursday 30 March

	SESSION 5: Agro-industrial uses of CAM crops. ***Chair: Maryna De Witt***
9:00-9:30	*Invited speaker:* *Dr. Paz Robert. Universidad de Chile* ***Cactus pear betalains as a source for coloring foods***
9:30-9:40	***Cactus pear mucilage: functional properties.*** *Du Toit A, De Wit M, Fouché HJ, Hugo A, Venter SL.*
9:40-9:50	***Selected Characteristics of Opuntia dillenii Cactus Beverage and Impact of thermal and non-thermal pasteurization.*** *Moussa Ayoub T, Jäger H, Knorr D, El-Samahy SK, Rohn S, Kroh LW.*
9:50-10:00	***Betalains stability in dry mixes for instant beverages.*** *Robert P, Vergara C, Castillo I, Cancino B, Sáenz C.*
10:00-10:10	***Sensory characteristics and physicochemical stability of pitaya fruit (Stenocereus queretaroensis Weber) liquor.*** *Corrales-García J, Hernández-Montes A, Vargas-Cano A, Quiroz-González B.*
10:10-10:20	***Microencapsulation of colorants from cactus fruit peel with mucilage and cellulose microfibers from cladodes.*** *Abrajún M, Aguilar-Romero MM, Ramírez-Gómez MM, Rodarte-Gómez JJ.*
10:20-10:30	***Sherbets from yellow-orange and purple cactus pear.*** *Sáenz C, Pérez T, Fabry AM, Medel M.*
	POSTER SESSION 3: Agro-industrial products
10:30-11:30	*Poster viewing (Coffee will be served)*
	SESSION 6: Pharmaceutical uses of CAM-crops and Cochineal. ***Chair: Paz Robert***
11:30-12:00	*Invited speaker:* *Prof. Mónica Nazareno, Universidad Nacional de Santiago del Estero.* ***Recent advances in medicinal and nutraceutical properties of cactus products***
12:00-12:10	***The wound healing effect of cactus pear oil.*** *Bardaa S, Khedir SB, Chabchoub N, Moalla D, Mseddi M, Rebai T, Sahnoun Z.*
12:10-12:20	***Evaluation of analgesic, anti-inflamatory and anti-ulcerogenic activities of Opuntia ficus-indica F. inermis cladode extract in rats.*** *Bendhifi Zarroug M, Feriani A, Zourgui L, Salhi Hannachi A.*

12:20-12:30 ***Cactus pear and cochineals: good agricultural practices and control.*** *Portillo L, Vigueras AL.*

12:30-12:40 ***Cochineal infestation, control measures and current status in Tigray cactus (Opuntia ficus-indica), Ethiopia.*** *Yemane K, Gebremeskel GT, Alem MT.*

12:40-12:50 ***Preparation and method of composition of herbal biopesticide for the management of cochineal insect of cactus in Tigray, Ethiopia.*** *Zeweld SW, Meles K.*

12:50-13:00 ***Predicting the impact of climate change on future cactus and cochineal distribution in Tigray, Ethiopia.*** *Abrha H.*

13:00-14:30 ***LUNCH***

POSTER SESSION 4: Pharmaceutical uses, cohineal and rural development

14:30-15:10 *Poster viewing (Coffee will be served)*

SESSION 7: Rural development and marketing.

Chair: Judith Ochoa

15:10-15:20 ***Changing perception of small holders about cactus pear in south Asia.*** *Louhaichi M, Kumar S, Clifton RK, Islam M, Hassan S, Qamar IA, Sarker A.*

15:20-15:30 ***The effect of fostering partnerships on broadening the food base: the role of cactus pear, an underutilized crop with unlimited potential, the South African perspective.*** *Venter SL, Fouché HJ, de Wit M, Mavengahama S, Coetzer G, Swart WJ, Amonsou EO.*

15:30-15:40 ***Cactus crop (Opuntia ficus-indica) to rehabilitate rangelands in semi-arid regions of Tunisia.*** *Gouhis F, Louhaichi M, Nefzaoui A.*

15:40-15:50 ***Research and development scenario of cactus pear (Opuntia ficus-indica) in Tigray, Ethiopia.*** *Yemane KB, Gebremeskel GT, Alem MT.*

15:50-16:00 ***Potential of Opuntia spp. seed oil for livelihood improvement in semi-arid Madagascar.*** *Hänke H, Barkmann J, Müller C, Marggraf R.*

16:00-16:30 *Closing lecture:*

Prof. Hichem Ben Salem, International Center for Agricultural Research in the Dry Areas.
Integration of cactus in livestock production systems and reduction of their water foot print – A climate-smart intervention.

16:30-16:45 *Summary of activities and conclusions of the General Meeting of FAO-ICARDA International Cooperation Network on Cactus Pear and Cochineal (CACTUSNET):*
Prof. Paolo Inglese, General Coordinator of CACTUSNET

16:45-17:15 *Prizes, awards, closing speeches.*

Poster sessions

Monday 27 March

POSTER SESSION 1: Genetic resources, CAM plants for forage and energy

1. Morphological characterization of cactus pear (O*puntia ficus-indica*) accessions from the collection held at Agadir, Morocco. Nefzaoui M, Lira MA, Boujghagh M, Udupa SM, Louhaichi M.

2. Multivariate analysis of phenotypic traits of forage cactus accessions in the semi-arid region of Pernambuco, Brazil. Nefzaoui M, Lira MA, Santos DC.

3. Quantitative and qualitative analysis of cladodes biomass from new selections of O*puntia ficus-indica* Mill. Mulas M, Dessena L.

4. Problematic of breeding by hybridization in cactus pear (O*puntia* spp): Apomixis or typical mendelian inherence of a polyploid? Núñez-Colín CA, Ramírez Granados JC, Gallegos-Vázquez C, Mondragón-Jacobo C.

5. Occurrence of thorns in clones of spineless cactus 'orelha de elefante mexicana' (*Opuntia stricta* Haw.) Santos, MVF, Souza TC, Mendoza PV, Santos DC, Silva MC, Lira MA, Cunha MV, Mello ACL, Dubeux Jr JCB.

6. Development of a crop improvement programme for cactus pear (O*puntia ficus-indica*) in South Africa. Mavengahama S, Fouché HJ, Venter SL, Coetzer G, Allen A, de Wit M.

7. Epigenetic variations in O*puntia* species following salt stress application. Bahia L, Ben Romdhane M, Boubakr H, Ammar B, Nefzaoui A, Ghorbel A, Zoghlami N.

8. Effect of continuous high temperature in sporophytic microsporogenesis initiation of *Opuntia ficus-indica.* Bouamama-Gzara B, Chebil S, Ben Salem-Fnayou A, Borgi M, Nefzaoui A, Ghorbel A.

9. Early adaptacion of five clones of *Opuntia* to agroclimatic diversity of northern Chile. Muñoz-Aravena V, Talamilla M, Franck, N.

10. Genotype x environment interactions of four clones of Opuntia established in Elqui and Codpa valleys, Chile. Muñoz-Aravena, V, Arancibia-Avendaño D, Talamilla M, Hardy Ch, Franck N.

11. Morphometric characterization of 36 wild variants of Xoconostle (*Opuntia spp*.) from Zacatecas, Mexico. Gallegos-Vázquez C, de Luna-Valadez JM, Valdez-Cepeda RD.

12. Assessment of different supplemental feeding strategies including cactus (*Opuntia ficus-indica*) for higher sheep productivity in Chakwal, Pakistan. Islam M, Razzaq A, Sawsan H, Louhaichi M, Qamar I, Rischkowsky B, Ibrahim MNM.

13. Replacement of forage cactus 'miúda' by 'orelha de elefante mexicana' in the diet of lactating crossbred cows. Ferreira MA, Silva RC, Santos DC, Oliveira JCV, Inácio JG, Silva JL.

14. Morphometry of rumen and intestinal tissues of sheep with dietary levels of forage cactus and water restriction. Cordova- Torres AV, Costa RG, Guerra RR, Araújo Filho JT, Medeiros AN, Rocha EHS.

15. Influence of varieties of forage cactus resistant to cochineal on growth performance of goats. Sousa FA, Silva DV, Nunes AR, Bispo SV.

16. Morphological characterization of *Opuntia* sps. accessions for potential use as a forage crop in dry areas of Bolivia. Lazarte L, Ramírez K.

17. Assessing the performance of Osmanabadi goats by feeding spineless cactus under field conditions. Aware MJ, Ghavate AM, Punde KK, Kauthale VK.

18. Influence of feeding spineless cactus on growth performance of Osmanabadi goat kids. Aware MJ, Ghavate AM, Punde KK, Kauthale VK.

19. Cactus pear as possible energy source for semi-arid environments. Danzì C.; Testa G.; Scordia D.; La Malfa S.; Timpanaro G.; Foti V.T.; Cosentino S.L.

20. Evaluation of cactus pear silages on growing lambs. Vazquez-Mendoza P, Miranda-Romero LA, Aranda-Osorio G, Burgueño-Ferreira JA.

21. Cropping system and manure source affects cactus (*Nopalea cochenillifera* Salm Dyck.) productivity. Miranda K, Dubeux Jr J, Silva M, Mello A, Santos M, Lira M, Cunha M, Ferraz I, Firemand T.

22. Potential production of biogas from plantations of Opuntia ficus indica available in the chilean "Norte Chico": an assessment. Varnero MT, Bedregal C, Homer I.

23. Effect of cactus addition to the diet of lactating sows on feed intake and productive behavior. Pérez SER, Ordaz OG, Juárez CA, Ortiz RR.

24. Ex – situ evaluation of creole tuna (O*puntia ficus-indica*) establishment on amended mine tailings. Varnero MT, Ramirez J, Ginocchio R, Homer I.

25. Liver function of sheep fed cactus species resistant to *Dactylopius sp.* Silva ANF, Silva TGP, Silva SMC, Sousa DR, Soares PC, Carvalho FFR, Batista AMV.

26. Serum profile of macrominerals in sheep fed cactus species resistant to D*actylopius sp.* Silva ANF, Silva TGP, Silva SMC, Sousa DR, Carvalho FFR, Batista AMV.

27. Increasing planting density reduces height and width of cactus. Mello ACL, Silva RM, Souza TC, Dubeux Jr JCB, Lira MA, Silva Jr JR, Silva MC.

28. Nutrient concentration in spineless cactus under different planting densities and harvesting management. Mello ACL, Silva RM, Souza TC, Dubeux Jr JCB, Lira MA, Santos MVF, Santos DC, Cunha MV.

29. Nutrient composition and *in vitro* digestibility of cactus pear cladodes (*Opuntia rastrera*) at different localities of northeast Mexico. Fuentes RJ, Charles RAV, Ruiz ZF, Garcia ER, Lopez TR, Aguilera JI.

Tuesday 28 March

POSTER SESSION 2: Ecophysiology and fruit production

1. Rumpa a cactus with commercial potential for gourmet market and others in the Metropolitan Region, Chile. Salvatierra A, Mora M.

2. Transpiration study in cactus pear (O*puntia ficus indica*). Ben Salem-Fnayou A, Abdellaoui I, Mliki A, Nefzaoui A, Ghorbel A.

3. CO_2 or light: what limits carbon assimilation of growing cactus pear cladodes? Franck, N, Alfaro F, Arancibia D, Muñoz V.

4. Spineless cactus in the Arabian Peninsula: adaptive behaviors and production performances. Ouled Belgacem A, Al Farsi S, Al Wawi HM, Al Yafei MS, Al-Sharari M, Al-Hamoodi A, Louhaichi M.

5. The use of wild and cultivated cacti in northern province of Cordoba, Argentina. Trillo C, Ahumada ML, Torrico Chalabe J, Demaio P.

6. Anatomical investigation of emasculation and gibberellic acid effects on early seed development of Opuntia ficus-indica (L.) Mill. Jedidi E, Ben Mahmoud K, Ayari O, Jemmali A.

7. Caracterization of rumba fruits (C*orryocactus brevistylus*) from northern Chile. Sáenz C, Pinto R, Fabry AM, Carmona JC, Franck N.

8. Predicting of stomatal conductance in *Opuntia ficus indica.* Savé RA, Acevedo E.

9. Relative water content as indicator of plant water status of 'roja dalia' cactus pear under irrigation regimens. Zegbe JA, Serna-Pérez A.

10. Palatable cacti fruits from northern Chile as an agro industrial alternative resource. Pinto R.

11. Fruiting cladode physical attributes of *Opuntia ficus-indica* (L.) Miller variety 'Rojo pelón' differ among years. López-García R, Valdez–Cepeda RD, Blanco–Macías F, Méndez–Gallegos S. de J.

12. Evaluation of *Opuntia ficus-indica* as a multi-purpose species under west Asia conditions. Hassan S, Inglese P, Kaabneh A, Ates S, Louhaichi M.

13. Propagation of *Opuntia ficus-indica* Mill. by cladode fragments. Mulas M, Dessena L.

14. Impact of cladode "acorazonamiento" on cactus pear commercial orchards. Mendoza-Orozco ME, Morales-Flores FJ, Mena-Covarrubias J, Ortega-Espinoza J, Méndez-Gallegos S. de J.

15. Effect of fruit load on cactus pear fruit size and quality under mediterranean and tropical climatic conditions. Franck N, Celi A.

16. Effect of 1-MCP on cactus pear fruit at different maturity stages during storage. Sortino G, Inglese P, Allegra A.

Thursday 30 March

POSTER SESSION 3: Agro-industrial products

1. Elaboration of lipstick with cactus pear seed oil and cochineal carmine. Arroyo Figueroa G, Medina Saavedra T, Rodríguez Ruiz S, Vigueras AL, Herrera Méndez CH.

2. Phenolic compounds in fruit-producing cacti. Moussa-Ayoub TE, El-Samahy SK, Kroh LW, Rohn S.

3. The rheological characterization of reconstituted freeze-dried mucilage for application in nutraceutical food products. Du Toit A, De Wit M, Fouché HJ, Hugo A, Venter SL.

4. Characterization of chilean consumers' attitudes and preferences toward different cactus pear colors. Mora M, Matamala P, Saenz C.

5. Gummy confections from cactus pear: chemical characteristics, texture profile and sensory quality. Sáenz C, Fabry AM, Contador L, Franck N.

6. Betacyanin profile of *Pilosocereus catingicola* (Gürke) Byles & Rowley subsp. *salvadorensis* (werderm.) zappi (Cactaceae). Barbosa AS, Goodger JQD, Andrade AP, Bruno RLA, Woodrow IE, Anjos F. Aquino IS.

7. Variability of phenolic compounds content and flavonoid in cactus pear varieties of *Opuntia* and *Nopalea* genres. Alves FAL, Andrade AP, Bruno R, Silva V, Santos DC, Silva DS.

8. Encapsulated cactus pigments as food colorants. stability and uses in a food model system. Otálora MC, Carriazo JG, Iturriaga L, Osorio C, Nazareno MA.

9. Comparative study of the encapsulation of betaxanthins (O*puntia megacantha*) by spray drying and ionic gelation. Otálora MC, Carriazo JG, Iturriaga L, Osorio C, Nazareno MA.

10. Bioactive compounds from O*puntia ficus-indica* in nanotechnology: biosynthesis of silver nanoparticles and applications. Villalba GF, Ferreyra Maillard APV, Gallucci MN, Dalmasso PR, Nazareno MA.

11. Effect of fermentation on the bioactive compound composition and antioxidant potential of *Opuntia sp*. fruit juices. Allendez G, López Alzogaray MS, Nazareno MA.

12. The nopal as a gelling agent in confectionery products (gummies). Escobar A, Figueroa MJ, Sandoval RP, Ramírez MM, Abraján MA, Pérez LE.

13. Selected characteristics of O*puntia dillenii* cactus beverage and impact of thermal and non-thermal pasteurization. Moussa Ayoub TE, Jäger H, Knorr D, El-Samahy SK, Rohn S, Kroh LW.

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1. Rearing cochineal (*Dactylopius coccus* Costa) under covered structural tubing conditions in Mexico. Ortega-Espinoza J, Méndez-Gallegos S de J, Blanco-Macías F.

2. Incidence of cochineal insects in cactus pear genotypes in the semiarid region of Pernambuco. Ferraz APF, Lira MA, Silva MC, Cunha MV, Santos MVF, Silva PSF, Santos DC.

3. Comparison production of cochineal in two companies in the state of Guanajuato, Mexico. Arroyo Figueroa G, Dzul Cauich JG, Vigil Flores JS, Paloalto Hernández DI, Vargas Rodríguez L.

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CAM METABOLISM: REACTIONS TO CLIMATE CHANGE WITH A HOTTER AND REGIONALLY DRIER WORLD

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My presentation begins by thanking the Organizing Committee for the IX International Congress on Cactus Pear and Cochineal plus many cactus colleagues with whom I have worked, especially on *Opuntia ficus-indica*, over the last four decades. Then the difficulty associated with quantifying increases in temperature will be mentioned as a prelude to the unambiguous evidence for increasing atmospheric CO_2 levels based on data from Mauna Loa, Hawaii beginning in 1957. The net CO_2 uptake by Crassulacean acid metabolism (CAM) plants over a 24-hour period will be compared with the other two photosynthetic pathways together with a brief mention of the resulting high water-use efficiency for CAM plants. The climate change effects of light, water, temperature, and atmospheric CO_2 level on CO_2 uptake of cacti and hence their productivity can be analyzed using an Environmental Productivity Index. Laboratory and field measurements show that their nocturnal CO_2uptake increases about 1% for each 10 ppm increase in atmospheric CO_2. Cacti, including *O. ficus-indica*, are extremely tolerant of high temperatures but quite susceptible to freezing temperatures. The effects of temperature on CO_2 uptake and the productivity of cacti are more nuanced, with nighttime temperatures being more important than daytime ones; the optimum nocturnal temperature is lower for *O. ficus-indica*(10C to 12C) than for pitayas and pitahayas. The varying effects of rainfall involved in global climate change on cacti depend on their use of CAM, with its predominantly nocturnal CO_2 uptake and the consequent remarkable water savings. Indeed, cacti can benefit from increased rainfall and are not threatened by diminished rainfall.

Keywords: Crassulacean acid metabolism (CAM), *Opuntia.*

CONFERENCES

FUNCTIONAL PROPERTIES: ACTUAL FRONTIER OF NATIVE AND IMPROVED CACTUS PEAR GERMPLASM

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The particular morphology of the cactus pear fruit, mainly the presence of hard seeds imbibed in the pulp has been the main deterrent for market expansion since its arrival into the international markets at the second half of the XX century. Its appeal as exotic fruit no longer has the effect of a decade ago, after the inclusion of numerous other tropical fruits in the same markets. Earlier this century the interest on the composition of the fruits - antioxidant content and activity, antidiabetic, anticarcinogenic and other benefitial effects- have been an important forces boosting fresh fruit consumption. They were driven by the extraordinary activity on the biomedical research, which for the first time devoted significant efforts to the study of all kind of natural products; vegetables, fruits, spices and herbs and its debatable quick diffusion of the results towards the consumer base. The improved fruit varieties of the past were the product of similar breeding objectives: wide adaptability, high yield, and market appeal and/or pest tolerance. New demands for improved varieties will need the same traits, but also, nutritional quality, and presence of particular active compounds useful to prevent non-infectious illnesses. The raw material to obtain them will continue to be the natural genetic variability, an intrinsic advantage of the cactus pear plant, which still possesses an extensive gene pool. In this presentation, we will discuss that intensive germplasm utilization is the best strategy for conservation, the effects of domestication and breeding on some functional properties of the cactus pear fruit, and the potential of lesser known accessions and selections to expand the market for cactus products. How will this approach will shape the future activities of germplasm conservation and breeding will be briefly covered.

EXPLORING THE POSSIBILITY OF PHOTOSYNTHETIC PLASTICITY IN *AGAVE SENSU LATO*

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Conservation of water acts as a primary driving force in terrestrial crassulacean acid metabolism (CAM) species evolution, particularly in semi-arid regions. CAM plants typically fix CO_2 at night when temperatures are cooler, resulting in lower transpirational demand. This adaptation contributes to higher levels of water-use efficiency than found in C_3 and C_4 plants. However, when soil water availability is high, some CAM plants shift to mostly daytime CO_2 uptake. Such plasticity could enable plants native to harsh desert environments, such as those in the *Agave* genus, to take advantage of seasonally abundant water for growth and development. To better understand whether this phenomenon in the *Agave* genus and if it confers any fitness advantage, we attempted to induce photosynthetic-mode shifting in several *Agave sensu lato* species. We hypothesized that *Agave sensu lato* species primarily uptake CO_2 at night under conditions of low water availability, but shift to diurnal uptake when well-watered. To determine the prevalence of CAM plasticity in species within *Agave sensu lato*, this study subjected 2- and 10-month-old seedlings and 2-year-old plants from 15 species to soil moisture levels ranging from dry to saturated conditions. Through gas-exchange and titratable acidity measurements, we found that young seedlings primarily use the C_3 photosynthetic pathway, and transition to CAM as they age. Mature agaves also do not change their photosynthetic pathway usage with changes in soil moisture levels. The persistent expression of CAM among all of these species is a strong indicator that the vast majority of *Agave sensu lato* are CAM obligates, and are unable to facultatively express CAM in response to water availability. Even so, agaves appear to be able to maintain respectable growth rates without switching from the metabolically costly CAM pathway to the less costly C_3 photosynthesis pathway. Since the expression of CAM appears to be obligate for *Agave* and not facultative, some other mechanism or mechanisms must be in use by agaves in order to achieve high levels of productivity, while maintaining high water-use efficiency.

CONFERENCES

"PITAHAYAS – EXOTIC SPECIES THRIVING IN EXTREME DESERT CONDITIONS: CHALLENGES IN DEVELOPING A NEW CROP"

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Pitahayas, dragon fruit, and vine cacti are the popular names used to describe the hemi-epiphytic species belonging to the genus *Hylocereus* (Cactaceae). *Hylocereus* species use the Crassulacean acid metabolism (CAM) photosynthetic pathway and are thus intrinsically adapted to extreme drought conditions. The plants are bloom at night, with the flowers remaining open and receptive for only a few hours. The different species bear large, attractive, juicy and sweet fruits, and therefore constitute attractive candidates for dryland agriculture. Practically unknown three decades ago, pitahayas today occupy a growing niche in the exotic fruit markets of Europe and USA, with increasing interest being shown worldwide. Although the native geographical areas of *Hylocereus* species are the tropical regions of northern South America, Central America and Mexico, they are currently being cultivated in Mexico, Colombia, Ecuador, the United States, Israel, Thailand, Australia and Vietnam, which is the largest exporting country. Traditional methods of cultivation have changed considerably in the new cultivation areas as technologies have been developed to increase productivity. Introduction programs focused on generating the know-how and developing agrotechniques for profitable and sustainable cultivation. Early studies revealed that *Hylocereus* species are sensitive to low temperatures (less than 3°C), salinity (in the soil or irrigation), high irradiation, and extremely high temperatures. The last of these four factors may delay or even inhibit flowering. Current agricultural practices have created a "revolution" in pitaya cultivation and yields; these include the use of vertical supports to allow climbing, shading to reduce irradiance and high temperatures, and drip fertigation. In addition, manual cross pollination is frequently applied due to the self-incompatibility system of several cultivars and the lack of natural pollinators in areas beyond the species' native habitats. Alongside the development of the above agrotechnologies, a breeding program was begun at Ben-Gurion University of the Negev, Israel to improve *Hylocereus* fruit traits and yields. This presentation provides an update on the current status of production, uses, genetic resources and on-going research programs on these exotic fruit crops and discusses the limitations, challenges and strategies for their future development and commercialization.

Keywords: agrotechniques, breeding, dryland agriculture, fruit crop, *Hylocereus.*

CACTUS FRUIT PRODUCTION: WHERE ARE WE AND WHERE ARE WE GOING TO?

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Cactus pear (*Opuntia ficus-indica*) fruit production has been growing marginally in the last 25 years, in terms of acreage or genetic variability of cultivated varieties, though technical management of the orchards has been largely implemented and some new Countries started a commercial fruit production. Fruit marketing had also a marginal evolution in terms of approaching new consumers, particularly in Europe, USA and Asia. Orchard systems and their yield potential are more or less the same as 25 years ago, though the average yield in many areas has increased also because of the implementation of technical information and cooperation in which Cactusnet –FAO-ICARDA played a major role. The understanding of such limitations to reduce the potential of this crop needs to be addressed to pave opportunities for new research ideas and new technical achievements. We need to imagine the cactus pear orchard of the future, in different areas and for different purposes. We need to understand how and to which direction the available genetic resources need to be implemented. We need to understand whether there is a chance to further develop the role of this crop and the consumption of its fruit in the market oriented agriculture as well as in the marginal areas. The rationale of this presentation is to analize the whole fruit production area, highlighting its strengths, weaknesses, opportunities and threats, after 30 years of research.

key words: perspectives, fruit production efficiency, quality.

CONFERENCES

CACTI AS AN ADAPTATION OPTION FOR LIVESTOCK FEEDING UNDER CHANGING CLIMATE IN THE DRY AREAS

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Drylands – in both developing and developed worlds- are hardly negligible. Home to 2.3 billion people or third of the world population, drylands cover 41 % of the world's land surface and span nearly 100 countries. Livestock production remains the main source of income of rural populations living in drylands. It represents a key component of resilient production systems and an indicator of wealth. The main constraint to livestock development is the insufficient and fluctuating feed supply. Seasonal droughts exacerbate fodder deficit, thus affect livestock performance. The livestock sector has been described as a major contributor to global warming, accounting for 18% of the world anthropogenic GHG emissions. Such large contribution of livestock to global warming is primarily the result of the highly intensive livestock system. In contrast, the livestock system in arid areas is primarily extensive in nature and contributes comparatively little to GHG emissions as compared to intensive livestock systems. Water scarcity is another important limiting factor in drylands threatening the sustainability of livestock-based systems. Global projections of water use show increasing withdraws in the next decades that will limit its use for agriculture and livestock production. In this scenario, cactus becomes the most prominent crops for the 21st Century. Cactus, a succulent and drought-tolerant species has potential to produce large amounts of biomass varying from 4 tons dry matter (DM)/ha/year with no input to more than 20 tons DM/ha/year. Cacti present high palatability, digestibility, and reduce the water needs to animals; however, they must be combined with other feedstuff to complete the daily diet, as they are poor in proteins and fiber, although rich in carbohydrates and calcium. Cladodes can provide a cost-effective supplementation for raising sheep, goats and cattle on rangelands. When cladodes are supplied to grazing goats that have access to alfalfa hay, the milk yield is increased by 45%. When cladodes are associated with a protein-rich feedstuff, they may replace barley grains or maize silage without affecting body weight gains of sheep and cattle. Animals consume considerable energy to reach water points and therefore, the high water content of cladodes is a solution to animal in dry areas. In fact, animals given sufficient supplies of cladodes require little or no additional water.

Keywords: feeds, climate change, drylands, livestock

CACTUS PEAR BETALAINS AS A SOURCE FOR COLORING FOODS

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The global market for natural food colors is projected to reach $1.3 billion by 2017. Considering that the international regulations increasingly restrict the synthetic colorants for foods, and simultaneously the consumers are looking for safe and healthy ingredients, cactus pear fruits, one of the few natural sources of betalains appear as a prominent raw material for coloring foods. Betalains are not homogeneously distributed in the cactus pear fruits. In some varieties they are more concentrated in the peel than in the pulp, and in other varieties it is the reverse. The occurrence of pigments in the skin opens another alternative to use the waste of the cactus pear industry to obtain colorants.

The two principal groups of betalains, the betacyanins (red) and the betaxanthins (yellow), show absorption at different wavelengths (540 and 480 mm, respectively). Their extraction and mainly their stability are the most important aspects to be considered for the success to obtain colorants for food application. Betalains stability is influenced by several factors such as, metals, pH, a_w, light, oxygen, enzymes, and temperature, being the last the most important degradation factor. The stabilization of betalains could be improved using microencapsulation technologies, such as spray drying, for use in industrial purposes and to ensure its bioavailability. Microencapsulation is described as a technique wherein a bioactive compound is encapsulated by a biopolymer, thereby protecting it from oxygen, water or other conditions to improve its stability. Different types of encapsulating agents have been used for cactus pear betalains microencapsulation; such as polysaccharides (starches, maltodextrins), proteins (soy) and blend polysaccharide-proteins. In all cases the percentage of encapsulation was high (98 %) for both betacyanins and betaxanthins. The degradation of betacyanins in the microparticles follows pseudo first-order behavior, being the degradation rate constant between 5-10 x 10^{-3} $days^{-1}$ at 60 °C for several encapsulating agents or combined systems, being almost certainly hydrolysis the main mechanism of betalain degradation during storage. The microparticles were applied in different food matrices, i.e. powders for instant beverages, showing a great stability. In conclusion, cactus pear colorants could be considered as a promising food additive, giving adds value to this special crop.

Keywords: Colorants, betalains stability, spray drying, microparticles, cactus pear.

Grant: FONDECYT Project N° 1110126

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RECENT ADVANCES IN MEDICINAL AND NUTRACEUTICAL PROPERTIES OF CACTUS PRODUCTS

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Cactus plants can be considered as multipurpose crops, since they provide not only food and feed but they are also sources of health-promoting substances. Cactus cladodes, fruits, seeds and flowers have been used as folk medicines in several countries for centuries. Recently, these properties, known by ancient civilizations, have gained interest among the scientific community. Notorious progress has been made by several research groups around the world searching evidences on the medicinal properties of cactus in terms of therapeutic uses and disease prevention. Nowadays, there are numerous reports indicating that the consumption of cactus products may have beneficial effects on consumers' health beyond their nutritive action. The growing demand for nutraceuticals correlates to an increased effort in developing natural products for the prevention of human diseases. Diverse functional foods are prepared to take benefits from the health benefits of cactus cladodes and fruits. Several manufactured products as cereal bars, soups, juices, marmalades, candies and syrups are currently available in the nutraceutical market. Furthermore, worldwide consumer interest is growing in these products prepared using natural ingredients. Cladodes have significant antiulcer effect, protective effect against gastric lesions as well as anti-inflammatory activity. Diet supplementation with cactus pear fruits in healthy humans has shown to decrease the oxidative stress, and, improves their overall antioxidant status. Opuntia cladodes were supplied to decrease cholesterol and triglycerides levels in plasma samples of rats. Experiments in diabetes mellitus non-insulin-dependent patients have confirmed the hypoglycemic effects of Opuntia streptacantha cladodes. Moreover, consumption of cactus young cladodes has shown to reduce obesity and blood glucose. Cactus pear extracts could be a promising alternative in cancer prevention for both normal and high-risk populations and prevention of recurrence in patients with previous cancers. Numerous high value-added products like nutraceutics, cosmetics and functional foods are currently available in the global market.

Keywords: Nutraceutics, medicinal uses, functional food, antioxidants, health benefits.

INTEGRATION OF CACTUS IN LIVESTOCK PRODUCTION SYSTEMS AND REDUCTION OF THE WATER FOOT PRINT - A CLIMATE-SMART INTERVENTION

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With the increasing understanding of the expected impact of climate change on the livelihoods, food security, and water supply and health there is increasing willingness of key actors in agriculture domain to set up SMART interventions to maximise food-feed production per drop of water. The decreasing water availability coupled with the increasing soil and water salinity are challenging agriculture production systems in the dry areas, mainly in North Africa and West Asia region. To cope with these conditions crop breeding programmes addressing tolerance to abiotic stresses, introduction of drought and or salt-tolerant plant species in these ecosystems and diet manipulation are seen as potential options to enhance sustainability of the production systems. We discuss here the importance and the role of spineless cactus (Opuntia ficus-indica) in the adaptation of livestock-based production systems to the drought conditions. It is well documented that cactus can grow at places with low annual rainfall and has a lower water footprint than a wide range of feedstuffs commonly used for feeding to livestock. Literature also suggests that higher is the proportion of fresh cactus in a diet, the lesser amount of drinking water is consumed by sheep, goats, steers and cattle. The replacement value of the cactus for water-demanding concentrate feeds like corn and barley in animal diets reinforces its value in terms of water saving and feed cost reduction. The presence of cactus in the diet increases the intake of low quality forages like cereal straws and barley and oat hays, and creates favourable conditions in the rumen that enhances the digestion of these feedstuffs. High in water and energy, cactus could make better use of halophyte-based diets for ruminants, which are low in energy and high in the salt. Cactus feeding dilutes the salt and also helps in its excretion from the animal body. Cropping barley between the rows of the cactus has been demonstrated to increase biomass and grain yields of barley. To conclude, cactus grows with minimum of water, and its feeding reduces the consumption of drinking water by ruminants, increases water productivity of livestock-based systems and increases farmers' income. These advantages would position cactus cropping as a promising option that helps farmers to cope with drought conditions.

Keywords: Cactus, livestock, production systems, water footprint, climate change

MORPHOLOGICAL CHARACTERIZATION OF CACTUS PEAR (*OPUNTIA FICUS-INDICA*) ACCESSIONS FROM THE COLLECTION HELD AT AGADIR, MOROCCO

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The North Africa region falls under arid and semi-arid climate and it is considered as a hot spot for climate change. To face feed shortage, increase income of the rural poor and to mitigate the effect of climate change, around 1 million ha of cactus crop has been planted in Tunisia, Algeria and Morocco. Aware of the importance of germplasm, in-situ collections are being initiated in the region where promising accessions have been introduced from many countries. The objective of this contribution was to assess the genetic diversity of 20 cactus pear accessions from the *in-situ* collection located in the INRA Morocco research station of Agadir using morphological characterization based on FAO-Cactusnet descriptor. The data were subjected to Principal Component Analysis (PCA) and Agglomerative Hierarchical Clustering (AHC) using XLSTAT 2015 package. The results showed that the accessions can be discriminated by the morphological descriptors. Many of these morphological descriptors are significantly correlated as the number of cladodes and the number of fruits (r=0.73), the number of cladodes and the plant diameter (r=0.73), the length of the cladode and the plant height (r=0.7), the length of the spine and the number of areoles (r=0.67). The cladode shape and the number of spines and areoles are the recommended descriptors, and are capable to discriminate accessions with a suitable accuracy. Other descriptors do not seem to influence the morphological characterization as the cladode thickness, the number of spine, the plant height and the cladode shape index. Therefore, Principal Component Analysis (PCA) and Agglomerative Hierarchical Clustering (AHC) are good tools to segregate accessions using a reduced number of morphological descriptors. Another important finding is that the number of morphological descriptors may be reduced without potential risk of reducing the accuracy of the phenotypic characterization.

Keywords: cactus pear, genetic diversity, phenotypic characterization, morphological descriptors, multivariate analysis

MULTIVARIATE ANALYSIS OF PHENOTYPIC TRAITS OF FORAGE CACTUS ACCESSIONS IN THE SEMI-ARID REGION OF PERNAMBUCO, BRAZIL

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Northeast Brazil with its semiarid tropical agroclimate is the most important growing area for fodder cactus in the world; about 600,000 ha are being cropped and contribute significantly to cattle feeding. Morphological characterization is the most widely used to assess genetic diversity of cactus pear. The objective of this contribution is to assess the genetic diversity of 279 accessions oriented toward forage production located in the Agronomic Institute of Pernambuco (IPA) in the Northeast of Brazil. Phenotypic characterization was achieved using the “FAO Cactusnet Descriptor for Cactus Pear”. Data were submitted to Principal Component Analysis (PCA) and to Agglomerative Hierarchical Clustering (AHC) using XLSTAT 2015 package. Many of the morphological descriptors were significantly correlated as the plant height to the plant width (r=0.55) and the cladode length (r=0.42) which is correlated to the cladode shape index (r=0.55). The number of spines was correlated to the spine size (r=0.91) and to the number of spine by areole (r=0.95). PCA shows that two vectors explain most of the variation; the first vector is represented by the plant and the cladode shape and the second vector by the spine number and length. Both PCA and AHC analyses revealed three genetically distinct groups: One group formed by the “Algerian” genotypes, “Chile Fruit”, “Copena F1”, “Gigante”, “IPA-20”; a second group with “Orelha de Elefante Africana” and “Redonda” varieties; and a third group comprises “Miúda” variety. Globally and based on morphological characterization, the genetic distances between most of the crosses are relatively small. The cluster analysis distinguishes within these three major groups, some subgroups where accessions are closely related. This is the case of (i) Sanrizil II – III – IV, Chile/1118, Jalpa, Copena VI, Tobarito, Marmillon/1327, Redonda and Oreja de Elefante; (ii) cv. 1281, Marmillon/1311, Skinner court, Directeur, Algerian, Copena F1, cv. 1258 and Fausicaulis; (iii) Atlixco, Moradilla and Chile/1317; (iv) Nopalea Miúda, Blanco Michocan and Blanco San Pedro; (v) Gigante, Penca Alargado and Blanco San Pedro; Mexican cv/1296, Villa nueva, Liso forrageiro, Politlan, Oaxaca, Liso M Aleman, Algeria/1267, Amarillo Milpa Alta and Marmillon/1327.

Keywords: Cactus pear, genetic diversity, phenotypic characterization, morphological descriptors.

ASSESSMENT OF GENETIC DIVERSITY OF BRAZILIAN AND MEDITERRANEAN CACTUS CULTIVARS BY SSR MARKERS AND MORPHOLOGICAL TRAITS

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The objective of this research was to compare phenotypical and molecular-based methods in assessing genetic diversity of cactus pear from two *in-situ* collections, located in the Mediterranean Basin (Agadir, Morocco) and the Northeast of Brazil. Fifty accessions (30 accessions from IPA, Pernambuco, Brazil and 20 accessions from INRA Agadir, Morocco) randomly selected were subjected to phenotypic and molecular characterization. Phenotypic characterization was achieved using FAO Cactusnet descriptor while the molecular characterization used the SSR (Simple Sequence Repeats) technique and 8 recently recommended primers (Opuntia 3, Opuntia 5, Opuntia 9, Opuntia 11, Opuntia 12, Opuntia 13, Ops 9 and Ops 24). The phenotypic data have been subjected to principal component analysis (PCA) and agglomerative hierarchical clustering (AHC) using XLSTAT 2015 package. The Unweighted Pair Group Method with Arithmetic Mean (UPGMA) dendrogram based on Nei's genetic distance has been used for molecular, and the relationship between morphological and molecular traits was assessed by Mantel test. SSR analysis revealed 72 alleles with an average allele number of 9 per locus. All microsatellites used were found to be discriminative with a mean value of Polymorphic Information Content (PIC) estimated at 0.458. Genetic dissimilarities estimated between the accessions varied widely, suggesting that an important genetic variability exist in the collection. All the markers used were either informative or highly informative and can be recommended to detect genetic diversity in *Opuntia* species; the most discriminant markers are Ops 24 and Opuntia 9 and the less discriminant is Opuntia 5. The relationship between phenotypic traits and the allele based genetic distances from the SSR analysis was highly significant (r=0.4, p=0.01) and obtained for the first time while using SSR for molecular characterization. Consequently, SSR technique is one of the best tools to assess the level of genetic diversity in *Opuntia* germplasm collections; it complements phenotypic characterization and it is recommended for planning breeding programs and to revise the current taxonomical classification.

Keywords: cactus pear, genetic variability, phenotypic characterization, microsatellite markers

ASSESSMENT OF FOUR CACTUS (*OPUNTIA FICUS-INDICA* (L.) MILL) ACCESSIONS FOR GROWTH, YIELD AND QUALITY PARAMETERS UNDER POT CULTURE

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A pot experiment was conducted at BAIF Development Research Foundation, Urulikanchan, Pune, India to study performance of various cactus accessions for green biomass production as a source of fodder for livestock. Four cactus accessions namely 1270, 1271, 1280 and 1308 were evaluated during 2014-2016. Single matured cladodes of individual accessions were planted in plastic pots having 28 cm diameter and 24 cm height and filed with soil, sand and farm yard manure in 40:40:20 proportions during the month of August 2014. No any chemical fertilizers were applied. The plants were watered at one month interval during post monsoon season. The plants were harvested 18 months after planting by keeping basal cladode during the month of January 2016. The growth and yield observations like plant height, cladode length, breadth and thickness, number of areoles, number of cladodes per plant, fresh biomass yield were recorded. The fresh cladodes were analysed for nutritional parameters like dry matter, crude protein, crude fiber, ether extract, ash and silica. After three months of harvesting, the regeneration in the basal cladodes was monitored for the sprouting and development of the new cladodes.

The study revealed that highest green biomass yield per plant was recorded in accession 1270 (1.74 kg) followed by accession 1271 (1.45 kg), accession 1280 (1.39 kg) and lowest was in accession 1308 (1.36 kg). The maximum fresh weight per cladode was observed in accession 1280 (448.84 g) followed by accession 1270 (436.75 g), accession 1271 (394.73 g) and minimum was in accession 1308 (150.69 g). The more number of cladodes were found in accession 1308 (9.0) followed by accession 1270 (4.0), accession 1271 (3.69) and less was in accession 1280 (3.10). The longer cladodes were recorded in accession 1280 (31.85 cm) with cladode width of 13.16 cm, thickness of 1.49 cm and plant height of 73.89 cm. The nutritional analysis of the green cladodes revealed dry matter in the range of 8.24 to 11.15 %, crude protein content (4.00 to 6.03 %) and crude fiber (7.06 to 8.15 %). The highest crude protein content was recorded in accession 1280 (6.03 %). After three months of harvesting of the cladodes in the pots, the basal cladode showed regeneration and development of new cladodes ranging from 1.5 to 4.75. Accession 1308 put out more number of cladodes within three months from harvest.

At this juncture from above study it appeared that the accession 1270 recorded highest green biomass yield in 18 months period under Pune conditions.

Keywords: Pot culture, cladodes, growth, biomass yield, nutrients

QUANTITATIVE AND QUALITATIVE ANALYSIS OF CLADODES BIOMASS FROM NEW SELECTIONS OF *OPUNTIA FICUS-INDICA* MILL.

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The objective of this research was to analyze the chemical-physical characteristics of the cladodes of six accessions from the Sardinia germplasm and twelve new hybrids (Hy). Six cladodes per tree for eighteen field replications was the sample size. Cladode length, width, thickness, fresh weight, dry weight, dry matter content, and ash content were determined, as well as the content of macro and micro-elements (P, N, Na, K, Ca, Mg, Fe, Cu, Zn, Mn), and the fiber content of the cladodes expressed as acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL). Data analysis showed significant differences in physical and chemical characteristics of the biomass from the 18 selections. Cladode fresh weight ranged from 724.0 g (Hy-92sm1) to 1626.6 g (Hy-92sm4). Dry matter content was comprised between 4.17% (cv Sanguigna) and 5.91% (Hy-93sm3), while ash content calculated on dry matter was between 17.19% (Hy-92sm2) and 27.73% (2/30). Phosphorus content ranged from 0.11% (Hy-92sm1) to 0.31% (Hy-C15-2), potassium between 1.67% (cv Sanguigna, Hy-C15-6) and 3.57% (Hy-92sm2), and sodium between 0.06% (Hy-C15-6) and 0.11% (cv Sanguigna, cv Gialla, Hy-C15-1). The selection Hy-C15-1 was the one with the least content of Mg, Cu and Zn, with values of 0.55%, 4.33 ppm and 19.50 ppm respectively. The NDF ranged from 18.3% (Hy-C15-4) to 27.6% (Hy-92sm4), the ADF from 12.6% (Hy-C15-6) to 20.8% (Hy-92sm4) and the ADL content ranged from a low 3.45% (Hy-93s146) to a maximum of 7.57% (cv Sanguigna). Results showed the great variability of chemical composition of cladodes, thus indicating such genotypes are more suited for consumption in animal feed.

Keywords: cactus pear, cladode, mineral composition , fiber content, cultivar selection.

PROBLEMATIC OF BREEDING BY HYBRIDIZATION IN CACTUS PEAR (*OPUNTIA* SPP): APOMIXIS OR TYPICAL MENDELIAN INHERENCE OF A POLYPLOID?

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Opuntia is a complex genus with horticultural importance; it has been reported several reproductive complications as polyploidy and apomixis. In addition, cactus pear has problems with the breeding by hybridization because it has a low effectivity, which was attributed to apomixis like an asexual propagation method; nevertheless, the typical segregation of a polyploid would explain this phenomenon in better way than other reproductive complications, even these exist. That is why the present research derived the Mendelian inherence for one *locus* with two and three alleles and calculated the probabilities of heterozygosity in an octoploid system in order to clarify the possible segregation to obtain in a cactus pear hybridization. Cactus pear by the fact of to be polyploid showed a high heterozygosity and it can generate in a model of one *locus* from nine different genotypes (two alleles) to 6435 different genotypes (eight alleles). As it was not known if in the cactus pear traits there are complete dominance, codominance, partial dominance, or over dominance (heterosis) then it is difficult to predict its inherence, like it is possible in diploids, and it is also complicated the calculations to validate genes of single inherence. Because of that, it is important to generate these models to improve the breeding programs of cactus pear worldwide.

Keywords: Population genetics, multiple alleles, breeding of polyploids

OCCURRENCE OF THORNS IN CLONES OF SPINELESS CACTUS 'ORELHA DE ELEFANTE MEXICANA' (*OPUNTIA STRICTA* HAW.)

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The spineless cactus clone 'Orelha de Elefante Mexicana' (*Opuntia stricta* Haw.) is a genotype resistant to cochineal carmine pest (*Dactylopius opuntiae* Cockerell). However, this clone has many thorns, making it difficult to grasp and chew as forage, limiting animal consumption. In addition, the thorns cause difficulty in harvesting and cultivation. The experiment was carried out at the experimental research station of Pernambuco State Agricultural Institute (IPA), located in Arcoverde, during the period from January 2014 to June 2015, and aimed to evaluate the amount of thorns in 10 clones of 'Orelha de Elefante Mexicana'. This included clones produced from seeds in previous selections. The clones were identified as Planta mãe, Lisa 1, Lisa 2, Seg CV, Seg 1, Seg 2, Seg 3, Seg 4, Seg 5 and Seg 6. The soil of the experimental area is classified as Regosol and rainfall during the experimental period was 771 mm. Fertilization was performed with 20 t of organic matter/ha/year using cattle manure. Planting was done in January 2014, using spacing of 1.4 m × 0.5 m and a completely randomized design with 10 repetitions of one plant each. The variables analyzed were size and quantity of thorns. The evaluations were performed on secondary cladodes of 18-month-old plants. The amount of thorns was determined by assigning values ranging from 0 to 3, with 0 referring to absence of thorns, 1 a few thorns, 2 the average occurrence of thorns and 3 the occurrence of many thorns. For the size of thorns we used the following scale: 1 for short thorns with size ranging between 11.69 and 21.81 mm; 2 for medium, 21.82 to 28.56 mm, and 3 for large, between 28.57 and 31.94 mm. There were significant differences between clones for both the quantity and size of thorns. For the quantity, clone Seg CV presented many and the other clones showed few thorns. As for the size of thorns, the Seg CV clone showed large thorns, clone Planta mãe average thorns and Lisa 1 and Lisa 2 short thorns. The changes in the number and size of thorns indicate possible gains obtained in the breeding program for forage purposes.

Keywords: Cactaceae, semiarid, thorn size, thorn amount

DEVELOPMENT OF A CROP IMPROVEMENT PROGRAMME FOR CACTUS PEAR (*OPUNTIA FICUS-INDICA*) IN SOUTH AFRICA

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Spineless cactus pear, as a drought tolerant crop, is suitable for the arid and semi-arid regions of South Africa. The crop is still under utilized in South Africa although there is increasing awareness about its uses and a steady rise in its use for fruit and livestock feed. A partnership between the Agricultural Research Council (ARC) and the University of the Free State (UFS) is leading the public crop improvement programme of cactus pear in South Africa. The broad focus of this programme is to develop multipurpose spineless cultivars to cater for a broader market. The UFS presently hosts a field genebank of the ARC comprising of 42 cultivars which has been duplicated at the ARC in Pretoria. The main breeding criteria for the South African market are high fruit yielding cultivars of various flesh colours to cater for the local and export markets. The other main use of cactus in South Africa is as fodder. Therefore breeding for increased protein, mineral content and high cladode biomass and tolerance to high density planting are important. Cultivars that produce many seeds of high oil content are also desired yet there is also preference for seedless fruits. The possibility of breeding dual or multipurpose cultivars is also an essential objective of the programme. Based on these defined criteria and market requirements there is need therefore to optimise the breeding programme in South Africa to cater for the current and future breeding needs for the South African consumers. The South African market is known to prefer white fleshed fruit whereas the export market prefers coloured fruit, which provide more nutraceutical benefits. To meet the objectives, efforts have begun to acquire more germplasm and create more variation so as to have a wide genetic base for the identification of desired traits to breed new cultivars. There is need for skills development in cactus pear research especially in areas of the floral biology, genetics, pollination and breeding techniques of cactus pear. Collaboration with international institutions who are already experienced in the breeding of spineless cactus pear is also an important objective of this crop improvement programme.

Keywords: spineless cactus pear, breeding criteria, crop improvement, cultivars

GENOTYPE X ENVIRONMENTAL INTERACTIONS OF CACTUS PEAR (*OPUNTIA FICUS-INDICA*) IN THE SEMI-ARID REGIONS OF SOUTH AFRICA: CLADODE PRODUCTION

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The management of a fodder production program in arid and semi-arid regions is a challenge. Cactus pear proofed to be an ideal crop to stabilize fodder flow and mitigate the effect of drought. The aim of this study was to evaluate cultivars to serve this purpose. A cactus pear orchard with 42 cultivars, laid out as a complete randomized block design with two replicates of five data plants each, was used for data collection. Cladode production data was collected once a year in winter (June-July) for a period of 10 years. Fruit thinning was done during the first five years according to the recommendations for optimum fruit production. During the following five years no fruit thinning was done with the aim to increase total fodder production. Production data were correlated with rainfall data. During the first five years when fruit thinning was done a significant positive correlation of 85 % was recorded between cladode production and early summer rainfall (October - November). Where no fruit thinning was done a weak negative correlation occurred between cladode production and rainfall. During the first five years cultivar R1259 produced the highest cladode yield but R1251, Tormentosa, Berg x Mexican and Gymno Carpo were the most consistent cladode producers. When fruit was thinned Fusicaulis was the best performer in the first three years with Meyers and Roedtan in the last two seasons. However, Blue Motto, R1259, R1260 and Direkteur proofed to be the most consistent. October and November proofed to be the most critical rainfall months of the rainfall season, for cladode production.

Keywords: Cactus pear, cladode production, rainfall

GENOTYPE X ENVIRONMENTAL INTERACTIONS OF CACTUS PEAR (*OPUNTIA FICUS-INDICA*) IN THE SEMI-ARID REGIONS OF SOUTH AFRICA: FRUIT PRODUCTION

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The adaptability of a cactus pear cultivar to a specific environment is primarily a function of fruit yield. The fruit yield of local cultivars were very variable over a period of 10 years and the objective of this study was to investigate the role of climatic factors on fruit yield. Data was collected from a cactus pear orchard with 42 cultivars that was laid out as a complete randomized block design with two replicates of five data plants each. Twelfth cultivars were identified as potential fruit producing cultivars for the local and export markets. Fruit yield data was collected over a period of 10 years and compared with rainfall, heat units and maximum monthly temperature data. Data showed that cultivars differ significantly in their stability and genotype and environment interactions (GXE) played an important role in fruit production. Cultivar Van As, were the most consistent yielding cultivar over all 10 seasons. Season 4 and 5 were the highest yielding seasons when fruit thinning was done during the first five production years and cultivars Morado, Meyers, Zastron, Van As and Gymno Carpo yielded the most fruit. These cultivars also ranked the best when no fruit thinning was done during the next five years. A high correlation between fruit yield and the total rainfall from October to November (84.8 %) exist for the first five seasons which was not the case for heat units or maximum monthly temperature. From season 6, when no fruit thinning was done, a high correlation exist between fruit yield and the total rainfall for the period October to December (94.0 %) and between average monthly maximum temperatures for October (73.2 %), November (51.2 %) and December (82.4 %). The total rainfall for season 6, 8 and 10 was 311.0, 244.8 and 247.7 mm, respectively, compare with 78 and 137.3 mm for season 7 and 9, respectively, for the period October to December. Results indicated that rainfall distribution played a major role in fruit yield and not only the total rainfall for the season. Early summer rainfall (October-November) had a more significant effect on fruit yield than spring (July–September) or late summer (January) rainfall.

Keywords: Genotype, environment, rainfall, temperature, heat units

SCREENING OF CLADODES FROM 42 SOUTH AFRICAN SPINELESS CACTUS PEAR CULTIVARS FOR HUMAN FOOD APPLICATIONS

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In South Africa the cactus plant is mainly used as a fodder crop and therefore its application as human food, especially the cladodes, should be further explored. Mucilage extracted from cladodes could be used in many different ways in food products, since it can absorb large quantities of water. It has properties similar to that of other hydrocolloids such as xanthan and guar gum. It can be used to stabilize and thicken beverages and soups, as well as foaming- and suspension agents. Fourty-two cultivars (*Opuntia ficus-indica* and *Opuntia robusta*) were evaluated in terms of cladode morphology (size, weight, volume, width, length, diameter and surface area), cladode moisture- and solid content, mucilage yield and mucilage viscosity (line-spread test, falling marble- and separating funnel method). These were done to identify cultivars with ideal characteristics in terms of human food acceptability. The average cladode weight was 578.53 g (ranging from 400 g – 800 g), surface area was 2852.96mm^2, volume was 68.2070.96 mm^3, length was 347.93 mm, width was 188.95 mm and diameter was 10.37 mm. The average mucilage yield was 17% and ranged between 5% and 25%. The average moisture- and solid content was 87.08% and 12.92%, respectively. Cultivars were categorized into five groups in terms of the mucilage viscosity namely low, medium-low, medium, medium-high and high. Correlations between cladode size and weight, mucilage yield and viscosity as well as cladode moisture content and mucilage viscosity were determined for each cultivar. No correlation between size and weight of the cladodes with mucilage yield was found (r = -0.06). Positive correlations between cladode moisture content and mucilage yield (r = 0.55) and mucilage viscosity (r = 0.33) were observed, while the strongest positive correlation was observed between the mucilage yield and mucilage viscosity (r = 0.7). These were linked with mucilage yield in order to select cultivars for further analysis in food applications.

Keywords: mucilage, *Opuntia ficus-indica; Opuntia robusta*; viscosity, yield

RELATIONSHIP AMONG CULTIVATED *OPUNTIA FICUS INDICA* L. GENOTYPES AND RELATED SPECIES ASSESSED BY CHLOROPLAST AND MITOCHONDRIAL MARKERS

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The genus Opuntia belongs to the Cactaceae family and includes a range of species from 75 to 250 originated in North and South America. Its taxonomic classification is complicated for the relationships between phenotypic variation and ecological conditions, the inadequate morphological descriptors, the occurrence of polyploidy, the vegetative and/or sexual reproduction, and the frequency of intra and inter-generic hybridization. Cultivated *Opuntia* includes several species such as *O. albicarpa*, *O. amyclaea*, *O. cochenillifera* (syn. *Nopalea cochenillifera*), *O. ficus-indica*, *O. hyptiacantha*, *O. megacantha*, *O. robusta* and *O. streptacantha*). The phylogenetic relationships among about 60 cultivated genotypes and wild accessions belonging to 15 different species of *Opuntia* were inferred using cytoplasmic markers. These markers were considered for their maternal inheritance and for overcoming the multiple gene copy problem in polyploid phylogenetics already reported in Opuntia genus. In particular, in this work we combined capillary electrophoresis for newly designed cp SSR and High Resolution Melting (HRM) for SNVs analyses to identify chloroplast and mitochondrial DNA markers in a selected group of genotypes. The results confirmed the presence of polymorphism in the predicted cpSSR and SNVs and clearly evidenced that most of the studied genotypes were closely related to the *O. ficus-indica*. These results allow to question about the reliability of the current classification based on morphological parameters and support the hypothesis of the narrow genetic base of the most common cultivated *Opuntia*.

Keywords: High-resolution melting, microsatellite, capillary electrophoresis, SNPs, cpSSR

EPIGENETIC VARIATIONS IN *OPUNTIA* SPECIES FOLLOWING SALT STRESS APPLICATION

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In this study, we surveyed the epigenetic variations in salt stressed *Opuntias* belonging to five species; *Opuntia* species: *O. ficus indica Mill f. inermis*, *O. amyclea*, *O. streptacantha, O. robusta* and *O. engelmanii*. Plants response to salt stress (200 mM, 400 mM and 600 mM concentrations) was evaluated using thirty-two physio-morphological, biochemical and growth parameters. Then, RAPD markers were used to apprehend the epigenetic variations at the DNA level. Integrated together, morphological, biochemical and growth parameters identified *O. engelmanii var. longuiformis* as the most tolerant species to salt stress. However, *O. ficus indica* Mill *f. amyclea* and *O. robusta var. robusta* were released as the most sensitive. Besides, the studied species clustered onto three groups with *O. ficus indica Mill.f. inermis* being the most different. ANOVA indicated that the young cladode and aged cladode total chlorophyll contents were identified as the most discriminant parameters under 200 and 400 mM salt stress concentrations, respectively. The analyses of the epigenetic variations were conducted using the random primers UBC228, UBC231 and UBC241 that generated 59 polymorphic markers. Results have shown that in comparison to the control plants, 13 markers were lacking in the control but induced by salt stress application. On the other hand, 02 markers were only present in the control plants. Interestingly, some markers were only induced at the highest salinity concentration (600 mM) and two bands were specific of the tolerant species O. *engelmanii*. In all, the 19 detected specific markers may be strongly involved in Marker-Assisted Selection studies against salt stress in cactus. Therefore, DNA sequencing of these interesting private markers may aid the identification of putative salt resistance genes, and genetic transformation procedures will subsequently facilitate their introgression in *Opuntias* to cope soil salinization.

Keywords: *Opuntia*, salt stress, physiology, morphology, DNA, Hierarchical clustering, ANOVA

EFFECT OF CONTINUOUS HIGH TEMPERATURE IN SPOROPHYTIC MICROSPOROGENESIS INITIATION OF *OPUNTIA FICUS-INDICA*

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Microspore androgenesis reorientation to microspore embryogenesis has become a routine biotechnological tool for new cultivar development in a large number of crops, but its application is still limited in certain plant species such as *Opuntia*. In this study, we investigate, firstly the correlation between the external markers of floral-bud/anther to establish physical parameters for each cytological stage of pollen development. The following five stages of *Opuntia ficus-indica* pollen development (microspore mother cells, microspore dyads, tetrads, uninucleate and binucleate pollen grains) were associated to five floral and anther stages according to their length and morphology. On the other hand, to induce microspore sporophytic pathway, anthers corresponding to the five microspore developmental stages of 'Moore' cultivar were cultured on a solid modified Chée and Pool based medium under specific conditions. In fact, high temperature treatments (32 °C and 42 °C) were employed during 9 months of cultivation under 16h of photoperiod, while anthers used for control treatment were maintained at 24±1 °C. Results indicated that high temperature applied for long period promotes microspore embryogenesis pathway. Swelling and bursting of cultivated anthers is followed by microspores propagation on anthers surface. Multicellular pollen, proembryos, globular and elongated embryos were visible on the anthers walls, when anthers were cultured at 32 °C. While, the microspores continued gametophytic development resulting in pollen maturation when anthers were cultured at 42 °C. The reprogramming of the microspore and the first steps of the embryogenic pathway have been achieved in two cytological stages of pollen embryogenesis from microspores at uninucleate and binucleate stages. The reorientation of microspore from gametophytic to sporophytic pathway constitutes a crucial step in the design of protocols for the regeneration of microspore-derived embryos and double haploids plants, for future potential applications in breeding programs of this economically important crop in Tunisia. We conclude that heat treatment trig pollen embryogenesis. In fact, the present work reveals a novel mechanism for efficient microspore embryogenesis induction in *Opuntia ficus-indica* using continuous high temperature treatment.

Keywords: Embryos, heat treatment, microspores, *Opuntia ficus-indica*

EARLY ADAPTACION OF FIVE CLONES OF *OPUNTIA* TO AGROCLIMATIC DIVERSITY OF NORTHERN CHILE

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The 'norte chico' zone of northern Chile (Regions of Atacama and Coquimbo) is characterized by low rainfall and frequent droughts which severely hamper the performance the economically relevant fruit production industry. In order to develop alternatives which can better cope with this conditions we assessed *Opuntia* germoplasm as a low water requiring fruit production alternative. Five experimental plots were established in locations that represent the agroclimatic diversity of the 'norte chico'. The climatic diversity fo this zone is mainly driven by two gradient vectors: (i) Andes mountain valleys (east; high) – Pacific ocean costal ranges (west; low) and (ii) drier (north; Atacama) – less dry (south, Coquimbo). In order to capture these vectors two plots in Atacama (high and low) and three in Coquimbo (high, middle and low) were chosen and the early adaptation of 5 clones of *Opuntia* were evaluated during two growing seasons: 'verde' (1V; typical Chilean genotype, used as reference); 'naranja' (2N), 'salmón' (3S), 'morada' (4M) and *O. amyclea* (5AMY). Growth and development variables of the plants were measured, and related with climatic variables. Genotypes showed similar growth and development in all orchards, except in the middle valley of Atacama (less than others), while canopy volume of plants were higher in orchards of Coquimbo. In terms of the relationship of growth and development with climatic variables, we found that canopy volume and cladode production rate were promoted by higher photo-thermal quotient and higher minimal temperatures during spring and summer (above 11°C). The latter result confirms the positive effect of warm nighttime temperature on *Opuntia* metabolism. Regarding clones, 4M and 2N showed higher cladodes/plant than the reference genotype, and 3S and 5Amy had lower canopy volume than the rest. In high Atacama and middle Coquimbo, all clones, at the exception of 5Amy, bore fruit during the second season. Irrespective of genotype, average fruit weight was 70 g higher in middle Coquimbo than high Atacama. Comparing to our reference, the fruit weight was similar for 2M, lower for 4M and higher for 3S, all plots taken together. Taken together, planting 3S in middle Coquimbo appears as the most promising combination.

Keywords: *Opuntia*, germoplasm, early adaptation, photo-termic quotient

GENOTYPE X ENVIRONMENT INTERACTIONS OF FOUR CLONES OF *OPUNTIA* ESTABLISHED IN ELQUI AND CODPA VALLEYS, CHILE

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In Chile, cactus pear has been used for decades as an alternative for the development of agriculture in areas with low water availability which limits the cultivation of other fruit crops and its rusticity has allowed that smallholdings even exist under the conditions of hyperarid conditions of northern tip of Chile, in the oasis of Codpa. However, no varietal diversification exists in Chile, and almost all orchards use green fruit genotypes called "Verde criolla". On the other hand, germplasm that produces fruits of different colors is available in the country, but so far, it remains virtually unknown. In order to establish the potential of this genetic material two experimental plots were established in Vicuña (Coquimbo Region, central-northern Chile) and Codpa (Arica and Parinacota Region, nortehern limit of Chile), locations where cactus pear is currently present. Four genotypes were planted (1V, green fruit; 2S, orange fruit; 4M, purple fruit; and 5AMY, *O. amyclaea*, yellow fruit). Evaluations of growth, development and productivity traits were performed during the first productive season (three years). Although no statistical differences in plant height, canopy volume and size of stems were found; interaction between (i) total number of cladodes and (ii) yield were observed: in Vicuña plants had a higher total number of cladodes, highlighting 4M and 3S (57 and 48 cladodes/plant respectively), while 1V in Vicuña and 5AMY and 3S in Codpa exhibited fewer cladodes/plant (23, 23 and 26 cladodes/plant respectively). Cladodes of the 4th and 5th cohorts had more influence on these differences. On the other hand, in Codpa, plants produced significantly more fruit, highlighting 5AMY and 3S (9.02 and 8.9 k/plant respectively), while 5AMY in Vicuña exhibited the lowest yield (0.45 K/plant). Thus, plants privileged vegetative growth in Vicuña (number of cladodes/plant) over reproductive investment (yield). Although we cannot out-rule that the following season could have a similar performance to or greater than Codpa plants, the warmer climate of Codpa enabled a higher precocity in fruit production.

Keywords: cactus pear, genopypes, environment, interaction, cladodes

EVALUATION OF SOME MORPHOLOGICAL AND CHEMICAL CHARACTERISTICS OF 38 ACCESSIONS OF SPINELESS CACTUS UNDER QATAR ENVIRONMENTAL CONDITIONS

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The present study was conducted to evaluate 38 spineless cactus accessions (*Opuntia ficus-indica*) introduced to the research station of Rodhat Al Faras in Qatar. These accessions were planted and assessed for their morphological properties (growth, shape and color of the cladodes, etc.) and chemical composition (contents of protein, fiber and minerals) during two growing seasons (2011- 2013). Results showed highly significant differences between the studied accessions in all morphological parameters. The number of cladodes was 29.39 per plant on average and their mean length, width and thickness were around 36.27 cm, 18.26 and 0.78 cm respectively. On the other hand, the statistical analysis showed also a high significant difference at the level of the cladodes quality with the exception of calcium and phosphorus (P>0.05). The protein content in the cladodes varied between 7.9% - 13.5% with an average of 10.45%. However, the fiber content ranged between 6.6% - 10% with an overall average of 7.8%. This study recommends the selection of cactus accessions that combine cladodes with high productivity and high content of protein and fiber. There is a need to continue monitoring the performances of these accessions in the research stations and farmers' fields.

Keywords**:** Spineless cactus, cladodes, chemical composition, Qatar

DETERMINATION OF APOMIXIS AND POLYPLOIDIZATION IN *OPUNTIA FICUS-INDICA* (L.) Mill.

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The prickly pear is native to the Gulf of Mexico and the Caribbean. In Chile, the fruit is consumed fresh, but its production and consumption are not massive, because it has thorns in cladodes and fruits, and has numerous seeds in its pulp. Globally there are very few breeding programs, so most varieties are spontaneous mutations or chance seedlings. In Chile, genetic variability is reduced because the species is vegetatively propagated. When the species is sexually propagated there is abundant segregation in most of the characters, different levels of ploidy and, occasionally, polyembryonic seeds of apomictic origin are observed. The objective of this work was to characterize the genetic variability of 9 accessions of prickly pear and determine the existence of apomixis or changes in the ploidy of seeds from the 9 accessions. To do this, seed of the different accessions was germinated and chromosomes were counted in the seedlings to determine the level of ploidy and the presence of polyembryos. With respect to the morphological characteristics of the different accessions, great genetic variability was detected, particularly in the fruit. Segregants analyzed from the prickly pear accessions showed variations in the level of ploidy, both in relation to the parents and among them. In relation to the apomictic nature of the embryo, individuals of this origin were present in the following accessions: Beterraga, Mexican, Red, Green and Salmon. Expression of the apomictic character was better when the germination conditions were optimal.

Key Words: cactus pear, seeds, chromosome doubling

MORPHOMETRIC CHARACTERIZATION OF 36 WILD VARIANTS OF XOCONOSTLE (*OPUNTIA SPP*.) FROM ZACATECAS, MEXICO

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Opuntia xonocostle has been an important natural resource for Mexican peasants from prehispanic age. Nevertheless, wild ecosystems with *O. xoconostle* have been disappearing because of the agricultural frontier augmentation. Thus, there is an important strategy to classify and to conserve the natural genetic diversity of this resource. So, 36 issues of *O. xoconostle* located and collected from Zacatecas territory, were characterized by using 31 quantitative attributes. These variables were measured in accordance with UPOV guidelines. The database was used to carry out multivariate analyses. The two first principal components (PCs) explained 99 % of the total variability; the PC1 explained 98.81 %, and the PC2 explained 0.22 %. The PC1 structure was dominated by cladodes length and width and its ratio, number of areoles, number of areoles and spines on the central row, central row length, flower size (height), pericarpel length and width, number of lobules at the stigma, fruit size (length), fruit maximum diameter, fruit size and fruit maximum diameter ratio, areoles density on the fruit, diameter of the receptacle scar, peel width, seed size, pulp total sugar content, and peel pH. All these variables are positively inter-correlated. Afterwars, PCs eigenvalues were used to classify the 36 issues through a cluster analysis. As a result, 6 great clusters or classes of *O. xoconostle* were identified under the basis of cladodes, flower and fruit morphometric attributes. Our results confirm that in Zacatecas territory is a great genetic diversity to take into account in conservation strategies for using this resource.

Key words: *Opuntia*, Xoconostle, UPOV, Cluster analysis, Principal components analysis.

ASSESSMENT OF DIFFERENT SUPPLEMENTAL FEEDING STRATEGIES INCLUDING CACTUS (*OPUNTIA FICUS-INDICA*) FOR HIGHER SHEEP PRODUCTIVITY IN CHAKWAL, PAKISTAN

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Small ruminant production remains the main source of income of rural population living in arid and semi-arid regions of Pakistan. Sheep and goats raised in these areas are generally confronted with severe nutritional deficits in addition to negative impact of climate change. Cactus (*Opuntia ficus-indica*) was introduced to farmers in the dry areas of Chakwal in 2014 as a succulent and drought tolerant species with great potential to provide fodder reserve to fill the gap in feed resources. Cactus cladodes are high in water, sugars, ash and vitamins A and C, but they are low in crude protein (CP) and fiber. This study was conducted to compare the effect of three different supplemental feeds including oat, lucerne and spineless cactus in addition to a control treatment (farmer practice without supplementation) on sheep productivity. Four flocks were selected and t*en sheep* of similar age and weight per flock *were* sampled at random in a completely randomized design. The crude protein (15 %) and total digestible nutrients (TDN 67 %) of the three formulations were almost similar. Measurement of live-weight gain was recorded on a fifteen days intervals. Findings indicate that dry matter intakes was not significant and ranged from 0.9; 0.99; 1.04 to 1.02 kg DM/day for oat, lucerne, cactus and control. Ewes fed on oat and lucerne based supplemental feed showed equal higher live-weight gain (66.7 g/day) followed by cactus based supplemental feeding (33.3 kg/day) over a 60 day period. Live-weight of ewe grazing rangelands only (control) have the lowest gain per day (17 g/day). We conclude that, adding cactus in sheep feeding has a positive impact on live-weight gain compared to solely grazing poor rangeland conditions.

Keywords: cactus, supplemental feeding, small ruminant production, total digestible nutrients

REPLACEMENT OF FORAGE CACTUS 'MIÚDA' BY 'ORELHA DE ELEFANTE MEXICANA' IN THE DIET OF LACTATING CROSSBRED COWS

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The forage cactus 'Gigante' (*Opuntia ficus-indica* Mill) was the most used variety in the main dairy regions of Pernambuco state. However, a few years ago the carmine cochineal (*Dactylopius opuntiae*) was introduced in the Northeast of Brazil, expanding and decimating or compromising the productivity of thousands of hectares of forage cactus. Resistant varieties were identified, among which 'Miúda' [*Nopalea cochenillifera* (L.) Salm-Dyck] and 'Orelha de Elefante Mexicana' (*Opuntia stricta* Haw. Haw). The nutritive value of 'Miúda' has already been studied. One of the factors that highlight the 'Orelha de Elefante Mexicana' is the high productivity. This study aimed to evaluate the effect of replacing forage cactus 'Miúda' by 'Orelha de Elefante Mexicana' on nutrient intake, digestibility, milk production and composition, and feeding behavior of lactating 'Girolando' cows. Ten multiparous 'Girolando' cows (5/8) with an average body weight of 500 kg were distributed in a double simultaneous Latin square 5 × 5. The five experimental treatments consisted of total mixed ratios with different replacement levels of forage cactus 'Miúda' by 'Orelha de Elefante Mexicana' (0, 25, 50, 75 and 100%). Sugarcane silage:forage cactus:concentrate ratio (% of dry matter) used was 30:48:22. Intake and digestibility of nutrients, except for neutral detergent fiber, linearly decreased with the replacement. Milk production (12.7 kg/day), 4% fat corrected milk (12.10 kg/day), fat, protein, and total solids concentration (3.7, 3.34 and 12.6%, respectively) were not affected by the replacement. Similarly, milk urea concentration (15.3 mg/dL) and ingestive behavior were not altered by the inclusion of forage cactus 'Orelha de Elefante Mexicana' in replacement of 'Miúda'. It is recommended replacing forage cactus 'Miúda' by 'Orelha de Elefante Mexicana' in the diet of crossbred cows with average milk production of 12 to 13 kg/day.

Keywords: caatinga, dairy cattle, roughage, semi-arid

NUTRITIONAL EVALUATION OF SELECTED CACTUS PEAR (*OPUNTIA FICUS INDICA*) CULTIVARS OF TIGRAY, NORTHERN ETHIOPIA

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A study was conducted to determine the chemical composition, *in vitro* dry matter (DM) digestibility (IVDMD), and *in sacco* DM degradability of morphological parts (MP) (cladode and fruit peel) of four cactus pear (*Opuntia ficus indica*) cultivars (CPC), i.e., Garao, Keyh beles, Wadwada and Limo grown in northern Ethiopia. Limo is spineless while the rest of the cultivars are spiny. The DM contents of the cladodes and fruit peel were 126 and 284 g/kg, respectively. The crude protein (CP) content of both the cladodes and fruit peel was similar and was about 72 g/kg DM and, among the cultivars, Limo had higher CP content (77 g/kg DM) than the others (70 g/kg DM). The neutral detergent fiber (NDF) content ranged from 219 to 261 g/kg DM and was similar among cultivars and between plant parts. Cactus cladodes were rich in calcium but low in phosphorous (43 and 2.6 g/kg DM) while the respective values for the fruit peel were 2 and 0.06 g/kg DM. Significantly lower IVDMD was recorded for cultivar Wadwada (686 g/kg DM) as compared to cultivars: Garao (754 g/kg DM), Keyh beles (739 g/kg DM) and Limo (759 g/kg DM). The IVDMD was higher for the fruit peel than the cladode (756 vs 713 g/kg DM). *In sacco* DM degradability at all the incubation hours, potential degradability (PD) and effective degradability (ED) were all lower for the cladodes than the fruit peel (876 vs 912 and 710 vs 752 for PD and ED, respectively). The ED of the cladodes was similar among cultivars (range: 859 to 899 g/kg DM), while the PD for the fruit peel was higher for Limo (928 g/kg DM) than for Wadwada (881 g/kg DM) and values for the other cultivars were intermediate. Generally, the cactus pear cultivars evaluated in this study had comparable nutritional value in terms of most chemical components and in IVDMD and *in sacco* DM degradability parameters. Although variation existed between the cladodes and fruit peel of cactus pear, both are rich in water and ash, low in CP and cell wall components, and are high in IVDMD and *in sacco* DM degradability. Therefore, all the cultivars and both MP can be a good energy supplement to ruminants fed a fibrous diet and in the presence of sufficient protein. However, since the Limo cultivar contains slightly higher CP, this cultivar may be selected if there is a need for prioritization of the cultivars.

Keywords: Cactus pear cultivars, Digestibility; Degradability; Morphological parts

THE EFFECT OF SUPPLEMENTATION OF CACTUS PEAR (*OPUNTIA FICUS INDICA*) WITH *SESBANIA SESBAN* ON THE PERFORMANCE OF SHEEP

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A 7 days digestibility and 90 day growth trials using a completely randomized design (CRD) with six sheep per treatment was conducted to evaluate the effect of cactus pear (*Opuntia ficu indica*) cladode (C) along with *Sesbania sesban* (SS) supplementation on feed intake, digestibility, daily body weight (BW) gain (ADG) and carcass parameters of local Highland sheep fed a basal diet of urea treated teff (*Eragrsotis teff*) straw (UTTS). Thirty yearling male lambs with initial BW of 19 ± 1.3 kg (mean ± standard deviation) were randomly assigned to five treatments consisting of UTTS *ad libitum* alone (T_1), or supplemented daily with 250 g concentrate mix (CM, wheat bran and noug seed cake at 2:1 ratio) (T_2), 500 g C (T_3), 333 g C + 167 g SS (T_4), and 250 g C + 250 g SS (T_5). Supplements were provided on dry matter (DM) basis and cactus was fed fresh. The crude protein (CP) contents for UTTS, C, SS and CM were 96, 83, 206 and 238 g/kg DM, respectively. Urea treatment doubled the CP content of teff straw. Intake of UTTS (729, 641, 284, 350 and 413 g/day (SEM = 8.1) for T_1, T_2, T_3, T_4 and T_5, respectively) was depressed due to supplementation. Total DM intake was in the order of $T_2 = T_5 > T_4 > T_1 = T_3$ (729, 891, 784, 850 and 913 g/day (SEM = 8.1) for T_1, T_2, T_3, T_4 and T_5, respectively). Total CP intake ranged 69 to 115 g/day, and was in the order of $T_2 > T_5 > T_4 > T_3 = T_1$. Apparent digestibility of DM was improved by supplementation. Apparent digestibility of CP was in the order of $T_2 > T_5 > T_4 > T_3 > T_1$, and differences were consistent with that of total CP intake. ADG (17.9, 78.3, 22.2, 52.4 and 80.0 g/day (SEM = 1.98)) and hot carcass weight (7.2, 12.0, 7.9, 9.5 and 11.5 (SEM = 0.18) for T_1, T_2, T_3, T_4 and T_5, respectively) were both highest for T_2 and T_5, intermediate for T_4 and lowest for T_1 and T_3. In conclusion, supplemental concentrate mix to UTTS at 250 g/day had a comparable effect with supplementation of a mixture of 250 g/day cactus cladodes and 250 g/day *S. sesban* on the performance of sheep. Conversely, sole cactus cladodes supplementation to UTTS did not significantly impact animal performance as compared to the sole UTTS feeding. Therefore, for efficient utilization of cactus cladodes as a supplement, the cladodes need to be fed along with a protein rich dietary ingredient such as *S. sesban*. Thus, cactus pear along with *S. sesban* as in T_5 could effectively substitute a conventional concentrate mixture of noug seed cake and wheat bran.

Keywords: concentrate mix; *Opuntia ficus-indica*; *Sesbania sesban*; sheep performance

MORPHOMETRY OF RUMEN AND INTESTINAL TISSUES OF SHEEP WITH DIETARY LEVELS OF FORAGE CACTUS AND WATER RESTRICTION

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The present study aimed to evaluate the effects of water restriction and the use of forage cactus on the morphometric characteristics of rumen papillae of Santa Inês sheep. Forty two Santa Inês sheep were used (± 100 days and ±18.74 kg). The animals received diets with 0, 30, 50 and 70% of forage cactus and water ad libitum, except for animals under water restriction, until they reached 32 kg. After slaughter, rumen tissue samples (5 x 5 cm) were collected from the craniodorsal region and were processed by standard histological analysis. Variables were rumen papillae length and intestinal mucosal height. The experimental design followed a 3 (inclusion of forage cactus) x 2 (with water and without water) factorial arrangement. Variables were analyzed using Tukey's test at 5% significance. Water restriction had no influence on the studied variables. There were differences compared with the control treatment, with longer rumen papillae in treatments using forage cactus (4.4 vs 6.4mm respectively).The intestinal mucosal height decreased, being 1.83 mm in the control diet and 1.67 with the 70% treatment. The inclusion of forage cactus in the diet of sheep improves the rumen morphometry, enabling greater absorption of volatile fatty acids, however at high levels decrease the height of the intestinal mucosa which leads to decreased intestinal absorption.

Keywords**:** Intestinal mucosa; *Nopalea cochenillifera*; rumen morphology

INFLUENCE OF VARIETIES OF FORAGE CACTUS RESISTANT TO COCHINEAL ON GROWTH PERFORMANCE OF GOATS

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This study aimed to evaluate the effect of feeding different varieties of forage cactus on feed intake, digestibility, and ruminal and blood parameters of goat kids. Forty castrated goat kids were used, with initial weight of 15.05±0.96 kg and about five months old. The experimental diets were composed of four treatments: a control diet (Tifton grass hay, corn meal, and soybean meal) and three forage cactus varieties ("Orelha de Elefante", "Baiana", and "Miuda") plus tifton and soybean meal. For the total and daily weight gain, the goat kids were weighed weekly. Feed intake was expressed as dry matter intake (kg/day) divided by the metabolic weight ($P^{0.75}$). The determination of the nutrient digestibility coefficients was performed using the *in vivo* digestibility method, with total feces collection. Rumen parameters (pH, N-H_3, and VFA) and profile of blood metabolites, protein, energy, and mineral were determined. The experimental design was a completely randomized block with four treatments and 10 repetitions. Data were evaluated by analysis of variance, adopting the Tukey test at 5% probability. There were no significant differences (P> 0.05) for the dry matter intake, variables (g/day), feed efficiency, and average daily gain when goat kids were fed forage cactus varieties. The pH (6.87, 7.1, 7.05, and 6.83) and ruminal ammonia concentration were influenced by the type of diet; however, the highest values of ruminal ammonia were found in the treatments control (20.56 mg/dl) and with Orelha de Elefante (17.62 mg/dl), but remained at levels suitable for ruminal digestion and fermentation of fiber. The use of different varieties of forage cactus resistant to cochineal may be recommended for goat kids without affecting growth performance, rumen function, and blood metabolites.

Keywords: confinement, feed efficiency, weight gain

MORPHOLOGICAL CHARACTERIZATION OF *OPUNTIA* SPS. ACCESSIONS FOR POTENTIAL USE AS A FORAGE CROP IN DRY AREAS OF BOLIVIA

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Morphological characterization is an important procedure to identify desirable traits that could be used to detect accessions from *Opuntia* sps. with the purpose to be used as a forage in arid and semiarid zones of Bolivia. In this study, 80 accessions from *Opuntia* sps. were collected from Cochabamba and La Paz. The characterization was based on morphological traits using 2 years-old plants which were already well established in the experimental field at the Forage Research Center, Cochabamba. The descriptor used was the one previously published by Chessa, I; Nieddu, G., 1997. Plant descriptors, with five variables (qualitative and quantitative) and cladode descriptors with 24 variables (qualitative and quantitative) were considered. Multivariate principal component analysis and cluster analysis showed two groups, both with two sub-established groups; the first group belongs to accessions with upright, medium and arborescent habitus and the second group belongs to accessions with spreading and shrubby habit. The results of the cluster analysis indicate that the two groups obtained are independent of the origin of collection, suggesting that the high diversity of *Opuntia* sps. is not determined by the zone of collection. The accessions differed with respect to many morphological traits: thicker cladode; absence of thorns, form of plant, serous accession, longest cladode, and high number of cladodes. Other accessions formed a more homogeneous group. It has been observed in the majority of the studied accessions the following growth habits: spreading, shrubby, arbustive, medium and less, upright and arborescent. Four accessions with desirable traits to be used as a fodder were identified corresponding to 4 accessions. The traits considered for its use as a forage crop are: plants with none or few thorns, without diseases, long and wide cladode and high number of cladodes.

Keywords: Morphological characterization, *Opuntia* sps.

NUTRITIVE CHARACTERIZATION OF CLADODES OF SIXTEEN CULTIVARS OF SPINELESS CACTUS FROM DIFFERENT GEOGRAPHIC ORIGINS

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Cactus is an important alternative feedstuff for livestock raised in the dry areas.This importance relies mainly on its tolerance to drought conditions and its high fodder potential. Despite its low protein content, cactus cladodes are high in energy, water, and minerals. However, the nutritive value of cladodes could vary with their age and cultivars or accessions. In addition, season has also a significant effect on the chemical composition of cactus. Numerous cultivars of cactus have been introduced into Tunisia. Therefore, this study aimed to evaluate the nutritive value of 16 cultivars of spineless cactus growing in an in situ collection established in a semi-arid region of Tunisia. In summer, autumn, winter and spring, terminal and sub-terminal cladodes of each cultivar were collected from three plants. These were subjected to morphological characterization (length, width, and weight) and to the determination of their nutritive value. Shapes of all cladodes are typically oblong to spatulate-oblong. The two-year old cladodes were heavier and wider than the current year cladodes. Season affected significantly the chemical composition and gas production, using an *in vitro* rumen simulation technique, from cactus cultivars. The majority of cultivars had low CP level (40 g/kg dry matter, DM) except three of them which had levels above 55 g/kg DM. Total oxalates (70-140 g/kg DM) and Ca (40 to 60 g/kg DM) contents of all cultivars were high in cactus, irrespective of cultivar. Spring seems to be more favorable to have the more interesting chemical composition as in this season OM, CP and mucilage were highest and DM and total oxalates contents were lowest. For most cultivars, gas production was high, but depended on age, season and cultivars. However, gas production was correlated positively with MS, MO and mucilage contents and negatively with mineral and CP contents. It is concluded, that the nutritive value of cactus is different among the 16 cultivars and that such variation is affected by the age of cladodes and season. In any case, cactus remains the cost-effective feedstuff for ruminants in the harsh environments.

Keywords: Spineless, cultivars, season, age, nutritive value

ASSESSING THE PERFORMANCE OF OSMANABADI GOATS BY FEEDING SPINELESS CACTUS UNDER FIELD CONDITIONS

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Scarcity of fodder in India is the major challenge in raising animal production including small ruminants like goat. Tree fodders form the major part of a diet for goats. They do not normally consume crop residues even in the dry season. There is acute shortage of grazing land and browsing resources in the country because more and more area is being brought under crop cultivation. Feeding cactus in combination with other high fibre feeds such as crop residues can help to optimize diets along with plants with moderate to high protein content. The spineless cactus (*Opuntia ficus indica- a*ssorted accessions of 1270, 1271, 1280 and 1308*) is* an important substitute to farmers due to its considerable survival, propagation capacity and production potential under conditions of little rain and high temperatures. Hence this cactus feeding study was undertaken in goats in the field area of BAIF Development Research Foundation, Uruli Kanchan near Pune. An experiment on feeding spineless cactus in Osmanabadi goats was carried out for a period of 50 days. Eighteen Osmanabadi goats of 18 months age with average body weight of 32.83 kg were selected and randomly divided into two equal groups i.e. control group and experimental group including nine goats in each group. The goats were fed with standard feeding regime as per ICAR Standards and experimental group was supplemented with Cactus Feeding @ 750 g/day per Goat with other fodder and roughages like sorghum straw, Hybrid Napier, Lucerne and concentrate ingredients like grinded maize. All goats were used to graze for four hours daily. All the goats were provided liberal fresh, cool drinking water *ad-libitum*, throughout experimental period. The results of the experiment indicated that goats in experimental group fed with cactus gained higher total body weight of 2.9 kg and average daily gain in body weight of 58 g/day over the control group where the values were 2.10 kg and 42.00 g/day. This study revealed that cactus feeding in Osmanabadi goats enhances the performance of goats in terms of total body weight and average daily gain in body weight without any adverse effect. Cactus exhibits its acceptance and high palatability in goats and large quantities may be voluntarily consumed.

Keywords: Cactus, nutritional values, Osmanabadi Goats, body weight gain, daily gain in body weights

INFLUENCE OF FEEDING SPINELESS CACTUS ON GROWTH PERFORMANCE OF OSMANABADI GOAT KIDS

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Growth performance of goat kids is a crucial aspect in assessing the profitability of goat rearing. Growth of the kids is influenced by different factors amongst which feed and fodder are important ones. To achieve best growth rate, diet of the kids must be well balanced with different nutrient resources. Normally, some leguminous fodder is being fed to the kids during initial phase of growth which is not available during scarcity periods. Hence, feeding cactus in combination with other high fiber feeds such as crop residues can help to optimize diets along with plants with moderate to high protein content. The spineless cactus (*Opuntia ficus-indica* assorted accessions of 1270, 1271, 1280 and 1308) is an important substitute for farmers due to its considerable survival, propagation capacity and production potential under conditions of little rain and high temperatures. Hence, this cactus feeding study was undertaken in goats in the field area of BAIF Development Research Foundation, Uruli Kanchan near Pune. An experiment was carried out to assess performance of Osmanabadi kids by feeding them spineless cactus for a period of 50 days duration. Eighteen Osmanabadi kids of 1 month and 23 days age and average body weight of 13.22 kg were selected and randomly distributed into two equal groups, control group and experimental group including nine goats in each group. The goat kids were fed with standard feeding regime as per ICAR Standards and the experimental group was supplemented with Cactus Feeding at 300 g/day per kid with other fodder like lucerne and concentrate ingredients like ground maize. Quantity of different feed ingredients and fodder offered per day per head were ground maize 80 g, lucerne 150 g and napier & stylograss 300 g. All the kids were provided fresh, cool drinking water ad-libitum, throughout the experimental period. The results showed that kids in the experimental group fed with cactus gained greater total body weight and average daily gain in body weight which was 4.10 kg and 82 g/day during the 50 days of experimentation while the control group showed values of 3.25 kg and 65 g/day, respectively. It could be concluded that cactus feeding in Osmanabadi kids enhanced the performance of kids in terms of total body weight gain and average daily gain in body weight without any adverse effects. The kids may be fed with cactus which showed high palatability and large quantities may be voluntarily consumed.

Keywords: cactus, nutritional values, Osmanabadi kids, body weight gain, daily gain in body weights

CACTUS PEAR AS POSSIBLE ENERGY SOURCE FOR SEMI-ARID ENVIRONMENTS

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The cultivation of the Sicilian prickly pear plays a leading role in Europe with more than 90% of the production coming from Sicily (about 4,000 hectares of cultivated area). In Sicily the cultivation for food is present in different areas, which could increase by adding marginal lands currently not cultivated. In this lands prickly pear dedicated to biomass production for energy purpose (eg. Biogas) could be cultivated. This allows the energy production from biomass avoiding the competition with food crops for the use of the soil. The production of energy from the prickly pear could be obtained by using the by-products resulting from the processing and marketing of the fruit and from crops dedicated to the production of energy using varieties of prickly pear selected for forage or biomass production. The aim of this work was to evaluate the methanogenic potential of products and waste of the Sicilian prickly pear chain. The biochemical methane potential (BMP) was determined in an automatic methane potential testing system (Bioprocess Control, Sweden) equipped with a sample incubation unit, a carbon dioxide absorption unit, six µflow unit and a µflow data acquisition unit. The first results of the experiment carried out on the pruning residues have showen that the degradability of cladodes is very fast, almost half the time needed from biomass used for energy purpose like giant reed. The obtained methanogenic potential of prickly pear (270 Nml g^{-1} VS) was higher than other biomass of energy crops evaluated in the laboratory (120 Nml g^{-1} VS and 150 Nml g^{-1} VS, respectively in *Arundo donax* and *Saccharum spontaneum*). Comparing the obtained methanogenic potential of prickly pear with literature data it results comparable to that of maize harvested at late ripening (280 Nml g^{-1} VS) but lower than maize harvested from end milk ripeness to end wax ripeness (340-420 Nml g^{-1} VS).

Keywords**:** Biogas; energetic valorization; marginal lands

ENERGY RECOVERY FROM WASTE AND BY-PRODUCTS OF THE CACTUS PRODUCED IN ITALY: PRELIMINARY WORK

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The use of renewable energy sources is becoming increasingly necessary. Biomass is the most common form of renewable energy. In general, cactus pear presents an exceptional ability to produce biomass especially under soil and climate conditions unfavorable for most plant species. The aim of this study was a technical-economical evaluation of energetic valorization of the by-products of the cactus pear chain, constituted mainly by residues of regular pruning, delayed green pruning ("scozzolatura"), thinning of fruits, etc., in regards to the agricultural phase and waste products and by-products of commercial processing for the industrial phase. The recovery of these biomass for energy purposes could generate evident benefits both on the environmental level because there is not competition in the use of the land but promotes the disposal of by-products for alternative uses, but also at firm level because it represents an integration of farmer income increasing revenues (sales of energy) or reducing the cost (own consumption of energy produced and recovery of the processing costs). From a methodological point of view, the work was divided into a territorial research with a questionnaire to 20 stakeholders and the development of a crop loss account for the assessment of investments and energy production costs. In a first step the potential productions at local level are defined and some technical and economic considerations (biomass potential and related economic aspects) on the requirements for the recovery of these biomasses and choices of processing plants are developed. So as to define a territorial system aimed to produce energy (collection and processing) that, for the technology chosen (biogas), guarantee supplies able to make favorable the cultivation and to minimize transportation costs. The study showed the potential of realization of two biogas plants of, at least, 700 kW each, one in eastern Sicily (Catania) and one in western Sicily (Palermo), to exploit the potential methanogen cactus (waste and by-products). In conclusion, the economic approach demonstrates the performance potential of the proposed project and its economic and environmental sustainability for the local production system.

Keywords: Supply chain organization cactus pear's energy; technical and logistical problems; economic aspects.

EVALUATION OF CACTUS PEAR SILAGES ON GROWING LAMBS

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In Mexico, the cactus pear plantations for vegetable or fruit production have to be trimmed in some months of the year. The pruned material needs to be preserved to be used as forage during the critical part of the year. One biotechnology that can be used is the ensiling procedure. The objective of the present work was to evaluate the effect of including cactus pear silages to complete diets for growing lambs. Nutritive value, voluntary feed intake and apparent and *in vitro* dry matter (DM) digestibility were determined for four diets (treatments in a DM basis): T1) Control (Basal diet with 0% silage) diet; T2) Corn silage (25%) in the basal diet; T3) Cladodes silage (74% of cladodes, 19% of corn stalk and 7% of sugar cane molasses) diet (23.4%); and T4) Cladodes and fruit silage (44% of cladodes, 30% cactus pear fruit, 23% corn stalk, and 3% sugar cane molasses) diet (20.2%). Diets were formulated to be iso-proteinic (15% CP) and iso-energetic (2.7 Mcal kg^{-1} DM). Eight male Ramboullet/Creole lambs with an average body weight of 23 ± 3 kg were used and allocated in individual pens (2.5 x 1.5 m). Four feeding periods of 15 days each (12 days for adaptation plus three days of sampling: feed offered, feed not consumed, and feces (lambs equipped with harness), two lambs per treatment). The diets were offered twice a day (0800 and 1600 h). Data was analyzed under complete randomized and Latin square (4 x 4) designs; means were compared by the Tukey test with α=0.05. Complete diets differed ($P<0.05$) in dry matter (92.8, 76.1, 77.7 and 79.9%), ashes (9.0, 10.8, 15.7, and 13.0%), neutral detergent fiber (29.2, 30.2, 25.1, and 33.1%), and acid detergent fiber (16.5, 21.5, 12.4, and 11.1%), contents for treatments 1, 2, 3 and 4, respectively. Voluntary feed intake (1.3, 0.7, 1.1 and 0.9 kg d^{-1}) and apparent digestibility of the DM (74.1, 67.2, 70.1 and 72.9%) for treatments 1, 2, 3 and 4, were similar ($P>0.05$). *In vitro* DM digestibility (81.3, 76.1, 77.9 and 79.3%) were different for treatments 1, 2, 3 and 4, respectively. In conclusion, cactus pear silages can be included in complete diets for sheep up to 25%, without affecting their performance.

Keywords: Sheep, cactus pear, silages, composition.

CROPPING SYSTEM AND MANURE SOURCE AFFECTS CACTUS (*NOPALEA COCHENILLIFERA* SALM DYCK.) PRODUCTIVITY

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Cactus is an important fodder option for livestock in semiarid regions. Cactus provide energy, minerals, and vitamins, but it is usually low in fiber and protein. Tree legumes such as gliricidia [*Gliricidia sepium* (Jacq.) Kunth ex Walp.] and leucaena [*Leucaena leucocephala* (Lam.) De Wit] are adapted to regions with 500-600 mm rainfall. These legumes have potential to complement fodder from cactus by providing fiber and protein. Manure is often the only fertilizer source available for producers. Manure type might affect cactus productivity and interact with cropping systems. This research assessed cactus productivity under three cropping systems and four manure sources. Cropping systems included: 1) cactus (*Nopalea cochenillifera* Salm Dyck. cv. IPA Sertânia) in monoculture; 2) cactus + leucaena; 3) cactus + gliricidia. Manure sources tested included cattle, sheep, goat, and broiler litter. Manure application was based on the N concentration, applying the equivalent to 200 kg N ha^{-1}. Tree legumes were planted in double rows (9 x 1 x 0.5 m) and cactus planted between double rows, spaced 1 x 0.25 m. Treatments were allocated in a split-plot design in a complete randomized block design. Cropping system was the main plot and manure source the split-plot, with four blocks. Cactus was harvested after two years of regrowth. In the cactus/legume systems, cactus samples were taken at different distances from the trees (1, 2, 3, and 4 m). There was a significant interaction ($P < 0.05$) between legume and distance, with cactus showing greater productivity near leucaena trees, but not near gliricidia trees. Cactus productivity was similar ($P = 0.08$) under the three cropping systems (22.0, 28.3, and 24.5 t of DM ha^{-1} 2 $yr.^{-1}$ for cactus/gliricidia, cactus/leucaena, and cactus in monoculture, respectively). Cattle (27.5 t DM ha^{-1}) and sheep (28.4 t DM ha^{-1}) manures lead to greater cactus productivity compared to goat manure (22.7 t DM ha^{-1}) and broiler litter (21.2 t DM ha^{-1}). Integrated cactus-tree legume systems maintained cactus productivity and provided an extra source of N and fiber to livestock. In addition, in the long-term, biological N fixation from legumes might benefit the soil organic matter.

Keywords: agroforestry, alley cropping, forage, legume, semiarid

VALORISATION OF NOPAL CLADODES AND SEEDS

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The Nopal *(Opuntia ficus indica*), cultivated by small producers, is traditionally used for production of fruits, industrial products, forage and “cochinilla”. Cladodes can also be used for a number of other purposes. We evaluated other uses of nopal cladodes. One of the uses is biogas production from anaerobic bio-digestion of cladodes. The daily energy need for a rural family of five people can be met from 3.61 m^3/day biogas. Considering that 10 Mg ha^{-1} $year^{-1}$ of dried cladodes are produced and that 3 kg of dried cladodes produce 1 m^3 of biogas, it is possible to obtain the biogas needed annually by the family from only 0.4 ha of cactus plantation. If we calculate the dollar value of the biogas by its capacity to replace commercial gas, the annual value corresponds to US$1,078 (assuming that 1 m^3 of biogas is equivalent of 453 g of LPG). Also, in biogas systems, liquid biofertilizer that contains nutrients and organic material, is obtained. In addition, on emptying the digester, solid materials are obtained which could be used as fertilizer. One Mg of solid biofertilizer is equivalent to 40 kg of urea, 50 kg of potassium nitrate and 94 kg of triple superphosphate. Assuming an average price of 0.32 US$ kg^{-1} of fertilizer, each Mg of biofertilizer would be worth 58.8 US$. The dried and crushed cladodes can be used for direct burning or can be used in combination with coal burning. It has a calorific value of 3,850 - 4,200 Kcal kg^{-1}. It is also possible to obtain ethanol from the cladodes, but the production technology is more complex. At a larger scale, 8.6 L of ethanol could be produced from 100 kg dried cladodes and 24.7 L of ethanol from 100 kg of dried fruits, for concentrations of ethanol above 98 %. The ethanol production is not competitive when compared with production from fermented fruits. Other use, being the extraction of fatty acids from fruit seed residues and their transformation into biodiesel. However, each fruit has between 150 and 300 seeds, and the oil contents ranged between 98 and 139 g kg^{-1} of seed, therefore, it is only profitable if associated with a fruit processing industry.

Keywords: Nopal, Biodiesel, Biogas

POTENTIAL PRODUCTION OF BIOGAS FROM PLANTATIONS OF OPUNTIA FICUS INDICA AVAILABLE IN THE CHILEAN "NORTE CHICO": AN ASSESSMENT

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Renewable energies have attracted considerable attention, in the past years, not only at a national level, but also at the global one. This project investigates the use of cactus pear plantations as the main source for the production of biogas and their energy potential for northern Chile. Biogas is an energy alternative for the agricultural sector and is obtained by fermentation processes of different wastes produced daily. Besides the generation of biogas, it is also possible to obtain a stabilized waste that can be incorporated into the soil. The soil in dry and semi dry zones of northern Chile is poor in organic matter content, which makes it difficult to grow crops. The cactus pear (*Opuntia ficus indica*) adapts easily to poor soils and prevailing environmental conditions. The specie possesses a superficial fleshy root system that facilitates the absorption of water. Also, the CAM metabolism allows it to withstand droughts and profit from eventual rains by closing the stomatas during day and night, and opening them early in the morning. Another important feature of this specie is its biomass production, reaching around 30 Mg ha^{-1} with the application of good management practices. For this reason and for its high potential to produce biogas it is considered a good energy alternative for the northern Chile. To define the best biodigester to use, this will depend on the use and the costs associated. The estimated potential for biogas production from Opuntia plantations in the northern Chile is 13,406 m^3 kg^{-1} d^{-1}. This can be further improved by adding other wastes produced in the area.

Keywords: *Opuntia ficus indica*, biogas, fertilizer, alternative energy, biomass.

EFFECT OF CACTUS ADDITION TO THE DIET OF LACTATING SOWS ON FEED INTAKE AND PRODUCTIVE BEHAVIOR

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Metabolic factors affecting sows during lactation, such as, blood glucose (BG) increase and insulin resistance, leads to decreased feed intake, negatively affecting productive sow's productive performance. Cactus could be an unconventional strategy for regulating the glycolytic pathway, mitigating resistance to insulin. The aim of this research was to investigate the effect of cactus (*Opuntia ficus-indica*) addition to the diet of lactating sows on feed intake and productive performance, according to season and parity number (PN). Seventy-two hybrid sows pregnancies were analyzed over a 12-month period. Sows entered the maternity ward in groups of 6/month; they were split into two groups (G): 1) control (CG; n=35), sows fed conventionally; and, 2) experimental (EG; n=37), which was provided with commercial feed plus cactus (1% of the live weight pre-parity). Response variables included blood glucose (BG), daily (DFI) and total feed intake (TFI), body weight loss (BWL), weaning estrus interval (WEI), and subsequent litter size (SLS). Statistical analysis were performed using mixed models. The interactions G*day, G*season and the nested NP(G) effect showed statistical differences (P<0.001) on the analyzed variables. The lowest (P<0.05) BG levels were for the EG, on the 10th lactation day: 47.0±7.9 and 56.1±5.9 mg/dL pre and post-prandial, respectively. DFI and TFI were higher for sows from the EG regardless of NP and season (P<0.05). Fall was the season that showed greater TFI (P<0.05): 109.0 vs 121.4 kg for CG and EG, respectively. Greater LBW according to the PN was for 3rd parity sows in the CG (13.8%) and 4th parity sows in EG (6.9%) (P<0.05), the highest LBW was found on summer (P<0.05): 12.7% for CG and 8.2% for EG. Sows from the EG showed lower (P<0.05) WEI (5.5 days) regarding the CG (6.1 days) and higher SLS, up to 1.8 more piglets according to season (P<0.05). The addition of cactus to the diet of lactating sows reduced levels of BG during lactation which had an impact on better behavior of the variables: DFI, LBW, WEI and SLS.

Keywords: *Opuntia* spp., glucose, hypophagia, lactation, weight loss.

NUTRITIVE VALUE OF 'RAKETAMENA' [*OPUNTIA STRICTA* (HAW.) HAW.] AS A FODDER IN MADAGASCAR

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'Raketamena' *[Opuntia stricta* (Haw.) Haw.] is considered a major invasive species in Southern Madagascar. Problems related to this species include its invasiveness, losses in livestock, and health problems for humans consuming the fruits. Raketamena is taking over areas previously utilized by crops or native species. Local reports indicate losses of livestock consuming raketamena, but no scientific explanation for the causes leading to cattle death due to raketamena have been found in the literature. Ideally, raketamena could be potentially replaced by other cactus species who are known for their potential as a fodder or fruit production. It would be important, however, to identify potential ways to utilize the raketamena in order to generate income for local population during this replacement process. Local population could benefit from raketamena utilization, and at the same time replace it by other more productive species. We collected fruit, cladode, and root samples of raketamena in Southern Madagascar in order to analyze its nutritive value and potential utilization as fodder. Samples were collected from five different plants and sundried. Plant components (cladodes from top 2/3 of the plant, cladodes from the base, fruits, and roots) were exposed to a hot water treatment (63°C for 12 h). Plant components were dried in an air-circulated oven at 55°C for 72 h, and milled to pass a screen of 2 mm thereafter. Samples were analyzed for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), C, N, $\delta^{15}N$, and $\delta^{13}C$. Roots and stems presented respectively 65% and 55% NDF and 49% and 41% ADF, being both potential fiber sources to supplement cactus diets. Further analysis of fiber effectiveness and feeding trials are required to prove the concept. Cladodes had 35% NDF and 0.9% N (5.6% crude protein), which is typical for other cactus used for livestock feeding. Stable isotopes ranged from -14.17 to -15.27‰ for $\delta^{13}C$ and from 8.84 to 11.75‰ for $\delta^{15}N$. Fruits presented greater N concentration (1.3% or 8.1% CP) and NDF of 67.5%. Results obtained from this research will guide future programs for utilization of raketamena as a fodder in Madagascar and other countries where this species is also considered a problem.

Keywords: fodder, livestock, *Opuntia stricta*, raketamena, semiarid

EX – SITU EVALUATION OF CREOLE TUNA (*OPUNTIA FICUS-INDICA*) ESTABLISHMENT ON AMENDED MINE TAILINGS

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In Chile, there are about 870 mine tailings, of which 746 are abandoned; and most of them are located between the Antofagasta and the O'Higgins Regions of the country. Due to the semiarid Mediterranean climate type of north-central Chile, the fine particles of dried tailings are exposed to physical agents such as wind and short-heavy rains, which can disperse them to the environment, contaminating waterways and surrounding soils. Cultivation of Creole Tuna (*Opuntia ficus-indica* (L.) Mill) is presented as an option for the phyto-stabilization of post-operative tailings in arid and semiarid zones, as its biomass can be used for clean energy production, among other productive uses. The present study evaluated the establishment of Creole tuna on tailings amended with goat manure and mine leaching gravel at different rates. The experiment was conducted for 20 weeks under controlled laboratory conditions. Physical and chemical characteristics of the substrates and chemical characteristics of pore water were determined. Both aerial and root biomass production and metal (Cu, Zn and Fe) concentration in roots and shoots were measured. Based on results of the present study, we can conclude that application of both goat manure and mine leaching gravel increase the rooting capability of *Opuntia ficus-indica* (L.) Mill on mine tailings. Regarding aerial biomass production, even though differences were found between controls and the treatments, it is not possible to state categorically that the application of these amendments resulted in increased production. Goat manure and mine leaching gravel applications decreased the bioavailability of the mineral elements reducing their translocation to aerial structures; although, they did not seem to be very effective in terms of decreasing absorption of Cu in roots. However, it is not possible to rule out external contamination of metals in root tissues. Salinization problems were detected in treatments in which goat manure, was added, which affected the root growth. This problem is increased in pot trials. Therefore, further evaluations under field conditions are recommended. Finally, it is also relevant to evaluate the long-term response of *Opuntia ficus-indica* (L.) Mill. in order to generate more accurate responses with respect to their development and production capacity.

Keywords: Phytoremediation, phytostabilization, goat manure, mine leaching gravel, metals.

LIVER FUNCTION OF SHEEP FED CACTUS SPECIES RESISTANT TO *DACTYLOPIUS SP*

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Alkaline phosphatase (ALP) is a hydrolase enzyme responsible for removing phosphate groups from many types of molecules. It is present in a number of tissues including liver, bone, intestine, and placenta. We have found serum ALP increase in small ruminants as function of forage cactus in diet. Serum ALP increase could be associated to bone disease and hepatobiliary disease. The aim of this work was to evaluate the effect of cactus species resistant to *Dactylopius sp* on the liver function in sheep. A diet composed of napier grass hay, corn, soybean meal and mineral mixture was used as control diet. Part of elephant grass hay and corn of the control diet were replaced by one of the following cactus variety: *Opuntia stricta, Nopalea cochenilifera and Nopalea sp.* All diets allowed daily average gains of 200 g. Forty sheep were randomly allocated in one of four rations (10 replications by treatment). After 60 days on diets, blood sample was collected and the animals were slaughtered. We evaluated the activity of ALP, alanine aminotransferase (ALT) aspartate aminotransferase (AST) and gamma-glutamyl transpeptidase (GGT) and the weight of the liver. Replacement of napier grass by forage cactus, regardless of variety, increased liver weight as well as enzymatic activity of ALP. Serum activity of GGT was higher in animals fed diet based on *Nopalea sp* compared to control diet. These results indicate damage in liver of sheep.

Keywords: AST, ALT, GGT, liver weight

SERUM PROFILE OF MACROMINERALS IN SHEEP FED CACTUS SPECIES RESISTANT TO *DACTYLOPIUS SP*

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The forage cactus has high concentrations of Ca, Mg and K and low of P and Na. However, the presence of oxalate in cactus might have an effect on mineral metabolism in small ruminants. Forage cactus inclusion in diets for small ruminants increases serum ALP and manipulate renal functions by reducing K excretion. Serum ALP increments could be associated with disorders of bone or liver, or both. The aim of this work was to evaluate the effect of cactus species resistant to *Dactylopius sp* on the metabolism of minerals in sheep. A diet composed of Napier grass hay, corn, soybean meal and mineral mixture was used as control diet. Part of elephant grass hay and corn of the control diet were replaced by one of the following cactus varieties: *Opuntia stricta, Nopalea cochenilifera and Nopalea sp.* All diets allowed daily average gains of 200 g. Forty sheep were randomly allocated in one of four rations (10 animals by treatment). After 60 days on diets, blood samples were collected and the animals were slaughtered. We evaluated the serum Ca, Mg, P, K, Na, Cl and the weight of the 12th rib. Replacement of Napier grass by cactus, regardless of the variety, increased plasma concentration of Ca (8.4 mg/dL x 7.0mgdL) and Mg (3.98 mg/dL x 2.26mgdL) compared to control diet, but did not affect the concentration of P, K, Na nor Cl. The weight ($g/BW^{0,75}$) and concentration of dry matter and mineral matter of rib were not affected by the use of cactus in the diet.

Keywords: rib, Ca, Mg, P, K

INCREASING PLANTING DENSITY REDUCES HEIGHT AND WIDTH OF CACTUS

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Spineless cactus is largely used in semiarid zones of Brazil. *Opuntia stricta* Haw has low requirement of soil fertility and high productivity, but it is necessary to evaluate the response of this cultivar to the management. This research was carried out at the experimental research station of Pernambuco State Agricultural Institute (IPA), located in Arcoverde, from June 2011 to July 2013. We tested the effect of planting density (55,556; 27,778; 13,889 and 6,944 plants ha^{-1}), harvest frequency (annual and biennial), and cutting intensity (preserving 'mother' cladode or primary cladodes) on the development of spineless cactus cv. "Orelha de Elefante Mexicana" (*O. stricta* Haw.). Treatments were allocated in a randomized complete block design, with split-split plot arrangement and 4 replications. The soil of the experimental area is classified as Regosol (or Entisol) and rainfall during the experimental period was 477 mm, below historical average of 670 mm $year^{-1}$. Fertilization was performed with 200 kg N ha^{-1} using urea and 20 t ha^{-1} yr^{-1} of organic matter (cattle manure). The variables analyzed were plant height and plant width. Plant height was greater in plants harvested every two years for both cutting intensities. When harvested annually, plants were higher if primary cladodes were preserved (not harvested). For the biennial harvest, there was no effect of cutting intensity. Plant height reduced linearly with increasing planting density, reducing from 88.4 to 69.3 cm, from 6,944 to 55,552 plants ha^{-1}, respectively. In plots harvested annually and with preservation of 'mother' cladodes, plant width reduced from 115.5 to 66.6 cm, from 6,944 to 55,552 plants ha^{-1}, respectively. With the preservation of primary cladodes, the plant width reduced from 178.0 to 77.72 cm, from 6,944 to 37,857 plants ha^{-1}, respectively. In plots with biennial harvest and preservation of 'mother' cladodes, plant width reduced from 203.5 to 103.2 cm, from 6,944 to 37,857 plants ha^{-1}, respectively. However, with preservation of primary cladodes, plant width was linearly reduced from 178.1 to 83.7 cm, from 6,944 to 55,552 plants ha^{-1}, respectively. Increasing planting density reduces height and width of cactus. Plants with biennial harvest exhibited greater height.

Keywords: Cactaceae, cutting, frequency, *Opuntiastricta* Haw.

NUTRIENT CONCENTRATION IN SPINELESS CACTUS UNDER DIFFERENT PLANTING DENSITIES AND HARVESTING MANAGEMENT

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Cactus cultivar 'Orelha de Elefante Mexicana' (*Opuntia stricta* Haw.) has low requirement on soil fertility, high productivity, and resistance to cochineal carmine (*Dactylopius opuntiae* Cockerell). This research was carried out at the experimental research station of Pernambuco Agricultural Institute (IPA), located in Arcoverde, Pernambuco State, from June 2011 to July 2013. We assessed the effect of planting density (55,556; 27,778; 13,889 and 6,944 plants ha^{-1}), harvest frequency (annual and biennial), and cutting intensity (preserving the 'mother' cladode or primary cladodes) on cladode nutrient concentration of spineless cactus 'Orelha de Elefante Mexicana'. Treatments were allocated in a randomized complete block design, with split-split plot arrangement and 4 replications. The soil of the experimental area is classified as Regosol (or Entisol) and rainfall during the experimental period was 477 mm, below historical average (670 mm $year^{-1}$). Fertilization was performed with 200 kg N ha^{-1} using urea and 20 t of organic matter ha^{-1} yr^{-1} using cattle manure. Response variables included N, P and K concentration. The N and P concentrations were affected by interaction between harvesting frequency and cutting intensity. In plants with annual harvest, it was observed greater N and P concentrations when the mother cladode was preserved; however, with biennial harvest, there was no effect of cutting intensity. Plant N concentration was 11.0; 8.9; 6.1 and 6.8 g kg^{-1}, and plant P concentration was 3.4; 2.2; 2.3 and 2.3 g kg^{-1} for P, for annual harvest preserving the mother or primary cladodes and biennial harvest preserving the mother or primary cladodes, respectively. Planting density also affected plant P concentration, with quadratic response, increasing from 1.59 to 3.01 g kg^{-1}, with 6,944 and 41,646 plants ha^{-1}, respectively. Plant K concentration was affected only by harvest frequency, with greater K concentration in plants harvested annually. Harvest frequency and cutting intensity affected plant N and P concentration. Cladode P concentration increased up to 41,646 plants ha^{-1}. Plants with annual harvest had greater K concentration.

Keywords: Cactaceae, cutting, frequency, *Opuntia stricta* Haw.

NUTRIENT COMPOSITION AND *IN VITRO* DIGESTIBILITY OF CACTUS PEAR CLADODES (*OPUNTIA RASTRERA*) AT DIFFERENT LOCALITIES OF NORTHEAST MEXICO

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The objectives of this research were to determine the nutritional content and *in vitro* digestibility of dry matter (IVDMD) of *Opuntia rastrera* in four locations at the Northern State of Coahuila, Mexico. Three representative samples of cladodes of *Opuntia rastrera* were obtained in each of four rural areas of Arteaga, General Cepeda, Ramos Arizpe and Saltillo. A bromatological analysis of samples was carried out as described by the A.O.A.C. (1990). To determine acid detergent fiber and neutral detergent fiber, the methodology described by Van Soest (1994) was used. The data were analyzed with a completely randomized design with four treatments and three repetitions.

The results indicate that there were no differences (P> 0.05) among locations in the dry matter content (9.90-11.19 %), organic matter (66.21-75.92 %), crude protein (4.31-5.37 %) and ether extract (1.66-1.80 %), however differences (P> 0.05) in crude fiber (17.87-25.79 %), acid detergent fiber (33.87-46.02 %) and neutral detergent fiber (55.44-71.39 %), ash (19.16-28.61 %), nitrogen free extract (21.96-44.72 %) and dry matter digestibility (42.74-69.42 %) of *Opuntia rastrera* were found. This seems to reflect factors such as age of the plants, period in which the samples were taken, soil type and site of collection.

According to the results, it is widely recommended to use this specie for animal feeding, since *Opuntia rastrera* plants have a similar nutritional composition as well as a good value in terms of digestibility, plus it provides important amounts of water and fiber. It is important to note that *Opuntia* plants do not cover nutritional requirements of animals so its use should be implemented with some other feeds or components, especially protein, which each producer fits economically and available and thus to obtain better results in terms of animal production.

Keywords: Nutrient content, *In vitro* digestibility, *Opuntia rastrera*, Northeast Mexico

CACTUS PEAR'S POTENTIAL TO SUSTAIN LIVESTOCK PRODUCTION IN DROUGHT STRICKEN AREAS: A CASE STUDY OF OPPERMANS COMMUNITY IN THE FREE STATE PROVINCE OF SOUTH AFRICA.

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Small scale farming is under increasing socio-economic pressure due to small uneconomical farming units, increasing production costs, droughts and unreliable rainfall during critical periods of the growth season. In the arid regions of South Africa farmers are mostly limited to cattle farming. Farmers face seasonal stock losses during winter and early summer months due to fodder shortages. Managing risk has become a part of their daily lives. South Africa urgently needs new initiatives for sustainable rural development. The objective of this project was to improve and stabilise the livelihoods of people in the rural areas by means of spineless cactus pear (*Opuntia ficus-indica*). In the Oppermans community 26 households each with two ha of cactus pear are taking part in this case study. A multipurpose cultivar, Morado, was planted. Cactus pear not only plays a role in stabilising animal production and mitigating the effects of droughts, securing the food base but also has a huge potential as a bio-energy resource. Cactus pear has a high biomass yield compared to other rain fed systems of the semi-arid regions due to its high water use efficiency. Cactus pear is adapted to marginal soils and therefore does not compete with cash crops. Although cactus forage is not a complete feed source, it contains high levels of digestible energy which usually is unavailable. It is also an important source of water for the herd. Due to the inclusion of cactus pear in their farming system, the Oppermans have managed to eliminate the usual livestock losses during the last two extremely dry seasons. Furthermore, the potential for value adding and establishment of small agribusinesses that will create jobs and wealth will be part of the upscaling of this programme into this and other communities.

Keywords: *Opuntia ficus-indica*, cactus pear, small scale farming, drought mitigation

BEHAVIOR OF SELECTIONS OF EULYCHNIA ACIDA PHIL. UNDER IRRIGATION CONDITIONS, AFTER 8 YEARS

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The dryland of the Region of Coquimbo is characterized by a deterioration of the native flora and a high erosion of the soils, limiting any economic development of the agricultural sector. In this sense, it is important to search for complementary productive alternatives based on species adapted to these conditions such as Eulychnia acida known as Copao. Wild populations have low natural regeneration (0.4%) with a growth rate of about 2-3 cm per year in plants.

The objective of this work was to evaluate ecotypes, under irrigation conditions, and to generate indicators of growth and production in plants propagated from stems.

The phenology and productivity growth assessments were recorded annually. The data were subjected to a descriptive statistical analysis and to an ANDEVA in a completely randomized design with a 5% Duncan test of means.

The plants have generated ramifications, and their growth varies among ecotypes. Branches began to be visualized from year 3 from its planting, which in turn begin to fructify after three years. After 8 years, 90% of the total plants produced fruits and 42% of them produced from the first year. There are differences regarding the growth between the plants of the different localities, reflected in the number and length of branches

The fruiting habit tends to be different than that observed in wild populations. Growth rates and reproductive phenology are determined under these conditions.

REPRODUCTIVE PHENOLOGY OF FACHEIRO IN AGRESTE OF PARAÍBA, BRAZIL

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Pilosocereus catingicola (Gürke) Byles & Rowley subsp. *salvadorensis* (Werderm.) Zappi is one of the species with the highest value of ecological importance in some vegetation types of the Agreste of Paraíba, however information on its ecology are necessary considering the conservation and use programs of this specimens in the region. In this sense, the objective was to increase knowledge of the Cactaceae family phenology in Brazil by assessing the *P. catingicola* subsp. *salvadorensis* phenology in *caatinga* areas of the Wasteland of Paraíba. Thirty individuals with a minimum height of 2.0 m selected over contiguous areas of *caatinga* were marked. The phenophases were quantified using the activity index, the percentage of individuals in the phenophase and an intensity index, obtained by counting the number of structures produced in each phenophase observed per plant. The statistical procedures was performed in the BioEstat® software using Pearson correlation between variables. Phenological patterns follow the rainfall series with positive correlation with all reproductive phenophases. The blooming peak period occurs in February and the phenophases of flower budburst, blooming and fruiting in March in the population of Arara. The temperature is the climate component positively correlated with all reproductive phenological phases in all the specimens, with a significant effect on flowering. A negative correlation between the humidity and the manifestation of phenophases was found in the Arara population. In the population of Areial, the phenological patterns correlated negatively with precipitation events. The flowering period, except in August, occurred throughout the year, the peak of flowering was in April, budburst, blooming and fruiting in March. Temperature was one of the most influential climatic components in the flowering phenophases, budburst, blooming and anthesis in Areial. The humidity had a negative correlation with most phenophases studied, except for fruiting phenology. The phenological patterns of the population of Boa Vista accompanied thermic and wet rainfall events. These specimens show flowering in February and April, blooming, budburst and flowering in March. The temperature has a positive correlation for all phenophases, with significance at the stage of flowering and budburst. In Boa Vista, the air humidity is positively correlated with all reproductive phenophases studied.

Keywords: Facheiro, caatinga, conservation

WATER USE EFFICIENCY OF CACTUS PEAR AND PITAHAYA AS COMPARED TO OTHER ARID ZONE ADAPTED FRUIT TREES

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Cactus pear (*Opuntia ficus-indica*: *Ofi*) and pitahaya (*Hylocereus undatus*: *Hu*) are fruit producing CAM species. Because (i) CAM species exhibit high water use efficiency (WUE: dry mass production/transpiration) and (ii) the fruits from *Ofi* and *Hu* are valued in the local and export fresh and processed fruit markets, these species have been proposed as a water-saving strategy for fruit production in arid zones. The aim of this study was to quantify the WUE efficiency of *Ofi* and *Hu* under the local conditions of the semi-arid fruit production zone of Chile and compare it to the WUE of C3 fruit trees adapted to this zones. We established a two-year trial in which we planted one year old plants of *Ofi*, *Hu*, pomegranate (*Punica granatum*: *Pg*), fig (*Ficus carica*: *Fc*) and tamarillo (*Cyphomandra betacea*: *Cb*) in 50 L pots containing perlite. The substrate was covered with plastic in order to avoid evaporation. The plants were drip irrigated and the pots weighed before and after each irrigation in order to estimate transpiration. At a 20 day interval, during the two growth seasons (september-may), three plants per species were uprooted and their dry mass obtained. The slope of the relationship between cumulated dry mass and cumulated transpiration of each species was considered as the WUE. Thereafter, WUE was normalized by DPV in order to generate values which could be extrapolated to other zones. Our results showed that *Ofi* and *Hu* had similar WUE of 18.6±1.3 and 16.5±1.4 $g_{[DM]}$ $kg^{-1}_{[H20]}$, respectively, which were significantly higher, by an average factor of 5.3, than *Fc* and *Pg* (WUE = 3.4±0.1 and 3.2±0.1 $g_{[DM]}$ $kg^{-1}_{[H20]}$, respectively). *Cb*, on the other hand, had significantly lower WUE than the rest of the species with a value of 2.5±0.2 $g_{[DM]}$ $kg^{-1}_{[H20]}$, in the typical range of other C3 fruit trees. These results confirm that CAM are excellent water saving species for arid zone fruit production and can save between 80 and 85% water per unit dry mass as compared to C3 fruit tree species.

Keywords: water use efficiency, cactus pear, pitahaya, fruit trees, arid zones

TRANSPIRATION STUDY IN CACTUS PEAR (*OPUNTIA FICUS INDICA*)

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The intensification and large scale cultivation of cactus pear worldwide imposes its regular irrigation, especially in semi-arid regions, for an optimal yield. In this context, the evaluation of cactus pear transpiration could be an important element for irrigation control and economy. In this respect, the transpiration of two cactus pear cultivars was monitored under greenhouse conditions on the basis of several physiological and climatic variables. The climatic data were obtained using a data logger station and a control system based on temperature, humidity and solar radiation sensors. Spineless "Gialla" and spiny "Moore" cultivars were compared using rooted plants originating from young and adult cladodes. Among the physiological parameters, cladode area measurements were obtained based on destructive and non destructive methods that allowed to establish correlations based on linear regressions between the area and the length (l) and width (w) of each cladode. Cladode area was then calculated using the elaborated correlations. Transpiration monitoring was based on weight measurements by means of an electronic balance. The results show high correlations ($R^2 \geq 0.96$ and $R^2 \geq 0.93$) between the area and the length and width of the cladode in Moore and Gialla cultivars, respectively. On the other hand, spiny adult plants from Moore cultivar had slightly lower but not significantly different cladode area index (3.54) than Gialla cultivar (3.64). Within three months of cultivation under greenhouse, mean daily transpiration rates were higher in Moore (1.55 mol $plant^{-1}$ d^{-1}) than in Gialla adult plants (1.34 mol $plant^{-1}$ d^{-1}). On a unit cladode area basis, comparable mean daily transpiration rates were measured between adult plants of Moore (6.16 mol m^{-2} d^{-1}) and Gialla (5.27 mol m^{-2} d^{-1}) cultivars. However, significantly higher daily transpiration rates were observed in both Gialla and Moore young plants (12.94 mol m^{-2} d^{-1} and mol m^{-2} d^{-1}, respectively). The comparison of daily transpiration between young and adult plants allowed to demonstrate a higher transpiration rate in young plants than adult plants in both cultivars. Eventhough night relative humidity level seems to affect the transpiration rates in both cultivars, still no correlations could be established between the daily transpiration rates and climatic parameters such as temperature and relative humidity.

Keywords: spiny; spineless; transpiration; cladode; relative humidity.

CO_2 OR LIGHT: WHAT LIMITS CARBON ASSIMILATION OF GROWING CACTUS PEAR CLADODES?

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Plant carbon assimilation via photosynthesis can be estimated as the minimum rate allowed by three factors: (i) CO_2 concentration in the carboxylation sites, (ii) the regeneration of Rub-BP in the Calvin cycle which depends on the reducing power and ATP derived from light reactions and (iii) the triose-phosphate use efficiency driven by sink demand for carbohydrates. In the case of cactus pears (*Opuntia ficus-indica*: *Ofi*), a CAM plant, CO_2 absorption and light reactions are chronologically separated: the former occurring during the night, when stomata open and, the latter, occurring during the day, when light is available. This chronological pattern confers CAM plants a high water use efficiency because stomatal opening happens under the low atmospheric water demand conditions of the night when relative humidity is higher and temperature is lower than during daytime. During the night, CO_2 is stored in the vacuoles in the form of malate. While CAM plants can sense the amount of malate in their cladodes, they cannot predict how much light they are going to intercept during the following day. We measured dusk and dawn titratable acidity along with carbon exchange (IRGA: LiCor 8100) in growing *Ofi* cladodes under full light and 50% shading during three subsequent days; half of the plants were switched to the other treatment during the third day. We also estimated potential photosynthetic light use by performing light response curves of electron transport rate (ETR) with a chlorophyll fluorometer (Hansatech FMS2). Our results show that carbon assimilation was tightly associated to potential ETR of the preceding day and less correlated to malate content at the preceding dawn. These results indicate that, under irrigated conditions, *Ofi* CO_2 uptake during the night is directly controlled by the light availability during the preceding night rather than by cladode C content. Although these results must be analyzed with care because few series of light scenarios were studied, they indicate that some inefficiency in light use could take place during sunny days which follow a cloudy one.

Key words: Cactus pear, CAM photosynthesis, carbon, light use, CO_2 absorption.

SPINELESS CACTUS IN THE ARABIAN PENINSULA: ADAPTIVE BEHAVIORS AND PRODUCTION PERFORMANCES

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Limited water resources are the main challenge facing agricultural developments in dry areas. Thus improving the crops water use efficiency (WUE) is considered the greatest one. In an attempt to alleviate feed shortages and producing less water consuming forages, in 2015, 38 spineless cactus accessions (*Opuntia ficus-indica* var. *inermis*) well-known for their high drought tolerance were introduced to Oman. This collection was serving as nursery to further introduce cactus to neighboring countries including Qatar, Saudi Arabia, UAE and Yemen. The introduced accessions were subjected to the different comparison studies on their adaptability to the local environment in order to select the most suitable ones. In each country, cladodes and fruit production parameters were evaluated and the response of the accessions to water stress (UAE), salinity (Oman) and frost (northern region of Saudi Arabia). In Oman, studies revealed significant differences among the accessions with regard to regeneration of pads. One accession from Algeria (*Opuntia ficus-indica* var. *lengissima*) was identified as superior, having produced 19 pads during May-September as compared to 5 - 17 pads for the other accessions. In Qatar, results showed that fruit production varied significantly between accessions both in shape and in weight. It ranges from 17 to 7 with an average of 11 Kg per plant. In Saudi Arabia, results showed that there was no significant difference of the effect of two irrigation levels (2500 and 5000m^3 ha^{-1} $year^{-1}$) on the annual production of pads which varied from 5 to 8 per year. Similar results were obtained in UAE, where no significant differences between three irrigation levels (50, 75 and 100% of the crop water requirement). On the other hand, it seems that the tolerance to salinity is not as much as for water stress, experiments conducted in Oman have showed that all accessions have suffered from rise in soil salinity as indicated by the yellowing of the mother pad and low counts of new pads. Even though the accessions presented different performances, all the results showed that spineless cactus has great potential to perform well under the harsh environmental conditions of the Arabian Peninsula.

Keywords: Spineless cactus, water stress, Arabian peninsula

SOIL VOLUME: THE EFFECT OF POT SIZE ON ROOTS AND CANOPY GROWTH PERFORMANCE OF CACTUS PEAR

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The influence of soil volume on roots and canopy growth performance of cactus pear (*Opuntia ficus-indica*) was studied at Palermo University. In November 2014, 1 year old *Opuntia ficus-indica* cladodes were planted in five different size of pots 49, 33, 18.5, 9 and 6 L. Three replicates (plants) per pot size were dug out at 6 and 12 months. The resulting experimental design was a randomized complete block design with three replications (each replication was one plant in one pot size). Roots were washed and roots length was manually measured. Roots fresh and dry weigh was obtained. Cladode surface area, cladode thickness, number of new cladodes, cladode fresh and dry mass were measured and recorded for each plant. Results indicate a significant effect of pot sizes (*P<0.01*) on root length, root fresh weight, and dry weight in both studied intervals. Roots of cuttings planted in pot sizes 49 and 33 L exhibited significantly the highest values of length, fresh and dry weight. Increasing the pot size enhanced the thickness, fresh and dry weight of the cladodes (*P<0.01*) in both interval but not the surface area. Mother cladode dry weight was affected by the smallest pot size (*P<0.01*). In the first interval, number of the new cladodes for both first and second generation was not affected by the pot size. On the contrary, in the second interval, pot size exhibited significant effect on new cladode production and pot sizes 49 and 33 L recorded the highest (*P<0.05*) number of new cladodes. In both intervals no second generation new cladodes were observed in 9 and 6 L pot sizes. In both intervals, the root dry weight was strongly correlated to the root length and fresh weight (r =0.89 to 0.99, *P < 0.01*), total cladodes fresh and dry weight (r =0.64 to 0.95, *P < 0.01*) and to mother cladode fresh weight (r =0.71 to 0.95, *P < 0.01*). These results suggest that the limitation of soil availability resulted in root and canopy growth limitation.

Keywords: *Opuntia ficus-indica*, roots/canopy mass, roots length, roots surface area, cladodes mass

THE USE OF WILD AND CULTIVATED CACTI IN NORTHERN PROVINCE OF CORDOBA, ARGENTINA

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The Northern Province of Cordoba in Argentina shows a mosaic of xerophytic forest environments: salt marshes, shrub lands, thorn forest and fragments of agricultural and livestock landscapes. Semi-Arid climate has allowed a high regional diversity of wild cacti, and It has promoted the commercial and family farming of cultivate species. In such environments are developing, among others, family-based productive systems: handicrafts for sale, touristic services and livestock production for their own consumption and local trade. These kinds of people identify themselves as "Criollos" and they have a local ecological knowledge useful for management of plant resources in this particular environment. In order to investigate the perception, use and management of wild and cultivated cactus among Criollos in Northern Córdoba, we made 10 field trips between 2014-2016, interviewing 49 persons with semi-structured interviews, complemented with photographs of cacti species and tours along domestic and natural environments. Interviews were focused on questions about: classification criteria, local nomenclature, management practices, and value and associated environments of each species. Interviewed persons mentioned 12 wild species, 2 cultivated species of the genus *Opuntia* and 6 cultivated etno-varieties corresponding to *Opuntia ficus-indica* (L.) Mill, as well as 15 different uses and 6 management practices, including harvesting, tolerance, protection, induction, transplantation and cultivation. Concerning the type of environment in which the species grew: domestic environment or "de la casa" was characterized by the presence of *O. robusta* and 4 etno-varieties of *O. ficus-indica*, associated with food, fodder, cleaning uses, trade, ornamental use, apiculture and fences building, and with transplanting and growing as more frequent practices. Natural environment or "monte" was characterized by the presence of 2 etno-varieties of *O.ficus-indica* and 12 wild species associated with feed and food uses, with collection, protection, tolerance and induction as more frequent practices. For all species and etno-varieties, valuation was important or very important, especially for the inhabitants of villages near salt marshes (“Salinas Grandes”), who have few alternative plant resources for their livestock.

Keywords: Ethnobotany, small producers, Chaco environment, management, use.

ANATOMICAL INVESTIGATION OF EMASCULATION AND GIBBERELLIC ACID EFFECTS ON EARLY SEED DEVELOPMENT OF OPUNTIA FICUS-INDICA (L.) MILL.

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In cactus pear (*Opuntia ficus-indica*) seeds are known to be essential for normal growth of fruits. Their size and shape are determined by seed number and distribution. Moreover, the edible pulp tissue develops from the funiculi and external integuments of the seeds and the peel develops from the ovary mesocarp. The fruits contain both viable and aborted seeds and, in some cases, aborted ones may be able to partially contribute to the pulp tissue regeneration. The present work was carried on in a clone belonging to *O. ficus-indica* for which apomictic potential has been elucidated before starting the flower treatments. The treatments, which consisted in emasculation and gibberellic acid GA_3 (0 and 500 ppm) application at anthesis, were applied in order to set up their effect on the seed development from flower opening until day 30 after anthesis. Anatomical analysis was used. Compared to open pollinated control, seed development was not significantly affected by these treatments up to 15 days after anthesis. Indeed, in absence of fertilization due to emasculation, ovules developed vegetatively until this stage. After that, emasculated flowers showed drastic abortion of seeds with deformed teguments caused by degenerated nucellar tissues. Neither funicular papillae nor pulp were observed. Nevertheless, GA_3-treated flowers showed better seed development than untreated ones. However, comparison with open pollinated control revealed less development, including partially aborted seeds that had almost normal nucellus, integuments and pulp initials. Despite its known implication in the inhibition of embryo development, GA_3 contributed in the maintenance of the funicular cell activity giving rise to papillae that constitute the initial step of pulp formation.

Keywords: Cactus pear, Emasculation, Gibberellic acid, seed, anatomy

CARACTERIZATION OF RUMBA FRUITS (*CORRYOCACTUS BREVISTYLUS*) FROM NORTHERN CHILE

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Corryocactus brevistylus is a robust shrub branching near the base (1 to 3 m high), distributed from Ayacucho (14º 30' S) in Perú to Tarapacá (21º 10' S) in northern Chile. Their edible fruit is known as "rumba" in Chile and "sancayo" in Perú. The aims of this study were to characterize fruits and pulp of “rumba” and to define the main sensory attributes to future sensory evaluation. Analyzed fruits were collected in Chiapa (Chile) (19º32'S, 69º12'W, 3200 m). Color parameters (L, a*, b*, C*, h°), weight (g), height and width (cm) and pulp yield (%) were determined in the fruits (n=15). Acidity (% citric acid), pH, soluble solids (°Brix) Vitamin C (mg AA/100 mL juice), antioxidant capacity (ORAC), as µm eq. Trolox/100g, and total phenolics (mg GAE/100g f.w.) were determined in the fruit pulp. All the analyze was done in triplicate. A Focus group composed by seven expert judges defined the main sensory attributes for the evaluation of quality and preference for fresh fruit.

Rumba fruits showed and external dark green color (L=43.2±2.3, C*=22.9±3.0, h°=95.7±5.5), weight 371± 64 g, height 8.3±0.6 cm, width 8.5±0.5 cm, pulp yield of 62±6.3 %. The fruit pulp shows a pH= 2.6 ± 0.01, 2.2±0.02 % acidity, 2.3±0.1 °Brix; ss/acidity=1.0, 16±2.1 GAE/100 g f.w., 33.01±0.82 mg AA/100 mL juice and an antioxidant capacity of 654±60 µm eq. Trolox/100 g. The Focus Group proposed as visual characteristics in a sensory evaluation scale, the general appearance of the fruit and the transparency of the pulp. In flavor attributes, the aroma intensity and herbaceous aroma; and in taste, acidity, juiciness, fibrous structure, pulp disintegration and seeds crunchiness. Acceptability was also recommended to be included in the evaluation scale considering that this is an unknown fruit for urban Chilean consumers. With this information, a non-structured sensory evaluation scale was developed. Rumba is a very juicy and sour fruit that could be a new alternative of wild crops offering a new and sour taste, especially suitable to quench thirst, as is needed in arid zones.

Keywords: *Corryocactus brevistylus*, rumba, sancayo.

Grant: Fundación para la Innovación Agraria (FIA). PYT-2016-0151.

PREDICTING OF STOMATAL CONDUCTANCE IN *OPUNTIA FICUS INDICA*

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In species C3 and C4 stomatal conductance (gs) can be predicted applying Fick's first law to describe the diffusion of gases through the stomatal pore. However the area available for water vapor diffusion on CAM Opuntia ficus indica (OFI) changes against different levels of water availability and presents complications that modify the predictions. The aim of this study was to analyze the anatomical differences on the epidermal tissue of OFI that could explain and evaluate the response of different treatments on water availability over the conductance stomatal and transpiration, especially at night. The study was conducted in cladodes children of OFI that were 20 days old at the Center of Equipment and Services Technological Support (CESAT), of the Biomedical Institute Sciences Faculty of Medicine, University of Chile. The treatments analyzed were five: no irrigation, field capacity used as a reference (Ref), Ref-20%, 30% and Ref-Ref-40%. Photomicrographs were used on Scanning Electron Microscopy (SEM) and optical microscopy photographs for identify the stomatal density (approx: 60 large stomata per mm 2). The variables evaluated were: number of stomata, stomatal pores size, encrypted guard cells and configuration of the relationship between the area occupied by stomata of the total area. The results were subsequently subjected to ANOVA and Tukey multiple comparisons. Statistics Significant differences between treatments with and without irrigation were detected in the fraction of the caulinar surface of cladodes children occupied by stomata. Paradoxically, the gs of OFI predicted by this methodology indicate higher stomatal conductance on more stressed treatments on OFI.

Keywords: CAM, g_s, Opuntia, SEM.

CACTUS PEAR ROOTS TURNOVER AND TOTAL CARBON SEQUESTRATION RATE DEPENDS ON SOIL VOLUME AVAILABILITY

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The influence of soil volume availability on roots carbon turnover and carbon sequestration rate of cactus pear (*Opuntia ficus-indica*) was studied during three years trial. Since April 2014, 1- year-old cladodes were planted in five different pots size (60, 4, 23, 11 and 7 kg of soil). Due to destructive approach up to nine pots were prepared according to a randomized block design. Three times from April 2014 to June 2016 three pots were destroyed to estimated roots fresh and dry weight. Soil was 1 mm sieved and SOC and $\delta^{13}C$ were determined. Considering $\delta^{13}C$ of cactus pear (-21) and soil used in the trial (-25.4), root carbon turnover, SOC mean resident time, mineralization rate and total contribution of cactus pear to SOC stock were calculated. A repeated measure ANOVA, on all soil analysis, was performed. Results showed a high significance between pots volume and sampling time. $\delta^{13}C$ of soil showed a progressive increase in relation to sampling date and pots size. Pot size, in fact, positively affects roots weight for kg of soil, soil carbon and New Carbon Derived. Mean Resident Time (MRT) of new carbon depended on soil volume, ranging from 8 g of C to 4 g o C for year for larger and smaller pot respectively. In cactus pear (*Opuntia ficus-indica*) soil volume strongly influenced soil carbon turnover in relation to roots growth and turnover.

Keywords: *Opuntia ficus-indica*; SOC; soil analysis

RELATIVE WATER CONTENT AS INDICATOR OF PLANT WATER STATUS OF 'ROJA DALIA' CACTUS PEAR UNDER IRRIGATION REGIMENS

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In Mexico, cactus pear cultivation under drip-irrigation is growing from year to year. However, water for irrigation is scarce in this region, therefore soil and plant water status monitoring are key parameters for an effective irrigation scheduling. Nevertheless, plant water status (PWS) cannot be determined conventionally due to the anatomy and morphology of this plant. The objective of this research was to observe the behavior of the relative water content (RWC) as PWS indicator in 'Roja Dalia' cactus pear under drip-irrigation regimens. The experiment was conducted in Zacatecas, Mexico. Irrigation treatments (IT) were: non-irrigated (NI, as control), supplemental irrigation (SI), and full irrigation (FI, as control). Treatments were arranged in an incomplete randomized design with three replicates. Volumetric soil water content (θ) was monitored in the IT before and 24 h after each irrigation event by time domain reflectometry. The RWC was determined from two plants per replication (three) per treatment as follow: two stems' segments from one year old fruiting cladode per plant were taken out with a cork borer (17 mm internal diameter) and placed in a sealed plastic vials and transported to the lab. The specimens were individually weighed to determine the fresh weight (W_f), turgid weight (W_t, samples into the vials were hydrated to full turgidity), and dry weight (W_d, samples were oven dried at 65ºC to constant mass). Then RWC was calculated: RWC (%) = (W_f-W_d/W_t-W_d) x 100. This was done from 12:00 to 13:00 h each sampling date. Fruit growth (FW) was measured weekly (fruit diameter) with a digital handheld calliper from five fruits per replication, per treatment. The RWC was significantly higher in FI and SI cladodes than in NI cladodes between 0 and 71 days after full bloom (DAFB). The latter was reflected during the FW between 64 and 85 DAFB where FW was deleyed in NI compared to FI and SI FW. After that, NI FW recovered its growth at the level of SI FW. We observed that both RWC and FW are sensitive to changes of θ; therefore, both parameters deserve to be further studied in view to optimize an irrigation schedule.

Keywords: *Opuntia* spp., water savings, fruit size distribution,

PALATABLE CACTI FRUITS FROM NORTHERN CHILE AS AN AGRO INDUSTRIAL ALTERNATIVE RESOURCE

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The north of Chile includes the regions of Arica-Parinacota and Tarapacá between 17°30'S and 21°30'S covering an area of 51.143 km^2.The native flora of these two regions comprises about 720 species of vascular plants which have a degree of greater threat than regions farther south, due to restricted distributions and decrease in quality of habitat. Nineteen of this species belong to the Cactaceae family. Here we present nine of them that could be a potential alternative resource for local residents. In recent times there has been a migration from small towns towards the development poles. Andean people historically have focused their economic activity mainly in lama and alpaca husbandry and cultivation of quinoa and potatoes. Villages in the Andean foothills grow alfalfa, corn, garlic and oregano. But the increased desertification and declining trend in rainfall in recent decades allows only small-scale production. Cacti represent a productive agricultural alternative in these arid areas. We visited most of regional markets and interviewed many people from different communities in order to obtain information about edible cacti fruits. We also tested all cacti fruits with pulp. The cacti with food value that produce edible fruits are *Eulychnia iquiquensis* "copao" at the coastal zone (700-1000m), *Browningia candelaris* "sabaya", *Corryocactus brevistylus* "rumba" and *Haageocereus chilensis* "maksa" at the preandean zone (2000-3500m) and *Echinopsis atacamensis* "pasakana"*, Echinopsis ferox* "sancave" and *Tunilla shoerensii* "airampo" at the high lands Andean zone (3700-4000m). All these species need a long term ecological restoration. This information will be analyzed according to the conservation status of stocks, the possibilities of enhancing fruit production through agro-industrial development with irrigation facility and biochemical profile of the fruits.

Keywords: Cactaceae, productive value, northern Chile.

Grant: Fundación para la Innovación Agraria (FIA). PYT-2016-0151.

REGULATION OF STOMATAL OPENING VIA PHOTOTROPINS – BLUE LIGHT RECEPTORS – IN THE CAM PLANT H*YLOCEREUS UNDATUS*

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CAM plants use nocturnal CO_2 uptake via open stomata at night time, to store the fixed CO_2 as organic acids. During daytime, behind closed stomata, refixation and assimilation of CO_2 by the Calvin-cycle occurs. In CAM plants young stems and flower buds exhibit daytime stomatal opening (C_3), whereas mature cladodes and fruit exhibit the characteristic nocturnal stomatal opening of CAM plants. Blue light induces stomatal movements through phototropin receptors, which regulate stomatal opening of C3 plants. We cloned in *H. undatus* three phototropin genes- *PHOT1a*, *PHOT1b* and *PHOT2* and determined the expression patterns of *PHOT1a* and *PHOT1b* in young and mature stems during daytime and nighttime and to sequence the promoter region of *PHOT1b*. Stomata of young stems responded to dark and blue light, they closed in dark and opened in response to blue light, however stomata of mature stems did not respond to dark or blue light. Overall comparison of the expression between genes revealed that levels of *PHOT1a* in mature stems were similar during day and night times. The expression of *PHOT1b* was induced during nighttime in both mature and young tissues. Both genes expression was suppressed during daytime and induced during nighttime in young tissues. Analysis of *PHOT1a* and *PHOT1b* promoters showed many common signals including motifs for light regulated genes, phytochrome regulation, cold or drought- induced gene expression, guard cell functioning, auxin and abscisic acid responses, circadian expression; and few specific signals including Ca^{2+} responsiveness and oxidative phosphorylation machinery. It is interpreted that young stems of the CAM plant *H. undatus* behaves like C_3 plants. In the course of evolution *PHOT1a* gene was duplicated and the expression of the genes is different in mature and young stems during day and nighttime due to different promoter regions which contain cis-elements allowing expression under different conditions and tissues.

Keywords: Stomata, *Hylocereus undatus*, phototropin, blue-light

FRUIT QUALITY AND FLOWER VOLATILES OF THE COLUMNAR CACTI *CEREUS PERUVIANUS* AND *CEREUS JAMACARU*

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The columnar cacti *Cereus peruvianus* and *C. jamacaru* are new potential exotic fruit crops suitable for cultivation in arid zones due to their palatability, and unique aroma and taste. To evaluate the marketing demands and the preferred flavor by consumers we conducted experiments aimed to characterize fruit quality attributes employing physical and chemical methods accompanied by consumers' organoleptic evaluations. Organoleptic tests indicated that the overall perceived taste, sweetness, acidity and general aroma qualities of *C. peruvianus* fruits were superior to those of *C. jamacaru.* The studies were supported by physical and chemical evaluations conventionally used for quality determination, such as titratable acidity, pH, sugars, polysaccharide, total soluble solids content and volatile composition. We carried experiments to determine the aroma volatiles constituents of the fruits employing aroma volatile extraction from fruit pulp coupled to GC-MS analyses. The main fruit volatile constituents of both *Cereus* species are the monoterpene alcohol (*S*)-linalool and its derivatives. (*S*)-linalool content increased upon fruit maturity and upon fruit storage, concomitantly with increases in (*S*)-linalool-synthase activity, an enzyme that converts geranyl diphosphate to (*S*)-linalool. Little is known about the biology of the flowers under the conditions prevailing in Israel. The pollinators of the nocturnal flowers are not known and currently all flowers are hand pollinated for fruit set. Hence, we characterized the volatiles emitted by the flower to attract pollinators. Flowers were enclosed in plastic bags through which air was passed and volatiles were adsorbed to a SPME column. The eluted volatiles were injected to GC-MS for identification. In contrast to fruits, the main component of the scent of *Cereus peruvianus* flowers is the sesquiterpene alcohol nerolidol. Our studies provide the necessary tools to rationalize the biochemical origin of quality attributes in fruits and flowers of columnar cacti.

Keywords: *Cereus spp.*; Cactaceae; sugars; acids; volatiles; (*S*)-linalool

INFLUENCE OF THE NURSE PLANT EFFECT OF *PROSOPIS FLEXUOSA* DC. ON NUTRIENT CONTENTS AND PRODUCTIVITY OF *OPUNTIA ELLISIANA* GRIFFITHS

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In arid conditions, the low quality of the forage and water shortage could be eased by the introduction of *Opuntia* species. The cladodes contain high soluble carbohydrate, calcium and carotene contents, while they are low in protein and fiber. Furthermore, the adaptation of *Prosopis* to herbivory is the main reason for its dominance in silvopastoral systems in arid and semiarid areas of America. A number of species grow well usually under *Prosopis* canopy, responding to a higher nutrient content in the soil, creating "islands of fertility". The hypothesis of this research was that the productivity and nutrient contents of the cactus planted under *P. flexuosa* will be higher than of those planted outside the canopy, and that these parameters will be influenced by the cactus position, north or south from the center of the tree. Furthermore, the frost damage to cactus will be higher outside the canopy. The experimental design incluided 12 plants under the canopy of *Prosopis* and 17 outside of it, located in CRICYT's campus (32° 53' 45'' S 68° 52' 28'' 840 msnm). After one year, the totality of the cladodes was harvested, except the double cladodes planted at the beginning of the experiment. The average cladode production per plant was 5.7 and 3.1 under and outside the canopy, respectively. The bromatological values were: moisture (91.9 and 89.1%), organic matter (89.8 and 76.9%), crude protein (8.0 and 4.4%), acid detergent fiber (18.3 and 13.8%), potassium (3.6 and 3.2%), phosphorus (0.11 and 0.07%), calcium (4.5 and 5.8 %) and sodium (0.02 and 0.04%), under and outside the canopy, respectively. Moisture, organic matter, crude protein, acid detergent fiber, potassium and phosphorus values were higher and statistically different under the canopy, whereas calcium and sodium values were higher outside the canopy ($P<0.05$). Dry matter/plant productivity (48.75g and 35.26g), neutral detergent fiber (31.6 and 29.0%) and magnesium (1.86 and 1.83%) values were not affected by the position under or outside the canopy respectively. The north or south orientation did not influence any of the analyzed parameters. Frost damage was not observed outside the canopy.

Keywords: *Opuntia*, *Prosopis*, productivity, nutrients.

RELATIONSHIPS BETWEEN FRUIT ATTRIBUTES AND FRUITING CLADODE DRY OR FRESH MATTER IN *OPUNTIA FICUS-INDICA* (L.) MILLER VARIETY 'ROJO PELÓN'

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Opuntia ficus-indica (L.) Miller is becoming a relatively common crop, especially in dry areas around the world because of its rapid growth rate, undemanding propagation, and high water use efficiency. This species is cultivated for its fruit in at least 18 countries. *Opuntia ficus-indica* (L.) Miller grows under a wide range of environmental conditions, which implies a great variability in fruit yield and fruit ripening, among other aspects. However, there is scarce knowledge about fruit yield and fruit quality dependence on within-tree factors such as plant architecture, fruiting cladode position and cladode characteristics taking into account several growing seasons. Thus, we addressed the dependence of fruit attributes to the weight of fruiting cladodes for the 'Rojo Pelón' variety by means of the boundary line approach by considering a 3-year database (2012, 2013 and 2014). The experimental orchard was established in June 2006 at the 'Centro Regional Universitario Centro Norte' of the 'Universidad Autónoma Chapingo', which is located near the city of Zacatecas, Mexico. Results suggest that 14.4 to 33 g could be the minimum fruiting cladode dry weight (CDW) required for producing fruits. In general, above ≈106 g CDW or cladode excess dry weight, the number of fruits per cladode decreased. Considering data from the three years, cladodes with 1,497 g of fresh weight were able to produce mean fruit weight per fruiting cladode (MFWC) of 154 g. The maximum load (1,602 g) occurred on one-year-old fruiting cladodes with 1,629 g of fresh matter, and corresponds to 2014. Notably, fruiting cladode excess dry or fresh matter required for producing fruit could be an important factor in order to avoid high variation between productivity levels in successive years. These attributes may be convenient indexes for predicting which cladodes will produce fruits.

Keywords: Cactus pear**,** fruiting cladode, fruit load, fruit number, fruit weight

EFFECT OF GA_3 + ETHEPHON ON GLOCHID REMOVAL AND CACTUS PEAR FRUIT QUALITY

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The market for cactus pear fruit requires prior glochid removal, this process can be made in the traditional way (manually) or mechanically (with machines). However, both forms cause injuries and damage to the fruit. The effect of growth regulators for preharvest removal of these small spines, also called “ahuates”, has been experimentally evaluated; this method has shown excellent and promising results to induce preharvest fall of glochids without damaging the fruit. In this study the effectiveness of GA_3 (50 ppm) + ethephon (700 or 900 ppm) on the glochid removal and its effects on fruit quality in cactus pear varieties San Martin, Villanueva and Sangre de Cristo were determined. In a commercial plantation of cactus pear of the three varieties (it the producing Region of Acatzingo, State of Puebla, Mexico). From anthesis, consecutive weekly applications of GA_3 in combination with ethephon were made. The number, length and fall of glochids were evaluated, and fruit quality parameters (weight, shape, color, total soluble solids and firmness) were also assessed; postharvest physiological changes during 14 days of storage at room temperature were also evaluated. Both treatments induced an elongation of around 65 % in glochids; in general it was also observed 87-90 % drop of glochids in harvested fruits. Besides, it was also observed that the glochids which remained on the fruits were easier for mechanical removal. On the fruit quality there were slight, positive or negative effects, depending on the variety and treatment.

Keywords: Cactus pear, gibberelic acid, glochid fall, growth regulators, fruit quality.

FRUITING CLADODE PHYSICAL ATTRIBUTES OF *OPUNTIA FICUS-INDICA* (L.) MILLER VARIETY 'ROJO PELÓN' DIFFER AMONG YEARS

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Opuntia ficus–indica (L.) Miller is used in at least 18 countries for fruit production. Due it grows under a wide range of environmental and management conditions, yield varies highly among countries, production systems, trees and fruiting cladodes. However, information about relationships between yield and environmental factors is really scarce. Then, the aim of this research work was to identify relationships between fruiting cladode fresh weight, fruiting cladode dry weights or load and yearly precipitation (2012, 2013 and 2014) for the case of *O. ficus-indica* (L.) Miller variety 'Rojo Pelón'. Data from an experimental orchard established in June 2006 at the 'Centro Regional Universitario Centro Norte' of the 'Universidad Autónoma Chapingo', which is located near Zacatecas city, were used to achieve the mentioned aim. One-year-old fruiting cladodes having from 1 to 15 fruits were collected. Their fresh and dry weights, and load (total fruit weight) were registered. Precipitation data were downloaded from the website of the 'Comisión Nacional del Agua', the official national institution in charge of registration of meteorological and climatological data. Averages of fruiting cladode physical attributes were plotted against precipitation of the year when they grown. Results suggest one-year-old fruiting cladode fresh weight could depend on yearly precipitation, and the load could also be dependent on fruiting cladode fresh weight. Remarkably, the highest load occurred on one-year-old cladodes grown during 2013 (the wettest year), corresponding to 2014 fruiting cladodes (the heaviest cladodes).

Keywords: One-year old cladodes, cladode fresh weight, yearly precipitation

EVALUATION OF *OPUNTIA FICUS-INDICA* AS A MULTI-PURPOSE SPECIES UNDER WEST ASIA CONDITIONS

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The agronomic potential of *Opuntia ficus-indica* (L.) Mill. a multi-purpose crop is becoming increasingly apparent in arid and semi-arid regions. Nevertheless, the main limitation for the adaptation and distribution of *O. ficus−indica* is the cold temperatures that cause severe freezing damage or ultimate plant death. The objectives of this study were to assess the cold tolerance of different cactus pear cultivars with various origins and quantify their forage production potentials under semi-arid conditions of Jordan. Cladodes of a total of 40 cactus pear cultivars were planted in April 2013 using a completely randomized design with five replicates. Frost damage was recorded visually after each occasion of frost occurrence in each year, and number of cladodes per plant was quantified. Five cladodes from each established plant were cut and weighed to estimate the cladode green biomass weight. Significant differences in cold/freezing tolerance, pad numbers and biomass production among tested *Opuntia ficus-indica* cultivars were detected (*P<0.01*). COPENA V1, 74115_Bab Toza, and 74001 cultivars produced the highest number of pads. 69223_Burbank Azrou, 2_25_15 and Bianca de Bonacardo were the most frost tolerant snice no frost effect observed on any cladode. Seedless Roccapalumba had the lowest number of cladodes and showed high sensitivity to low temperatures. The average cladode weights of 69242_Matmata, 69246_Oueslatia, and COPENA V1 were the highest while Red Roccapalumba and 10_FOZA10 had the lowest average cladode weight. The findings of this study showed a significant positive correlation between number of cladodes and the average cladode weights (r = 055, P<0.01). Based on the high variations, it can be concluded that the potential of spineless cactus is high to greatly benefit livestock production in arid cold regions especially if we consider cultivar adaptation potential in order to choose the suitable cultivar for each environment.

Keywords: West Asia, forage productivity, frost damage, semi-arid, CAM

PROPAGATION OF *OPUNTIA FICUS-INDICA* MILL. BY CLADODE FRAGMENTS

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Agamic propagation of *Opuntia ficus-indica* by cladode rooting allows a low rate of plant multiplication as compared to other woody plants. One-year-old cladode fragmentation is a possibility to obtain many small cuttings having homogenous characteristics. However, some physiological characteristics of these cuttings are not well known such as the relationship among tissue loss of water, storability, viability and rooting ability. One-year-old cladodes of the cultivar 'Gialla' were taken from plants growing in Sardinia in May. Cladodes were portioned in parallelepipeds of 10-12 cm^3 of volume always having at least two bud areolas in one of the basis. Average dry matter content of cladodes at the start of the experiment was around 8%. Cuttings were submitted to a drying treatment in a ventilated oven at 35 °C for 72, 96 and 120 hours. Cutting weight loss was respectively of 30.7%, 34.4% and 35.4% after treatments. Dried cuttings were tested for rooting ability by deposition over a sandy substrate for 120 days under open air conditions. In September, the variation of the cutting with respect to the initial weight was recorded. Only the cuttings submitted to 96 hours of drying treatment showed a positive variation with an increase of 6.9%, while treatments of 72 and 120 hours respectively lost 18.8 and 24.8%. Rooted cuttings were 85.7, 92.6 and 83.9% in the 72, 96 and 120 hours treatments, while two roots per cutting were recorded in all treatments. However, the cuttings treated for 96 hours showed the highest dry weight of the roots with 1.0 g, root mean length with 17.0 cm and number of shoots per cutting with 0.45.

Keywords: Cactus pear, agamic propagation, cladode fragments, cutting treatment, rooting

IMPACT OF CLADODE "ACORAZONAMIENTO" ON CACTUS PEAR COMMERCIAL ORCHARDS

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The cactus pear (*Opuntia spp*.) is one of the most important crops in Mexico. Its productivity depends on several agronomy practices, including the insect and disease management. Currently, a very distinctive symptom has been observed on the cladodes, and it will be called "acorazonamiento" in this study. The cladodes have damage on their apical region that is followed by a scaring process, and then, they stop the production of vegetative and reproductive buds in the affected area. The aim of this work was to determine the economic impact of the cladode "acorazonamiento" in cactus pear commercial orchards. The tissue of cladodes with "acorazonamiento" presents rupture of the cuticle, with detachment of the cellular walls, and even the chlorenchyma could be damaged. This cladode deformation has an incidence up to 33% of the plants in a cactus pear orchard, as a result, the yields, volume of production and the grower's economy are negatively affected. The cladodes with "acorazonamiento" have losses from 50 to 80% of the vegetative and reproductive buds, while 1 to 20% of the photosynthetic area is lost. There were three main shapes of cladodes deformed with "acorazonamiento": "heart", "dry bean seed" and "hand saw"; the heart shape was the most commonly found. The proportion of healthy/deformed cactus pear shoots is 3.18/1.67 if the shoots are coming from a healthy mother cladode; when the shoots are coming from a mother cladode with "acorazonamiento" the proportion is 2.71/1.67, indicating a lower probability for an affected cladode to generate healthy new shoots. The cladode "acorazonamiento" damage the apical tissue, and limit the production of vegetative and reproductive buds in the affected area. Thus, there is a need to carry out studies to identify the causal agent in order to deploy a management strategy for the problem of cladode "acorazonamiento".

Keywords: Disorder, disease, economic losses, yield

CLIMATIC INFLUENCES ON FRUIT QUALITY AND SENSORY TRAITS: A FIVE-YEAR EVALUATION

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Cactus pears were imported and used as mainly fodder crops in South Africa. Interest in commercial fruit production increased during the past few years. Since *Opuntia ficus-indica* and *O. robusta* flourishes in arid and semi-arid regions, it is worth looking into its potential not only as a fodder crop in dry seasons, but also for fruit production. Fourty-two cultivars are being evaluated at an experimental orchard at Bloemfontein in the Free State Province in South Africa. Twelve cultivars with commercial fruit production potential were selected for evaluation of fruit eating quality as well as the effect of climate thereon. These were evaluated over five seasons. Fruits were thinned by hand to no more than eight fruit per cladode which were left to develop to maturity. Correlations were drawn on the influence of maximum temperature, heat units and rainfall on fruit quality. Rainfall had a significant positive effect on total soluble solids (TSS) content, fructose content and percentage titratable acidity (% TA), while it had a negative effect on fruit mass, glucose content and the betacyanin (Bc) and betaxanthin (Bx) pigment contents. Fruit mass correlated negatively with total heat units from July to January, while % pulp correlated positively with total heat units. TSS, glucose, fructose and % TA had significantly negative correlations with heat units for December and January, while Bc and Bx weakly correlated positively with heat units in December and January. Maximum temperatures had similar effects on fruit mass and % pulp as observed for heat units and TSS, glucose and fructose also followed the same trend for the warmer months. Percentage TA and pigments (Bc and Bx) had a positive correlation with maximum temperatures. From this data it is clear that all climatic factors measured correlated to changes in fruit quality, although the effect of rainfall was most profound.

Keywords: fruit quality, rainfall, heat units, maximum temperature

INFLUENCE OF AGE OF CLADODE, GROWTH HORMONE AND CLADODE PIECES ON PROPAGATION OF CACTUS PEAR (*OPUNTIA FICUS INDICA*)

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A nursery experiment was undertaken at BAIF Development Research Foundation, Pune to determine the appropriate age, number of cuts of cladodes and hormone treatments for production of propagules to address the limited availability of elite cactus germplasm for large scale cultivation in India. The study envisaged to elicit the influence of age of cladode, application of growth hormone and number of pieces of cladode for propagation of cactus under shade net during rainy season of 2015. Cladodes of 6 and 12 months age of four accessions namely 1270, 1271, 1280 and 1308 were taken from the mother plants during the month of August 2015. The cladodes were kept for curing under room temperature for 30 days, thereafter the single cladodes were cut into 2, 4, 6 and 8 pieces, keeping uncut portion at one side. The cladodes were planted erect in pots after fungicide treatment and dipping in various IBA concentrations. The survival, sprouting, number of cladodes, cladode length, width and thickness were monitored at monthly interval. The study revealed that during the curing period of 30 days the weight loss per cladodes was 6.38 %, 7.24 %, 7.42 % and 14.42 % in accessions 1270, 1271, 1280 and 1308 respectively. The significantly highest survival was recorded in single cladode piece (77.78 to 80.55 %), followed by 2 pieces (50.00 to 69.44 %) and least was in 8 pieces (25.00 to 33.33 %) at 30 days after planting. There was decreasing trend in survival at 60, 90 and 120 days after planting which was 63.89 to 66.67 %, 36.11 to 50 % and 19.44 to 30.55% with single, 2 pieces and 8 pieces respectively. The age of the cladodes has not affected the survival percentage. The days to sprouting was significantly influenced by cladode pieces. The single piece cladodes were sprouted in 21 days and as the number of cladode pieces increased, the days required for sprouting was also increased and 8 pieces cladodes took 85 days for sprouting. Similarly the number of cladodes, cladode length, breadth and thickness significantly differed with cladode pieces and bigger size cladodes were noticed in single pieces and smaller were in 8 pieces cladodes. It could be concluded that cladode of six months and above may be selected for propagation and single cladodes gave maximum survival percentage with better sprouting, growth and size of cladode, however the smaller cladode piece of 1/8 size could be used for multiplication when very limited planting material is available.

Keywords: Cladode, propagation, survival, propagules

EFFECT OF FRUIT RIPENING ON MORPHOLOGICAL AND CHEMICAL CHARACTERISTICS OF *OPUNTIA FICUS INDICA* FROM MOROCCO

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Cacti are flowering plants; the flowers produce seed-bearing fruit. In Morocco, as in other North African countries, the most widespread species of cactus are *Opuntia dillenii, Opuntia vulgaris, Opuntia compressa* and *Opuntia ficus-indica*. The latter is the main species that produces edible fruits (cactus pears). Few scientific publications have focused on the physical and chemical characteristics of the cactus fruit and were limited to the fruit at full maturity stage. The objective of the present study was to examine the morphological and physiochemical characteristics, at different stages of maturity, as related to apparent peel color variations of the most abundant *Opuntia ficus-indica* cultivars in Morocco: *Aissa, Moussa*, *Shoul* and *Dellahia.* The first harvest or the green stage corresponded to the green color of fruit, the second harvest or intermediate stage of maturity corresponded to fruit that color between yellow and green and the last harvest or advanced maturity corresponded to a red fruits. All the analyses were performed according to international standards; morphological characteristics focused on several parameters such as weight (g), length (cm), width (cm), shape and size of the fruit etc. The physiochemical characteristics, determined at different stages of maturity, were pH, acidity, moisture, ash, Brix, content of sugars, vitamin C, and oil content. The morphological results showed that some parameters such as length, width and weight of fruits and skin varied from one variety to another but did not change depending on maturity stage. In the physiochemical study, the results showed that the acidity and moisture decreased with the advancement in maturity; however, the pH, Brix, total sugars, vitamin C and oil content varied from one variety to another and increased with the advance in maturity. This investigation showed the potential value of cactus-pear fruits as a good natural source of energy, and antioxidants such as vitamin C. Based on its low acidity and high sweetness, cactus-pear pulp could be very suitable as a natural additive or substitute material in the production of many foodstuffs.

Keywords: *Opuntia ficus-indica*, morphological study, physiochemical study, maturity stage.

IN VITRO PROPAGATION OF SELECTED *OPUNTIA* SPECIES WITH TEMPORARY IMMERSION SYSTEMS FOR LARGE-SCALE PRODUCTION

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The species of *Opuntia* genus, along with those of other genera of *Cactaceae*, are more and more considered as chance crop in many arid and semiarid environments for their high water use efficiency. These species can be cultivated either for fruit production (*prickly pears*) or for biomass production, the latter being used for animal feeding, but also as renewable energy source. In such a picture, the development of an efficient nursery activity is advisable in order to match the request of high quality propagation material for high density plantations. Furthermore, in order to speed up the diffusion of selected genotypes, and to avoid the diffusion of pests and diseases, *in vitro* culture can play an important role. This research deals with the set up and evaluation of micropropagation protocols for *Opuntia* species and varieties using Temporary Immersion Systems (TIS). With the aim of identifying the most suitable conditions in terms of culture medium, of microclimatic conditions, of explant tipology and of system management, a number of trials have been performed along two years using both an automatized and a conventional bioreactor management system. The experiments were carried out in the commercial Plantform© bioreactors and allowed to define specific protocols for a model variety (ARL) and then for two interesting *Opuntia* varieties (namely 'Gigante' and 'Orelha de elefante Mexicana'). Besides, a number of other selected genotypes has been introduced *in vitro* and could be quickly devoted to massive propagation. The protocols include efficient multiplication rate, acclimation, *ex vitro* rooting methods, mother plants nursery management and, overall, allow obtaining cuttings to be transported without soil along a rather long period. This process allows the diffusion in time and space, and for relevant quantities, of selected propagation material certified for phytosanitary and genetic aspects for efficient plantations.

Keywords: Micropropagation, nursery, certification, intensive plantation, cuttings

SITUATION ANALYSIS OF *OPUNTIA FICUS INDICA* IN MOROCCO

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In Morocco, growing cactus has undergone remarkable development during recent years. Since 2008, when the Moroccan Green Plan was launched, thousands of hectares of cactus are planted every year in different regions. Tens of cooperatives and private companies are established and several new cactus-based products are designed and developed. Different universities and research institutes were interested in cactus, several research works were conducted and significant results are published. However, those efforts are always facing several challenges that hinder the development of cactus industry: yields are still lower than they should be, postharvest losses are sometimes very heavy, orchards are managed in traditional way, the formidable pest (cochineal) has just appeared in Morocco, and areas of infestation are becoming increasingly widespread. We here present the current situation of cactus crop in Morocco including: area expansion, uses, academic research studies, cooperatives and products, the issue of cochineal, national and export markets of cactus products, future prospects. We will conclude on the needs of the cactus pear industry in Morocco and cooperation strategies via FAO-ICARDA-CactusNet.

Keywords: *Opuntia ficus-indica*, Morocco, Cochineal

EFFECT OF FRUIT LOAD ON CACTUS PEAR FRUIT SIZE AND QUALITY UNDER MEDITERRANEAN AND TROPICAL CLIMATIC CONDITIONS

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With the aim of studying the effect of fruit load on cactus pear (*Opuntia ficus-indica*) fruit yield and quality, two trials were carried out: one in which different fruit loads were adjusted at the cladode levels (2, 4, 6, 8, 10, 12, 14 y 16 fruits/cladode) in El Noviciado, Chile (Mediterranean climate) and a second trial in which seven plants with different natural fruit loads were evaluated in the same locality and in Valle del Chota, Ecuador (tropical climate). In both trials lower fruit loads reduced yield but increased fruit fresh mass, size (polar and equatorial diameter) pulp/peel ratio and firmness. On the other hand, in both trials, increasing fruit load reduced the proportion of juice in the pulp whereas no effect on pulp soluble solids, pH and titratabel acidity were observed. When comparing localities, very similar responses of fruit yield, fresh mass and firmness to fruit load were observed. This indicates that these variables are highly controlled by fruit load, irrespective of the edapho-climatic differences. On the other hand, for similar fruit load levels, the Chilean locality achieved higher pulp/peel ratio and soluble solid content tan the Ecuadorian locality. As to adjusted vs. natural fruit load in El Noviciado, throughout fruit load levels, adjusting the fruit load at the cladode level allowed achieving higher fruit yield and fresh mass as compared to natural fruit load which, in turn, more drastically reduced fruit yield (when decreasing fruit load) and fresh mass (when increasing fruit load). This indicates that fruit growth mainly depends on assimilate and nutrient supply by the cladodes they grow on. From an agronomic point of view it was concluded that (i) fruit load management practices aiming to control cactus pear fruit yield, fresh mass and firmness can be equally applied under edafo-climatic conditions as diverse as those of El Noviciad and Valle del Chota and (ii) adjusting fruit load to eight fruits per cladode in El Noviciado allows achieving an optimal fruit yield and quality combination. The latter conclusion must consider commercial aspects related to the prize achieved by different fruit qualities in the targeted market.

Keywords: fruit load, fruit size, yield, soluble solids, cactus pear

EFFECT OF 1-MCP ON CACTUS PEAR FRUIT AT DIFFERENT MATURITY STAGES DURING STORAGE

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1-Methylcyclopropene (1-MCP) is an ethylene antagonist widely used to retain quality and prolong the postharvest storage period of various climacteric fruits. To date, there is few information about the effects of 1- MCP on postharvest storage performance of cactus pear fruits. Recently, data found that exposure to 1-MCP at d 1.0 ml L^{-1} had several beneficial effects in preserving postharvest quality of cactus pear fruits, as indicated by inhibition of peel color change. In this study we investigated the effect of 1-MCP on quality of cactus pear fruit harvested from the scozzolatura crop at early and late ripeness stages. Fruit at two different ripening stages: “commercial ripe” (CR = fruit commercially ripe with 90% green ground-color and 10% orange color) and the “ripe on tree” (ROT = late fruit ripe on tree with 100% orange color and no green ground-color). Fruit were then sanitized by immersion in 200 mg kg^{-1} of sodium hypochlorite for 5 min, and stored at 8 °C for 30 days. Color (L* and ΔE), visual appearance, crunchiness score, carotenoids, phenolics content and respiration rate were measured at harvest and after 7, 14, 21 and 30 days. The results did not show beneficial effects of 1 MCP in terms of color, visual and crunchiness score, contrarily, significant differences occurred in all samples in terms of carotenoids and polyphenols content.

Keywords: Respiration rate, decay, 1-methylcyclopropene, sensory test, shelf life

REDUCING POSTHARVEST DECAY IN CACTUS PEARS BY DIP TREATMENTS WITH IMAZALIL OR AZOXYSTROBIN

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Postharvest decay in cactus pear is a minor problem in fruit marketed directly after harvest, while may represent a major cause of losses when fruit are cold stored or subjected to cold quarantine treatments. Unlikely, so far no postharvest fungicide is registered to control postharvest decay of cactus pears. Thus the objective of this study was to evaluate the efficacy of two worldwide known fungicides, imazalil (IMZ) and azoxystrobin (AZO), registered for postharvest treatments of various fresh produce species, to control decay on cactus pears. Second crop cactus pears cv Gialla were dipped in 500 mg L^{-1} IMZ or AZO and stored at 1 °C or 8 °C and 90-95 % RH for 2 or 3 weeks, respectively, plus one additional week at 20 °C and 55-60 % RH to simulate retail conditions. At the end of storage, decay incidence ranged between 16 and 23 % in control fruit, while the percentage of losses in treated fruit ranged between 3 (IMZ) and 5 % (AZO). Despite no significant difference was detected between the two fungicides in terms of percentage of rotten fruit, IMZ seemed to be more active than AZO to control Penicillium decay. Both chemicals ameliorated fruit response to chilling injury but a slightly higher decline in freshness, associated with a faster transpiration activity, occurred in AZO treated fruit.

Based on these results, considering the complexity of the registration process of new chemicals and the easer procedure required to manufactures to apply for use extension of already registered pesticides, both chemicals could be good candidates as potential fungicides to control postharvest disease of cactus pears.

Keywords: azoxystrobin, cactus pears, decay, imazalil, storage

QUALITY CHANGES AN MARKETABILITY OF WAXED CACTUS PEARS CV GIALLA DURING STORAGE

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Shriveling and peel disorders together with decay are the major causes affecting postharvest life of cactus pears and their marketability. Coatings have long been used in different fruit species to reduce transpiration rate, minimize surface defects and make the fruit more attractive to consumers. In this study, "Citrashine", a shellac-polyethylene based wax registered for citrus fruit, was sprayed on second crop cactus pears cv Gialla before storage.

Fruit were stored at 20 °C and 60 % RH for 2 weeks or at 6 °C and 90-95 % RH for 4 weeks followed by an additional week at 20 °C to simulate the marketing conditions (SMC).

In fruit stored at 20 °C, waxing increased shining, reduced shriveling and weight losses and improved the overall appearance. However, internal fruit quality (pH, titratable acidity, total soluble solids) after the first week declined at a faster rate than control fruit and, at the sensory analysis, an unpleasant presence of off-flavor was detected. In cold stored fruit peel disorders were reduced and generally fruit were scored better than control fruit for overall appearance. Waxing had a negligible effect on decay incidence, but seemed to favor the development of dry rot while reducing the percentage of fruit developing Penicillium decay. Chemical and sensory quality did not show relevant differences between waxed and control fruit at the end of cold storage, but declined at a faster rate in waxed fruit during the week of SMC.

Keywords: cactus pears, decay, peel disorders, quality, storage

RUMPA A CACTUS WITH COMMERCIAL POTENTIAL FOR GOURMET MARKET AND OTHERS IN THE METROPOLITAN REGION, CHILE

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Rumpa (Copao) (*Eulychnia acid* Phil) is a columnar cactus native of Coquimbo´s Region,Chile. This species natural distribution is throughout this region and its fruits, collected in the wild, appearance and characteristic sour taste, are recognized as typical of the Elqui Valley. Small farmers collect the fruit and sell it for fresh consumption. In this respect, the objective of this study was to prospect the market and raise marketing guidelines for commercial product development. The research consisted on interviews applied to qualified informants in order to effectively cover the whole gourmet market chain: chefs and restaurant managers, supermarkets, ice cream parlors and pastry shops. The sample consisted of 13 qualified informants, who were provided with different Rumpa based products: fresh, frozen pulp, dressing, nectar and jam. Among the most relevant results we found a clear preference for the fresh product, because its exoticism and versatility, secondly the frozen pulp because of its comfort and versatility, then the pulp; the rest of the products were positively evaluated. In general, acidity of the fruit and the presence of black seeds in the pulp were the positive evaluated features. In conclusion, these findings can raise a market space for fresh and derivatives of the Rumpa. To make this business sustainable in the long term, it is necessary to implement a supply chain for small size business, which can grow to medium size, which means, among other things, available refrigerated storage chambers. The initial economic evaluation has given for the above investments and estimated revenues and costs, the following performance indicators: NPV = 13,116,494.43 Chilean pesos; IRR = 32.91%

Keywords: Rumpa, Copao, Gourmet Market, Cactus

PREFERENCES TOWARD CACTUS PEAR IN MINIMUM PROCESS: AN APPROACH FROM THE CONSUMER THROUGH GRAPHICS STIMULUS

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The trend of food consumption is oriented there are products that require less preparation time. In this case one of the main problems that limit the consumption of cactus pear is the extraction of its epidermis with thorns, which implies a greater time of dedication. For this reason, the objective of this research is to understand consumer behavior of cactus pear minimally processed in the Metropolitan Region of Chile. For this, a survey was conducted to 400 consumers, residents in the municipality of Florida, Metropolitan Region, Chile. The sample was for convenience. Statistical data processing is carried out with principal component analysis, hierarchical cluster and conjoint analysis. In the case of the latter analysis to assess the preferences respondents, photographs of different types of cactus pear minimally processed (Green, Purple and Orange), the which were presented sliced cut and packaged in trays Aislapol and covers with a film of PVC. Attributes evaluated were price, origin zone, place of sale and colour. In this regard, it was possible to identify three market segments, "Practical" with 48.8%, "Essential" with 18.5% and "Healthy" with 13.5% of the total population, respectively. The attribute most valued in terms of minimally processed cactus pear in the sample was price, followed by the place of sales, the origin zone and ultimately the color. The supermarket is the most favorite place in all segments, but in the case of the "Practical" there is also preference for convenience stores. In the 3 segments no preference for cactus pear produced in the south central area. Nonusers correspond to 19.2% of all respondents and within the grounds of non-use, the amount of thorns has is the main limiting why respondents do not eat the fruit.

Keywords: Cactus pear, Minimum process, Fourth Gama, Consumer, Segmentation and preferences.

SUPPLEMENTAL IRRIGATION IMPROVES WATER USE EFFICIENCY, YIELD, AND FRUIT QUALITY OF 'ROJA DALIA' CACTUS PEAR

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Cactus pear is grown mainly under rain-fed conditions in marginal semi-arid and arid highlands of central and north-central Mexico. Drip irrigation may increase fruit yield ~3.5-fold. However, the effects of supplemental irrigation (SI) on preharvest and water saving have not been assessed previously. This study compared the effects of SI against non-irrigation (NI) and full irrigation (FI) on water saving, water use efficiency (WUE), fruit production (FP) and its components, and fruit quality (FQ) of 'Roja Dalia' cactus pear. Irrigation treatments (IT) were: NI for a control, SI, and FI. Treatments were arranged in a complete randomized design with three replicates. The response variables were: irrigation water applied (IWA), WUE, FP, fruit size distribution (FSD), and FQ. The FQ determinations were: mean fruit weight (MFW), flesh firmness (FF), pulp and peel weights, total soluble solids concentration (TSSC), and dry matter concentration (DMC) of fruit. The experiment was conducted in Zacatecas, Mexico, close to the Tropic of Cancer. At harvest, SI saved ~52% of IWA, increased the efficiency of IWA ~1.4-fold, but reduced FP by 12.9% compared to FI. FI and SI plants produced over 70% of the most marketable fruit (Categories 1 and 2), while NI plants had only 28% Category 2 fruits. The quality indicator FF and pull-to-peel ratio were similar among IT, while NI fruit had the highest TSSC and DMC and the lowest MFW. SI produced similar responses to FI, with saved irrigation water and enhanced FP, FSD, and MFW, but reduced TSSC and DMC. Nevertheless, SI has potential for growing cactus pear in this region and similar production zones around the world where water availability is limited.

Keywords: *Opuntia* spp., water savings, fruit size distribution,

NUTRITIONAL AND TECHNOLOGICAL QUALITIES OF THE FRUITS OF TEN MOROCCAN ECOTYPES OF CACTUS PEAR (*OPUNTIA FICUS-INDICA*)

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The study of physical, chemical and biochemical parameters of cactus pear allows to evaluate their nutritional and technological qualities which can guide the agro-industrialists in processing these fruits. This work focused on the study of some physical, chemical and biochemical criteria of the fruits of cactus pear (*Opuntia ficus-indica*) of ten Moroccan ecotypes, named E08, E18, E22, E24, E35, E43, E44, E53, E55 and E62, which they are planted in the experimental field of the National Institute of Agricultural Research in Tassaout (Marrakesh region). The studied parameters of fruit juices are: moisture, pH, total titratable acidity (% citric acid), soluble solids (°Brix), color (L*a*b* and chroma C* parameters), ash, water activity (a_w) and contents of phenolic compounds, carotenoids and betalains. This study has shown heterogeneity of ecotypes for almost half of the studied criteria. Indeed, for the physical and chemical characteristics, ecotypes showed heterogeneity for a_w, total titratable acidity and color. On the other hand, the 10 ecotypes are homogeneous for humidity, pH, ash content and Brix. The fruit juices are characterized by high humidity (87.50 to 88.97 %), medium pH (5.61 to 6.00) and low acidity (0.059 to 0.075 g citric acid/100 g). Interesting Brix values were recorded (12.37 to 13.67 °Brix) giving sweet taste to these fruits. Similarly, interesting ash contents, which provide good nutritional value, were found for the 10 ecotypes (from 1.69 to 2.21 g/100 g of dry matter). The phenolic compounds contents of the 10 ecotypes can be considered as interesting especially the content of E22 ecotype. This allows considering these fruits as an important source of antioxidants with great interest to human health. The E53 ecotype was the richest in carotenoids. The 10 ecotypes are also rich in betalains pigments including betaxanthins. This characteristic is very interesting for food industry, not only through nutritional effects, but also for the extraction of natural colorants that can replace synthetic colorants increasingly not appreciated by consumers. This study will be pursued by the proposal of ways of valorization of these 10 ecotypes in food industries.

Keywords: Morocco, cactus pear, *Opuntia ficus-indica*, physical, chemical and biochemical parameters, quality.

SENSORY CHARACTERISTICS AND PHYSICOCHEMICAL STABILITY OF PITAYA FRUIT (*STENOCEREUS QUERETAROENSIS* WEBER) LIQUOR

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Columnar cactus pitaya fruits with red flesh were studied to determine the effect of different proportions of alcohol, pulp and sugar on the sensory characteristics of pitaya fruit liquor as well as to asses its physical and physicochemical stability after six months of storage. A preference test was performed before the sensory characterization and physicochemical stability study was carried out. The results showed that consumers preferred liquors with an alcohol content lower than 26% and syrups with a total soluble solid (TSS) content higher than 30% (450 mL water/kg sugar and 3 mL vinegar/L water). Consequently, three formulations were proposed: 1) 40% pulp, 20% alcohol (96° proof) and 40% syrup; 2) 40% pulp, 22% alcohol (96° proof) and 38% syrup; and 3) 40% pulp, 25% alcohol 96° (proof) and 35% syrup. Color parameters (luminosity, hue and chroma), TSS, pH, density and viscosity were evaluated, and finally an affective and a descriptive test were carried out. The greatest luminosity and chroma values 35% and 30.8 respectively were showed in liquor with formulation 1; the best (redder) hue angle values (49°) were found in liquors made with formulations 1 and 3. The greatest values of TSS concentration, density and viscosity were observed in liquor with formulation 1 (55.5 °Bx, 1.13 $g \cdot cm^{-3}$ and 24.9 $kg \cdot m^{-1} \cdot s^{-1}$, respectively), the lowest pH was detected in liquor with formulation 3 (4.6). All three formulations were equally preferred regardless of the different physicochemical characteristics mentioned above; however, the descriptive analysis showed that all three formulations had different characteristics; liquor with formulation 1 was sweet, with a pitaya and almond flavor, and a sweet aroma. Liquor with formulation 3 was sourer, more astringent, and presented a more intense alcohol flavor and aroma. Liquors with formulations 2 exhibited intermediate attributes intensities. Although the almond aroma and viscosity were detected in all liquors, these descriptors were not relevant for the preference test. Formulation 1 presented a profile with the greatest values for positive attributes and the least for the negative ones, after 6 months storage.

Keywords: Cactus, stability, alcohol, sensorial

ELABORATION OF LIPSTICK WITH CACTUS PEAR SEED OIL AND COCHINEAL CARMINE

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The cactus pear oil, is obtained from the seeds of the fruit of cactus pear, however in Mexico has not had a major impact on society even though it has great benefits as antioxidant, vitamin E and agents that protect against free radicals among other properties more. On the other hand cochineal is an insect that produces a red pigment, which is used for dyeing textiles, pharmaceuticals, food and cosmetics. The objective of this study was to develop a lipstick with cactus pear seed oil and carmine. For the formulation was employed waxes and carmine, was to evaluated two types of oil: castor oil and cactus pear fruit oil seed; for each lipstick three replicates were performed; also the physicochemical characteristics: appearance, texture, odor, density, melting point and color (CIELab spectrum). All the lipsticks, it had appearance, texture and odor similar. With respect to the density and melting point, the lipstick made from cactus pear seed oil, it had the lowest values (1.19g/ml±0.02; 63.5°C±0.50), in comparison with castor oil, the density and melting point found to be higher (1.83g/ml±0.01; 67.66°C±0.58); also was observed changes color based on the oils used, the deep red was obtained with prickly pear seed oil and tenuous with castor oil. It was concluded that the cactus pear seed oil can be used in the preparation of lipstick with additional value as a product with antioxidant properties.

Keywords: Cactus pear, seed, oil, lipstick, cochineal

PHENOLIC COMPOUNDS IN FRUIT-PRODUCING CACTI

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The positive relation between increasing the daily consumption of fruit and vegetables rich in natural bioactive compounds and reducing risks of different degenerative diseases has been widely reported. Manifold studies attributed most of these positive impacts to the dietary phenolic compounds and in particular flavonoids. Therefore, public and scientific interest has been increasingly turned to the health impacts gained by increasing the daily intake of the dietary phenolic compounds. The dietary phenolic compounds refer to a wide range of substances intensively occurring in different plant tissues. Both phenolic acids and flavonoids are the major groups. The potent antioxidant activity and health benefits of phenolic acids and flavonoids are widely reported. Information about polyphenols in the different plant parts and tissues of the fruit-producing cacti (*Opuntia* spp., *Cereus* spp. and *Hylocereus* spp.) widely varies in literature data with a kind of inconsistency. However, an example of predominant phenolic acids found in cacti tissues is ferulic acid. Regarding flavonoids, with an exception of the fruit's pulp, flavonols are the predominant substances (i.e. isorhamentin glycosides) found in different cacti tissues. Besides pharmacological properties and bioactivities of the flavonoids, there are different recent studies reporting the use of flavonoids as markers for authentication or detecting adulteration of different processed fruit and vegetable products. As a result, this present contribution aims at reviewing the occurrence and content of phenolic content following environmental stresses on these promising cacti increasingly cultivated in the arid and semi-arid regions worldwide. Besides concluding their probable positive health impacts, this contribution pays an attention towards the available evidences about the stability of the phenolic compounds and the probable exploiting of flavonols in authentication of cactus processed foods.

Keywords: Fruit-producing cacti, phenolic acid, flavonoid, occurrence, authenticity

THE RHEOLOGICAL CHARACTERIZATION OF RECONSTITUTED FREEZE-DRIED MUCILAGE FOR APPLICATION IN NUTRACEUTICAL FOOD PRODUCTS

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Mucilage extractions could exert therapeutic, nutritional and functional advantages if applied as a functional ingredient in innovative nutraceutical food products. Mucilage has unique flow behaviour that should be fully understood in order to predict its behaviour during processing, preparation and consumption. Extraction and drying of mucilage from mature cladodes from eight cultivars, harvested in winter (July 2014) involved a patented procedure of *slicing cladodes, microwave cooking, macerating, centrifuging at 8000 rpm for 15 min and freeze-drying at* -60 °C for 72 hours. The viscosity of 5 % reconstituted freeze-dried mucilage, was investigated at 50 rpm after 60 s using a rotational RV Brookfield Viscometer (disk spindle 6). Flow behaviour was determined by manipulating the concentration (4, 6, 8, 10, 12 and 14 %), controlled rate (5, 10, 20, 50 and 100 rpm), time intervals (15, 30, 60, 90 and 120 s), temperature (5, 10, 20, 40, 60 and 80 °C), pH (>11, 9-10, 8-9, 7-8, 5-6, 4-5, 3-4 and 1-2) and ionic strength (NaCl, $CaCl_2$, $FeCl_3$ at 0.1, 1, 10, 100 and 1000 mM) of reconstituted mucilage. The eight different cultivars had different viscosities between 106 and 328 cP. Increased mucilage concentration caused increases in viscosity (400-1200 cP). In the rate and time interval tests, mucilage *showed non-Newtonian, pseudoplastic tendencies but no rheopectic behaviour, thus with increasing rates viscosities decreased from 942.9 to 131 cP, while it remained unchanged as time lapsed.* Temperature influenced viscosities as it increased at colder temperatures (203-418 cP) and decreased at warmer temperatures (67-120 cP). Mucilage exhibited dynamic yield points (0.22-0.74 % torque), indicating the force needed for it to start moving. In alkaline regions (>11-8) viscosities increased (360-2600 cP) and decreased (60-1000 cP) in acidic (6-1) regions. Monovalent ions had little (982.5-585 cP), divalent more (997.5-530 cP) and trivalent the most (1010-480 cP) influence on viscosity. The properties of the innovative developed products, environmental conditions and handling could have adverse effects on the textural properties of mucilage-containing food products which could influence the processing, packaging and use. Mucilage should be selected carefully to complement the properties of food products.

Keywords: *Opuntia ficus-indica*, cactus pear cladodes, mucilage, viscosity, flow behaviour, nutraceutical products

CACTUS PEAR MUCILAGE: FUNCTIONAL PROPERTIES

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The demand for functional foods is ever expanding as more and more consumers are getting obese or allergic to dairy, eggs or gluten. In the pursuit of fat and allergen-free food, concerned consumers are choosing dairy-free, fat-free and egg-free products. Mucilage is a hydrocolloid gum, extracted from cactus pear cladodes, that contains water-soluble fibre, protein, minerals and antioxidants. Mucilage has been proven to successfully replace substantial portions of fat, eggs and dairy in food products without affecting the textural quality of the products. Investigation of the functional properties in the dehydrated powder of four cultivars (*Opuntia ficus-indica* Algerian, Morado, Gymno-Carpo and *O. Robusta* Robusta) was undertaken as it was important to understand and predict the hydrophilic/hydrophobic tendencies. It was investigated by dissolving freeze-dried powder in water or oil and after centrifugation and decantation, the solubility-, holding- and absorption capacity was determined. Emulsification was determined by homogenizing freeze-dried powder with equal amounts of water and oil. The Kjeldahl method (AOAC, 2000) was used to determine the crude protein content. Freeze-dried mucilage powders had very high solubility index, water- and oil absorption as well as water- and oil holding capacities. It displayed very high emulsification and emulsion stability as the oil and water was immediately and completely emulsified. Higher viscosity mucilage displayed more effective hydrophobic/hydrophilic association and had more successful fat-replacement and stabilization properties. As protein content is indispensable for true emulsifying features, *O. Robusta* Robusta was the most suitable cultivar as it demonstrated the highest viscosity mucilage along with twice the protein content compared to other cultivars. Fat-, egg- or dairy replacement products had good textural quality and they were described as creamy, smooth and the mouthfeel were highly acceptable. Mucilage is a natural, health improving product that the food industry could benefit from. It showed strong potential as a functional ingredient.

Keywords: *Opuntia ficus-indica, O. robusta*, solubility, emulsification, holding capacity

CHARACTERIZATION OF CHILEAN CONSUMERS' ATTITUDES AND PREFERENCES TOWARD DIFFERENT CACTUS PEAR COLORS

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The objective of this research was to characterize the preferences of Chilean consumers based on their attitudes toward different colored cactus pear ecotypes (*Opuntia* spp.). To accomplish the above mentioned objective, a survey with closed questions was designed (including different topics as sensory characteristics) and applied to 80 consumers (males and females between 15 to 74 years old). Six colored cactus pear ecotypes (Purple, Green, Yellow, Dark Orange, Pale Orange, Red) were tasted, and the opinions about different sensory attributes were registered. The cactus pear fruits were presented as pieces for tasting and maintained at temperature between 8 and 10 °C. The 6 ecotypes were placed in each booth simultaneously, whole and halved; therefore the peel thickness could be appreciated. Consumers observed the different external characteristics of the 6 ecotypes studied. The experiment was conducted in 2 legs associated with different harvesting time, in early February and March. Each consumer had to perform the external evaluation first and then taste each fruit, to avoid biases. The information was analyzed by ANOVA, factorial and cluster. The main results show that the Green and Yellow fruits were the most preferred from the point of view of taste, with 34.4 % and 41.2 % of preferences respectively, while the Purple and Dark Orange were the least accepted, with 26.9 % and 28.1 % of disapproval respectively. The appearance of the fruit from the first harvest obtained the highest acceptance values, where the Yellow cactus pear showed 31.2 % and Green cactus pear 30.0 % of preferences. For the second harvest, the Yellow cactus pear remained in the first place, but the Red cactus pear climbed to the second place. Three market segments have been identified, one of them where the people claim to be regular cactus pear consumers (47 % of the total) and have a positive attitude towards cactus pear, but especially for Yellow and Green ecotypes. This is in agreement with their favourable disposition toward the texture and juiciness of the fruit.

Keywords: *Opuntia* spp*, cactus pear,* preferences, segmentation

SHERBETS FROM YELLOW-ORANGE AND PURPLE CACTUS PEAR

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Ice-cream and sherbets are foods on the raise and could be an attractive alternative to add value to colored cactus pear. The objectives of this work were to formulate sherbets based on yellow-orange (YS) and purple (PS) cactus pear pulps and determine their chemical, physical and sensory characteristics. Four sherbet formulations were tested with different cactus pear pulp levels (25 %, 30 %, 35 % and 40 %) added to a base solution of water, sugar and agar-agar contents. The sherbets were made in a Gelataio Magnum Plus GC4000, SIMAC (Italy) ice maker and stored at -15±2 °C. Color parameters (L, a*, b*, C*, h_{ab}), betalains (indicaxanthin and betanin) by HPLC, antioxidant capacity (ORAC) as µm eq. Trolox/100g, overrun (%) and specific weight (g/mL) were determined. Quantitative Descriptive Analysis (QDA) was carried out with a Focus group that determined the sensory quality descriptor (color intensity, appearance, aroma intensity, cactus pear aroma, sweetness among others). Twelve trained judges determined quality attributes and a consumer's test with 60 people was carried out to determine acceptability. A non-structured scale (0-15 cm) was used for quality and acceptability tests. A completely randomized block design was applied to the sensory analysis. The results were analyzed by ANOVA ($p<0.5$ %) and Tukey's multiple comparison test. The best formulation for each type of sherbet was chosen according to quality and liking test, being 40 % and 35 % pulp added for yellow-orange (YS) and purple (PS) cactus pear pulp, respectively. The soluble solids were 15.83±0.32 and 15.93 ± 0.81 °Brix, for YS and PS, respectively. Indicaxanthin content was 44.28±1.67 mg/L for YS and betanin content 76.21±12.39 mg/L for PS. ORAC values were 51.5±4.2 and 56.6±11.9 as µm eq. Trolox/100g, for YS and PS, respectively. The overrun was 18.13 and 7.53 % for YS and PS, a lower value than commercial sherbets, probably due to the artisanal type elaboration which incorporates less air than industrial equipments. Color properties shows a*= 24.24±0.93 and h_{ab}=74.10±0.19 for YS and a*=52.20±2.20 and h_{ab}=30.42±0.57 for PS, in accordance with the visual color of each pulp. The acceptability of the sherbets was 9.35±2.97 and 9.01±3.07 for YS and PS, respectively, high values for any food product. Sherbets open a new alternative to process cactus pear taken advantage of the attractive color, high acceptability and bioactive compounds of this fruits.

Keywords: *Opuntia ficus-indica*, cactus pear sherbets, colored cactus pear

GUMMY CONFECTIONS FROM CACTUS PEAR: CHEMICAL CHARACTERISTICS, TEXTURE PROFILE AND SENSORY QUALITY

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Gummy confections made from purple cactus pear could be a new alternative for small farmers, because consumers are looking for safer, functional and attractive foods. The objective of this work was to evaluate the physico mechanical, chemical and sensory properties of purple cactus pear gummy confections (GC). The GC was prepared with purple cactus pear pulp (*Opuntia ficus-indica*), unflavored gelatin, sugar and water according to previous trials. The mechanical properties of GC were analyzed using a texture analyzer TA-XT plus through two different tests: Texture Profile Analysis (TPA) and punction. For TPA test, samples were compressed twice using 75-mm-diameter probe, and deformation was fixed at 70 %. The punction test consisted of a single puncture throughout the sample with a 2-mm-diameter probe. Soluble solids (°Brix), moisture, aw, color parameters (L, a*, b*, C* and h_{ab}), betalains by HPLC (mg betanin eq./100 g), total phenolic content (mg GAE/100 g), antioxidant capacity (ORAC) as µm eq Trolox/100g, were measured. A Focus group determined the sensory quality descriptors (color intensity, transparency, aroma intensity, cactus pear aroma, cooked fruit aroma, sweetness, cactus pear taste, hardness, gumminess) a non-structured scale (0-15) was used for these parameters and acceptability. The chemical and physical analyses were carried out in triplicate. The average force obtained from the puncture test was 1.36 N and 0.19 N/mm for elasticity, while the TPA test showed an average gumminess of 111, and an average hardness of 143 N. The gummy confections show a dark purple brilliant and attractive color (L=4.7±1.2, a*=26±4.9, b*=7.3±2.0, C*=27±5.2, h_{ab}=15±1.3), 2.3±0.02 mg betanin eq./100 g, 71.5±0.3 °Brix, 73±1.3 mg GAE/100 g, a high antioxidant capacity 1796 µm eq Trolox/100 g compared with similar foodstuffs, a moisture of 21.5±0.6% and aw=0.755±0.05, therefore the product could be classified as an intermediate moisture food. The trained panel described the gummies with a high intensity color (11), medium hardness (8), medium cactus pear aroma (7.4) and medium cactus pear flavor (8.5). This preliminary study shows high possibilities to produce this kind of products at small scale level being an alternative for little farmers involved in the production of cactus pear fruits.

Keywords: *Opuntia ficus-indica*, confectionery gels, purple cactus pear, texture, sensory characteristics.

Grant: Fondo de Innovación para la Competitividad (FIC) FIC-Arica y Parinacota. Código BIP 30209072-0.

BETACYANIN PROFILE OF *PILOSOCEREUS CATINGICOLA* (GÜRKE) BYLES & ROWLEY SUBSP. *SALVADORENSIS* (WERDERM.) ZAPPI (CACTACEAE)

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The cacti are important plant genetic resources of the Brazilian semiarid, with potential for the extraction of bioactive compounds. In this sense, the objective was to separate, quantify and characterize the chemical constituents of morphological parts of *Pilosocereus catingicola* (Gürke) Byles & Rowley subsp. *salvadorensis* (Werderm.) Zappi with occurrence in areas of *caatinga* in the Westland of Paraiba. We collected morphological parts of root, stem and fruit in the Arara, Areial and Boa Vista, PB. Physical and chemical characterization tests were made of fruit, phytochemical screening, extraction, quantification and qualification betalains. Fruits were freeze-dried Freeze LF 3000 Terroni®. The samples were then crushed and a rate of two grams was solubilized in a methanolic solution with sodium ascorbate in distilled water. The precipitation of the hydrocolloid was performed followed by filtering in Phenomenex® membrane. The quantification of antioxidant compounds was performed in absorption spectrophotometer Mertek® SP-870 (600 nm). The separation of the compounds was carried out by high performance liquid chromatography (RP-HPLC Agilent® 1200 system) coupled to a mass spectrum (MS) Agilent® 6520 by double QTOF MS ion spray (ESI) with a thermostated column (C18 Luna) and photodiode array detector. The fruits showed higher weights and lower pulp yields in V with predominantly red bark (mature) and VI with dark red bark maturation stages. The firmness values decreased with the maturation and increase in soluble solids. The maturity stage V was characterized as ideal for harvest of *facheiro* fruit according to its physical characteristic (weight) and physical and chemical characteristics as soluble solids and titratable acidity. The morphological parts of root and stem of *P. catingicola* subsp. *salvadorensis* showed presence of steroids, flavonoids and saponins and betalainic chromoalkaloids in the fruit. Betacynins are the alkaloids group with the highest expression in the fruit by betanin, decarboxy phyllocactin, iso-betanin, 17-decarboxy betanin, phyllocactin, 2-decarboxy-2,3-dehydrobetanin, iso-phyllocactin, 6'-O-malonyl-2-descarboxy-betanin, Unknown betacyanin, ap-phyllocactin, Betanin-6-O-(6''-O-trans-4-coumaroyl)-B-sophoroside and lampranthin II. The population of Arara yields more betaxatinas and distinguished from Areial and Boa Vista. The specimens express more betacyanins than betaxanthins. Apparently, these constituents are similar among the specimens, however variable along the environments as consequence the hydric and hydroregulation.

Keywords: Betalains, facheiro, semiarid

VARIABILITY OF PHENOLIC COMPOUNDS CONTENT AND FLAVONOID IN CACTUS PEAR VARIETIES OF *OPUNTIA* AND *NOPALEA* GENRES

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Cactus pear is the most cultivated forage in the Northeast Brazilian semiarid region that contributes significantly to the feeding of livestock, especially in times of drought. Research has revealed that cactus pear has a high content of various chemical compounds considered natural herbal remedies that can add value to their products. Many factors affect the chemical composition of plants: soil and weather conditions, plant age, varieties, species, etc. The objective of this study were to determine the phenolic compounds content and flavonoids in cactus pear varieties of *Opuntia* and *Nopalea* genera grown in the semiarid region of Brazil in two collection periods (dry and rainy). In the research, three year old cladodes from these varieties of cactus pear were used. Cactus pear cladodes were collected in the Experimental Station of the Agronomic Institute of Pernambuco (IPA), located in the city of Arcoverde, State of Pernambuco, Brazil. The materials used were: IPA-100003 (*O. ficus indica*), IPA-200016 (*O. stricta*), IPA-200008 (*O. atropes*), IPA-200149 (*O. larreri*), IPA-100004 (*N. cochenillifera*), IPA-200021 (*N. cochenillifera*) and IPA-200205 (*N. cochenillifera*). The phenolic compounds content and flavonoids was determined in the raw ethanol extracts, by spectrophotometric method. The content of phenolic compounds ranged from 1.24 mg GAE g^{-1} DM (IPA-200205) to 2,85 mg GAE g^{-1} DM (IPA-100003) (dry season); and 1.99 mg GAE g^{-1} (IPA-200205) to 5.41 mg GAE g^{-1} DM (IPA-200021) (rainy season). In the rainy season the content of phenolic compounds among the varieties was superior to the dry period values, ranging from 44 % (IPA-100004) to 157 % (IPA-200008). The flavonoids content ranged from 1.53 mg QE g^{-1} DM (IPA-200205) to 3.02 mg QE g^{-1} DM (IPA-100003) (dry season); and 0.90 mg QE g^{-1} DM (IPA-200016) to 3.43 mg QE g^{-1} DM (IPA-200008) (rainy season). The content of flavonoids among the varieties was higher in the dry season, except for IPA-200008 and IPA-100004 which had higher values in the rainy season. This variation was 7.5 % (IPA-100004) to 51.4 % (IPA-200149). The content of phenolic compounds in cactus pear cladodes of both genres vary among the botanical varieties studied and between periods of collecting material.

Keywords: Food analysis, forage, phytochemicals, secondary metabolites, semiarid

ENCAPSULATED CACTUS PIGMENTS AS FOOD COLORANTS. STABILITY AND USES IN A FOOD MODEL SYSTEM

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Opuntia fruits are good sources of betacyanins and betaxanthins which can be used as natural red-purple and orange-yellow food colorants, respectively. Pigment encapsulation has been assayed to improve its stability. In this work, encapsulated betacyanins (EBC) and betaxanthins (EBX) were prepared by spray drying (SD) and ionic gelation (IG), using maltodextrin combined with cladodes mucilage and calcium alginate matrix, respectively. The encapsulated pigments were characterized; besides, the storage stability and functional properties of EBC and EBX were compared, being the latter more stable than the red-purple pigments. Degradation reaction of encapsulated betalains followed pseudo-first order for SD kinetic and first-order for IG one. Encapsulated pigments (EBC and EBX) were successfully applied in two different food model systems: yogurt (SD microcapsules) and jelly gum (IG dry capsules). The pH value of yogurt (pH 4.3) and low moisture content of jelly gum (a_w 0.40) were important parameters in the microbiological stability during the storage. Color is the first criterion that is used in the acceptance or rejection of a product by consumers, and it is an important attribute of quality for the food industry. Model food systems presented a vivid red-purple and orange color after one month of storage under refrigeration (4°C). Color changes in these products were evaluated between the samples at the beginning and after 30 days of storage, showing the stability of the betalains in the food model systems. The encapsulated pigments those prepared by SD and by IG are both promising functional additives which can be used as natural colorants for healthy foods taking into account the well reported medicinal properties of betalains.

Keywords: betalains, temperature, relative humidity, yogurt, jelly gum.

COMPARATIVE STUDY OF THE ENCAPSULATION OF BETAXANTHINS (*OPUNTIA MEGACANTHA*) BY SPRAY DRYING AND IONIC GELATION

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Betalains obtained from cactus pear fruits can be used as food colorants to replace artificial ones; being pigment stability one of the technological issues to be solved. Two different encapsulation technologies, spray drying (SD) and ionic gelation (IG), were evaluated as stabilization strategies for betaxanthins (BX) extracted from orange pulp fruits of *Opuntia megacantha.* Maltodextrin combined with cladode mucilage was used as SD encapsulating agent; while, calcium alginate was assayed as IG matrix comparing with freeze-dried fruit pulp (CP) as control. SD microcapsules and IG capsules containing cactus BX were prepared and characterized by analyzing total pigment contents and composition (HPLC-MS) as well as color parameters (CIELab). Encapsulation efficiency (%EE) was measured. Moisture content, water activity (a_w), particle sizes and morphology, glass transition temperature, thermogravimetric properties and total dietary fiber contents were also evaluated in both types of capsules. Besides, radical scavenging activity retention and stability of the encapsulated pigments under different storage temperatures and relative humidities were studied. Results showed that the encapsulation technique, the encapsulating agent concentration and the BX/encapsulating agent ratio strongly influenced the particle properties. The antioxidant capacity was proportional to betalain contents in the capsules. A higher dietary fiber content was found in the SD and IG capsules due to the presence of mucilage and alginate in the matrix, respectively, than CP. The best results in terms of BX stabilization were obtained for SD capsules, although both encapsulation techniques led to improved pigment stability, especially under dry conditions in contrast to CP. The hydrolysis pathway was the main degradation mechanism and betalamic acid was the major product formed after storage. Encapsulated BX has the potential to be used as natural pigments, soluble in water, with functional properties for the food industry.

Keywords: betalains, dietary fiber, antiradical activity, storage.

BIOACTIVE COMPOUNDS FROM *OPUNTIA FICUS-INDICA* IN NANOTECHNOLOGY: BIOSYNTHESIS OF SILVER NANOPARTICLES AND APPLICATIONS

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Nowadays, significant progress is made worldwide to scientifically demonstrate the functional and medicinal properties of cactus. Thus, cacti are considered an important source of bioactive substances and excellent candidates for food and pharmaceutical industries.

There is a growing scientific interest on nanoparticles and mainly of silver nanoparticles (AgNPs) to develop different products. AgNPs possess unique properties, such as high electrical conductivity, chemical stability, catalytic and antimicrobial activity. Traditionally, AgNPs have been synthesized *via* physical and chemical procedures that often use toxic materials. Recently, biosynthetic methods using microorganisms or plant extracts have emerged as an attractive alternative based on an environment-friendly green chemistry.

In this scenario, and regarding its composition in betalains, polyphenols, mucilage, and other specific bioactive compounds, cactus cladodes and fruits appear to be promising candidates as source of phytochemicals responsible for the reduction of Ag^{+} ions and stabilization of AgNPs. Thus, a simple, economic and efficient eco-friendly method for the biosynthesis of stable, monodisperse silver nanoparticles (AgNPs) using *Opuntia ficus-indica* cladode or fruit extracts is presented. Different reaction parameters (concentration of plant extract, substrate concentration, pH, temperature and reaction time) were optimized to synthesize AgNPs with controlled properties. Water was used as the environment benign reaction medium and plant metabolites as reducing and capping agent, making the process ecofriendly. AgNPs synthesis was confirmed by UV-vis spectroscopy and nanoparticles were characterized by transmission electron microscopy displaying spherical and pseudospherical morphology. The *in vitro* antimicrobial efficacy of AgNPs against representative Gram-positive and Gram-negative bacteria, was also evaluated showing antibacterial activity against clinical strains of *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* at picomolar concentration levels. In addition, a mechanistic study of the catalytic activity of biosynthesized AgNPs indicated that they can act as a redox catalyst in the methylene blue dye degradation. This work reports a green method for the synthesis of AgNPs using *Opuntia ficus-indica* extracts which act as both reducing and capping agent. These biosynthesized AgNPs showed that can be applied for antimicrobial strategies as well as environmental catalysts.

Keywords: Green synthesis, Silver nanoparticles, Plant extracts, Antioxidants

EFFECT OF FERMENTATION ON THE BIOACTIVE COMPOUND COMPOSITION AND ANTIOXIDANT POTENTIAL OF *OPUNTIA SP*. FRUIT JUICES

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The effect of fermentation of fruit juices of two types of *Opuntia sp.* (purple and green pulp fruits) on bioactive compounds and antioxidant potential was evaluated. The fermentation was performed with previously isolated yeast from naturally fermented juice of *Opuntia sp*. fruits. Ethanol tolerance of yeast to different concentrations of fortified wine (10-12-15 % v/v) was evaluated for 7 days at 28 °C, sealed with vaspar plug. Yeast previously activated for 48 hours at 30 °C in potato dextrose broth (PG) broth was inoculated at 0.2 % v/v of pasteurized juice in a 125 mL Erlenmeyer flask. Thereafter, it was incubated for 5 days at 28 °C. Total soluble solids (TSS), pigment (betaxanthins and betacyanins) concentrations, phenolic contents and antioxidant properties were determined at the beginning and at the end of fermentation process. Yeast showed excellent growth in the fortified musts at 10 and 12 % v/v but it was scarce at 15 % v/v. The CO_2 pressure generated during fermentation indicated that the strain was able to grow in the alcoholic medium. The phenolic content was higher in the purple fruit juice than in the green one (2.29 and 1.90 mg gallic acid/g of juice, respectively). The same was the case for the antioxidant capacity. *Opuntia* juice fermentation slightly increased the phenolic content as well as the antiradical capacity. TSS reduced due to fermentation from 15 to 12° Brix in the green juice and from 13 to 9 °Brix in the purple one. Initially, the betacyanin contents were 23.7 and 116.0 mg betanin/g juice and betaxanthin contents were 6.4 and 71.1 mg/g juice for the green variety and the purple one, respectively. After fermentation, betacyanin contents were 18.1 and 113.3 mg/g juice and betaxanthin contents were 4.9 and 78.7 mg/g juice, for green and purple variety, respectively. Fermentation did not significantly affect the bioactive compound contents and properties of *Opuntia* fruit juices.

Keywords: Yeast, betalains, alcoholic beverages.

MICROENCAPSULATION OF COLORANTS FROM CACTUS FRUIT PEEL WITH MUCILAGE AND CELLULOSE MICROFIBERS FROM CLADODES

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The capability of cellulose microfiber and mucilage from *Opuntia ficus-indica* as microencapsulating agents to stabilize the pigment of the peel was evaluated. The purified cellulose was sonicated to maximum power for 1 h to obtain the microfibers and they were characterized in their microstructure changes occurring during the obtaining process. The peel of red cactus fruit was cut in pieces (1 x 1 cm) and mixed with water, then they were shacked 30 min, ground and centrifugated. The supernatant was concentrated by lyophilization and it was characterized chemical and physically. The mucilage was obtained from the pad after been peeled, ground and blanching by centrifugation and drying with ethanol. Emulsions with the three components were prepared, so that the amount of cellulose was varied in different proportions (10, 15 and 20 % based on the mucilage quantity). The red pigments were microencapsulated by freeze-drying. Qualitative tests were performed: color, solubility in water, milk and organic solvents and the rate of disintegration of the capsule in water. This work evidenced that the freeze-drying process is favorable for microencapsulation of betalains from cactus fruit peel since the encapsulation efficiency was 83.45% for the sample with lower content fiber. Regarding the color, by increasing the content of cellulose microfibers in the matrix of capsules L and a* values increased while b* decreased. The solubility of the microcapsules in aqueous media decrease while increase the proportion of cellulose microfibers. These microencapsulates are promising functional additive to be used as natural colorant in the food industry.

Keywords: Betalains, microfibers, sonication

THE NOPAL AS A GELLING AGENT IN CONFECTIONERY PRODUCTS (GUMMIES)

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The objective was to develop a gelatinous gummy (gelled product), with added natural nopal and pineapple pulp, as well as soluble fiber (inulin), with the end goal of satisfying the consumer's need to meet the recommended daily fiber intake while also reducing the caloric content of the gummy. Nopal is a food source in Mexico. This vegetable has high moisture content. Its fiber content is very important as this is greater than 20 % of its dehydrated weight with a soluble to insoluble ratio of 30:70. This allows for it use in the development of fiber-rich foods, thus being a great candidate for its use in the "sugar-free" confectionary industry. Given that its technological properties are comparable to other biopolymers used to manufacture gelled and aired products, it would be a viable ingredient in this industry. Four gummy experimental formulations were made. The first one consisted of 8 % nopal pulp, 24 % pineapple pulp, and 7% inulin; resulting in a strong and cohesive gel. The inulin concentration was reduced to 4 % for the second formulation; a gel with less cohesiveness was obtained. The following formulations were based on the first two but with lower fruit pulp content (5.44 % nopal and 8.66 % pineapple), and using two different final cooking temperatures. This resulted in a much softer texture. The last two variants of the product were evaluated for its physical properties with a commission of 30 consumers judges. Two distinct tests were performed: a test that analyses properties that the consumers distinguish and another one that tests general acceptance of the products qualities. As for the taste, both gummies were found to have a similar value. Regarding the texture, 82 °Brix obtained higher rating than 84. These assessments showed that between the two variants, the 82 °Brix gummy was preferred.

Keywords: gummies, fiber, nopal, confectionary industry, reduced calories

SELECTED CHARACTERISTICS OF *OPUNTIA DILLENII* CACTUS BEVERAGE AND IMPACT OF THERMAL AND NON-THERMAL PASTEURIZATION

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Opuntia ficus-indica fruit is the most common and consumed cactus fruit worldwide, but its juice exhibits a comparatively high pH value (6.0–6.2) and TSS (11.5–13.5 ºBrix) which might require an intensive thermal treatment for preservation. This might impact negatively some quality attributes. In contrast, some other *Opuntia* cactus fruits might deserve more attention. One of them is *Opuntia dillenii* cactus fruit (in the past misleadingly described as *Opuntia macrorhiza*), which exhibits desirable technological characteristics of a comparatively low pH value (≤ 3.7) and a moderate TSS value (≤10.5 ºBrix). This places the fruit or its corresponding products in the category of low acid foods (<4.5). Moreover, *O. dillenii* fruit or juice exhibits a comparatively higher antioxidant activity which is due to its high content of vitamin C (approx. 55–60 mg/100mL), betacyanins and phenolic compounds. The present contribution aimed to investigate the impact of the pulsed electric field (PEF) and high hydrostatic pressure (HHP) on the microbial safety, physicochemical and rheological characteristics and the predominant bioactive substances of the *O. dillenii* beverage comparing to a conventional thermal pasteurization. The mashed fruits were macerated using commercial enzymes, pressed and then diluted to reduce viscosity before pasteurization. Results showed that all pasteurization technologies used in the present study caused a high reduction in microorganisms found in control juice to <10 CFU/mL. No significant change happened in the physicochemical or rheological characteristics of the beverages. While thermal pasteurization resulted in a significant reduction of approx. 22 % in the vitamin C, the non-thermal pasteurization resulted in a high better retention. Total phenoic content (including isorhamnetin 3-*O*-rutinoside as predominant flavonol) was slightly increased in all beverages. A slight reduction in total content of betacyanins was observed. The electron paramagnetic resonance (EPR) spectroscopy showed that PEF and HHP pasteurized beverages exhibited antioxidant activity quite close to that of fresh beverage, while a non-significant reduction observed in the antioxidant activity of thermal pasteurized beverage. However, further results showed that rheological characteristics and intensive color of *O. dillenii* juice could be successfully exploited as substitute (≤ 25 %) in production of strawberry beverages.

Keywords: *Opuntia dillenii* beverage, pulsed electric field, high hydrostatic pressure, pasteurization, ascorbic acid.

COLORING FOODS FROM YELLOW-ORANGE CACTUS PEAR

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Food coloring is a concept developed by the UE in order to highlight the importance of natural colorants and their safe and healthy properties. The aim of this study was to obtain coloring foods from yellow-orange cactus pear (*Opuntia ficus-indica)* pulp by vacuum concentration and freeze drying. Concentrate coloring food was obtained in a Büchi rotavapor (30 °C, 17 mbar) up to 45±1 °Brix and freeze dried powders in a Shin BioBase FD5508 equipment, using maltodextrin as carrier in 1:1 ratio (pulp soluble solids: maltodextrin). The products were characterized and tested their stability in storage at room temperature (23±2 °C) during 30 days. Color parameters (L, a*, b*, C* and h°) were measured in a Hunter Lab Ultra Scan Pro and total color change (ΔE*) was also calculated. Betaxanthins were determined by HPLC. Both food colorants were tested in a soft-drink model. Betaxanthins and color degradation for soft-drinks were evaluated during storage at 4±1 °C. Betaxanthins contents were 256.53±4.81 mg IE/kg and 263.76±5.21 mg IE/kg in the concentrate colorant and freeze dried powders, respectively. A visible color change respect to fresh pulp in the concentrate and powders was observed, being of 39.2 and 43.1, respectively. In the concentrate the betaxanthins decrease was not significant during storage, but a perceptible color change (ΔE*=15.0) was detected. However, betaxanthins content and color parameters showed not significant changes in freeze dried colorant during the storage (ΔE*=5.6). Nevertheless, both food colorings showed good stability during storage at room temperature. Regarding the performance as colorants in soft-drinks model, betaxanthins degradation was significant when both colorants were applied. Degradation rate constants for soft-drinks were $k=2.0x10^{-1}\pm6.0x10^{-3}$ $days^{-1}$ and $k=1.57x10^{-1}\pm8.0x10^{-3}$ $days^{-1}$, for freeze dried and concentrate colorant, respectively, being significantly different. Total color changes of 10.7 (soft-drink with concentrate) and 15.7 (soft-drink with freeze dried) were reached at the end of the storage. Results obtained indicate that powders could be used for coloring instantaneous food. The concentrate shows a potential as coloring food stored at low temperatures and applied in chilled matrices as yogurt or ice creams.

Keywords: *Opuntia ficus-indica,* betaxanthins, colorants concentrate, freeze-dried.

BETALAIN STABILITY IN DRY MIXES FOR INSTANT BEVERAGES

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actus pear betalains are natural pigments with potential as colorant in foods. However, their stability is one of the most important aspects to be considered for the success in food application. The aim of this work was to study the stability of betalains microparticles from purple cactus pear in dry mixes for instant beverages.

Purple cactus pear pulp (CP) and an ultrafiltered extract (UF) were used to prepare the microparticles. The pulp was obtained from peeled cactus pear in a screw press (2 mm sieve) and the UF extract in a multi tubular ceramic membrane (0.64 bar). The microparticles were obtained by spray drying in a Büchi 290 equipment. Capsul® (C) and K-4484 (K) were used as encapsulating agents. Four systems of microparticles were obtained: CP-C, CP-K, UF-C and UF-K.

The ingredients used for the formulation of dry mixes were: sucrose (86 g/L), microparticles (12.5 g/L), raspberry flavour (1 g/L), citric acid (1.5 g/L), potassium sorbate (0.18 g/L), sodium benzoate (0.14 g/L) and ascorbic acid (0.02 g/L). The method “mix in bag” was used to blend the ingredients, defining the time needed to have a homogenous blend. To determine the stability of betalains of the dry mixes, stored at 30 °C during 20 weeks in darkness, samples every 7 days were withdraw to determine the betacyanins and betaxanthins content. The retention (%) of betalains, solubility in water and pH of the mixes were determined.

The mixing time for the best blend was 12 min; the betacyanins and betaxanthins contents did not show significant differences among blends ranging 0.027-0.032 mg BE g^{-1} for betacyanins and 0.012-0.014 mg IE g^{-1} for betaxanthins. The solubility for all the mixes was up to 99 % and the pH for the reconstituted mixes was up to 2.7.

The retention of betacyanins and betaxanthins in the dry mixes reached values between 69-94% and 75-95%, respectively. The dry mix with UF-K microparticles had a betacyanins retention percentage significantly higher than P-K (extract effect) and UF-C (encapsulating agent effect). The high retention percentage of all the dry mixes studied shows that this type of product could be used to prepare instant beverages or syrups for confectionery purposes.

Keywords: Microparticles, betalains stability, cactus pear, dry mixes.

Grant: Project FONDECYT N° 1110126

IMPROVEMENT OF OXIDATIVE STRESS TOLERANCE IN *SACCHAROMYCES CEREVISIAE* BY FERMENTED CACTUS PEAR JUICE SUPPLEMENTATION

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Consumption of cactus pears from *Opuntia ficus-indica* is strongly recommended due their health-promoting features. However, long-term storage represents the main drawback to the commercialization of this fruit. The development of a fermented cactus pear juice (F-CPJ) using autochthonous lactic acid bacteria constitutes an important biotechnology for the exploit of this fruit. The aim of this study was to evaluate the effect of F-CPJ with autochthonous *Lactobacillus plantarum* S-811 on oxidative stress tolerance of *Saccharomyces cerevisiae. S. cerevisiae* is a fast-growing and easy to grow eukaryotic organism and is an excellent model for evaluating in a living organism the protective effect against oxidative stress. To evaluate the antioxidant response induced by CPJ and F-CPJ, cultures of *S. cerevisiae* were incubated with the juices (amounts equivalent to 50, 250 and 500 mg/L of phenolics) during 18 h at 28 °C. Cells were then exposed to sub-lethal oxidative stress, using 0.5 or 4 mM H_2O_2. After stress treatments, cells were cultured in YPD medium and incubated for 18 h at 28 °C. To evaluate the oxidant effect in each culture, growth-ratio curves (GRC) and effect curves (EC) were constructed as follows: RC = quotient between the growth curve (GC) of the culture exposed to oxidant and the GC of the non-exposed culture; EC = GRC for the culture pre-incubated with the juice was divided by the GRC for the culture pre-incubated without juice. Against a final concentration of 0.5 mM H_2O_2 there was not observed a significant protective effect by any of the evaluated juices. However, against 4 mM H_2O_2, CPJ and F-CPJ showed a significant protective effect, that was much higher with the F-CPJ (up to 15 times protection) than CPJ (up to 4 times protection). These results suggest that F-CPJ with *L. plantarum* S-811 could be a suitable choice for the development of a CPJ with improved functional properties.

Keywords: Oxidative stress, *Lactobacillus plantarum* S-811, *Saccharomyces cerevisiae. S. cerevisiae*

PREDICTING THE IMPACT OF CLIMATE CHANGE ON FUTURE CACTUS AND COCHINEAL DISTRIBUTION IN TIGRAY, ETHIOPIA

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Climate change brings higher temperatures, altered precipitation and increase level of atmospheric carbon dioxide. It has strong links with poverty and hunger. To reduce the problem, climate adaptation and resilience mechanisms are better solutions. Resilience and adaptation activates are related with selection of drought tolerant plant species as cactus and beneficial insects as cochineal. The study takes places in Tigray, Northern Ethiopia. In this study, the species occurrence (presence) sites were considered. The collected data was analyzed through maximum entropy model (MAXENT 3.3.3k) and R-software. They were predicted based on General circulation model five (GCM 5) called Climate Community System Model version-4 (CCSM4) for three time slices (Current, 2010-2039, 2040-2069, 2070-2099) under two Representative Concentration Pathway (RCPs 4.5 and 8.5). Mean temperature of the study area will be increased of 1.69 °C, 2.57 °C and 3.51 °C during 2010-2039, 2040-2069 and 2070-2099 respectively when compared with current. In addition, future projections of precipitation are more complex to disentangle. Thus temperature and precipitation variation will affect cactus and cochineal distributions. Most suitable areas of the species are with a mean temperature from 18 °C to 26 °C with annual rainfall ranging from 220-600 mm. Due to these environmental factors, the species are suitable in Southern, Southeastern, Eastern zones and in some part of the Central (Ahferom Woreda) zones of the region at recent and future time. Climate change effect will be not significant. Most suitable areas for cochineal are with mean annual temperature ranging from 6 °C up to 24 °C with annual rainfall ranging from 250-450 mm. And 91 % of cochineal distribution depends on cactus presence. Only 9 % will be affect with climate parameter. This also does not affect with climate change rather it spreads in the future. While if there is no management of cochineal as in the studied area it will risky for cactus survival. It became more risk in high emission scenarios of the future time slices (2010-2099). In addition, coupled effect of climate change and cochineal would affect the cactus in 2050 (RCP 4.5), 2050 (RCP 8.5), 2070 (RCP 4.5) and 2070 (RCP 8.5) by 67 %, 74 %, 56.4 % and 95.67 % respectively. The study recommends well designed management strategies to ensure cactus survival as well as its ecological, economic and social benefits.

Keywords: Climate change, Cactus, Cochineal, Maxent, Representative Concentration Pathway (RCP)

PREPARATION AND METHOD OF COMPOSITION OF HERBAL *BIOPESTICIDE* FOR THE MANAGEMENT OF COCHINEAL INSECT OF CACTUS IN TIGRAY, ETHIOPIA

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Cactus (*Opuntia ficus-indi*ca) is grown mainly in the eastern & southern areas of Tigray and the fruit is locally known by the vernacular name "*Beles*". It is the livelihood of people in some districts of Tigray and used as livestock feed. However, currently the plant is suffering from the attack of a cochineal (*Dactylopius coccus* C.) insect pest. The *cochineal insect* is one of the potentially damaging pests which grow and reproduce on cactus cladodes. The insect was introduced from South Africa to Tigray region in April 2003 without Pest Risk Analysis for safety. Accordingly the insect was experimentally released at different areas in Tigray. Recently, a public request has emerged and forwarded to the regional government to totally eradicate the insect from the cactus plant.

An experimental study, complete randomized, was conducted from December 2014 to May 2015 to extract and develop an eco-friendly organic herbal Biopesticide against cochineal, to compare the efficacy of different experimental spray preparations, and to develop a protocol for the preparation of botanical Biopesticide for easy application.

An indoor experiment was conducted within ventilated room available within the compound of the Mekelle University and an outdoor experiment was performed at field under the natural environment. Locally available and scientifically recognized medicinal and/or toxic plants were used in the experiment. The experimental groups of cactus were sprayed with author's herbal pesticide preparation, salt solution, liquid soap, dimethoate and water as a control. Cochineal insects were counted before and after the application of the sprays and mortality rates were calculated. Best effective herbal recipe against cochineal was selected.

The Author's preparation spray was found to cause high insect mortality (98.6 % indoor & 99.2 % outdoor) as compared to the other experimental sprays. For an urgent intervention, the current product is in use by the local bureau of agriculture for cochineal management in the region.

Keywords: Cactus, Cochineal insect, Experimental study, Herbal Biopesticide, Mortality

THE WOUND HEALING EFFECT OF CACTUS PEAR OIL

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Despite the achievements in modern medicine, there is no effective treatment for deep second-degree burns till now.Thus, *Opuntia ficus-indica* (L.)(cactus pear) which has very prominent extracted seed oilis investigated as post burn care. Therefore, the purpose of this study was to assess the wound-healing effect of cactus pear oil on partial-thickness burns induced by fractional CO_2 laser (an innovative up-to-date technique) in rats.There have been no systematic studies carried out to evaluate their wound healing potential.

Thirty rats completing partial-thickness burns by fractional CO_2 laser were randomly divided into three groups. The burns were measured, photographed, and topically treated daily with saline solution, “CYTOL BASIC®” and cactus pear extracted oil (0.52 µL/mm^2 of oil) until day 7. The response to treatments was assessed by macroscopic, histological, and biochemical parameters.

Cactus pear oil-treated showed significant improvement over the control and reference groups, for both general wound appearance and crusting. On day 7, the cactus pear oil-treated showed a significant decrease in the woundarea (final area was equal to 0 cm^2), initial injured area was 2.2 cm^2, when compared to the control and reference groups (final area was equal to 1.49 and 0.85 cm^2, respectively). Histological assessment of the cactus pear oil–treated group revealed good healing proprieties compared with the other groups. The collagen content in cactus pear oil–treated group was found to be significantly greater (270.67 ± 7.4 mg/g tissue) than that in all other groups. Their healing effect was attributed to its linoleic, oleic acids, tocopherols and sterols contents. Antibacterial and antioxidant activities of cactus pear oil might also contribute to its wound healing effect.

A clinical*case* would be presented to show the *clinical* efficacy ofcactus pear oil on wound healing.

Our experiment has shown, for the first time, a scientific evidence of the efficiency of cactus pear oil on wound healing.

Keywords: Prickly pear oil; Healing effect; Laser burns, Rat

REARING COCHINEAL (*DACTYLOPIUS COCCUS* COSTA) UNDER COVERED STRUCTURAL TUBING CONDITIONS IN MEXICO

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Along 400 years, use of cochineal (*Dactylopius coccus* Costa) was an important activity in Mexico. Nonetheless, various social, economic and commercial factors caused it were not cultivated during many years. In Mexico, climatic issues and natural enemies limit cochineal production under field conditions as its use is performed in other countries. By this way, a semi-confined system to raise cochineal and to produce dry cochineal insects (yield) was designated. The system consists of the use of hanging cladodes, which allow an efficient use of space. The hanging cladodes are placed within 'nopalotecas' that is in spaces of 16, 0.8 and 2.4 m of, length, width and height, respectively. The 'nopalotecas' are then placed under a structure of galvanized metal tubes, which cover an area of 1326 m^2 (52 m length and 25.5 m width). The structural tubing has 6 m height and is covered by a plastic cover. Each structural tubing has an installed capacity of 315 000 hanging cladodes. Then, it is possible to obtain yearly mean yields of 2 ton having 21 % of carminic acid. Long-term (13 yr) research results have allowed establishment of 17 production units in several country regions. They are compelling evidence of its competitiveness and technical feasibility. However, several limitations have also been identified, which have also been taken into account for its continuous improvement. In addition, various aspects must be considered just before its establishment: high-initial investment, availability of efficient technical advisors and trainers, enough suppliers of cladodes or high-yielding areas to produce its own raw material, and an identified market offering cost-effective prices, among others. This system could be an interesting business opportunity because its results suggest the possibility of having 7 kg of dry cochineal insects per day at a cost <$15 US dollars, and can offer employment to 10 people during all the year.

Keywords: reared insects, hanging cladodes, carminic acid.

EVALUATION OF ANALGESIC, ANTI-INFLAMMATORY AND ANTI-ULCEROGENIC ACTIVITIES OF *OPUNTIA FICUS-INDICA* F. INERMIS CLADODES EXTRACT IN RATS

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The *Opuntia ficus-indica* f. inermis aqueous cladodes extract (OCE) was investigated for the first time for analgesic, anti-inflammatory and anti-ulcerogenic effects in rats. The analgesic effect of OCE was tested using acetic acid inducing writhing methods. The carrageenan induced rat paw oedema was used to study OCE anti-inflammatory effect and the anti-ulcerogenic activity of OCE was tested by acetic acid induced gastric-lesion. The OCE was administered in rats at oral doses of 200, 400 and 600 mg/kg body weight and compared with Indomethacin (10 mg/kg), Paracetamol (100 mg/kg) and Ranitidine (50 mg/kg) standard drugs. The results of the analgesic effect showed that OCE has significant reduction in pain ($p \leq 0.01$) against hote plate test i.e. 23.33 % (200 mg/kg body weight), 53.33 % (400 mg/Kg body weight) and 63.33 % (600 mg/kg body weight) as compared to the standard drug, Indomethacin, which was 73.33 %. In the case of the anti-inflammatory effect, the results showed that OCE reduced the paw edema at three, four and five hours after λ-carrageenan administration. In addition, for the anti-ulcerogenic effect of the OCE extract against acetic acid ingestion in stomach rat, the levels of MDA (malondialdehyde) were reduced and the activities of SOD (superoxide dismutase) and GPx (glutathione peroxidase) in stomach tissues were raised by OCE. These results suggested that OCE possessed anti-inflammatory activities and the anti-inflammatory mechanisms might be related to the increase of the levels of CAT (catalase) in inflamed tissues and the dicrease in the MDA level.

Keywords: Biological activity, Cladode, *Opuntia ficus-indica, Oxidative stress*

COCHINEAL INFESTATION, CONTROL MEASURES AND CURRENT STATUS IN TIGRAY CACTUS (*OPUNTIA FICUS INDICA*), ETHIOPIA

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Its importance to the arid environment made cactus famous in Tigray not only as source of food and feed crop but also source of income and used as soil and water conservation plant. It is as emergency food/feed as coping mechanism during drought periods. In some parts, it becomes a substitute of the staple diet demand of a family for four to five months serving as a life-saving crop to humans and animals. It comprises about 25% of rural households' income. Though it have been neglected in research and development for a long time, recently there are some development works like expansion of plantation, diversification of utilizations and establishment of research institutions and factories. However, currently the plant is suffering from the attack of an insect known as Cochineal (*Dactylopius coccus* Costa) since 2011 which was introduced for the purpose of carmine production. But the carmine production is banned by the government due to its rapid and vast infestation which damages the total cactus production. Infestation increased from 3.8 ha to 60000 ha in both wild and private plantations which indicate that the infestation is expanding at an alarming rate. According study made by FAO (2014) 90% of cactus growers' attitudes with cochineal problems remain ambivalent and confused and 45% may ask a displacement, because they strongly believe on cactus for survival. To save the remaining plantations a control strategy devised and organized which set holistic management strategies and categorized the infested areas. Such that creating free zone for the free areas, opening orchard and cutting highly infested plants and spraying with insecticide, and improving orchard management. Hence, the government is in action and remarkable results recorded in reducing the infestation. Infestation in three new sites is under control through mass mobilization. The area of infestation and severity decreased in buffer areas. The need for biological control especially for the mountainous areas is not progressed.

Keywords: *Cochineal, infestation, cactus and control*

INCIDENCE OF COCHINEAL INSECTS IN CACTUS PEAR GENOTYPES IN THE SEMIARID REGION OF PERNAMBUCO

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Dactylopius opuntiae Cockerell (“carmine cochineal”) and *Diaspis echinocacti* Bouché (“cactus scale”) are the main cactus pear pests in northeast Brazil. This study aimed to evaluate the occurrence and damage of cochineal insects in different cactus pear genotypes. The experiment was carried out at the Instituto Agronômico de Pernambuco (IPA) (8° 3'50.31" S, 37° 13'25.33" W). Ten cactus pear clones were evaluated: “orelha de elefante mexicana”; IPA-20; F8; F21; “Miúda”; “IPA-Sertânia”; IPA-100421 "Sel. 21-6"; IPA-100418 "Sel. 21-7"; IPA-100419 "Sel. 21-13"; and IPA-100420 "Sel. 21-21". The first three are Opuntia, the others Nopalea. The design was a randomized complete block with three replications. The plant spacing was 1.5m between rows and 0.4m between plants. Each row had ten plants, and all were evaluated. At 670 days of growth, the plants have been assessed for the incidence and damage caused by insects. For infestation (I), the scores were: 0 (no infestation); 1 (initial infestation); 2 (mild infestation); 3 (moderate infestation); 4 (high infestation); and 5 (widespread infestation). For damage (D), the scores were: 0 (no apparent damage); 1 (initial chlorosis); 2 (generalized chlorosis); and 3 (cladodes drop). The “IPA-20” clone was severely attacked (I = 5, D = 1.67) by carmine cochineal (30 percent of plants died) and by the cactus scale, but with no apparent damage (I = 1, D = 0). The carmine cochineal attacked all plants of the F8 clone, but with less severity (I = 3, D = 1) and no mortality cladodes. The clone “orelha de elefante”, resistant to carmine cochineal (I = 0, D = 0), was moderately attacked by cactus scale (R = 2.67 D = 1.33), as was genotype "Sel. 21-6" in which we observed chlorosis and cladodes drop. Clones "Sel. 21-13" and “Sel. 21-21" have the potential for use in areas of occurrence of carmine cochineal and cactus scale (I = 0, D = 0) and “Miúda” and “IPA Sertânia” clones are options where both cochineal insects occur. The “orelha de elefante” can be used when the objective is the prevention of carmine cochineal attacks.

Keywords: *Dactylopius opuntiae*, *Diaspis echinocacti*, plant resistance, “orelha de elefante mexicana”

COMPARISON PRODUCTION OF COCHINEAL IN TWO COMPANIES IN THE STATE OF GUANAJUATO, MEXICO

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In the municipalities of Abasolo and Salvatierra in the state of Guanajuato, Mexico, there are two companies producing cochineal. The first is located in Abasolo in the region known as El Bajio, in the Southwest part of the state, at an elevation of 1760 m asl with sub-warm, sub humid climate prevailing in most of the territory. On the other hand the town of Salvatierra, is situated in the Southern part of the state with an altitude, of 1749 m asl, temperate and humid climate throughout the year. The objective of this paper is to show a comparison of cochineal management, between two companies. The methods consisted of applying a survey, in each company, about the most important points of cochineal rearing, such as: insect infestation system, parameters measured during life cycle, carminic acid content, etc. Then a management comparison between each municipality was done in order to elaborate a general proposal for cochineal rearing for this region of Guanajuato. As a result it was found that both companies obtained cochineal broodstock from different sources, and used similar infestation methods. Although with different climatic conditions in each place during the development of the insect; Abasolo presented a maximum temperature of 38°C in May, and the minimum at about 5 °C during January, and in Salvatierra the maximum temperature was 33.4 °C also in May and minimum of 2 °C alto in January. The percentage of carminic acid was also found regarding each place (18-23 % for Abasolo and 18-20 % for Salvatierra). With the recorded information was possible to present a general proposal for cochineal rearing in the region.

Keywords: *Dactylopius coccus*, carmine insect, management, proposal.

CACTUS PEAR AND COCHINEALS: GOOD AGRICULTURAL PRACTICES AND CONTROL

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There are ten species of *Dactylopius* insects distributed in two origin regions (North and South America), the more important species due to their world spreading and commercial interests are *D. coccus* (fine cochineal) and *D. opuntiae* (wild cochineal), both species native to Mexico. Since centuries ago, these two insects have led dramatic events among man, cactus pear, and cochineals, and until now these histories are a recurrent model in regions where cactus pear and cochineals are non-natives species. The main factor in order to prevent (and even to control) these issues is GAP (Good Agricultural Practices), which involves a compilation of principles to be applied in any farm during its production and post-production processes. The goal of this paper is to show the importance of GAP and some controls of cochineals in *Opuntia* plantations.

After being in touch with cactus pear producers from several countries, and sharing good time with colleagues, the authors have easily elucidated that control of cochineals depends on many factors of each place where it would be applied (ecological, social, political, etc.), particularly in those regions where cactus pear and cochineals are non-natives species. Among the most common controls are pesticides (chemical and botanical), detergents, pressurized water, silicon powder, and of course, natural enemies; paradoxically, the less common control used is GAP. It is important to outstand that an almost useless activity is trying to control cochineal in cactus pear plants outside of a farm, it means in its naturalized place or "wild areas"; the control always is more effective in plantations with a commercial purpose. Biologic control with some significant results, most of them recently emerged, has a tremendous potential to hold cochineal populations in cactus pear plantations, but still is under develop.

Key words: *Opuntia*, *Dactylopius*, Pest, non-native species

EXOCHOMUS CHILDRENI MULSANT (COLEOPTERA: COCCINELLINDAE) PREDATOR OF *DACTYLOPIUS OPUNTIAE* (COCKERELL) (HEMIPTERA: DACTYLOPIIDAE)

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Dactylopiidae is a family monogeneric of American, which has twelve species, six are endemic from Mexico and the southern United States (Vigueras and Portillo, 2014). Some dactylopidos have been used as biological control agents for cactus pear in other regions of the world. The plague most important for farmers of nopalitos, fruit and forage is *Dactylopius opuntiae* (Cockerell), whose control is based on the use of toxic insecticides and bio-insecticides lately. Due to excessive toxicity of insecticides, the use of predators of this insect is required; the natural enemies include the adults and larvae of many species of coccinellid, beetles, diptera,moths and brown lacewings. This paper was objective to present a new predator for *D. opuntiae* the state of Jalisco and Zacatecas, México.

From an orchard of cactus pear in Zacatecas and Jalisco, Mexico were collected larvae and adults of *Exochomus childreni* Mulsant to start the colony which was fed *Dactylopius opuntiae*; breeding was carried out in non-controlled conditions inside of entomological cage, with temperature 25.5 ° C, R.H. 50% and photoperiod of 16: 8 h (light: dark). The duration of the life cycle, generations and predation capacity was evaluated.

As results was presented the insect stages: egg, four larval instars, pre-pupa, pupa and imago; also was obtained three generations at 35, 56 and 91 d; each generation produces an average of 113, 121 and 34 insects. The second generation was more successful with more individuals. It was determined that the predator food preference were nymphs I, II and adult females; temperature, relative humidity and light, were factors significant for breeding, development, eating habits and fertility under semi-controlled conditions, this was seen with the decrease of individuals in the third generation.

Keywords: predator, coccinellidae, cactus pear, biological control

PROTECTIVE EFFECT OF CACTUS CLADODE EXTRACT AGAINST CHLORPYRIFOS-INDUCED IMMUNOTOXICITY, OXIDATIVE STRESS AND GENOTOXICITY IN RATS

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Opuntia ficus-indica (Cactaceae family) is a typical Mediterranean plant, mainly used in food and traditional folk medicine. The present study was designed to evaluate the protective effect of *Opuntia ficus-indica* extract against chlorpyrifos (CPF)-induced immunotoxicity in rats. The experimental animals consisted of four groups of Wistar rats (5–6 weeks old) of eight each: a control group, a group treated with CPF (10 mg/kg), a group treated with O*puntia ficus-indica* young cladodes (2-3 weeks) water extract (100 mg/kg), and a group treated with cactus extract then treated with CPF. These components were daily administered by gavage for 30 days. After treatment, immunotoxicity was estimated by a count of thymocytes, splenocytes, stem cells in the bone marrow, relative weights of thymus and spleen, DNA aspects, and oxidative stress status (lipid peroxidation, SOD, CAT, GPx) in these organs. The statistical analysis of our results was performed by using the software SPSS 11.0. Data are presented by descriptive analysis (mean S.D for 6 independent experiments). Results concerning the immunotoxicity of chlorpyrifos (CPF) showed that CPF could induce thymus atrophy, splenomegaly, and a decrease in the cell number in the bone marrow. It also increased the oxidative stress markers resulting in elevated levels of the lipid peroxidation with a concomitant decrease in the levels of enzymatic antioxidants (SOD, CAT, GPx) in both spleen and thymus, and also degradation of thymocyte and splenocyte DNA. Consistent histological changes were found in the spleen and thymus under CPF treatment. However, administration of *Opuntia ficus-indica* young cladodes extract has a potential protective effect against CPF -induced immune damages. *Opuntia ficus-indica* young cladodes have been demonstrated to possess excellent antioxidant activities.

Keywords: Chlorpyrifos, *Opuntia ficus-indica*, immunotoxicity, oxidative stress

POTENTIAL OF *OPUNTIA SPP*. SEED OIL FOR LIVELIHOOD IMPROVEMENT IN SEMI-ARID MADAGASCAR

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The littoral of the Mahafaly Plateau in southwestern Madagascar is a global biodiversity hotspot. The area is semi-arid and prone to droughts, as well as to other environmental risks, resulting in frequent crop failures, famines, and extreme poverty. Thus, the identification of suitable non-agricultural income sources has been identified as a crucial step for the sustainable development of the region. In this contribution, we assessed the potential of *Opuntia* seed oil production as an income alternative. Cacti of the *Opuntia* genus are highly abundant in the region, particularly as living fences on private farmland. From the seeds of its fruit, high-priced seed oil can be extracted. To investigate its economic potential, we inventoried *Opuntia* in field hedges through vegetation inventories, and estimated the amount of seed oil that can be produced per household based on field sampling and laboratory analysis. To assess the socioeconomic impact of a potential large-scale project of regional *Opuntia* seed oil production, we conducted interviews with 51 farming households on human *Opuntia* consumption, the utilization of its cladodes as fodder, and other livelihood functions.

We found five different *Opuntia* varieties in the research region. Our results show that two varieties are highly important socioeconomically, and contribute >50% to total food intake during periods of food shortage (annual lean or hunger season). Also, these varieties are eaten as a key water source. In contrast, the other three *Opuntia* varieties are not eaten by local residents and contribute little to regional livelihoods. These varieties are spinier, and their fruits are virtually inedible due to a high seed content. The combination of low nutritional value and high seed content suggests promising seed oil production potential for these varieties for *Opuntia*. To avoid remaining competition risks between human nutrition and the commercialisation of local *Opuntia* seeds, sourcing strategies should exclusively target the fruit of the two high seed varieties.

Keywords: *Opuntia*, seed oil, Madagascar, livelihood improvement, food security

SESSION 7: Rural development and marketing

CHANGING PERCEPTION OF SMALL HOLDERS ABOUT CACTUS PEAR IN SOUTH ASIA

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Increasing demands on already-scarce water resources across the world's dry areas require alternative sources of animal feed – specifically crops that have more efficient uses of water. One alternative with the potential for widespread production is cactus pear (*Opuntia ficus indica*). This species originated in the tropical and subtropical Americas. It can be found in a wide variety of agro-climatic conditions across the entire American continent. The plant has spread to new areas where it continues to provide a myriad of benefits to human and animals. Until recently, cactus was not always accepted in South Asia (particularly India and Pakistan). It was associated with its close cousin *Opuntia stricta* with big thorns and invasive propagation, having rumors of being associated with the underworld. Recent projects lead by the ICARDA to introduce cactus pear were initiated in 2012. The projects aim to promote the plant as a feed for livestock as it is a drought resistant succulent plant that is thorn free and holds lots of water. Several accessions from various origins have been evaluated for their adaptation under local conditions. The most promising ones are being disseminated to farmers. This study examined the adoption of cactus pear across projects in South Asia with social and ecological diversity. Over 300 households were targeted and offered cactus pads to plant in their home garden along with necessary technical backstopping. Several field days were organized to increase to build awareness about the spineless cactus. Preliminary findings show that fear has changed to acceptance. Farmers have become enthusiastic about its multipurpose uses, income generating potential, and adaptability to climate change. As a result, demand is higher than the current supply. The potential gains from cactus production across the world's dry areas could be immense. However, efforts are still needed to ensure the plant's potential is effectively realized. Properly executed, these efforts offer an opportunity to not only raise incomes and improve livelihoods, but strengthen resilience. As dry areas are forced to contend with higher temperatures and more variable rainfall resilience will become more important in the years ahead.

Keywords: Dry areas, livelihood, poverty alleviation, climate change, spineless cactus

SESSION 7: Rural development and marketing

CACTUS PEAR RESEARCH PRODUCTION, IMPACT AND TRENDS IN MAINSTREAM JOURNALS

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We analyzed both qualitatively and quantitatively indexed bibliographic records from Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SCIE) from 1900 to 2015 to identify production, impact and trends of cactus pear international scientific community. We searched for the concepts or key words 'opuntia' as well as the common names of cactus pear and its products. We found 1472 documents, from which 66% were published during the last ten years, and more than 80% after 1990; these data show the relevance and dynamism of cactus pear research during the last years. The highest number of citations per document up to 2015 was 20.81 for papers published from 1991 to 2005, versus 5.88 for those published from 2005 to 2015. The highest numbers of citations were for two papers on antioxidant properties of *O. ficus-indica* published in 2002, (202 and 194 citations up to 2015). The Journal of the Professional Association for Cactus Development (JPACD) had the highest number of scientific papers (92) and had 479 citations up to 2015, or 5.2 citations per document. The impact factor (IF) of JPACD is 0.3, and is ranked 30 among 33 in the "Horticulture" category of Journal of Citation Reports (JCR). The paper with most citations was published in the Journal of Agricultural and Food Chemistry (IF = 2.912. Q1) which ranked second among 56 in "Agriculture, Multidisciplinary" JCR category. México and the United States publish 50% of all production, but recently Tunisia, Brazil, France and South Korea started to standing out. The main research areas where scientists publish according to SCIE and SCCI are: *Plant Sciences, Agriculture, Food Science Technology,* and *Environmental Sciences Ecology*, which recently have focused on *Chemistry, Pharmacology* and *Nutrition*. This is related to trending research on functional properties and biological activity of active ingredients such as Antioxidant, Metabolism and Polysaccharides. The identified trends would allow setting strategies, synergies and scientific and technologic policies for research and decision making in those countries where the species is considered as important.

Keywords: *Opuntia*, scientific production, scientific production evaluation, scientometrics, bibliometrics

SESSION 7: Rural development and marketing

THE EFFECT OF FOSTERING PARTNERSHIPS ON BROADENING THE FOOD BASE: THE ROLE OF CACTUS PEAR, AN UNDERUTILISED CROP WITH UNLIMITED POTENTIAL, THE SOUTH AFRICAN PERSPECTIVE

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South Africa is experiencing/facing significant socioeconomic challenges, including poverty, high unemployment rates, food insecurity, economic decline and energy crisis, which are compounded by climatic factors. The effect of declining water resources, extended droughts, increased desertification and climate change on food security and economic growth prompted the South African government to develop the Food and Nutrition Strategy and Agricultural Policy Action Plan which aims towards coordinated, multi-disciplinary, -institutional and -sectoral responses to critical national priorities of job creation, skills- and enterprise development, poverty alleviation, food and nutrition security. In alignment with these strategies, the Agricultural Research Council (ARC) acknowledged the importance of strategic partnerships towards the development of appropriate solutions. The methodology used in the South African perspective was to establish a collaboration centre on broadening the food base with the purpose to ensure availability of a wider range of nutritious crops/food as well as to develop new/novel crops, food products and ingredients for enterprise development, value chains, income generation and job creation. The objective is to collaborate and share knowledge to address these complex of problems by bringing expertise from various disciplines and organisations together and to use the partnership in leveraging other important networks and partners at both national and international levels. Cactus pear (*Opuntia Ficus-indica* and *O. robusta*) is increasingly becoming an important food, forage, cosmoceutical and nutraceutical crop in South Africa. It is a drought tolerant/mitigating, water use efficient crop and used for a diverse range of applications in South Africa. For a long time, it was only utilized as a source of animal feed, but recent growing interest in the various other potential uses saw the crop to establish itself as an important multi-purpose crop. It also opened up opportunities for export, job creation and income generation in the small holder farming sector. The research and development of cactus pear was identified as one of the top 5 priority crops for the collaboration centre on broadening the food base. The purpose of this paper is to discuss the context of the collaboration on the research of the food application aspects of this multi-functional crop within the context of the Sub-Sahara Africa Region Framework for Cactus Pear Research and Development. It can be concluded that the establishment of the collaboration centre developed a sound foundation from which further partnerships could be explored and developed.

Key Words: multi-purpose, cactus pear, collaboration, food security, drought tolerant.

SESSION 7: Rural development and marketing

RESEARCH AND DEVELOPMENT SCENARIO OF CACTUS PEAR (*OPUNTIA FICUS INDICA LL.*) IN TIGRAY, ETHIOPIA

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Tigray, northern Ethiopia, characterized by desert conditions prevail in the east, changing to semi desert, thorn savanna, and mountain savanna moving westward into the tropical highlands. More than 85% of the population is directly dependent on agriculture for a livelihood, but, with long periods of drought, compounded by excessive human and livestock pressures on the land, though famines are not uncommon, reduced high human and livestock mortalities due to cactus. It is also used as a fuel, as a live fence, for soil conservation, and source of household income. It is integral and impressive part of a strategy for food and feed security. It is grown in mixed bush ecosystem, irregularly planted and placed on very steep slopes to deter erosion. To assess the current research and development scenarios review of published materials and institutional reports done. Though very limited; some development and researches have been done especially on cultivar identification and utilization by different development and research institutions. Adigrat University, Helvetas Ethiopia, FAO, REST, TARI, Mekelle University are the major actors. Local names are given associated to their taste, location, color, etc. More than 40 cultivars have been identified/developed in Erob wereda. Cultivars *"Ger'ao"* and *"Sulhuna"* (respectively means sweet and smooth) represent 80% of plantations. Six and four cultivars were identified in Mekhoni and Subha-saesie weredas, respectively. Farmers of the latter wereda prefer to grow spiny cultivars, to provide a sure protection against browsing animals. Strictly, spineless cultivars are only found in areas of difficult access and in very controlled home yards. A huge area of cactus is utilized from the foothills of the mountain chains, to the hilly areas and in backyards. About 80 cactus cultivars were identified in two zones (southern and eastern). In addition some researches on nutritional and economic done. 25% of HH income is from Beles and at least two HH members for three months get job on selling the fruit. It is a time to strengthen research and development activities and institutions.

Keyword's: research, development, cactus, cultivars and fruit

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CACTUS CROP (*OPUNTIA FICUS-INDICA*) TO REHABILITATE RANGELANDS IN SEMI-ARID REGIONS OF TUNISIA

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The area of rangelands in Tunisia is estimated at 4.5 million hectares, or 27.4% of the total area of the country. Currently rangelands contribute 10 to 25% of livestock feed requirements, compared to 65% in the sixties, reflecting the important rangeland degradation and loss. The latter is estimated at about 6,100 ha per year. The area of rangelands affected by severe erosion is estimated at 1.8 million ha. Direct factors are responsible for the loss / degradation of rangelands as rangeland cropping, illicit wood collection, overgrazing and climate change. Among the underlying causes of rangeland degradation are mutations of pastoral systems, the complexity of the land tenure, inappropriate development policies and regulations.

A national strategy of rangeland rehabilitation was launched by the Tunisian Ministry of Agriculture in 1990 and included among others shrubs (Atriplex, Acacia) and spineless cactus (*Opuntia ficus-indica*) plantations at large scale. This strategy is implemented by the Office of Livestock and Pasture (OEP) focusing on private rangelands and following an innovative approach. A contract is established between OEP and farmers where the role of each partner is clearly specified. OEP provides the cactus pads and the equivalent of 70 $ US per ha as incentives to cover costs related to planting. This amount is given under the form of improved technologies such as urea treatment of straw, feed blocks etc. In addition, OEP provides technical assistance to farmers. As soon as planted the plot is put under rest for 3 years where grazing is banned; farmer is committed to protect and to take care of the cactus crop including supplemental irrigation if needed. Depending of the climate aridity, cactus is planted in rows spaced 5 to 15 m and 1 m between pads. Thus the planting density varies between 1000 and 8000 pads per ha. From 1990 to 2016, 142,000 ha of rangeland have been improved used spineless cactus. Non improved rangelands produce 0.2 to 0.5 tons dry matter per ha as feed. After cactus plantation, the feed biomass increases to 6 to 12 tons dry matter per ha. In addition to this significant increase if forage production, other benefits should be included such as fruit production for self-consumption or sale, reduction of soil erosion, improvement of biodiversity, shelter for wildlife, and carbon sequestration.

Keywords: Semi-arid, rangeland improvement, forage production, Tunisia, improved technologies, rangeland contribution

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