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Macro nutrients extraction in escabeche pepper (*Capsicum baccatum var. pendulum*) under Chicama valley conditions

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A trial was conducted at San Eficio farm in Paijan, Ascope Province,Chicama Valley, La Libertad Region. Soil type was sandy, very low EC (0.004dS/m), pH 8.87, low organic matter content (0.46%) and high level of available phosphorus (26.84 ppm). The objective was to determine the curve of macronutrients extraction (N,P,K,Ca,Mg and S). Two fertilization levels were used: 133-65-188-26-22 and 266-130-377-52-44 of N, P_2O_5, K_2O, MgO and S kg ha^{-ha}. Leaves, stem and fruit fresh and dry weight were determined at 15, 30, 45,60,75,90,105,120,135,150 y 165 days after transplanting, and fruit yield. Fertilization level 133-65-188-26-22 of N, P_2O_5, K_2O, MgO and S kg ha^{-1} showed the highest yield with 18.62 ton ha^{-1}. Fertilization level 266-130-377-52-44 of N, P_2O_5, K_2O, MgO and S kg ha^{-ha} yielded 17.09 ton ha^{-1} Nutrient extraction was highest using the lower fertilization level with no statistical differences with the high fertilization level.

Chile Yahualica Variety: Morphological and Molecular Characterization for Variety Registration

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Chile Yahualica belongs to the Solanaceae family and it is cultivated in nine municipal districts of the state of Jalisco and two of the state of Zacatecas in México.

As part of the application for the Designation of Origin “Chile Yahualica”, the morphological and molecular characterization is required for the registration of the variety, according to the descriptors of the "Technical Guide for the Varietal Description of Pepper (Capsicum annuum L.)" of the National Seed Inspection and Certification Service (SNICS) under the Department of Agriculture, Livestock, Rural Development, Fisheries and Food of the Mexican government.

For morphological characterization, data of plant height, width and length of the leaf petiole were taken. With regard to the fruit characterization, length, width, petiole length, color, weight and number of seeds were registered according to the mexican norm NMX-FF-107/1-SCFI-2014. Also, molecular characterization by Amplified Fragment Length Polymorphism (AFLP) was performed. In addition to the features requested by SNICS, sensory evaluation and quantification of capsaicinoids was performed.

Currently, the official procedure at SNICS is underway and it is expected that the Designation of Origen will be issued by the end of 2016.

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Partial root-zone drying of two Peruvian chili peppers

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Out of 1,808,302 hectares with agricultural crops under irrigation in Peru, 88% is under gravity irrigation (INEI, 2012). Gravity irrigation efficiency is around 30% so water-saving techniques are required, such as high frequency irrigation. This task will benefit from the participation of farmers in the research and a good dialogue between personnel responsible of crop management and water management. There is evidence that partial root-zone drying (PRD) saves water in the genus *Capsicum* cultivated outdoors and in greenhouses. The objective of this experiment was to determine the effect of PRD on yield and fruit quality of *Capsicum baccatum* L.var *pendulum* and *Capsicum chinense* (escabeche chili and panca chili, respectively) cultivated in a subtropical desert (dd-S) life zone. The statistical model was factorial in split plots with two factors: type of irrigation (partial root drying - PRD, complete irrigation - CI) and crop variety. Frequency and time of irrigation was managed by a local farmer and controlled by the researcher, taking into account the limitations in water distribution and availability in the valley. Irrigation took place with an average frequency of 7 days in both systems. Agronomic and flow measurements were done in the 2013 (first cropping season: transplant) and 2014 (second cropping season: regrowth after pruning) seasons. Parameters such as yield, fruit fresh weight, fruit length and fruit thickness did not show statistical differences between treatments; in contrast, plant height, fruit diameter and dry weight of panca chili and fruit diameter of escabeche chili showed significant reduction. PRD allowed 22% and 30% of water saving in escabeche and panca, respectively, while irrigation water use efficient (IWUE) reached 19% and 47% in 2013 and 2014, respectively. The increased IWUE demonstrated the water saving capacity of PRD for *Capsicum* production in the Mala valley, indicating the potential of this technique to improve crop production of smallholders in this region prone to limitations in the supply of irrigation water.

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The Nutritional Science of Breeding Peppers for the Processing Industry,

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Peppers (chiles) are the number one spice food ingredient in the world because of their mild capsaicin content and the many health aspects of the pod. Mexican food is the number one ethnic food in the U.S.A. because of peppers. Breeding peppers for the processing industry is a herculean task. Every major processing entity requires and demands peppers with their own unique characteristics with respect to types, size, color, flavor, pungency, fruit dry matter, resistance to insects, diseases and health related issues. Bell pepper is the most highly consumed pepper type in the U.S.A, followed by long green/red, cayenne, jalapeño, tabasco, paprika, serrano, habanero, ancho, cherry, pimiento, yellow pickling types. The end product can be fresh market for all and or processed into whole, sliced pickled, picante sauces, etc. In 1970, the Texas Agricultural Experiment Station at Weslaco placed emphasis in obtaining genetic resistance to important pepper viruses and insects. Fifteen different genotypes from Mexico, Central and South America, possessing heritable resistance to local isolates of tobacco etch virus, pepper mottle virus, cucumber mosaic virus, potato virus Y, tobacco mosaic virus, and tobacco ringspot virus were identified. Hybridization of these stocks with the best commercial cultivars of 25 different types yielded thousands of improved breeding lines utilizing the backcross method, two seasons/year, for 30 years. These lines have been screened for resistance to Phytophthora root rot, leafminer, pepper weevil, white fly, and tropical environmental stresses. As early as 1971 the Texas Agricultural Experiment Station pepper breeding program began looking at the nutritional aspects of all pepper types. **Thousands** of improved, superior pepper breeding lines of different types were developed and evaluated twice/year. These genetic packages contained multiple disease and insect resistance, tropically adapted (high temperature flower set), high color, flavor, high yielding (concentrated fruit for mechanical harvest), earliness. Health related issues included high concentrations of Vitamins C, A, anti-inflammatory cancer preventing antioxidants, i.e. flavonoids (luteolin, quercitin, etc.). Thousands of germ plasm packages were distributed throughout the world. Screening at every generation yielded **nine** new named cultivars: **TAM BELL-1. TAM MILD CHILE-1, TAM MILD JALAPEÑO-1, TAM BELL-2, HIDALGO SERRANO, TAM MILD CHILE-2, RIO GRANDE GOLD-SWEET, TAM VERACRUZ –HOT JALAPEÑO, and TAM JALORO-HOT YELLOW JALAPEÑO.** The release of the **"TAM MILD JALAPEÑO-1"** in 1981 was a major milestone. It revolutionized the entire U.S.A. salsa picante industry which outsold **sugar** based tomato ketchup by 1990 and thereafter. The **TAM VERACRUZ,** replaced most existing hot jalapeño varieties.

Successful breeding efforts continue under the direction of Dr. Kevin Crosby at Texas A&M University, Texas A&M AgriLife Research at College Station, Texas. Subsistence farmers throughout the world are able to grow these peppers with more security and less cost. Increased food production is accomplished utilizing fewer chemicals and less acreage, making it easier to maintain environmental quality. This has important implications for more efficient production of other foods in a sustainable agricultural system.

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Molecular Characterization of CMS Lines and Standerdization of Hybrid Seed Production Technique in Chilli (*Capsicum annuum* L.)

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The heterosis has been commercially exploited in several vegetable crops, but very few commercial hybrids are available in chilli. The greater extent of out crossing and large number of viable seeds produced by crossed chilli fruit facilitate for development of commercial hybrids. The required goals of increasing productivity in the quickest possible time can be achieved only through heterosis breeding which is feasible in this crop. However, the cost of hybrid chilli seeds is quite high due to high labour cost. In *Capsicum*, very few stable nuclear-cytoplasmic male sterile (CMS) lines are known because male sterility expressions in CMS lines have been found to be temperature sensitive. Temperature alteration may induce a degree of variation in male sterility; ranging from complete to partial. Exploitation of natural out crossing could render commercial hybrid seed production technology economically viable through use of male sterile lines. Hence, concerted efforts are required to be made to identify the stable male sterile lines along with maintainer and restorer lines for exploitation of heterosis. Study has been initiated with CMS associated gene fragment marker to understand the marker flow in segregating population and nature of dominance of the marker. The marker was successfully amplified in A, B, R, F1 and F2 population and the presence of marker was established by obtaining PCR product of band size 600bp, amplification was not observed in B and R line. Further study is underway to trace out the markers for restorer and maintainer lines.

The CMS based hybrids have been developed and tested over a location and years. Two high yielding hybrids namely RCH-42(JNA1/BVC-42) and BCH-42(ACA1/BVC-42) have been identified at University of Agricultural Sciences, Raichur, Karnataka, India. These hybrids are found to be 50 to 60% more potential than that of the non CMS based hybrids. But the hybrid seed production of CMS based hybrids is yet to be standardized. Hence, the research on standardization of hybrid seed production technology was undertaken to commercialize these hybrids. The experiment was conducted at experimental field of University Campus with 3 replications using 2 male sterile lines *viz*., JNA1 and ACA1and 1 fertility restorer line BVC-42. The seedlings were transplanted at the ratio of 3 sterile : 2 fertile, 2 sterile : 2 fertile, 2 sterile : 1 fertile for natural pollination. However, 2 sterile : 1 fertile was the transplanting ratio for artificial pollination. Non significant differences were observed in case of all the above ratio for fruit setting in natural pollination. The number of fruit setting was different with different male sterile lines. Male sterile line JNA1 could set 15.5 -16.3 fruits plant^{-1}. However, Male sterile line ACA1 registered 23.2 - 25.5 fruits plant^{-1} in natural pollination. We were able to produce 250 - 300 fruits plant^{-1} and 70 - 100 fruits plant^{-1} by artificial pollination using male sterile lines JNA1 and ACA1, respectively. The fruit setting under natural condition was adversely affected by presence of nectar to attract the natural pollinators in chilli. In artificial pollination 150 - 175 buds were pollinated in 20 minutes using a skilled worker with 69 - 95 per cent fruit set using male sterile lines without emasculation. However, only 40-50 buds were pollinated with emasculation and pollination in 20 minutes with 25 - 35 per cent fruit setting. Fruit setting was dependent on the time of pollination; 80-95 percent fruit setting was observed during 9.00 am to 11.00 am and 60 - 70 percent fruit setting was recorded after 11.00 am to 12.00 noon with 25 - 32^{0}C temperature. However, 30 - 35 percent fruit setting was reported between 9.00 am to 11.00 am and 20-35 percent fruit setting was recorded after 11.00 am to 12.00 noon with 32 - to 33^{0}C temperature. The artificial crossing may be extended up to 2.00 pm during cloudy weather with temperature range from 25 - 32^{O}C with fruit setting success rate of 40 - 60 percent.

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A snapshot of hot pepper cultivars in Brazil - challenges and opportunities for breeding programs

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The registration and protection of plant cultivars in the Ministry of Agriculture, Livestock and Food Supply (MAPA) is an important and mandatory step for seed production and commercialization in Brazil, and assures the genetic identity and varietal quality of cultivars. Cultivar protection allows royalties to be paid to private and public breeding programs. In May 2016 there were 129 cultivars of

hot pepper registered in the National Cultivar Registry (RNC), including the species *C. frutescens, C. chinense, C. annuum,* and *C. baccatum.* Today, only seven cultivars are protected in the National Service of Plant Variety Protection (SNPC) and four of them were developed by Embrapa (BRS Sarakura, BRS Garça, BRS Juruti and BRS Nandaia). Currently, seven seed companies have in their portfolios chile pepper cultivars, including Malagueta and Tabasco pepper (*C. frutescens*), Dedo-de-Moça and Cambuci (*C. baccatum* var. *pendulum*), different types of *C. chinense* (Biquinho, Murupi, De Cheiro, Bode, Cumari-do-Pará, Habanero, Bhut Jolokia) and *C. annuum* (Jalapeño, Cayenne) and other hot pepper types as well as semidomesticated species (*C. baccatum* var. *praetermissum*); there is predominance of open-pollinated cultivars. Out of the 129 cultivars, 97 are available in the market, and 20% of those are hybrids. Unfortunately, there is no consolidated data on pepper seed volume commercialized per year in the country. Small farmers have the tendency to use their own seeds, despite the availability of high-quality seeds of most pepper groups, which may have an impact on production and crop uniformity. Part of the Brazilian companies that sell pepper seeds do not maintain their own breeding programs and depend, therefore, either on imported cultivars or the development of cultivars in Brazil through partnerships with public institutions, such as universities, and research and development institutions. Embrapa Vegetables' breeding program is considered to be the largest public investment in hot pepper breeding, and has focused on the development of cultivars of different pepper types with superior agronomical and processing characteristics and multiple disease resistance. Pepper research has been constantly challenged by different factors including the need to: a) increase yield and fruit quality, and reduce the use of pesticides; b) improve the quality of raw material used by industry; c) define harvest parameters for best fruit quality; d) support the private sector in monitoring the quality of processed products, particularly pepper sauces; e) develop extremely hot cultivars as well as cultivars for new market niches (Calabrian peppers); and f) develop mechanical harvest alternatives due to lack of labor. The program has released several cultivars, inbred lines, populations and hybrids resistant to different pathogens which have had major impact in the country. As an example, the Jalapeño type cultivar BRS Sarakura, a protected cultivar, is responsible for a large share (>50%) of the hot pepper sauce made in Brazil. Except for BRS Sarakura and BRS Garça, which are of exclusive use of one company for a contractual time, other cultivars released by Embrapa have been licensed for seed production and sale by different seeds companies. Upcoming demands in the horizon include cultivars for organic production, product traceability, high nutritional and functional quality of fresh fruit and sauces, and release of cultivars from previously unexplored groups.

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Applications of Plant Growth Regulators for Pepper – A Review

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Development and application of biorational products such as plant growth regulators (PGRs) has received increasing interest from the chemical industries due to their direct role in enhancing economical traits such as transplant quality, stress tolerance, root/shoot growth, fruit set, parthenocarpy, fruit size, nutrient composition and ultimately crop yield. PGRs when applied externally can modify plant morphology and reproductive development of economically important crops such as pepper (Capsicum *annuum* and *Capsicum chinense*).The most common PGRs used in commercial vegetable production are abscisic acid (ABA), gibberellic acid (GA_3) and auxins (indole-3-acetic acid, IAA; naphthalene acetic acid, NAA). Our group at Texas A&M AgriLife Research found positive effects of foliar application of ABA on growth and physiological responses in sweet and hot peppers A study comparing physiological antitranspirants showed a strong effect of ABA in reducing stomatal conductance and photosynthesis while increasing leaf and stem water potential. ABA was also an effective growth holding agent, extending the marketability of pepper transplants in the nursery. Unlike GA inhibitors, like uniconazole, the suppression of stem elongation by ABA was reversible (Agehara and Leskovar, 2015). A recent study in sweet pepper (Pérez-Jiménez et al., 2015) showed that GA_3 reduced yield but improved plant height and quality of fruits. Another study by Tiwari et al. (2012) emphasized the importance of auxin inducing early signaling in fruit set, but also underlined the need of coordinated GA biosynthesis. Belakbir et al. (1998) showed that NAA treatment did not improve fruit quality, but increased marketable yield significantly relative to gibberellin-treated pepper. A common theme when evaluating PGRs and signaling compounds is that plant responses are strongly influenced by rates, timing, frequency and plant age. Plant responses to PGRs also involve complex nutritional (such as nitrate) and signaling pathways that are linked at several levels of integration, causing alterations in morphology and physiology. This mini review will highlight key root and shoot responses to PGRs including case studies for applications in pepper.

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Tospoviruses and Thrips and Integrated Resistance Management Strategies in Pepper in Florida

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Florida ranks second in the production, and value of bell pepper in the US. In 2015, Florida produced over one-half billion pounds of bell pepper on over 12,000 acres, valued at over 220 million dollars.

In recent years, several invasive species of thrips have become established in Florida and have become major pests. Damage to crops results from thrips feeding and egg-laying injury, thrips vectoring plant viruses, the cost of control measures, and the loss of pesticides due to resistance.

The key pest thrips in pepper is the western flower thrips, *Frankliniella occidentalis*. It was introduced and became established in northern Florida in the mid-1980s. In 2005, the western flower thrips emerged as a major problem in the pepper producing areas of southern Florida. The melon thrips, *Thrips palmi* became established in southern Florida in the early 1990s, where it has become a pest of pepper and eggplant. The chilli thrips, *Scirtothrips dorsalis*, is a recent invader in central and southern Florida where it has the potential to become a pest of pepper.

In addition to thrips, several tospoviruses including tomato spotted wilt virus, groundnut ringspot virus and tomato chlorotic spot virus have become established in South Florida increasing the need for pepper growers to manage thrips effectively. The western flower thrips is an efficient vector of all three tospoviruses present in Florida.

Experience in Florida has shown that use of insecticides alone is inadequate to manage thrips. Resistance to pyrethroid, carbamate, and organophosphate classes of insecticides in western flower thrips populations has been documented in many locations. Populations of western flower thrips probably arrived already resistant to most of these broad-spectrum insecticides.

Growers in all regions of Florida initially responded to these invasive thrips with calendar applications of broad-spectrum insecticides. This has resulted in a classic "3" R situation: resistance to insecticides (including new reduced-risk insecticides); resurgence of thrips populations due to the killing of natural enemies and competing native species of thrips; and replacement with various other pests that are induced by the application of the broad-spectrum insecticides.

The most efficacious insecticides for western flower thrips in fruiting vegetables are in the spinosyn class. However, resistance to spinosyns has been documented in pockets in Florida

Thrips in peppers are controlled naturally by minute pirate bugs. Establishing a biologically based integrated pest management program incorporating scouting, UV reflective mulches, conservation biological control and reduced-risk insecticides has proven to be the most effective way to manage thrips and thrips vectored tospoviruses in pepper.

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Physicochemical characterization of 20 Peruvian chili peppers landraces

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More than 300 chili peppers landraces are available in Peru. Although they are widely consumed, they have not been properly valorized, nor as fresh material nor in terms of their industrial use. The main objective of this study was to characterize 20 chili peppers in terms of capsaicinoids, carotenoids, fiber, pectin and consistency. The landraces were obtained from the Capsicum germplasm collection of the Vegetable Crops Research Program of UNALM.

Capsaicinoids were extracted with acetonitrile and measured by a HPLC equipped with UV absorbance and fluorescence detectors and a reverse-phase column C-18 (Collins *et al.*, 1995). Based on these data the pungency level (Scoville Heat Units, SHU) was calculated. The color analysis was conducted with a Minolta® colorimeter. The total carotenoid content was spectrophotometrically determined using a β-carotene standard. Carotenoid profiles were also obtained by a HPLC equipped with DAD detector and a reverse phase column C-30 (Lemmens *et al.*, 2013). Lastly, some structure-related characteristics were studied: pectin content was spectrophotometrically determined after a chemical hydrolysis to obtain galacturonic acid (Blumenkrantz and Asboe-Hansen, 1973); dietary fiber was measured using a Megazyme® enzymatic kit and consistency was determined using a Bostwick index (Christiaens *et al.,* 2012).

With regard to pungency, low SHU values were found in *Panca*, *Escabeche* and *Escabeche Pacae* (2800 – 4000 SHU) while the highest value was found for *Chico* (49500 SHU). With regard to color properties, the highest L* value was observed for *Mochero* and *Miscucho*, both yellow with negative a* values (green component). High positive a* values (red component) were found for *Cerezo redondo*, *Cerezo triangular*, *Escabeche rojo*, *Arnaucho*, *Picante* and *Bola*. High positive b* values (yellow component) were found for *Limo*, *Mochero*, yellow *Miscucho*, *Escabeche pacae*, *Miscucho* and orange *Miscucho*. In terms of total carotenoids content, *Panca* (230,72 mg of β-carotene/ 100 g pulp) showed the highest value and the lowest values was observed for *Miscucho amarillo* (2,68 mg/100g). The carotenoid profiles displayed capsanthin as the most important carotenoid in red chilies and violaxanthin in yellow ones. In case of total dietary fiber, *Cacho de cabra rojo* showed the highest value (19,52 g/100g) and *Escabeche pacae* the lowest one (5,43 g/100g). In addition, *Escabeche rojo* contained the highest galacturonic acid content (298,86 mg GalA/ g alcohol insoluble residue – AIR) and *Cerezo triangular* the lowest one (76,64 mg GalA/ g AIR). This content seems to coincide with a low Bostwick index value and moisture content). On the other hand, *Cacho de cabra amarillo* showed the highest Bostwick index.

The data presented in this paper create a starting point for understanding how transformation processes can affect functional properties and characteristics of chili pepper based foods.

Evaluación Sensorial Gastronómica de Ajíes Nativos Orgánicos del Perú

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Una evaluación sensorial gastronómica de 80 ajíes nativos orgánicos del Perú, fue realizada en los laboratorios de la Universidad Le Cordon Bleu (ULCB). Los ajíes recién cosechados fueron del Programa de Hortalizas de la Universidad Nacional Agraria La Molina (UNALM).

Para el presente estudio hubo un total de 4 cosechas en el 2015, la primera para la prueba preliminar y las restantes para el análisis sensorial. La prueba preliminar se realizó en abril con 11 accesiones, en un Focus Group, con estudiantes del VIII ciclo de Ingeniería en Industrias Alimentarias de la ULCB, para determinar los atributos y descriptores gastronómicos del análisis sensorial de ajíes. Los atributos y descriptores fueron: Color (suave, medio e intenso), Aroma (frutal, floral, herbáceo, propio), Intensidad de aroma (débil, moderado y potente), Grado de picor (no pica, pica suave, pica moderado, pica fuerte), y Aceptabilidad general (no me gusta, no me gusta ni me disgusta, me gusta). Asimismo, se recogieron las recomendaciones para el uso gastronómico de cada uno de los ajíes de acuerdo a sus características.

El análisis sensorial se llevó a cabo, en mayo, con 19 expertos de la gastronomía; 08 Chefs docentes y 11 estudiantes de Gastronomía de Le Cordon Bleu. Se utilizó una hoja de calificación para una cuantificación descriptiva cuantitativa relativa para el Análisis Descriptivo Cuantitativo (QDA). Cada panelista recibió por cada sesión: una bandeja con 04 muestras de ajíes, una hoja de evaluación por muestra y un vaso de leche para el intercambio de sabor entre muestras.

Los resultados del estudio de la evaluación sensorial, mostraron que los ajíes poseen aproximadamente el 75% intensa tonalidad; 60% aroma propio; y de este, el 60% son moderadamente aromáticos; asimismo, con respecto al grado de picor, alrededor del 35%, 25% y 25.5%, es moderado, fuerte y suave, respectivamente; y casi 14.5% no pica. De lo cual se desprende que más del 85% de los ajíes nativos, son considerados picantes por su considerable percepción sensorial de capsaicina. Con respecto a las recomendaciones de uso en cocina, el 15% para decoración, el 15% para ceviches y tiraditos; el 14% para cremas, el 10% para salsas, y 46% otras preparaciones. Del 100% de ajíes (80), el 32.5% (26) también es para pastelería o preparaciones dulces, siendo el 38% para mermelada, 23% chutneys y otros 31%.

La presente investigación basada en los expertos de gastronomía de Le Cordon Bleu, tuvo como objetivo reconocer y cuantificar sensorialmente los atributos y descriptores de los ajíes nativos orgánicos, así como recoger sus preferencias y recomendaciones, para la elaboración de las diversas preparaciones gastronómicas.

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Jalisco Agroalimentary Giant

Eng. Héctor Padilla Gutiérrez,
Ministry of Agriculture, State Goverment of Jalisco, MX

This document presents the significant advances that the State of Jalisco, has obtained in the agricultural sector in recent years.

The highlighted special points are:

1. Agroalimentary health, safety and biodiversity.
2. Planning and market development: Production under contract.
3. Technical asistence and precise training.
4. Modernizatión of agricultural infraestructure.
5. Financing and risk management.

In agricultural exports, in 2015 Jalisco has grown 8.86%, compared with México, which grow 6.18%. In the period of January to February of 2016, compared in the same period in 2015, Jalisco grow 20.45%

Recently it has concluded a study, to search for the appellation of origin of Chile Yahualica, with the direct intervention of the Ministry of Agriculture of the State of Jalisco.

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Evaluation of pungency, phenolic compounds and antioxidant capacity of 21 accessions of Capsicum baccatum

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Peppers of specie Capsicum baccatum L., one of 30 species from Capsicum spp. that are a source of nutrients and bioactive compounds with potential biological activity. In this study twenty-one accesiones of Capsicum baccatum L. from collection characterized taxonomically and originating in northern Peru (coast and forest) were evaluated by the content of capsaicinoids, hydrophilic phenolic compounds and antioxidant activity. All fruits from the selected accessions have been dried, ground; has been made an extraction with acetonitrile and another with methanol. The pungency was calculated by conversion to Scoville units (SHU) of capsaicinoid content (capsaicin, dihydrocapsaicin and nordhidrocapsaicina) in acetonitrile extracts, quantified by HPLC; phenolic compounds were spectrophotometrically determined with gallic acid pattern and the hydrophilic antioxidant activity was determined by the TEAC assay using the radical cation $ABTS^{+\bullet}$, both analyzes of the extracts with methanol. The principal component analysis (PCA) showed similarities between the content of phenolic compounds, antioxidant capacity and content of capsaicin that also obtained a positive correlation with each other, the maximum pungency was calculated in 72 085,6 SHU. Overall, these results suggest that in this specie Capsicum baccatum L. there is a potential association between phenolic content and content of capsaicin, which corresponds to other works and contributes to the promotion of these native chilies.

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Effect of thermal treatment on color and carotenoid content of three Peruvian chili pepper sauces

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Chili peppers originate from South America. They are mainly used as a source of flavor and color in Peruvian cuisine. Carotenoids are the most important color components in chili peppers. However, the characterization of raw materials from lesser-known landraces and the effect of pretreatments and pasteurization when preparing a sauce have not been studied. The principal objective of this study was to evaluate the effect of pasteurization on color and total carotenoid content of three chili pepper sauces. The landraces were obtained from the Capsicum germplasm collection of the Vegetable Crops Research Program of UNALM.

The color analysis was conducted with a Minolta® colorimeter. The total carotenoid content was determined spectrophotometrically using a β-carotene standard. Pasteurization treatments (90 and 100°C) were conducted and compared with a non-pasteurized sauce (chili paste, water, oil and citric acid to adjust the pH to 4.3) for each landrace. Color (ΔE) and total carotenoid content were measured before and after each treatment.

The three landraces used as raw material were: *Chico* (red color, 81,09 mg β-carotene/ 100 g pulp)); *Miscucho naranja* (orange color, 34,71 mg β-carotene/ 100 g pulp) and *Miscucho amarillo* (yellow color, high positive b* value, 2,68 mg β-carotene/ 100 g pulp). High values of ΔE when comparing pasteurized and non-pasteurized sauces (higher than 3 for all cases) indicate well visible differences in color due to the pasteurization process. Except for *Miscucho amarillo*, in all cases the total carotenoid content decreased upon blanching.

The data presented in this paper create a starting point for understanding how transformation processes can affect functional properties and characteristics of chili pepper based foods.

Effect of Hot Air and Far Infrared Drying Process in Drying Red Pepper.

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In this study the effects of different drying processes using hot air and far infrared in drying red pepper were compared. When red pepper was dried at 50 and 80 Celsius until moisture content reaches 15%, it took 465 and 285 min, respectively in hot air drying and using far infrared drying it took 140 and 40 min, respectively. The drying rate in the far infrared drying is much higher than the hot air drying. Rehydration ratio was increased with increasing drying temperature in both processes, but water holding capacity was higher in far infrared drying. Retention of capsaicin is the highest in far infrared drying at 80 Celsius. L value was the highest in far infrared drying at 50 Celsius and the lowest in hot air drying at 80 Celsius. Above results show that the physicochemical characteristics of red pepper are preserved more in far infrared drying than in hot air drying.

Currently they have been tested infrared dehydration in three varieties of peppers in Peru. Considering Peru one of the center of origin of *Capsicum* spp., studies using infrared emission can be better oriented to obtain higher levels of capsaicin and bioactive compounds.

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Management of *Neosilba pendula* (Bezzi), a Fruit-fly Borer Affecting Pepper Fields in the Peruvian Coast

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The research aimed to determine basic information gaps toward a sustainable pepper integrated pest management system in the Peruvian Coast. Several fruit flies species were monitored affecting pepper fields including *Neosilba pendula* (Lonchaeidae), a previously recorded secondary pest.

Field observations recorded *N. pendula* damaging pepper fruits without previous entrance hole by any other insect. Bait traps catched 2-3 adults/day at the peak fruit season, and randomized fruit sampling yielded up to 12 larvae per fruit. A randomized complete block design experiment comparing paprika pepper, jalapeño hot pepper, ancho sweet pepper, and blocky sweet pepper yielded similar adult and larval infestations, showing no insect preference. An integrated pest management based on adult trapping, destruction of damaged fruits and spinosad-based spraying insecticides reduced insect pest damages significantly.

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Cultural aspects associated with the production of Yahualica pepper (C*apsicum annuum*)

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Yahualica pepper (*Capsicum annuum*) is the name by which the hot pepper produced in the geographical region of “Los Altos de Jalisco” is known. This region comprises 9 municipalities of the

state of Jalisco and 2 of the neighboring state of Zacatecas. Producers attribute particular characteristics to Yahualica chili associated with the geographical conditions of this region, mainly soil and climate, as well as limited use of mechanical implements for harvesting and drying. The main producer is the town of Yahualica de Gonzalez Gallo, from which the chili is named after. The inhabitants of this town have taken Yahualica chili and its cultivation as part of their culture and have incorporated various cultural expressions consolidating some of its traditions. Hence, its fruit has become a symbol or element of identity, which has spread and is reflected in countless articles and products that are distributed in regional and international markets where their region of origin is recognized. Also, year after year popular events that coincide with the end of the annual crop cycle in which both fresh and dried pepper are supplied, as well as countless products made with the chili pepper, giving prominence to local and national cuisine, and who considers this fruit as an indispensable ingredient in the Mexican diet. Human factors required for the protected designation of origin for Yahualica pepper are presented in this study.

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Inheritance of Resistance to Powdery Mildew from C. baccatum var. baccatum and C. annuum.

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Powdery mildew (*Leveillula taurica*) is a growing problem in field culture of peppers (*Capsicum annuum*) in the United States. Bell, Anaheim and jalapeño peppers are all highly susceptible to the disease. Multiple reports of resistance have been published, including accessions of *C. baccatum*, *C. frutescens* and *C. annuum*. We screened several reported *C. annuum* sources of resistance (HV12, PBC 167), but found them to be susceptible in the greenhouse at College Station. Numerous accessions of *C. baccatum* exhibited immunity to the pathogen over multiple seasons and after controlled inoculations. A selection of *C. baccatum* var. *baccatum,* with resistance to powdery mildew and leafminer, was used as a pollen parent and crossed onto more than 100 different *C. annuum* parents. Only three viable seeds were recovered from a single cross (Serrano 33 x *C. baccatum*). The three resulting plants were grown for one year in the greenhouse and all exhibited complete resistance to powdery mildew. This suggested the presence of dominant resistance gene(s). Several backcross families to *C. annuum* lines were generated. One of these families involved a high quality jalapeño inbred line with extreme susceptibility to powdery mildew. This fertile backcross plant was self-pollinated and backcrossed again to the jalapeño parent to generate F2 and BC2 populations. The F2 population was planted in the greenhouse during the fall of 2014 and carried through the winter of 2015. Severe powdery mildew infection occurred in the greenhouse and all F2 plants were also inoculated with spores from susceptible jalapeño leaves. After 5 months of exposure, 86 F2 plants and 18 BC2 plants were rated for severity of powdery mildew infection on a scale of 1 to 5 (no infection to complete leaf coverage and heavy sporulation). In the BC1F2 population, segregation for resistance was obvious. Chi Square tests support either a single dominant gene (P=.65) or three dominant genes (P=.50), depending on the stringency of resistance phenotyping. The six most resistant plants were backcrossed or crossed to elite inbred lines. Seeds of 75 new, experimental hybrids were generated for field testing in 2015. During the greenhouse screening, we identified another source of resistance, 'Hidalgo.' This is a serrano type pepper with a complex pedigree, released for its resistance to TEV and PVY. We also screened several breeding lines which had 'Hidalgo' in their pedigree and found one, S02-117 to be resistant to PM. This F12 inbred line and four F1 hybrids with other, susceptible inbred lines were planted at Uvalde during 2015, Severe *L. taurica* infection began to occur in late September and by November the entire field of peppers was infested. Disease ratings were taken in late November for all entries. S02-117 and its four F1 hybrids all exhibited high level resistance (1-1.5). This suggests a dominant resistance gene, but relationship to the resistance derived from *C. baccatum* is not known. During early 2016, S02-117 was crossed with a resistant selection from the BC1F2 population to generate a population for allelism testing.

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PHYTOPHTHORA CAPSICI IN PERU

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Phytohpthora capsici es un Chromista que es reconocido a nivel mundial como agente causal de pudriciones radicular. En Perú, el cultivo de *Capsicum* sp se ha desarrollado actualmente en distintos agroecosistemas: Costa (Norte como la Región Lambayeque; Centro, Región Ancash, Lima; y Sur, Región Arequipa), Valles Interandinos (Cajamarca), Ceja de Selva (Oxapampa, Puno, Cusco).

Phytophthora capsici está presente, principalmente, en los agroecosistemas de Costa y de Ceja de Selva; las condiciones de temperatura favorecen el desarrollo de este patosistema en Costa; mientras que en Ceja de Selva las condiciones de humedad relativa (existencia de nieblas) y lluvias (como en Quince mil, Puno) aunado a la temperatura favorecen el desarrollo de epidemias. Los síntomas varían, en Costa se observa predominantemente la pudrición radicular, salvo cuando hay desarrollo de anomalías de lluvias en Costa Norte, en tales casos hay desarrollo de tizones en follaje; en Ceja de Selva a parte de las pudriciones radiculares se observa en el caso de rocoto (*Capsicum pubescens*) una pudrición en el fruto a la que los agricultores denominan "pela – pela", por la característica de liberación del epicarpio. En un análisis preliminar con aislamientos de distintas partes de la Costa se determinó semejanzas que permitieron considerar una mínima variabilidad genética. Como consecuencia de este resultado, entre el 2005 al 2007 se hizo una prospección en distintas zonas de producción pero solo del valle de Barranca y Supe (Costa Central). Se colectaron 227 aislamientos de 4 especies de *Capsicum* (*C. annum, C. chinense, C. pubescens* y *C. frutescens*). Todos estos aislamientos fueron del grupo de apareamiento A2; por AFLP, 221 tuvieron el mismo genotipo (PcPE-1) a pesar de haber sido colectados de distintos lugares. Estos resultados indican que la reproducción clonal maneja la estructura poblacional de *Phytophthora capsici* en la Costa del Perú. En el 2008 se hizo otra prospección en Oxapampa y alrededores, se colectaron 219 aislamientos de 3 especies de *Capsicum* (*C. pubescens, C. annum* y *C. baccatum*), en este caso se detectaron los 2 grupos de apareamiento A1 y A2; aunque el A1 en mínima proporción. Por SNP se encontraron 9 genotipos. Estos resultados indican una mayor diversidad de *Phytophthora capsici* en ceja de Selva que la existente en la Costa.

Predicting Pepper Fruit Yield Based on Temperature and Solar Radiation

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Abstract: Two separate experiments were conducted in bell pepper (*Capsicum Annum* L.) in order to evaluate the effects of temperature and radiation on fruit yield. The results of the temperature experiment were integrated into the radiation experiment to give an overall empirical model for potential pepper fruit yield grown in greenhouse. In the temperature experiment, pepper plants were planted during the summer time of Israel in the Arava region in a commercial, one hectare greenhouse, equipped with a cooling wet-mat system. Eleven plots were assigned along the 80 m down the row from the wet mat. Air seasonal temperatures were affected by the distance from the wet-mat and linearly increased at the rate of 0.036 °C/m, while relative humidity was not affected. Fruit yield dropped from 19.4 kg/m at a distance of 20 m, to 13.1 kg/m^2 at 80 m away from the wet-mat, respectively. Yield regression decreased linearly with increased temperature at -11%/°C. In the radiation experiment, during the summer time of Israel in the Western Negev region, three sweet pepper varieties were grown under six radiation treatments, which accumulated to the following relative global radiation fractions (I_{int}/I_{out}): 0.72, 0.61, 0.46, 0.38, 0.32 and 0.21 from outside radiation. The three varieties did not differ in their response to radiation. The seasonal temperature normalized yield response to radiation quantity at 21 °C (Y_{21}) yielded a linear regression formula with a slope of 7.6×10^{-3} kg/m^2/MJ. The multiplicative model of temperature and radiation on fruit yield was found to predict well the potential fruit yield for various locations and seasons in Israel.

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Respuesta productiva de dos variedades de *Capsicum annuum* L. en organoponía semiprotegida en Cuba

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La Agricultura Urbana desarrolla diferentes modalidades para incrementar la producción de hortalizas en las condiciones tropicales de Cuba. La investigación se llevó a cabo en condiciones de organoponía semiprotegida en La Habana, donde se estudió la respuesta productiva de los cultivares de *Capsicum annuum* L. ´Lical´ y ´Verano-1´ con el uso de una variante de nutrición biorganomineral. La misma se estableció utilizando una mezcla de materia orgánica de conjunto con inóculos microbianos (hongos micorrizógenos arbusculares, *Azotobacter chroococcum* y *Bacillus megatherium*), 30 g de fertilizante mineral [$N/P_20_5/K_20$ = 9/13/17] y el testigo de producción (mezcla de suelo y estiércol vacuno a razón 1:1). Se evaluaron indicadores fisiológicos como la altura de las plantas, número de hojas, las fenofases del cultivo, la Tasa Relativa de Crecimiento (TRC) y la Tasa Absoluta de Crecimiento (TAC) en diferentes momentos y los componentes del rendimiento. La variante biorganomineral mostró incrementos significativos en los indicadores evaluados en comparación con el testigo de producción. En la variedad de *Capsicum* ´Lical´ se incrementó el rendimiento aproximadamente en 1.5 kg/m^2 y en la variedad ´Verano-1´ se alcanzaron rendimientos de más de 6.0 kg/m^2, con lo que se logró duplicar los obtenidos en el testigo de producción. Los resultados avalan la utilización de la nutrición biorganomineral para aumentar la producción los cultivares de *Capsicum annuum* L. en organoponía semiprotegida.

Respuesta de 32 Genotipos de *Capsicum* al Ataque de *Phytophthora capsici.*

Ñique R. M.R., Delgado J. M.A.

En esta investigación realizada en las instalaciones del Tinglado y Laboratorio de Fitopatología de la Universidad Privada Antenor Orrego de Trujillo La Libertad se evaluó el comportamiento de 32 genotipos de *Capsicum* provenientes de la colección del Departamento de Horticultura de la Universidad Agraria La Molina frente al ataque del Oomycetes *Phytophthora capsici*.

Para esta prueba se usaron concentraciones crecientes de inóculo el cual fue obtenido de plantas de *Capsicum* que presentaban pudrición radicular como síntoma típico de *P.capsici*. Las concentraciones empleadas fueron equivalentes a 10^3 10^4 y 10^5 zoosporas mL^{-1}. Las unidades experimentales estuvieron constituidas por una planta con 8 repeticiones siendo una de las variedades más comerciales y susceptibles de la zona utilizada como testigo.

Los resultados evidenciaron que 4 genotipos de *Capsicum* mostraron resistencia a la concentración más alta de inóculo, pues en ellas no se observaron síntomas de esta enfermedad.

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Aji – Treasure of the Incas

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Peru is home to a great diversity of *Capsicum* species both wild and domesticated. To Peruvians, aji is the spice of life, but to the rest of the world they are a treasure waiting to be discovered like the gold of the Incas. The Incas found *Capsicum* so important in their lives, that they worshiped the aji as one of the four brothers of their creation myth. “Agar-uchu” or brother aji was believed to be the brother of the first Incan king.

In 1989, Noel D. Vietmeyer and colleagues with the U.S. National Research Council published a book entitled “The Lost Crops of the Incas,” and in it they stated that aji (*Capsicum baccatum*) and rocoto (*C. pubescens*) are some of the lost crops of the Inca. More than 25 years later, the aji and the rocoto are still waiting to be the next big thing in the food world. Any true chile aficionado must travel at least once to Peru to sample the cuisines flavored with the aji and rocoto.

The aji is one of the most aromatic and flavorful *Capsicum* species, and is easily distinguished by the yellow- or green-spotted corollas of its flowers. The Inca used aji as the major spice to season the potato. An even lesser known *Capsicum* is the rocoto, with its characteristic black, wrinkled seeds. It produces fruits sometimes as large as bell peppers, but instead of being mild, they are hot! It is this species where most of the “minor” capsaicinoids were discovered. An unusual fact about the rocoto is that it only occurs in cultivation; it is the only domesticated *Capsicum* species where the wild ancestors have not been identified, although genetically it is closely allied to *C. eximium*. Rocoto is tolerant of cooler temperatures and cannot tolerate heat such as in the southwestern United States.

Peru has endemic wild *Capsicum* species, for example, *C. tovarii*, locally known as *mukúru*. The species is found in the Rio Mantaro basin, where yet other undiscovered wild species may exist. The wild *Capsicum* is a vital source of useful genetic source for resistance to viral, bacterial, and fungal diseases. They also contain genes for greater environmental adaptation, which will be important in the future with climate change.

Capsicum genetics and breeding are evolving at an astounding rate toward a genomics approach, whether it is marker-assisted selection, comparative plant genomics, or genetic transformation. The recent discovery of the CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats)-Cas9 mechanism, and its targeted genome editing promises to bring a new era to plant genetics and breeding. The development of efficient and reliable ways to make precise, targeted changes to the genome of plants is a long-standing goal for plant breeders. One of the more important aspects of the CRISPR-Cas9 system is that currently the process is not considered to produce a “GMO” crop. Thus plants changed by using this system do not have to be labeled GMO.

The Spanish conquistadors discovered the gold treasures of the Inca. Today, we are discovering the treasure of Peruvian *Capsicum*. Most breeding and selection has been concentrated on *Capsicum annuum*, but the capsicums of Peru deserve our attention. Recent developments, including a better understanding of the evolutionary relationships, availability of new germplasm, and a superb group of researchers, are synergizing *Capsicum* research. The aji and the rocoto could encourage specialty uses that might project these relatively unknown *Capsicum* into a prominent place in the cuisines of the world. The *Capsicum* species of Peru are a golden treasure and a valuable resource for all *Capsicum* researchers.

Respuesta de Variedades de *Capsicum* al Ataque del Virus del Moteado Suave del Ají.

Palomino A.J.M., Ñique R.M.R. y Delgado J.M.A.

Resumen

Con el propósito de evaluar la respuesta de diez variedades comerciales de *Capsicum* al ataque del Virus del Moteado Suave del Ají (PMMoV) se condujo esta investigación en el Tinglado y Laboratorio de Fitopatología de la Universidad Privada Antenor Orrego de Trujillo. Las variedades utilizadas fueron Ethem Cherry Pick Habanero HC-96-A Chocolate Habanero HD 46A Rojo Habanero Magnum Naranja Morrón Mano de Piedra Morrón Aristóteles Jalapeño Perfecto Páprika Anahehim Sonora y Pimiento Piquillo se usó como testigo a la variedad Papri Queen por ser la más cultivada y presentar mayor susceptibilidad a este virus. Para la inoculación se tomaron plantas de *Capsicum* que previamente habían sido diagnosticadas con la infección del PMMoV. Las evaluaciones se iniciaron 4 días después de la inoculación observándose que las variedades mostraban diferente

sintomatología. Así, las variedades Habanero HC-96-A chocolate, Habanero Magnum Naranja y Páprika Anaheim Sonora fueron las más susceptibles pues en estas variedades se observó necrosis en hojas que posteriormente devino en muerte regresiva síntoma muy característico de este virus. Otras variedades tales como Ethem Cherry Pick Habanero HD 46A Rojo Jalapeño Perfecto Pimiento Piquillo y Papri Queen mostraron un fuerte mosaico en hojas hasta la deformación de los frutos. Las variedades en las que se registró menos intensidad de daño fueron Morrón Mano de Piedra y Morrón Aristóteles pues en éstas solo se observó lesiones locales lo cual estaría indicando que estas variedades presentan cierto grado de resistencia a este virus.

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Effect of thermal treatment on pectin content and rheological profile of three Peruvian chili sauces

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Chili peppers are an important raw material in Peruvian cuisine, especially to make sauces, although only three horticultural types dominate the processing industry (*Escabeche-mirasol*, *Panca* and *Rocoto*). In this context, raw material cell wall polysaccharides (e.g. pectin) play a crucial role. In addition, there is a lack of information about the effects of pasteurization on these properties. The principal objective of this study was to evaluate the effect of pasteurization on pectin content and rheological profile of three sauces. The landraces were obtained from the Capsicum germplasm collection of the Vegetable Crops Research Program of UNALM.

Pectin content was spectrophotometrically evaluated based on galacturonic acid (GalA) determination, after obtaining the alcohol insoluble residue (AIR) (Blumenkrantz and Asboe-Hansen, 1973). Consistency was measured using a Bostwick index (both paste and serum were considered) based on the method of Christiaens *et al.*(2012). Pasteurization treatments (90 and 100°C) were conducted and compared with a non-pasteurized sauce (chili paste, water, oil and citric acid to adjust the pH to 4.3) for each landrace. Pectin content and rheological properties (G' and G'' were measured in function of stress and frequency in a Discovery H-3 rheometer, based on the method described by Gamonpilas *et al.*, 2011) were measured before and after each treatment.

The three raw material landraces showed the following properties: *Chico* (red color; Bostwick index value = 5,83); *Miscucho naranja* (orange color; Bostwick index value = 3,63) and *Miscucho amarillo* (yellow color; Bostwick index value = 2,63). The GalA content was increased with thermal treatments for *Chico* (from 95 to 170 mg GalA / g AIR) and *Miscucho amarillo* (from 154 to 195 mg GalA / g AIR) (heat-induced solubilization of pectins). In case of *Miscucho naranja*, the GalA content decreased only at 90°C pasteurization (from 165 to 138 mg GalA / g AIR) (cell wall material leached during processing). With regard to rheological properties, no differences were found between thermal treatments, the *Chico* landrace showed high values of G' and G'' (more elastic than viscous behavior).

In general, the results showed that significant differences were found between landraces, thermal treatments did not result in large changes. The data presented in this paper create a starting point for understanding how transformation processes can affect functional properties and characteristics of chili based foods.

Bell Pepper Production in Florida

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Florida is the leader in bell pepper winter production in the US with 12,400 acres planted with a value of $165 million in the 2014 season. Palm Beach County leads Florida's pepper production with 45% of all peppers produced in the State. Most of the state's bell pepper crop is transplanted in double rows on polyethylene-mulched raised fumigated beds using either drip or seep irrigation. Forty percent of the Florida growers use stakes and twine around the bed perimeter to the bed to contain the plants. Standard spacing is 6 feet between bed centers, with plants typically planted 9 to 12 inches apart with a plant population of 19,360 to 14,520 plants/acre. The majority of the bell varieties grown for fresh-market are hybrids with a determinate upright growth habit that require 2 to 3 manual

harvests. These cultural practices account for as much as 40 to 55% of the total pepper production cost, estimated at $17,000/acres. Bacterial leaf spot caused by *Xanthomonas euvesicatoria* is a major ongoing disease for peppers produced in Florida. However, growers can overcome the disease by planting resistant varieties. Phytophthora root and crown rot, caused by the oomycete *Phytophthora capsici* Leonian, is soil-borne plant disease that causes economic losses on bell pepper production. Control of the disease is limited by fumigation and resistant varieties. Pepper weevil, *Anthonomus eugenii* Cano, is the most important insect pest of pepper production in Florida. Damage is the destruction of blossom buds and immature pods. Both adult and larval feeding causes bud drop. Successful pepper production is always challenging and often difficult in Florida. However, it remains an economically feasible production enterprise for growers during the winter.

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Genetic and Molecular Analyses for Resistance to *Cucumber mosaic virus* and *Chilli veinal mottle virus* in Chilli (*Capsicum annuum* L.)

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Chilli is an important vegetable and spice crop. The pepper production in India is constrained by many viruses. *Cucumber mosaic virus* (CMV) and *Chilli veinal mottle virus* (ChiVMV) are aphid borne major destructive viruses affecting chilli crop production.Strategic breeding programmes for virus resistance require the identification of sources of resistance, information on inheritance and identification of molecular markers linked to resistance gene(s) to accelerate breeding programmes. In this study, fifty *Capsicum* genotypes including breeding lines were screened against CMV and ChiVMV through mechanical inoculation. Symptoms varying from chlorotic local lesions to severe leaf distortion were observed and eighteen immune genotypes were identified against CMV. Whereas for ChiVMV, dark green vein banding to severe shoe string symptoms were observed and seventeen genotypes were found immune. Ten parents were selected and crossed in half diallel fashion. 45 F_1

hybrids were screened for resistance against both the viruses separately. Only one hybrid, IHR2451 x IHR500 showed resistance against CMV and all resistant x resistant F_1 hybrids were found resistant against ChiVMV. Further the inheritance studies using advanced populations (F_2 and back crosses) showed that the CMV resistance is polygenic recessive and ChiVMV resistance is monogenic recessive in IHR2451 and IHR4503. Co-infection studies indicated that ChiVMV resistance deviated from the normal monogenic recessive nature with increased per cent of resistant plants and also increased concentration of virus load in some of the susceptible plants due to co-inoculation with CMV. Several resistant gene analogs were isolated from genotype, IHR2451 using degenerate primers. 119 RGAP markers were used for parental polymorphism survey between the resistant *cv.* IHR 2451 and susceptible *cv.* IHR 3476, and twenty-one markers produced polymorphic bands. For CMV resistance only RGA4 marker showed BSA polymorphism but it failed to show polymorphism among the segregating individuals, however showed the consistent polymorphism among the resistant lines screened indicating that this may be linked to QTLs associated with the CMV resistance. For ChiVMV resistance, RGAP markers K5-HD6, K7-HD6, and K8-HD6 were found polymorphic by bulk segregant analysis. Use of the K5-HD6 marker was extended to screen individual plants in the F_2 and B_1 generations and was found to co-segregate with ChiVMV resistance. Furthermore, K5-HD6 was validated in different ChiVMV-resistant lines where it could clearly differentiate between resistant and susceptible lines. Therefore this marker may be used effectively during marker-assisted selection for resistance to ChiVMV. In conclusion,CMV resistance is polygenic recessive in nature indicating the recurrent selection breeding procedure using QTL-linked marker-assisted selection is the best approach. ChiVMV resistance is monogenic recessive in nature and therefore, simple marker-assisted backcross breeding is the best breeding approach.

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Optimización del proceso de extracción de capsaicinoides de residuos de ají amarillo (*Capsicum baccatum var. Pendulum*) y panca (*Capsicum chínense*)

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RESUMEN

Se realizó la extracción y cuantificación de capsaicinoides de residuos (placenta o venas de ají amarillo (*Capsicum baccatum var. Pendulum*) y panca (*Capsicum chínense*), provenientes de la industria de ajíes. Los capsaicinoides obtenidos fueron utilizados en la formulación de bioinsecticidas para el control de insectos plagas de cultivos de quinua y maca los cuales son productos de exportación. Las venas de ají fueron acondicionadas, se separó las semillas, las venas fueron secadas, molidas y tamizadas, se obtuvo un tamaño de partícula uniforme. El proceso de extracción de capsaicinoides, se realizó con etanol al 99,9% en diferentes condiciones de temperatura, tamaño

de partícula de la matriz vegetal, velocidad de agitación y relación muestra: solvente. Los parámetros que permitieron una mayor extracción fueron: 60ºC, tamaño de partícula de 0.425 – 1 mm, agitación de 270 rpm, relación muestra: solvente de 8:30 (p/v) y 25 horas. La identificación y cuantificación se realizó por cromatografía líquida de alta resolución (HPLC), en condiciones isocraticas, se utilizó una fase móvil de agua acidificada con 1,0% de ácido acético (A) y acetonitrilo (B), en una proporción de 50:50 v/v, el tiempo total de separación y detección fue de 20 min. La lectura se realizó a 280 nm. Los capsaicinoides de las venas de ají se identificaron comparando el tiempo de retención y el espectro de los estándares puros de capsaicina y dihidrocapsaicina. Con el área de los estándares se elaboró una curva de calibración con las concentraciones de 0,02; 0,06; 0,1; 0,14; 0,18 mg/ml. Se detectaron tres capsaicinoides: Nordihidrocapsaicina, Capsaicina y Dihidrocapsaicina. Los subproductos de ají panca, reportaron un mayor rendimiento de capsaicinoides, siendo 16,492; 349,99 y 102,27 mg/100 g ms de nordihidrocapsaicina, capsaicina y dihidrocapsaicina, respectivamente. La capsaicina es la que predomina en un porcentaje del 74,66%, seguido por dihidrocapsaicina (21,82%) y nordihidrocapsaicina (3,52%). Los residuos o venas de ají panca presentan un potencial de capsaicinoides, superior al de las semillas y pericarpio. Estos compuestos bioactivos tienen propiedades quimopreventivas.

Breeding by design to create a nematode and *Leveillula* resistant pepper blocky cultivar to Peru

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Capsicum species are among the most important vegetable crops in Peru. Part of the capsicum production is destined to the local market and part is exported to several countries, particularly that of sweet paprika and sweet pepper products. Red blocky peppers are exported as fresh or processed products. The most important pathogens in pepper production in Peru are nematodes and *Leveillula taurica*. In order to reduce losses from these pathogens, local growers are currently using some type of chemical control. There are severe restrictions on chemical residues from importers, like as the United States and other European countries, on capsicum products from Peru. In order to make available alternatives for the control of these pathogens, with reduction in the chemical spray

program, reduction in the production cost (estimated in US$1,483.20/ha just for the control of *Leveillula*) and also reduction in the risk of environmental contamination by chemicals, Sakata Seed Sudameria has carried out a pepper breeding project by design to Peru. The target is to create a blocky cultivar with resistance to both pathogens. The project started in 2011 and was based on conventional breeding techniques. Most of the breeding work was carried out at Bragança Paulista Breeding Station, of Sakata, in Brazil. As a result of this project a red blocky F1 hybrid, cv. AF21366, was obtained which presents good agronomical characteristics and also genetic resistance to nematodes and *Leveillula taurica*. In the case of nematodes the resistance covers several *Meloidogyne incognita* and *Meloidogyne javanica* races. In the case of *Leveillula taurica* the resistance has presented good stability under different production areas. The new red blocky F1 hybrid, cv. AF21366, has the potential to establish a new paradigm in the Peruvian market by helping the grower, the country economy, the environment and final costumers and consumers. Additional trials under the Peruvian production conditions are under way to fully validate the resistances and agronomic characteristics.

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Agro-morphological, Chemical, Nutritional and Sensorial Characterization of 50 Peruvian Chili peppers

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Peru is one of the centers of biodiversity of the genus *Capsicum*. It is estimated that there are about 2,000 varieties of peppers, some of which are used as ingredients in our traditional dishes; however, most of them are underused or endangered.

With the aim of adding value to our native *Capsicum* species, 32 Peruvian chili pepper accessions from an experimental station of INIA, located in Huaral (Lima), as well as 18 commercial samples collected in Chincha (Ica), Villa Rica (Pasco) and Pucallpa (Ucayali) were investigated for their agronomical (plant height, growth habit, number of fruits per plant, yield/ha) and morphological (color, shape, length, diameter, weight) characteristics.

All these 50 samples, belonging to five domesticated species (*Capsicum annuum, C. baccatum, C. chinense, C. frutescens* and *C. pubescens*), were also analysed for their nutritional value (proteins, fat, fiber, carbohydrates, fatty acids, carotenoids, ascorbic acid), bioactive compounds (total phenolics, flavonoids, capsaicin, dihydrocapsaicin, nordihydrocapsaicin, volatile compounds) and antioxidant activity (ABTS and ORAC assays).

A sensory panel of experts was formed after 10 months of training. This panel used Quantitative Descriptive Analysis (QDA), based on the quantification of 6 aroma (oregano, herb, passion fruit, apple, citric, fruit) and 4 flavour (sweet, pepper, sour, tomato) descriptors, to assess the key attributes of the 50 chili peppers pulps.

Chili peppers selected for this study showed a wide variety of agro-morphological characteristics: fruit length (6.4 – 122.2 mm), fruit diameter (5.1 – 64.4 mm), fruit weight (0.2 – 90.2 g), plant height (27.4 – 197.6 cm), number fruits per plant (13 - 1128) and yield (0.6 – 44.2 t/ha).

Some chili peppers with interesting nutritional components were: ají Panca (protein: 25.7%, carotenoids: 896.4 mg β-carotene/100 g); Pucunucho (fat: 9.7%, ascorbic acid: 328.3 mg/100 g), Limo (fiber: 30.1%); Ayucllo (oleic acid: 60.4%), Picudito rojo (linoleic acid: 64.9%); Mirasol (total phenolics: 1.7 mg EAG/100 g). Ají Mirasol showed good antioxidant activity (ABTS: 6.5 mmol Trolox/100 g; ORAC: 7505.7 µmol Trolox equiv/100 g).

The most pungent chili peppers were Macruzori picante and Pucunucho (71200 Scoville Units). Capsaicinoids content were always higher in placenta and seeds than in the pulp.

Many chili peppers (Tomatito rojo, Dulce, Escabeche, and others) containing only traces of capsaicinoids in the pulp showed interesting sensory attributes (fruit, herbal, pepper, sweet, apple, oregano) which could be important for gastronomic purposes. Some moderately pungent peppers, but with good aroma and flavour (passion fruit, citric, fruit and apple attributes) were Ají Mono, Amarillo, Challuaruro, Corazón de paloma amarillo and Charapita amarillo.

These results may be of great value for commercial farmers and the gastronomic sector.

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Caracterización Químico-Nutricional y Sensorial de Ajíes Nativos Peruanos Cultivados en Ica-Perú

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Pese a la gran diversidad de ajíes nativos peruanos, son pocos los empleados en la gastronomía y aún menos, los aprovechados por la industria. Sin embargo, la apertura de nuevos mercados para ajíes frescos, hace necesaria su caracterización química y sensorial para su puesta en valor tanto a nivel nacional, como internacional.

En el presente trabajo, se determinó el aporte nutricional, perfil de ácidos grasos, contenido de capsaicinoides, compuestos fenólicos, flavonoides, capacidad antioxidante, perfil de compuestos

volátiles y sensorial de los frutos de seis accesiones de ajíes nativos peruanos: Charapón, Amarillo, Ayucllo, Challuaruro y Limo; todos cultivados de manera orgánica por la empresa Agroexport Topará (Chincha, Ica, Perú).

En general, los principales nutrientes fueron los carbohidratos (35.7 -60.7%), seguidos de las proteínas (14.5-22.5%) y fibras (15.4-30.1%). La evaluación del perfil de ácidos grasos por cromatografía de gases acoplada a espectrometría de masas (GC-MS), permitió identificar 8 ácidos grasos mayoritarios para todas las muestras. El ácido linoleico fue el más abundante para todos los ajíes (6.4 - 53.1%), a excepción del Ají Amarillo que presentó mayor contenido de ácido palmítico (54.5%).

La cuantificación por cromatografía líquida de alta eficiencia con detector de arreglo de diodos (HPLC-DAD) de los 3 capsaicinoides más abundantes (capsaicina, dihidrocapsaicina y nordihidrocapsaicina) determinó mayor contenido total en venas y semillas (152.4 – 895.1 µg/g) con respecto a pericarpio (5.2 – 85.0 µg/g). El ají con menor contenido de capsaicinoides en pericarpio fue el Amarillo, mientras que el ají entero seco más pungente fue el Ayucllo (2670.1 µg/g de capsaicinoides totales y 40052 Unidades Scoville).

El contenido de fenoles totales (según método Folin-Ciocalteau) fue 133.43 – 166.32 mg EAG/100 g de muestra fresca (MF). El análisis de flavonoides por HPLC-DAD evidenció la presencia de luteolina (10.6-52.4 µg/g MF), quercitina (19.8 – 37.1 µg/g MF) y kaempferol (2.60–6.63 µg/g MF). La capacidad antioxidante, cuantificada por el método ORAC (Oxygen Radical Absorbance Capacity), mostró valores en un rango de 591.7-1013.2 mmol-equivalentes de Trolox/100 g MF.

El análisis de compuestos volátiles mediante la Microextracción en Fase Sólida (SPME-Solid Phase Microextraction) seguida de GC-MS, evidenció la presencia de más de 60 compuestos volátiles para cada uno de los ajíes. El hexil-*n*-valerato fue el único compuesto volátil mayoritario presente en más de un ají: Charapón y Limo.

Finalmente, el análisis sensorial mediante la metodología del QDA (Análisis Descriptivo Cuantitativo) permitió analizar los descriptores de olor y sabor más importantes para cada ají, destacando el pimiento y el frutal para la mayoría. Se encontró correspondencia entre los resultados del QDA y los compuestos volátiles identificados por GC-MS, especialmente para el descriptor frutal.

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Evaluation of Pepper Production Under Different Polyethylene Film

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Evaluation of direct and diffuse solar radiation interference on physiological characteristics and production of pepper under three conditions of cultivation: the open field, green house with low-density polyethylene film - light diffuser (LDPF-diffuser) and green house with common polyethylene film using a red rectangular hybrid (Melina) grafted on rootstock hybrid (AF8253). The transmissivity values of global solar radiation were 56.0 and 73.3% for light diffuser and common polyethylene film environments respectively with small reduction in transmissivity to photosynthetically active radiation, compared to the global, with 50.1 values and 71.1% for light diffuser and common film environments, respectively. On average diffuse fraction in the field was approximately 25.8%, 55.3% and 96.5% for common film to light diffuser, reflecting the photosynthetic efficiency. It was observed that the Leaf Area Index (LAI) was higher in the light diffuser film production environment and consequently the

first 12 harvests were greater: Total number of fruits by m^2: 36 fruits that resulted 6.59 kg m^2 of mass at green house with light diffuser film, 31 fruits that resulted 5.24 kg m^2 at green house with common polyethylene film and 10 fruits that resulted 1.81kg m^2 at open field. It was also observed that the use of light diffuser film its better in the summer months, means, when there is lighter. When the solar radiation falls below 8,4MJ $m^{-2}day^{-1}$ (trophic limit), it was observed that pepper production decreased.

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Valuation of Chili Collected in Bolivia

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Bolivia is the centre of origin of the Capsicum genus with a great genetic diversity. In addition to the five cultivated species, (*Capsicumannuum* L., *C. chinenseJacq.*, *C. frutescens* L., *C. baccatum* and *C. pubescens* Ruiz & Pav), there is in Bolivia a record of the following wild species: *C. baccatumvar. baccatum, C. caballeroiNee*, *C. cardenasii* Heiser & P.G.Sm, *C. ceratocalyx*Nee, *C. chacoense*Hunz, *C. eximium*Hunz, *C.coccineum* (Rusby) Hunz and *C. minutiflorum* (Rusby) Hunz. The working collection conserved at the Pairumani Phytoecogenetic Research Center (PPRC) was collected

throughout the national territory and is composed of cultivated and wild species: *Capsicumbaccatum, C. chinense, C. frutescens, C. pubescens, C. baccatumvar. baccatum, C. caballeroi, C. cardenasii, C. ceratocalyx, C. chacoense, eximium C*., and *C. minutiflorum* and the species *C.annuum* introduced and cultivated by farmers of the country. The project funded by the GIZ "Rescue and promotion of native chilies in its centre of origin" which was conducted jointly by Bolivian, Peruvian, German partners and the Bioversity International, aimed to develop knowledge and test innovative approaches to increase the use of the native crops diversity and the neglected ones, in order to improve the incomes of poor farmers and provide a more diverse and sustainable production, in response to the growing demand for food and differentiated high-value ingredients. It allowed them to study the diversity of Bolivian chilies, which eventually can be used in the development of improved and/or incorporated varieties into value chains. The following has been conducted: the taxonomic study, the morphological, molecular and biochemical characterization, the agronomic evaluation and processing tests of the collection accessions conserved in the PPRC. The processing researches were performed jointly with the Institute of Food Technology of the University San Francisco Javier of Sucre. From the results of these studies, a prioritization of accessions with promising characteristics was conducted. These results obtained from the project served as the basis for the PPRC to continue with the development of a methodology for growing wild accessions, with selection for the formation of new varieties and fruit production for processing. Currently, there are several processed products, sauces, pickles, chocolates, jams, among others, for which we are in the stage of promotion and market opening, since these are processed products derived from chilies, known but little or not used in the domestic market. It also involve farmers to carry out a more diverse and sustainable production of native chili, in response to the growing demand for food and differentiated high-value ingredients.

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Guía de cultivares de ajíes y pimiento (*Capsicum*s pp.) conservados en la colección *ex situ* de INIFAT

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Dando seguimiento al esfuerzo realizado en el período 1981-2010 por recolectar, caracterizar, evaluar, documentar y conservar los recursos genéticos del género *Capsicum* se ha realizado el presente trabajo. Como parte de una estrategia por regenerar accesiones conservadas *ex situ* desde los años 1990-1997 en cámara

refrigeradas a temperaturas de 5-7ºC y colocadas en envase hermético laminado de aluminio de 11-20 µ de espesores inició en el año 2013-2014 la regeneración de un grupo de accesiones de la colección género *Capsicum.* Esta colección también fue caracterizada buscando fomentar el uso y determinar el estado de la conservación. Además para tener una mayor representatividad del genofondo presente en el país se incluyeron en el proceso de regeneración y multiplicación variedades avanzadas derivadas del programa de mejoramiento del INIFAT desarrollado por la Ing. Laura Muñoz de Con. El estudio se realizó empleando los listados de descriptores internacionales y la propuesta de Barrios (2010) con modificaciones y acondicionando los cultivares en una instalación de cultivo protegido unido a que se trabajó en el aislamiento de las accesiones para evitar el cruzamiento. Hasta el presente 2016 se han logrado regenerar 80 accesiones de un total de 396 para un 20% de total en el conjunto de las accesiones regeneradas se incluyen representantes de las especies (*Capsicum annuum*, *Capsicum frutescens*, *Capsicum chinense* y *Capsicum baccatum*) y abarca cultivares tradicionales, variedades modernas, y parentales silvestres. Entre los cultivares se observan formas que pueden ser destinadas a diferentes propósitos como vegetal fresco, industrial, condimento, medicinal y ornamental.

Organic production of native chili peppers of Peru

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Organic production suitable for smallholders conserving agrobiodiversity is promoted as a means to improve access to markets together with *in situ* conservation of genetic resources at risk. During the last 5 years, we have been growing our germplasm collection in a certified organic experimental farm at UNALM, in Lima. Here we describe the technologies implemented and we discuss the limitations and the potential of organic methods for different types of smallholder agriculture. Crop management, including pest and disease control, has evolved into a well developed system able to assure healthy and vigorous plants. There are, however, clear differences between the over 300 types of *Capsicum* grown every year. Main challenges are related with crop nutrition, including the use of organic inputs for fertigation, as well as the selection of landraces better adapted to this type of management. In the future, these technologies may also help to improve the current production systems of conventional commercial chili peppers, were synthetic pesticides are intensely used, very often without respecting the Days-to-Harvest Intervals. Organic yields of these commercial types of

chili pepper, however, do not yet match those of conventional agriculture. Recommendations for further research in agroecological methods are discussed.

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Genetic Characterization of a Bolivian Capsicum Collection by Using Morphological and SSR Markers

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The Capsicum genus has as a centre of origin to Bolivia; archaeological records have reported chili seeds since 7,500 years ago, which tell about the "uchus", as they are called in Quechua, used in religious ceremonies and as a medicinal agent because the fruit has antirheumatic, anti-inflammatory and antacid properties, but its use, as a condiment, had an impact on its dissemination. The genus has about 30 species between cultivated and wild, of which, only five species have been domesticated: *Capsicumannuum* L., *C. baccatum* L., *C. chínense* Jacq., *C. frutescens* L. and *C. pubescens* Ruiz &Pav., being *C. annuum* the most cultivated worldwide. Bolivia is a country that has diverse ecosystems with varied climatic and soil conditions, which allowed the development of a great

diversity of species and varieties of native chilies, its morphological and genetic diversity is quite wide, since its distribution range covers different ecological regions of the country. The working collection of the Pairumani Phytoecogenetic Research Centre (PPRC) dates from the late 80's and was collected throughout the country; this collection includes five cropped species and seven wild species. The growing interest in their use and consumption in the country, has made the PPRC to seeking and knowing more about their genetic and distribution, to maximize all their forms in a value chain. Thereby, it is why a morphological *ex situ* characterization of the accessions belonging to the Capsicum working collection of PPRC was conducted, taking all species found in the country in wild and cultivated form and using the IPGRI descriptors, now Bioversity. These data were compared with the collection region or cultivation area. 359 accessions of the collection belonging to the twelve species described in the country were selected. The morphological, taxonomical and molecular studies showed that, in gender Capsicum, exist an inter-specific hybridization capacity resulting in the appearance of groups different to the original parent and / or intermediate complex. These groups are closely related to each other, giving rise to a variability of forms of fruit rather important. Molecular data were obtained with 20 SSR markers, revealed in acrylamide gels. The results were analyzed with the NTS program and v2.10 and the Structure program to consolidate the genetic diversity and population structure and with DARWinv.5.0 for evaluating the relationships of different accessions with respect to the collection region or crop. The study allows to evaluating the genetic diversity and its relationship with the morphological variability and geographic components, which also allowed deepest studies regarding taxonomy.

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Resistencia genética de líneas de pimiento (*Capsicum annuum* L.) frente a *Meloidogyne incógnita*, raza 2 y su comportamiento agroproductivo en los sistemas de cultivo protegido en Cuba.

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Resumen

Para lograr híbridos con alto potencial de rendimiento, buena adaptación climática y resistencia a las principales enfermedades es necesario contar con genotipos con resistencia múltiple y de frutos grandes para ser explotados en el sistema de cultivo protegido, en Cuba. Los nematodos de agallas del género *Meloidogyne* constituyen en la actualidad un problema para la producción intensiva de hortalizas en casas de cultivos protegidos debido a la forma intensiva de producción que esta tecnología requiere. La especie *M. incognita* raza 2*,* es la más distribuida en éstos sistemas. Con el objetivo de conocer el comportamiento diferencial de diferentes genotipos de pimiento pertenecientes al Programa de Mejoramiento Genético con resistencia comprobada a Potyvirus y P. capsici, se estudió el espectro de acción de diferentes genes de resistencia. Se inocularon las plantas a una presión de inóculo de 5000 huevos - J_2.g de suelo-$^{-1}$. Se utilizó como control susceptible la variedad de tomate Campbell-28. La categorización de las líneas se determinó mediante el Índice de Agallamiento (IA), el Factor de Reproducción (FR), el Índice de Reproducción (IR) de los nematodos. Se evaluaron además parámetros agroproductivos. Las líneas HD149, HD330 y CM334 tuvieron un comportamiento inmune frente a *M. incognita* raza 2. Las líneas LB, BM29 y Nv manifestaron una elevada reproducción del patógeno. Los resultados agroproductivos arrojaron que el genotipo HA 330 fue el de mejor resultado alcanzado, en todos los caracteres. La línea BM29 fue la mejor en cuanto al número de semilla por frutos con 260 y la línea Nv en rendimiento en semilla (84.6). Se discute la respuesta mostrada por las líneas así como su posible uso como progenitoras para futuros híbridos F1 de pimiento bajo el sistema de producción protegida.
Palabras claves: *Capsicum annuum*. L., *Meloidogyne incógnita*, genes de resistencia.