Food Reviews International

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/lfri20

The Milpa as A Supplier of Bioactive Compounds: A Review

OG Méndez-Flores, H Ochoa-Díaz López, I Castro-Quezada, ZE Olivo-Vidal, R García-Miranda, U Rodríguez-Robles, CA Irecta-Nájera, G López-Ramírez & XM Sánchez-Chino

FOOD REVIEWS INTERNATIONAL
https://doi.org/10.1080/87559129.2021.1934001

The Milpa as A Supplier of Bioactive Compounds: A Review

OG Méndez-Flores [a], H Ochoa-Díaz López [b], I Castro-Quezada [b], ZE Olivo-Vidal [c], R García-Miranda [b,d], U Rodríguez-Robles [e,f], CA Irecta-Nájera [c], G López-Ramírez [g], and XM Sánchez-Chino [f]

[a]Cátedra-CONACyT, Health Department, El Colegio De La Frontera Sur, San Cristóbal De Las Casas, Chiapas, México; [b]Health Department, El Colegio De La Frontera Sur, San Cristóbal De Las Casas, Chiapas, México; [c]Health Department, El Colegio De La Frontera Sur, Villahermosa, Tabasco, México; [d]Escuela De Lenguas-Campus III San Cristóbal, Universidad Autónoma De Chiapas, San Cristóbal De Las Casas, Chiapas, México; [e]Departamento De Ecología Y Recursos Naturales. Centro Universitario De La Costa Sur. Universidad De Guadalajara, Autlán De Navarro, Jalisco, México; [f]Cátedra-CONACyT, Health Department, El Colegio De La Frontera Sur, Unidad Villahermosa, Villahermosa, Tabasco, México; [g]Departamento De Fisiología, Biofísica Y Neurociencias, Centro De Investigación Y De Estudios Avanzados Del Instituto Politécnico Nacional, Ciudad De México, México

ABSTRACT
Milpa is a traditional polyculture production system mainly composed of corn, beans and pumpkin, together with other edible plants. It represents an important food and nutrients supply, but also bioactive compounds source, such as phenols, anthocyanins, phytosterols, phytates, resistant starch, peptides, among others compounds that confer multiple health benefits. Therefore, the aim of this work was to gather the scientific evidence on the health effects of the bioactive compounds found in the plants that belong to the milpa. Although there are few studies that report the interaction between different biomolecules and crops in combination, as in meant to be at regular eating; evidence, here summarized, suggests that consumption of milpa vegetables has an active effect of biomolecules from these crops was found active, mainly on chronic non-communicable diseases. Thus, the main objective of this study was to summarize the scientific evidence on bioactive compounds found in the plants grown as part of the milpa and their health-related benefits.

KEYWORDS
Corn; beans; chili; pumpkin; quelites; health and nutrition; milpa

The milpa is a polyculture, where mainly corn (*Zea mays*), beans (*Phaseolus* spp.) and pumpkin (*Cucurbita spp*.) are grown; for this reason, it has been called the Mesoamerican triad. Despite a basic structure in the milpa system, differences can be found in the associated crops among regions and customs.[1] The diversity of the milpa lies in the management that each peasant family does, it depends on their tastes and needs and the environment in which it is grown.[2] The families cultivate the food that they will consume throughout the year in their milpas,[3,4] each family has its own configuration for the milpa system including the food plants available in their locality.

The milpa system is a dynamic reservoir of biological and nutritional resources. For instance, in tropical milpas stand out some varieties of chili peppers, quelites, tubers and tomatoes that are grown in the milpa[5] and they are the basic products in the diet of Mexicans since pre-Hispanic times and today they represent the subsistence agriculture.[6] Traditional polyculture systems, such as indigenous-managed milpas, host a large amount of plant genetic resources that, in general, have hardly been recorded and therefore underestimated, for example, Heindorf *et al.*,[4] reported 191 types of edible plants, comprising 84 species in milpas humid and sub-humid tropical zone of northeastern Mexico known as the Huasteca. This staple-based agricultural regime, called milpa, can largely overcome the

CONTACT Xm Sánchez-Chino xsanchez@mail.ecosur.mx Cátedra-CONACyT, Health Department, El Colegio De La Frontera Sur, Unidad Villahermosa, Villahermosa, Tabasco, México

nutritional deficiencies generated in family diet when it depends on individual crops, by the compensatory nutritional qualities of the other components from different crops.[5]

Diet, nutrition and health are tightly related aspects of life, which are affected by food affordability. Current changes in life style, which go hand in hand with the technological and economic development has led to food pattern transitions in people from México and around the world. There is a market tendency to consume high calorie dense food, which is extremely palatable, nutritionally unbalanced, low in diet fiber and water, besides to be budget priced industrial food. On the contrary, fruits, vegetables, complex carbohydrates and minimally processed food, which may be obtained from locality commodities or home agricultural systems, as the milpa, are less consumed among the population. This food transition entails also an epidemiologic transition that involves an increase in chronic non-communicable diseases (NCD) incidence.[7–9]

The NCD are metabolic disorders related to cellular energy budget and the consequent maladjustment of metabolic and signaling pathways, which may be connected to feeding. Type II diabetes, arterial hypertension and dyslipidemia disorders are intimately associated to overweight and obesity. Excessive lipogenesis derives from an unbalanced interplay between energy intake from food and organism caloric demands, thus chronic sub-clinic inflammatory status is activated in sequence with lipidic disarrangements and cellular metabolic accelerations that derives in increased reactive oxygen species production.[10] In this sense, the properties in corn, pumpkin, chili, tomatoes and quelites are desirable characteristics to be obtained from food.[11] Experimental evidence suggests that milpa vegetable elements may have beneficial effects on preventing or helping on treating NCD and also communicable diseases if are included in diet, since the milpa elements have various compounds with pharmacological effects.

Bioactive compounds in plants are diverse, their presence depends on environmental conditions. Most of them are generated through the secondary metabolism of plants, and their function is mainly as a reserve, defense, or for interaction with other plants, microorganisms and insects.[12] The synthesis of these compounds is influenced by geographic location, climatic, genetic factors, and interaction with other species. Therefore, it is essential to maintain biodiversity in crops to ensure permanent access to them. These compounds differ in their chemical nature; they have different molecular weight, polarity, solubility, bioavailability, metabolic pathways, and excretion. All of this will affect the distribution and concentrations of each compound at the target sites.[13]

At the moment there is scientific evidence about the health benefits of consuming the products we find in the milpa. Thus, it is important to know their individual mechanism of action and the interactions that may exist between them. For example, some organic acids function as surfactants for other molecules, polyphenols can increase the aqueous solubility of saponins and they, in turn, improve transmembrane transport of therapeutic molecules.[14] Chavez-Santoscoy[15] reported that flavonoids and saponins in black beans (*Phaseolus vulgaris L.*) could reduce cholesterol absorption by inhibiting the micellar solubility of cholesterol. On the other hand, Pan *et al*, [13] reported that b-carotene increases the bioavailability of lycopene in human plasma and quercetin-3-glucoside reduces the absorption of anthocyanins, for this, it is desirable that the consumption of food from the milpa be combined, since there can be synergistic effects, potentiating additives, although also antagonistic.[13]

Thus, the main objective of this study was to summarize the scientific evidence on bioactive compounds found in the plants grown as part of the milpa and their health-related benefits. This review approaches elucidating probable functional applications of food in isolation and in very particular preparations, as this research strategy gives valuable transposable information.

Corn

Corn is one of the most important cereals worldwide besides wheat that is staple food in several countries. In Mexico, most cultivated corn pertains to one sole species: *Zea mays*, which includes around 64 races and diverse landraces, a diversity that is threatened by experimental sowings and open cultivation of genetically modified corn.[16,17]

Chemical composition of this seed and its nutritional value depend on the genotype, variety, and environmental conditions. The main component of corn is starch (73%), such as amylose and amylopectin; followed by proteins (8–11%) and lipids (3 to 18%).[18] Corn kernel also contains carotenoids, which are found mainly in yellow genotypes, in the endosperm and in small amounts in the germ, phenolic acids generally covalently bind to cell walls, and approximately 75% is located in the aleurone and pericarp layer.[19,20]

Corn varieties differ on the size, the shape of both, grain and cob, the nutritional composition, its functional characteristics and the color (white, yellow, blue, red and purple). The blue, red and purple grains stand out for their high content of minerals and secondary metabolites such as ferulic acid, *p*-coumaric acid, cyanidin 3-glucoside, peonidin and pelargonidin, present in the pericarp, the aleurone layer and the cell wall.[21]

The phenolic compounds found in the cell wall are beneficial for colon health, because the materials of their cell wall are non-digestible for humans, so when they reach human colon they are metabolized by the intestinal microbiota, releasing some compounds, including diferulic acid that benefits colon health.[20] It has been shown that consuming corn confers bioactive properties: antioxidant, anti-inflammatory, activation of the enzymes of the metabolism phase 2, cell proliferation arrest and hypoglycemic.[21–23]

It has also been shown that some of the pigments remain intact even after cooking it in an alkaline solution to obtain the cooked grain,[24] so the tortilla provides these important components. Known *et al.*[25] in an *in vitro* study on the benefits of corn, selected 8 varieties (yellow, black, white and red grains) that were autoclaved, noted that thermal processing and pigmentation type of corn are important factors to enhance the antioxidant effect of this grain and related it with modification in the profile of individual soluble phenolic compounds due to its probable polymerization resulting from the heat treatment. They also reported that aqueous extracts of these varieties of corn could inhibit the enzyme β-glucosidase, thereby delaying glucose uptake, lowering blood sugar levels and mitochondrial reactive oxygen species (ROS) levels linked to hyperglycemia in non-insulin dependent diabetes mellitus models.

The corn can be consumed tender (corn cob) or dry; depending on its variety, it is used for different preparations. One of the most important ways to consume corn in Mexico is as *tortillas* and its derivates after cooking it in an alkaline solution (nixtamalization).

Nixtamalization generates significant changes in nutritional content and organoleptic characteristics of corn, such as: increases the calcium, iron, copper and zinc content, enhances niacin availability and lowers phytic acid content.[26] During nixtamalization, the phenolic content of the corn grain decreases[27,28] but baking the masa to obtain tortillas and frying tortillas has a small effect on the phenolic concentration and composition.[27] A slight increase of the free phenolics is observed when masa is transformed into tortillas and chips. The ferulic acid content of raw corn is lost in high amounts after nixtamalization since the aleurone layer and pericarp tissue are removed during cooking and steeping. However, free ferulic acid increases in masa, tortillas and tortilla chips.[27,29]

The alkaline cooking process also affects the corn anthocyanin content, but the loss differs among varieties according to the location of the pigment in the grain. The red corn with pigment in the pericarp presents greater losses of anthocyanin (73 to 100% of loss) than the blue corn with pigment located only in the aleurone layer (19.5 to 50.2% of loss). Nixtamalization also changes anthocyanin pattern in the blue corn: as the proportions of anthocyanins 6 and 8 decrease, the percentage of cyanidin 3-glucoside increases.[30] Cyanidin 3-glucoside has been recognized for its antioxidant, anti inflammatory and neuroprotective effects.[31] Further processing of masa into tortillas and chips does not have a significant effect on anthocyanin concentrations and the remaining content provides sufficient antioxidant activity.[27]

Another group of bioactive compounds that are affected by lime-cooking are carotenoids. In the latter process, around 50% of the carotenoids are lost. Despite this loss, considerable amounts of lutein, zeaxanthin and beta-carotene are still found in tortillas from pigmented corn varieties.[27]

Regarding cellular antioxidant activity (CAA), an investigation conducted in Mexico showed that tortillas made from native maize landraces retained 47.4 to 48.7% of the CAA found in raw grains. Nevertheless, when lime cooking extrusion process was used, the CAA of tortillas was higher (72.8 to 77.5%).[32] Similar results were observed when Oxygen Radical Absorbance Capacity (ORAC) was assessed: traditional tortillas had 16 to 52% lower ORAC than raw grains, but this difference was smaller when extrusion process was used (around 7 to 25%).[29] It should be noted that blue/purple corn tortillas have higher antioxidant capacity (29 to 33 µmoles Trolox/g dry sample) than white corn tortillas (15 µmoles Trolox/g dry sample).[30]

Besides the antioxidant properties, a recent report has shown that extract from blue corn tortillas has antiproliferative activity in certain cancer cell lines, such as: hepatocellular carcinoma (HepG2), lung carcinoma (H-460), cervix adenocarcinoma (Hela), mammary adenocarcinoma (MCF-7) and prostate cancer androgen dependent (PC-3). Interestingly, tortilla extract inhibited cell growth of the cancer lines at lower concentration (250 and 500 µg/mL) than blue raw corn extract, suggesting that nixtamalization process is beneficial.[33]

Corn oil has been reported to be rich in phytosterols: sitosterol (4.35 mg/g), campesterol (1.55 mg/g), stigmaesterol (0.70 mg/g) and cycloartenol (0.27 mg/g).[34] These compounds are structurally similar to cholesterol so they are able to compete for their absorption in the epithelial cells of the intestine without having an effect on fat-soluble compounds such as the essential vitamins for metabolism.[35]

Besides to phytochemical compounds, it has also been reported that some macronutrients, such as proteins, may have other health benefits. Jin *et al.*[36] reported that amino acid sequences obtained after gluten hydrolysis had a powerful antioxidant activity: reducing power and elimination capacity for the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical and the superoxide anion radical.

Beans (*Phaseolus* spp)

In Mexico, five domesticated species have been identified: *Phaseolus acutifolius, P. coccineus, P. dumosus, P. polyanthus, P. lunatus* and *P. vulgaris*. The main components of beans are carbohydrates (54–60%) and proteins (21–22%), which is why they are in fact one of the main sources of protein in developing countries, and in small amounts: crude fibre (6.3–8.5%) and lipids (2.5%).[37] Bean seed color is determined due to the presence and concentration of flavonols (mainly kaempferol and quercetin), glycosides, anthocyanins, condensed tannins (proanthocyanidins) and phenolic acids (ferulic, synaptic, chlorogenic and hydroxycinnamic acids), the highest proportion of these compounds are found in the ones with purple, black and brown colors.[38–40]

Xu and Chang[41] reported that black bean phenolic compound extracts showed antioxidant activity against DPPH and PRSC (Peroxyl radical scavenging capacity) with an IC50 (mean inhibitory concentration) similar to black soybeans tested in digestive system cancer cell lines (CAL27, AGS, HepG2, SW480 and Caco-2), prostate cancer (DU145), ovary cancer (SK-OV-3), breast cancer (MCF-7) and leukemia (HL-60). The authors related the anticarcinogenic effect with the content of total phenolic compounds, procyanidins, saponins and phytic acid.

Another compound of interest identified in bean seeds are lectins. In a study with experimental animals in early stages of carcinogenesis it was reported the effect of lectins from *P. acutifolius* cytotoxic on colon cancer cells.[42] This was related to antiproliferative and pro-apoptotic effects related to a decrease in the protein of the signal transduction pathway Akt in its activated form and an increase in caspase 3 activity, but not with the activation of p53. A positive effect on cell cycle arrest has also been shown in the G0/G1 phase. Specific gene expression related to apoptosis, where an increase in p53 and a decrease in Bcl-2 (protein implicated in the promotion of cancer through the avoidance of cell death) were observed.[43]

Lacerda *et al.*,[44] isolated a lectin with a size of 128 kDa, thermostable with radical scavening ABTS and DPPH. It also had antitumor activity against cells derived from melanoma and gastroprotective action against damage induced with ethanol. Similar effect was reported by Wu *et al.*,[45] in a lectin with a molecular mass of 24.3 kDa isolated from *P. lunatus* seeds reported an antiproliferative effect against leukemia cells and antifungal activity. Pan *et al.*,[46] identified a 66 kDa dimeric lectin stable at 20 to 70°C, with antitumor effect against CNE1, HepG2 and MCF7 cells (nasopharyngeal, liver and breast carcinoma), in addition to anti-inflammatory effects, for which the authors suggested its use in pharmacological therapies.

Also, protease inhibitors (PIs) of a protein nature have been associated with anticancer activity. In this sense, a Bowman-Birk type PI isolated from *P. acutifolius* showed this effect by increasing cell adhesion, decreasing the degradation of the extracellular matrix in cell lines what correlates with a decrease in the capacity for cell invasion *in vitro*, among the possible mechanisms proposed, the decrease in metalloproteinase-9 activity.[47]

In a model of acute colitis in experimental animals induced with sodium dextran sulfate (DSS) for 7 days and fed with diets with 20% cooked black beans showed that condensed tannins extracted from black beans had cytotoxic effects by inducing apoptosis in colon, breast and prostate cancer cells.[48] Dong *et al.*[49] studied the compounds with possible biological activity contained in the black bean peel and identified 24 compounds among which are: 12 triterpenoids and 7 flavonoids with antiproliferative activity against liver cancer cells (HepG2); rectal colon cancer (Caco-2) and breast cancer (MCF-7) in a dose-dependent relationship.

The consumption of bean seeds requires to have been previously processed, for which a soaking and cooking process is usually performed. One of the main concerns is that in general, the secondary metabolites are water soluble or heat sensitive. However, Zhang *et al.*[50] showed in murine models that bean consumption contributes to reducing the mRNA expression of inflammatory cytokines of the colon (IL-6, IL-9, IFN-g and IL-17A) and stress oxidative induced by DSS, as well as increase the presence of the anti-inflammatory molecule IL-10 and increased the mRNA expression of FasL (apoptosis mediator) and the number of apoptotic cells in the colon and cecal concentrations of short chain fatty acids (-SCFAs- such as acetate, propionate and butyrate).

Beans contain a fraction called non-digestible, consisting of soluble and insoluble fiber, resistant starch, oligosaccharides, polyphenols and some bioactive peptides[51] which are believed to have prebiotic effects, since post-intake, SCFAs are generated (butyrate and propionate) in the intestinal tract as a metabolic product of healthy bacterial populations for the colon. These compounds have a positive effect on genetic expression, regulation of cell growth and differentiation in various types of animal cells[52]

Haydé *et al*[51] demonstrated that the consumption of the non-digestible fraction of baby bean is able to regulate the expression of genes involved in the activation of the Tp53 protein, function as a defense against cell damage. The phytosterols, saponins and flavonoids of the black bean seed coat, have activity on the reverse transport and cholesterol metabolism, reducing the micellar solubility; thereof, phytosterols negatively regulate lipogenic genes such as SREBP1, FAS, and ABCG5, but positively the expression of CPTI in the liver, which promotes beta-oxidation of long-chain fatty acids.[15]

Due to the evidence of a low incidence of cancer associated with the consumption of beans, Thompson *et al*[53] studied the effect of common beans in a breast cancer model, focusing on systemic factors such as signaling dependent growth factor of insulin, in addition to routes associated with energy balance and cellular anabolism. They reported that induction of apoptosis is dose dependent and it is related to Bax and Bcl-2 dependent mitochondrial mechanisms in carcinomas.

Pumpkin

The pumpkin is creeping plant, it grows at the base of the corn plants; thus it helps to preserve the humidity of the floor and, due to the structure of its leaves and a substance it releases, to protect the rest of certain animals and insects.[54] The species generally found in the *milpa* are *Cucurbita pepo*, *C. moschata, C. argyrosperma (peninsula de Yucatan), C. fiscifolia*[55]. It is a very versatile vegetable because almost everything it is consumed: stems, leaves, tender and immature fruit, either tender in casseroles and salads or ripe in regional sweets, *moles* and soups. In addition to the fruit, its seeds are also consumed, when roasted with salt and chili as snacks, incorporated into mole "*pipián*" or as oil extracted from them to season salads and pasta.

Among pharmacological activities with which pumpkin pulp has been linked is its effect on diabetes, the pulp of *C. ficifolia*, has been associated with promoting insulin secretion, increased storage of glycogen in the liver and glycogen synthase level.[56] Jin *et al*.[57] demonstrated that the aqueous and ethanolic extracts of fresh *C. moschata*, rich in polysaccharides composed of heterogeneous monosaccharides such as glucose, galactose, arabinose and rhamnose are capable of reducing blood glucose concentration, while parallel increasing insulin in plasma. This mechanism was proposed for the prevention of diabetic nephropathy in mice administered with alloxan, a compound that induces diabetes through insulin deficiency. On the other hand, it has been reported that the ethanol extract of *C. moschata*, rich in protein-bound polysaccharides, at a dose of 1 g/kg has an effect similar to gliblenclamide (20 mg/kg) in the concentration and in the curve of insulin resistance in rats administered with alloxan.[58] Kwon *et al*.[25] reported that cooked pumpkin (*C. pepo*) extracts are capable of inhibiting the enzymes β-glucosidase and α-amylase, preventing the release of glucose from complex carbohydrates, consequently reducing blood glucose concentration.

Most of the pumpkin (*C. pepo, C. moschata* and *C. maxima*) beneficial effects on health have been reported in its seeds. They contain a large amount of protein (31.2%) and oil (49.3%), which is abundant in unsaturated fatty acids (mainly linoleic and oleic acid) and other components such as polyphenols, phytosterols, choline, vitamins and minerals. In traditional medicine, fresh or roasted seeds are used to relieve abdominal cramps and bloating caused by intestinal parasites, this effect has been related to their content of cucurbitacins, alkaloids (berberine and palmatine), amino acids and fatty acids.[59]

It was also reported that *C. ficifolia* has an important activity against systemic inflammation induced by obesity, which in turn is related to insulin resistance and progression to diabetes mellitus type 2 (DM2)' [60] this problem has been related to vulnerability to infections due reduces the immune system. Fortis-Barrera *et al*.,' [61] evaluated the daily administration of an aqueous extract of *C. ficifolia* in obese mice using a monosodium glutamate (MSG) induction model whose mechanism is increased body weight due to white adipose tissue accumulation, and exhibited high levels of inflammatory cytokines. Among their results, body weight loss was observed by decreases in mRNA expression and protein levels of TNFR2 and IL-6 also increased IFN-γ. In other experiment, the extract from *C. ficifolia* exhibited modulation of chronic systemic inflammation in obese mice in the MSG model and enhances the adaptive immune system in obesity. Treatment with the extract decreased body mass and reduced inflammation by suppressing the expression of TNF-α and IL-It has also been identified that its consumption has an effect as a secretagogue of insulin through an increase in Ca^{2+} of the calcium reservoir in the endoplasmic reticulum' [62] Another study reported that *C. ficifolia* was significantly able to down-regulate the genes responsible for adipogenesis and with it, the differentiation of adipocytes, which could have an antiobesity effect.[63] Added due to its antioxidant it is capable of reducing oxidative stress by decreasing H_2O_2 levels, increasing glutathione peroxidase activity and changes in the GSH/GSSG ratio, reduced resisting protein levels and increased IL-6 levels.[64]

Among the bioactive compounds that have been identified in pumpkin pulps are carotenoids, which importance in health lies in the fact of being a precursor of vitamin A together with a powerful antioxidant. Bergantin *et al*,[65]. reported the presence of lutein, violaxanthin with concentrations of 10.5 and 10.3 µg/g of fresh pulp, antheraxantina and astaxantina with concentrations between 1.7 and 1.1 µg/g of fresh pulp in *C. moschata*. These authors also reported that after some traditional treatments such as cooking and baking, there was a loss of bioactive compounds, 10% from cooked and 30% in baked pumpkins. Other bioactive compounds that have been identified in *C. pepo* and *C. moschata* are caffeic acid, quercetin, protocatechuic acid, *p*-coumaric acid and synapic acids' [66]. In terms of concentrations, very wide ranges are reported 0.57–18.40 mg/100 g of fresh carotenoid pulp, where pumpkins with more orange pulps are those with the highest content.' [67]. A phytochemical study in *C. ficifolia* allowed to identify the stigmast-7,22-dien-3-ol, stigmast-7-en-3-ol and salicin, which have reports of pharmacological activity and D-chiro-inositol (DCI), the latter has been associated with effect on glucose metabolism.[68,69]

In the case of *C. pepo* seeds, it has been reported that they have compounds such as cucurbitin, amino acids, fatty acids, berberine and palmatine, which have been associated with the anti-hemitic. Both, aqueous and ethanol extract from the seed made possible to control gastrointestinal nematode infections in animal models,[70,71] while its oil has shown positive results in efficient wound healing, what has been related to its high concentration of linoleic acid, tocopherols and sterols.[72] Also, methanol and hexanolic extracts from seeds of *C. argyrosperma* showed positive effects on the repair of corneal damage by inhibiting neovascularization in addition to decreasing the expression of inflammatory and angiogenic factors. The authors correlated it with the presence of phytochemicals such as flavonoids such as quercetin, luteolin and apigenin.[73] It has also been reported in seed oils of *C. moschata* and *C. argyrosperma* the presence of Chlorophyll b and squalene, among other phenolic compounds and carotenoids, which give it antioxidant properties.[74]

On the other hand, it has been reported that pumpkin seed oil comercial of the *C. pepo*, moderately reduced the signs of metabolic syndrome developed during high saturated fats diets and reduced the concentration of triglycerides, total cholesterol and LDL cholesterol in blood and decreased liver fibrosis.[75] Another major compound in pumpkin seeds are proteins, which have antioxidant capacity. This was reported in a study with experimental animals after intoxication with CCl_4 (carbon tetrachloride), the proteins from *C. pepo* seeds managed to reduce the levels of the enzymes lactate dehydrogenase, alanine aminotransferase, aspartate aminotransferase and alkaline phosphatase.[76] Although the mechanism is not proposed, the authors mention that it may be due to the profile of amino acids and nitrogen compounds contained in the seed. Other activities that have been reported after the hydrolysis of *C. moschata* proteins are antibacterial for both Gram positive and Gram negative bacteria.[77]

Other products present in the Mexican milpas

As mentioned above, in addition to corn, beans and pumpkin, you can find other products of vegetable origin. Among them, a great diversity of chili peppers, tomatoes, yucca, edible leaves known as quelites and others.

Chili

Chili is a condiment cuisine that confers flavor with few or no calories, an advantage over other flavorings also they are a good source of minerals, vitamin A, C and E, carotenoids, and phenolic compounds.[25,78] Due to its level of pungency, its consumption has been related to heartburn and conditions such as colitis and gastritis. However, it has been shown that chilis contain bioactive compounds, mainly the alkaloid responsible for puncture capsaicin, which has an effect on the cardiovascular system and the gastrointestinal tract. It has been reported that chili intake improves metabolic rate and relieves pain, prevents overweight, obesity and cancer, decreases the incidence of cardiovascular and gastrointestinal diseases.[79,80] In Table 1 we show some biological effects reported for capsaicin, main phenolic compound found in chili.

Tomatoes

Tomatoes (*Solanum lycopersicum*) are herbaceous plants. The tomato fruit has a characteristic red color due to its high content of carotenoid pigment that is synthesized during fruit ripening.[88] It is an important ingredient in traditional cuisine as well as in some industrial products, perhaps because it gives the products a reddish color which increases their organoleptic properties. Its consumption is related to the prevention of chronic non-communicable diseases such as cancer and in the prevention

Table 1. Biological effects reported for capsaicin, main phenolic compound found in chili.

Effect	Mechanism
Auxiliary in the treatment of type 2 diabetes mellitus.	Reduction of plasma glucose concentration and maintenance of insulin levels[79] inhibited the activity of the enzyme α-amylase and β-glycosidase so they reduce the absorption of glucose by cells[25]
Protection of the intestinal barrier	Increase in the Firmicutes/bacteroidetes ratio, increase in glucagon-like peptide in plasma and butyrate concentration, as well as a decrease in ghrelin[81]
Anti-obesity	Modulation of hypothalamic satiety increase in expression of thermogenesis genes, appetite and satiety regulation, inhibition of PPARγ expression, C/EBP -α and leptin. Positive regulation of adiponectin at the protein level, induction of apoptosis and inhibition of adipogenesis in preadipocytes and adipocytes Activation of TRPV1 channels by capsaicin in the diet, which causes browning of white adipose tissue[82,83] Inhibition of glucagon secretion, gastric emptying and appetite, so that food intake is decreased as well as inhibitory gastric polypeptide and decreases plasma ghrelin levels.[84]
Anti-cancer	Antiproliferative and cytotoxic effect. Inhibits phosphorylation of ERK and p38 MAPK, cell growth, angiogenesis and metastasis. Induces apoptosis by regulation of TRPV receptors, synergistically with docetaxel, inhibiting PI3K life/Akt/mTOR and activating AMPK.[85–87]

of cataracts and eye disorders.[89,90] Its main bioactive molecule is lycopene, which is one of the most powerful antioxidants against singlet oxygen inhibition added contain others molecules with biological activity such a β-carotene, α-tocopherol,[90] and phenolic compounds mainly: rutin apioside, rutin, naringenin chalcone, naringenin and chlorogenic acid.[91]

Yucca (*Manihot esculenta Crantz*)

Yucca (*Manihot esculenta Crantz*) is found mainly in the milpa from tropical areas. It is rich in carbohydrates (and 80 to 90% carbohydrate on dry weight) and contains non-nutritional compounds polyphenols, oxalate, and saponins. These compounds can have positive effects such an antioxidant, antiinflamatory,[92] anticancer and anticholesterol,[93] but also can have adverse effects on health, depending upon the amount and frequency ingested. For example, some physical interactions, such as surfactants, with other components of the digest and their ability to interact with the membranes of mucous cells, thus reducing the bioavailability of some nutrients.[94]

It is important to note that it contains cyanogenic glucosides, therefore before consumption it must be detoxified, which is achieved with thermal treatments or by dilute sodium bicarbonate solutions.[95]

Quelites

To the variety of crops that are sown within the cornfield, we found *quelites*, weed plants whose consumption in Mexico is determined regionally and culturally (Table 2). The species currently consumed represent only 3% of the 500 different identified by some authors in ancient Mexico.[16,96] The *quelites* are green leafy vegetables, tender stems, sprouts, buds or flowers that are consumed in different ways, whether raw, cooked or fried. The word *quelite* comes from Nahuatl word *quilitl* and evidences its ancient origin, since the *quelites* were high value resources among pre-Hispanic peoples such as the Aztecs. In Table 3, some studies are observed of the pharmacological potential of some quelites of frequent consumption in Mexico.

Among the main bioactive compounds stand out, in general, flavonoids (kaempferol, apigenin, luteolin, myricetin, quercetin, and chlorogenic, caffeic, *p*-coumaric, ferulic and rosmarinic acids) betacyanins, alkaloids and these are found in the roots, stem and leaves.,[100,104,124] which give them antioxidant properties either by trapping free radicals or by inducing the endogenous antioxidant system.[100,104] Other reported activities are anticancer, hypoglycemic and anti-diabetic properties.[,102,103,125] anthelmintic,[126] antiinflamatory[127]antileishmanial activity[128,129]

Table 3. Bioactive compounds contained in some of the most widely consumed quelites in Mexico according to CONABIO and their reported effects on health.

Papalo (*Porophylum ruderale* subsp. *Macrocephalum*)	Leaves	Flavonoids, tannins, saponins, alkaloids, fatty acids, volatile oils and anthranoids	Anti-inflammatory action on burns in experimental animals[97]
	Aerial parts	Thiophene derivatives: 5-methyl-2,2′:5′,2″-terthiophene and 5′-methyl- [5 –(4-acetoxy-1-butynyl)] −2,2′-bistiophene.	Lesions caused by *Leishmania* sp[98]
	Leaves	Phenolic compounds, ethylcyclohexane, ciclogeraniolane, and triethylether glycerol,	Antioxidante ABTS method using the 2,20 azino-bis(3-ethylbenzo-thiazoline -6-sulfonic acid)[99]
Verdolaga (*Portulaca oleracea*)	Aerial parts	Chlorogenic, caffeic, *p*-coumaric, ferulic and rosmarinic acids and flavonoids: quercetin and kaempferol	*In vitro* antioxidant activity assays DPPH. radical scavenging, ABTS radical scavenging and inhibition of lipid peroxidation[100]
	Aerial parts	Catechin, chlorogenic acid, salicylic acid and pyrogallol, flavonoids: rosmarinic acid, rutin and quercitrin, chlorophyll and carotenoids.	Antidiabetic, decreased glycated hemoglobin, and serum levels of glucose, TNF-α and IL-6 in diabetic rats[101]
	Aerial parts	Phenolic acids (ferulic acid and caffeic acid) and flavonoids (luteolin, myricetin, quercetin, apigenin) catecholamines components, the contents of noradrenaline (NA) and levodopa (L-dopa)	Hypoglycemic and antioxidant in cell line and mice[102]
	Aerial parts	Polysaccharides with molecular weight of 11 kD	Treatment of diabetes by modulation on insulin secretion/production[103]
	Aerial parts	Betacyanins	Neuroprotective effect, increased activities of the enzymes superoxide dismutases (SOD), catalase (CAT), glutathione peroxidase (GPx) and glutathione reductase (GR), reduction of lipid peroxidation, improvement of cognitive deficits[104]
	Aerial parts	Indole alkaloids (oleraindole A and oleraindole B)	Inhibition of cholinesterase and scavenging DPPH radicals[105]
	Seed	Polyunsaturated fatty acids, flavonoids, and polysaccharides	hypoglycaemic, hypolipidaemic and insulin resistance reducer effects in humans with type-2 diabetes
Quintonil (Amaranthus spp)	Leaves	Flavonoids, steroids, terpenoids	Antimicrobial activity[106]
	Leaves	Carotenoids and tocopherols	Antioxidant activity[107]
	Sprouts	Phenolic acids and Flavonoids	Antioxidant activity[108]
Romerito (Suaeda nigra),	Aerial parts	Phenolic acids, flavonoids	Antioxidant[109]
	Leaves	Phenolics, flavonoids and tannins cardiac glycosides	Antioxidant activity[110] Antibacterial and antifungal activity[111]
Quelite cenizo (Chenopodium berlandieri subsp. berlandieri),	Leaf	Flavonoides, terpenoides quercetin and chrysin caffeic, gallic, chlorogenic, vanillic, *p*-hydroxybenzoic, ferulic and syringic acids	Antioxidant activity, antitumor Activity. induce macrophage activation and Phagocytic activity, induce positive Immunomodulation in the body and induce nitric oxide production[112] Antibacterial and antifungal activity[113]
	Essential oil	Flavonoids, terpenoids, ascaridol, *p*-cymene	Induces apoptotic process, and DNA fragmentation in cancer cells.[114,115]
Huauzontle (Chenopodium berlandieri subsp. nuttalliae),	Leaves	Flavonoids, terpenoids, chrysin, triterpenoid, saponins	Antioxidant activity, antitumor activity. induce macrophage activation and phagocytic activity, induce positive immunomodulation in the body and induce nitric oxide production Antibacterial and antifungal activity[112,116]
	Leaves and stems	Flavonoids and phenolic compounds	Antioxidant[117]
	Leaves and stems	Loridzine, myricetin, quercetin, and phloretin, caffeic, gallic, chlorogenic, vanillic, *p*-hydroxybenzoic, ferulic and syringic acids	Antioxidant activity[113]
	Sprouts	Tannins, saponins	Strengthen the immune system[118] Vasoactive and antioxidant activities[119]

(*Continued*)

Table 3. (Continued).

Epazote (Dysphania ambrosioides)	Essential oil		Insecticide[110]
	Leaves	Vitamin C, phenolics and flavonoids. quercetin and catechin	Antioxidant activity, Hypoglycemic have counteract efects on bacterium responsible for triggering chronic gastritis, peptic ulcer diseases and gastric cancer.[120,121]
	Leaves	Carvacrol, phytol, squalene, vitamin E and sucrose	**Induction of the endogenous antioxidant system and anti-inflammatory**[122]
	Leaves	Phenolic and flavonoid	**Vasodilatory effect**[123]

Table 2. Main *quelite* species consumed in Mexico.[81,82].

Common name	Scientific name	Region of comsumption
Purslane	*Portulaca oleracea*	Northern of Mexico, derived from Tarahumara and Purépecha peoples.
Quelite or *huazontle*	*Chenopodium berlandieri*	
Quintonil	*Amaranthus hybridus*	Center of Mexico, Zapotec native zone, Chiapas and Tabasco
Epazote	*C. ambrosoides, Dysphania ambrosioides (syn.)*	From northern (by Tarahumara heritage) to the south of Mexico, with reports in Veracruz, Chiapas, Tabasco, Campeche and Oaxaca
Holy leaf	*Piper auritum*	Veracruz, Oaxaca, Tabasco, Chiapas y Campeche
Chaya	*Cnidoscolus aconitifolius*	Veracruz, Oaxaca, Tabasco, Chiapas, Campeche and Yucatán
Chepiles	*Crotalaria spp.*	Oaxaca, Chiapas, Tabasco and Campeche

In conclusion, the milpa is a traditional multicrop system in which the species planted depend on both, environmental and social factors. The consumption of the products grown in these crops could confer health benefits, due to its complexity, the effects already mentioned could be enhanced. Although there is little information on the mechanism of action on human health when consumed as a whole or combined with other foods; it is recommended that from the documented evidence, the study of the complex combinations of milpa foods on human health must be continued. Dominguez-Uscanga *et al.*,[130] evaluated the consumption of snacks made with a mixture of white corn and beans (70/30%), in a model of mice fed with a high-fat diet and evaluating its effect on dyslipidemia caused by this diet. Among their results, they reported that lipid storage decreased and it improved glucose metabolism, as well as the inhibition of PPARγ and SREBF2, genes involved in lipogenesis. Avila-Nava *et al.*,[131] evaluated the effect of consuming a traditional pre-Hispanic diet composed of mixtures of corn, beans, tomatoes, nopal, chia, and pumpkin seeds in obese rats, among their results they reported that after consuming these diets, weight gain, decreased glucose intolerance, regulation of triglyceride and leptin concentrations in liver and serum were controlled, as well as inhibition of protein oxidation and GSSG/ratio. GSH, in addition to an increase in the relative abundance of bifidobacteria and improvement of cognitive activity. These studies are relevant because as it is known, the consumption of industrialized or processed food products are favouring health problems in children and adults, such as obesity and diabetes. Both belong to the group of chronic non-communicable diseases and represent an important challenge for public health systems, as well as a strong impact on families` economy. Chronic non-communicable diseases have a multifactorial origin, however preventable by means of choosing the right diet.

Summarizing, data here reviewed point to the milpa system is a diverse source of bioactive compounds with functional capacity, which is based on the presence of compounds of a varied nature, including plant pigments, nutrients and secondary metabolites. The biological activity provided by the milpa products supply antioxidant effects, regulators of cell growth, cell metabolism, anti-inflammatory action and modulators of cell signaling, among other benefic actions against the pathological processes of NCD related to the current food transition. However, it is necessary to continue the efforts that contribute with knowledge to the mechanisms involved in the biological activity of these foods from the milpa and thus, contribute to the promotion of a functional diet based on the products of the same.

Disclosure of potential conflicts of interest

The author(s) declare no conflict of interest.

Funding

This work was supported by the CONACYT [Cátedras CONACYT, Proyect 530. Traditional foods,I.C.-Q. received a postdoctoral scholarship from C].

ORCID

OG Méndez-Flores http://orcid.org/0000-0003-2768-0002
H Ochoa-Díaz López http://orcid.org/0000-0002-8421-4983
I Castro-Quezada http://orcid.org/0000-0003-4419-5690
ZE Olivo-Vidal http://orcid.org/0000-0001-6242-7964
R García-Miranda http://orcid.org/0000-0003-3912-0985
U Rodríguez-Robles http://orcid.org/0000-0001-5667-8898
CA Irecta-Nájera http://orcid.org/0000-0001-9914-1230
G López-Ramírez http://orcid.org/0000-0002-0308-3580
XM Sánchez-Chino http://orcid.org/0000-0002-8599-8150

Author contributions

Conceptualization and coordination, X.M.S.C.; Writing – Original Draft Preparation, O.G.M.F. X.M.S.C., Z.E.O.V., -Search, Reading and Compilation of Information. X.M.S.C., O.G.M.F., H.O.D.L., R.G.M., U.R.R., R.G.M, I.CQ., C.A.I. N., G,L.R. All authors revised and approved the submitted version.

References

[1] Terán, S.; Rasmussen, C. H. Genetic Diversity and Agricultural Strategy in 16th Century and Present-day Yucatecan Milpa Agriculture. *Biodivers Conserv*. 1995, *4*(4), 363–381. DOI: 10.1007/BF00058422.

[2] Drexler, K. A.;. Government Extension, Agroecology, and Sustainable Food Systems in Belize Milpa Farming Communities: A Socio-ecological Systems Approach. *J Agric Food Syst Community Dev*. 2020, *9*(3), 85–97. DOI: 10.5304/jafscd.2020.093.001.

[3] Zizumbo-Villarreal, D.; Flores-Silva, A.; Marin, P. C. G. The Archaic Diet in Mesoamerica: Incentive for Milpa Development and Species Domestication. *Econ. Bot.* 2012, *66*(4), 328–343. DOI: 10.1007/s12231-012-9212-5.

[4] Heindorf, C.; Reyes-Aguero, J. A.; Van't Hooft, A.; Fortanelli-Martinez, J. Inter- and Intraspecific Edible Plant Diversity of the Tenek Milpa Fields in Mexico. *Econ. Bot.* 2019, *73*(4), 489–504. DOI: 10.1007/s12231-019-09475-y.

[5] Gurri, F. D.;. The Disruption of Subsistence Agricultural Systems in Rural Yucatan, Mexico May Have Contributed to the Coexistence of Stunting in Children with Adult Overweight and Obesity. *Collegium Antropologicum*. 2015, *39*(4), 847–854.

[6] Lara, P. E.; Caso, B. L.; Aliphat, F. M. El sistema roza, tumba y quema de los maya Itzá de san Andres y San José, Petén Guatemala. *Ra Ximhai*. 2012, *8*, 69–90.

[7] Drewnowski, A.; Popkin, B. M. The Nutrition Transition: New Trends in the Global Diet. *Nutr. Rev.* 1997, *55*(2), 31–43. DOI: 10.1111/j.1753-4887.1997.tb01593.x.

[8] Rivera, J. A.; Barquera, S.; González-Cossío, T.; Olaiz, G.; Sepúlveda, J. Nutrition Transition in Mexico and in Other Latin American Countries. *Nutr. Rev.* 2004, *62*, S149–57. DOI: 10.1111/j.1753-4887.2004.tb00086.x. PMID: 15387482.
[9] Moreno-Altamirano, L.; Hernández-Montoya, D.; Martín Silberman, M.; Capraro, S.; García-García, J. J.; Guadalupe Soto-Estrada, G.; Sandoval-Bosh, E. La transición alimentaria y la doble carga de malnutrición: Cambios en los patrones alimentarios de 1961 a 2009 en el contexto socioeconómico mexicano. *ALAN.* 2014, *64*, 4.
[10] Avelar, T. M.; Storch, A. S.; Castro, L. A.; Azevedo, G. V.; Ferraz, L.; Lopes, P. F. Oxidative Stress in the Pathophysiology of Metabolic Syndrome: Which Mechanisms are Involved? *J Bras Patol Med Lab.* 2015, *51*(4), 231–239. DOI: 10.5935/1676-2444.20150039.
[11] Petersen, K. S.; Flock, M. R.; Richter, C. K.; Mukherjea, R.; Slavin, J. L.; Kris-Etherton, P. M. Healthy Dietary Patterns for Preventing Cardiometabolic Disease: The Role of Plant-Based Foods and Animal Products. *Current Develop.Nutr.* 2017, *1*(12), cdn.117.001289. DOI: 10.3945/cdn.117.001289.
[12] Berni, R.; Cantini, C.; Romi, M.; Hausman, J. F.; Guerriero, G.; Cai, G. Agrobiotechnology Goes Wild: Ancient Local Varieties as Sources of Bioactives. *Int. J. Mol. Sci.* 2018, *19*(8), 2248. DOI: 10.3390/ijms19082248.
[13] Phan, M. A. T.; Paterson, J.; Bucknall, M.; Arcot, J. Interactions between Phytochemicals from Fruits and Vegetables: Effects on Bioactivities and Bioavailability. *Crit. Rev. Food Sci. Nutr.* 2018, *58*(8), 1310–1329. DOI: 10.1080/10408398.2016.1254595.
[14] Zhao, Q.; Luan, X.; Zheng, M.; Tian, X. H.; Zhao, J.; Zhang, W. D.; Ma, B. L. Synergistic Mechanisms of Constituents in Herbal Extracts during Intestinal Absorption: Focus on Natural Occurring Nanoparticles. *Pharm.* 2020, *12*(2), 128. DOI: 10.3390/pharmaceutics12020128.
[15] Chávez-Santoscoy, R. A.; Gutiérrez-Uribe, J. A.; Serna-Saldívar, S. O. Effect of Flavonoids and Saponins Extracted from Black Bean (Phaseolus Vulgaris L.) Seed Coats as Cholesterol Micelle Disruptors. *Plant Foods Hum. Nutr.* 2013, *68*(4), 416–423. DOI: 10.1007/s11130-013-0384-7.
[16] Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), México. https://www.biodiversidad.gob.mx/diversidad/alimentos/maices/razas-de-maiz. (accessed November 10, 2020)
[17] Mapes, C.; Basurto, F. Biodiversity and Edible Plants of Mexico. In *Ethnobotany of México, Interactions of People and Plants in Mesoamerica*; Lira, R., Casas, A., Blancas, J., Eds.; Springer, 2016; pp 83–131. DOI:10.1007/978-1-4614-6669-7
[18] Siyuan, S.; Tong, L.; Liu, R. Corn Phytochemicals and Their Health Benefits. *Food Sci. Hum. Wellness.* 2018, *7*(3), 185–195. DOI: 10.1016/j.fshw.2018.09.003.
[19] García-Lara, S.; Bergvinson, D. J. Phytochemical and Nutraceutical Changes during Recurrent Selection for Storage Pest Resistance in Tropical Maize. *Crop Sci.* 2014, *54*(6), 2423–2432. DOI: 10.2135/cropsci2014.03.0223.
[20] Rocha-Villarreal, V.; Hoffmann, J. F.; Vanier, N. L.; Serna-Saldivar, S. O.; García-Lara, S. Hydrothermal Treatment of Maize: Changes in Physical, Chemical, and Functional Properties. *Food Chem.* 2018, *263*, 225–231. DOI: 10.1016/j.foodchem.2018.05.003.
[21] Del Pozo-Insfran, D.; Brenes, C. H.; Serna Saldivar, S. O.; Talcott, S. T. Polyphenolic and Antioxidant Content of White and Blue Corn (Zea Mays L.) Products. *Food Res. Int.* 2006, *39*(6), 696–703. DOI: 10.1016/j.foodres.2006.01.014.
[22] Cuevas Montilla, E.; Hillebrand, S.; Antezana, A.; Winterhalter, P. Soluble and Bound Phenolic Compounds in Different Bolivian Purple Corn (*Zea Mays* L.) Cultivars. *J. Agric. Food Chem.* 2011, *59*(13), 7068–7074. DOI: 10.1021/jf201061x.
[23] Zhang, Q.; Gonzalez De Mejia, E.; Luna-Vital, D.; Tao, T.; Chandrasekaran, S.; Chatham, L.; Juvik, J.; Singh, V.; Kumar, D. Relationship of Phenolic Composition of Selected Purple Maize (*Zea Mays* L.) Genotypes with Their Anti-Inflammatory, Anti-Adipogenic and Anti-Diabetic Potential. *Food Chem.* 2019, *289*, 739–750. DOI: 10.1016/j.foodchem.2019.03.116.
[24] Urias-Peraldí, M.; Gutiérrez-Uribe, J. A.; Preciado-Ortiz, R. E.; Cruz-Morales, A. S.; Serna-Saldívar, S. O.; García-Lara, S. Nutraceutical Profiles of Improved Blue Maize (*Zea Mays*) Hybrids for Subtropical Regions. *F Crop Res.* 2013, *141*, 69–76. DOI: 10.1016/j.fcr.2012.11.008.
[25] Kwon, Y. I.; Apostolidis, E.; Kim, Y. C.; Shetty, K. Health Benefits of Traditional Corn, Beans, and Pumpkin: In Vitro Studies for Hyperglycemia and Hypertension Management. *J. Med. Food.* 2007, *10*(2), 266–275. DOI: 10.1089/jmf.2006.234.
[26] Wacher, C.; Nixtamalization, a Mesoamerican Technology to Process Maize at Small-scale with Great Potential for Improving the Nutritional Quality of Maize Based Foods. Food-based approaches for a healthy nutrition. 2003. 735–743.
[27] De La Parra, C.; Serna-Saldivar, S. O.; Liu, R. H. Effect of Processing on the Phytochemical Profiles and Antioxidant Activity of Corn for Production of Masa, Tortillas, and Tortilla Chips. *J. Agric. Food Chem.* 2007, *55*(10), 4177–4183. DOI: 10.1021/jf063487p.

[28] Salinas-Moreno, Y.; Hernández-Martínez, V.; Trejo-Téllez, L. I.; Ramírez-Díaz, J. L.; Iñiguez-Gómez, O. Nutritional Composition and Bioactive Compounds in Tortillas of Native Populations of Corn with Blue/purple Grain. *Rev Mex Cienc Agríc*. 2017, *8*(7), 1483–1496.

[29] Mora-Rochin, S.; Gutiérrez-Uribe, J.; Serna-Saldivar, S.; Peña, P.; Reyes Moreno, C.; Milán-Carrillo, J. Phenolic Content and Antioxidant Activity of Tortillas Produced from Pigmented Corns Processed by Conventional Nixtamalization or Extrusion Cooking. *J. Cereal Sci.* 2010, *52*(3), 502–508. DOI: 10.1016/j.jcs.2010.08.010.

[30] Salinas-Moreno, Y.; Martínez-Bustos, F.; Soto-Hernández, M.; Ortega-Paczka, R.; Arellano-Vázquez, J. L. Efecto de la nixtamalización sobre las antocianinas del grano de maíces pigmentados. *Agrociencia*. 2003, *37*(6), 617–628.

[31] Zhang, J.; Wu, J.; Liu, F.; Tong, L.; Chen, Z.; Chen, J.; He, H.; Xu, R.; Ma, Y.; Huang, C. Neuroprotective Effects of Anthocyanins and Its Major Component cyanidin-3-O-glucoside (C3G) in the Central Nervous System: An Outlined Review. *Eur. J. Pharmacol.* 2019, *858*, 172500. DOI: 10.1016/j.ejphar.2019.172500.

[32] Gaxiola-Cuevas, N.; Mora-Rochín, S.; Cuevas-Rodriguez, E. O.; León-López, L.; Reyes-Moreno, C.; Montoya-Rodríguez, A.; Milán-Carrillo, J. Phenolic Acids Profiles and Cellular Antioxidant Activity in Tortillas Produced from Mexican Maize Landrace Processed by Nixtamalization and Lime Extrusion Cooking. *Plant Foods Hum. Nutr*. 2017, *72*(3), 314–320. DOI: 10.1007/s11130-017-0624-3.

[33] Herrera-Sotero, M. Y.; Cruz-Hernández, C. D.; Trujillo-Carretero, C.; Rodríguez-Dorantes, M.; García-Galindo, H. S.; Chávez-Servia, J. L.; Oliart-Ros, R. M.; Guzmán-Gerónimo, R. I. Antioxidant and Antiproliferative Activity of Blue Corn and Tortilla from Native Maize. *Chem. Cent. J.* 2017, *11*(1), 110. DOI: 10.1186/s13065-017-0341-x.

[34] Mo, S.; Dong, L.; Hurst, W. J.; Van Breemen, R. B. Quantitative Analysis of Phytosterols in Edible Oils Using APCI Liquid Chromatography-Tandem Mass Spectrometry. *Lipids*. 2013, *48*(9), 949–956. DOI: 10.1007/s11745-013-3813-3.

[35] Li, Y. C.; Li, C. L.; Li, R.; Chen, Y.; Zhang, M.; Guo, P. P.; Shi, D.; Ji, X. N.; Feng, R. N.; Sun, C. H. Associations of Dietary Phytosterols with Blood Lipid Profiles and Prevalence of Obesity in Chinese Adults, a Cross-Sectional Study. *Lipids Health Dis.* 2018, *17*(54), 1–9. DOI: 10.1186/s12944-018-0703-y.

[36] Jin, D. X.; Liu, X. L.; Zheng, X. Q.; Wang, X. J.; He, J. F. Preparation of Antioxidative Corn Protein Hydrolysates, Purification and Evaluation of Three Novel Corn Antioxidant Peptides. *Food Chem.* 2016, *204*, 427–436. DOI: 10.1016/j.foodchem.2016.02.119.

[37] De Almeida Costa, G. E.; Da Silva Queiroz-Monici, K.; Pissini Machado Reis, S. M.; De Oliveira, A. C. Chemical Composition, Dietary Fibre and Resistant Starch Contents of Raw and Cooked Pea, Common Bean, Chickpea and Lentil Legumes. *Food Chem.* 2006, *94*(3), 327–330. DOI: 10.1016/j.foodchem.2004.11.020.

[38] Chávez-Mendoza, C.; Hernández-Figueroa, K. I.; Sánchez, E. Antioxidant Capacity and Phytonutrient Content in the Seed Coat and Cotyledon of Common Beans (*Phaseolus Vulgaris* L.) From Various Regions in Mexico. *Antioxidants*. 2019, *8*(1), 1–19. DOI: 10.3390/antiox8010005.

[39] Alvarado-López, A. N.; Gómez-Oliván, L. M.; Heredia, J. B.; Baeza-Jiménez, R.; Garcia-Galindo, H. S.; Lopez-Martinez, L. X. Nutritional and Bioactive Characteristics of Ayocote Bean (*Phaseolus Coccienus* L.): An Underutilized Legume Harvested in Mexico. *CyTA-J. Food*. 2019, *17*(1), 199–206. DOI: 10.1080/19476337.2019.1571530.

[40] Alcázar-Valle, M.; Lugo-Cervantes, E.; Mojica, L.; Morales-Hernández, N.; Reyes-Ramírez, H.; Enríquez-Vara, J. N.; García-Morales, S. Bioactive Compounds, Antioxidant Activity, and Antinutritional Content of Legumes: A Comparison between Four Phaseolus Species. *Mol.* 2020, *25*(15), 3528. DOI: 10.3390/molecules25153528.

[41] Xu, B.; Chang, S. K. C. Comparative Study on Antiproliferation Properties and Cellular Antioxidant Activities of Commonly Consumed Food Legumes against Nine Human Cancer Cell Lines. *Food Chem.* 2012, *134*(3), 1287–1296. DOI: 10.1016/j.foodchem.2012.02.212.

[42] Moreno-Celis, U.; López-Martínez, J.; Blanco-Labra, A.; Cervantes-Jiménez, R.; Estrada-Martínez, L. E.; García-Pascalin, A. E.; Guerrero-Carrillo, M. J.; Rodríguez-Méndez, A. J.; Mejía, C.; Ferríz-Martínez, R. A.; et al. Phaseolus Acutifolius Lectin Fractions Exhibit Apoptotic Effects on Colon Cancer: Preclinical Studies Using Dimethilhydrazine or Azoxi-Methane as Cancer Induction Agents. *Mol.* 2017, *22*(10), 1670. DOI: 10.3390/molecules22101670.

[43] Moreno-Celis, U.; López-Martínez, F. J.; Cervantes-Jiménez, R.; Ferríz-Martínez, R. A.; Blanco-Labra, A.; García-Gasca, T. Tepary Bean (*Phaseolus Acutifolius*) Lectins Induce Apoptosis and Cell Arrest in G0/G1 by P53(Ser46) Phosphorylation in Colon Cancer Cells. *Mol.* 2020, *25*(5), 1021. DOI: 10.3390/molecules25051021.

[44] De Lacerda, R. R.; Do Nascimento, E. S.; De Lacerda, J. T. J. G.; Da Silva Pinto, L.; Rizzi, C.; Bezerra, M. M.; De Almeida Gadelha, C. A. Lectin from Seeds of a Brazilian Lima Bean Variety (*Phaseolus Lunatus* L. *Var*. Cascavel) Presents Antioxidant, Antitumour and Gastroprotective Activities. *Int. J. Biol. Macromol.* 2017, *95*, 1072–1081. DOI: 10.1016/j.ijbiomac.2016.10.097.

[45] Wu, J.; Wang, J.; Wang, S.; Rao, P. Lunatin, a Novel Lectin with Antifungal and Antiproliferative Bioactivities from *Phaseolus Lunatus* Billb. *Int. J. Biol. Macromol.* 2016, *89*, 717–724. DOI: 10.1016/j.ijbiomac.2016.04.092.

[46] Pan, W. L.; Ng, T. B. A Dimeric *Phaseolus Coccineus* Lectin with Anti-oxidative, Anti-proliferative and Cytokine-inducing Activities. *Int. J. Biol. Macromol.* 2015, *81*, 960–966. DOI: 10.1016/j.ijbiomac.2015.09.034.

[47] García-Gasca, T.; García-Cruz, M.; Hernandez-Rivera, E.; López-Matínez, J.; Castañeda-Cuevas, A. L.; Yllescas-Gasca, L.; Rodríguez-Méndez, A. J.; Mendiola-Olaya, E.; Castro-Guillén, J. L.; Blanco-Labra, A. Effects of Tepary Bean (*Phaseolus Acutifolius*) Protease Inhibitor and Semipure Lectin Fractions on Cancer Cells. *Nutr Can*. 2012, *64*(8), 1269–1278. DOI: 10.1080/01635581.2012.722246.

[48] Bawadi, H. A.; Bansode, R. R.; Trappey, A.; Truax, R. E.; Losso, J. N. Inhibition of Caco-2 Colon, MCF-7 and Hs578T Breast, and DU 145 Prostatic Cancer Cell Proliferation by Water-Soluble Black Bean Condensed Tannins. *Cancer Lett.* 2005, *218*(2), 153–162. DOI: 10.1016/j.canlet.2004.06.021.

[49] Dong, M.; He, X.; Rui, H. L. Phytochemicals of Black Bean Seed Coats: Isolation, Structure Elucidation, and Their Antiproliferative and Antioxidative Activities. *J. Agric. Food Chem.* 2007, *55*(15), 6044–6051. DOI: 10.1021/jf070706d.

[50] Zhang, C.; Monk, J. M.; Lu, J. T.; Zarepoor, L.; Wu, W.; Liu, R.; Pails, P. K.; Wood, G.; Robison, L.; Tsao, R.; et al. Cooked Navy and Black Bean Diets Improve Biomarkers of Colon Health and Reduce Inflammation during Colitis. *Br. J. Nutr.* 2014, *111*(9), 1549–1563. DOI: 10.1017/s0007114513004352.

[51] Haydé, V. C.; Ramón, G. G.; Lorenzo, G.-O.-O.; Dave, O. B.; Rosalía, R.-C.-C.; Paul, W.; Guadalupe, L.-P.-P.; Vergara-Castañeda, H.; Guevara-González, R.; Lorenzo, G.-O.-O. Non-Digestible Fraction of Beans (*Phaseolus Vulgaris L.*) Modulates Signalling Pathway Genes at an Early Stage of Colon Cancer in Sprague-Dawley Rats. *Br. J. Nutr.* 2012, *108*(S1), S145–S154. DOI: 10.1017/S0007114512000785.

[52] Campos-Vega, R.; Guevara-Gonzalez, R. G.; Guevara-Olvera, B. L.; Dave Oomah, B.; Loarca-Piña, G. Bean (*Phaseolus Vulgaris* L.) Polysaccharides Modulate Gene Expression in Human Colon Cancer Cells (HT-29). *Food Res. Int.* 2010, *43*(4), 1057–1064. DOI: 10.1016/j.foodres.2010.01.017.

[53] Thompson, M. D.; Mensack, M. M.; Jiang, W.; Zhu, Z.; Lewis, M. R.; McGinley, J. N.; Brick, M. A.; Thompson, H. J. Cell Signaling Pathways Associated with a Reduction in Mammary Cancer Burden by Dietary Common Bean (*Phaseolus Vulgaris* L.). *Carcinogenesis*. 2012, *33*(1), 226–232. DOI: 10.1093/carcin/bgr247.

[54] Altieri, M. A.; Agroecología: Bases Científicas Para Una Agricultura Sustentable; Ed. Nordan–Comunidad: Montevideo, 1999. DOI:10.1007/BF02345332.

[55] Eguiarte, L. E.; Hernández-Rosales, H. S.; Barrera-Redondo, J.; Castellanos-Morales, G.; Paredes-Torres, L. M.; Sánchez-de La Vega, G.; Ruiz-Mondragón, K. Y.; Vázquez-Lobo, A.; Montes-Hernández, S.; Aguirre-Planter, E. Domesticación, Diversidad y Recursos Genéticos y Genómicos de México: El Caso de Las Calabazas. *TIP Rev. Espec. en Ciencias Químico-Biológicas*. 2018, *21*(2), 85–101. DOI: 10.22201/fesz.23958723e.2018.0.159.

[56] Miranda, M. E.; Escobar, M. C.; Ortega, C.; Sanchez, F.; Almanz, J. C.; Alarcon, F. J. *Cucurbita Ficifolia* Bouchéfruit Acts as an Insulin Secretagogue in RINm5F Cells. *Int. Biotech. Color J.* 2013, *3*, 8–14. DOI: 10.1016/j.jep.2016.04.061.

[57] Jin, H.; Zhang, Y.-J.-J.; Jiang, J.-X.-X.; Zhu, L.-Y.-Y.; Chen, P.; Li, J.; Yao, H.-Y.-Y. Studies on the Extraction of Pumpkin Components and Their Biological Effects on Blood Glucose of Diabetic Mice. *J. Food Drug Anal.* 2013, *21*(2), 184–189. DOI: 10.1016/j.jfda.2013.05.009.

[58] Quanhong, L.; Caili, F.; Yukui, R.; Guanghui, H.; Tongyi, C. Effects of Protein-Bound Polysaccharide Isolated from Pumpkin on Insulin in Diabetic Rats. *Plant Foods Hum. Nutr.* 2005, *60*(1), 13–16. DOI: 10.1007/s11130-005-2536-x.

[59] Patel, S.;. Pumpkin (Cucurbita Sp.) Seeds as Nutraceutic: A Review on Status Quo and Scopes. *Med. J. Nutr. Metab.* 2013, *6*(3), 183–189. DOI: 10.1007/s12349-013-0131-5.

[60] Wensveen, F. M.; Valentić, S.; Šestan, M.; Turk Wensveen, T.; Polić, B. The "Big Bang" in Obese Fat: Events Initiating Obesity-induced Adipose Tissue Inflammation. *Eur. J. Immunol.* 2015, *45*(9), 2446–2456. DOI: 10.1002/eji.201545502.

[61] Fortis-Barrera, Á.; García-Macedo, R.; Almanza-Perez, J. C.; Blancas-Flores, G.; Zamilpa-Alvarez, A.; Flores-Sáenz, J. L.; Cruz, M.; Román-Ramos, R.; Alarcón-Aguilar, F. J. Cucurbita Ficifolia (Cucurbitaceae) Modulates Inflammatory Cytokines and IFN-γ in Obese Mice. *Can. J. Physiol. Pharmacol.* 2017, *95*(2), 170–177. DOI: 10.1139/cjpp-2015-0475.

[62] Miranda-Perez, M. E.; Ortega-Camarillo, C.; Del Carmen Escobar-Villanueva, M.; Blancas-Flores, G.; Alarcon-Aguilar, F. J. Cucurbita Ficifolia Bouché Increases Insulin Secretion in RINm5F Cells through an Influx of $Ca^{(2+)}$ from the Endoplasmic Reticulum. *J. Ethnopharmacol.* 2016, *21*(188), 159–166. DOI: 10.1016/j.jep.2016.04.061.

[63] Alshammari, G. M.; Balakrishnan, A. Pumpkin (*Cucurbita Ficifolia Bouché*) Extract Attenuate the Adipogenesis in Human Mesenchymal Stem Cells by Controlling Adipogenic Gene Expression. *Saudi J. Biol. Sci.* 2019, *26*(4), 744–751. DOI: 10.1016/j.sjbs.2018.10.002.

[64] Fortis-Barrera, Á.; Alarcón-Aguilar, F. J.; Banderas-Dorantes, T.; Díaz-Flores, M.; Román-Ramos, R.; Cruz, M.; García-Macedo, R. Cucurbita ficifolia Bouché (Cucurbitaceae) and D-chiro-inositol Modulate the Redox State and Inflammation in 3T3-L1 Adipocytes. *J. Pharm. Pharmacol.* 2013, *65*(10), 1563–1576. DOI: 10.1111/jphp.12119.

[65] Bergantin, C.; Maietti, A.; Tedeschi, P.; Font, G.; Manyes, L.; Marchetti, N. HPLC-UV/Vis-APCI-MS/MS Determination of Major Carotenoids and Their Bioaccessibility from "Delica" (*Cucurbita Maxima*) and "Violina" (*Cucurbita Moschata*) Pumpkins as Food Traceability Markers. *Mol.* 2018 27, *23*(11), 2791. DOI: 10.3390/molecules23112791.

[66] Kulczyński, B.; Gramza-Michałowska, A. The Profile of Secondary Metabolites and Other Bioactive Compounds in Cucurbita Pepo L. And Cucurbita Moschata Pumpkin Cultivars. *Mol.* 2019, *24*(16), 2945. DOI: 10.3390/molecules24162945.

[67] Biesiada, A.; Nawirska, A.; Kucharska, A.; Sokół-Łętowska, A. Chemical Composition of Pumpkin Fruit Depending on Cultivar and Storage. *Ecol. Chem. Eng. A.* 2011, *18*, 9–18.

[68] Jessica, G. G.; Mario, G. L.; Alejandro, Z.; Cesar, A.; Ivan, J.; Ruben, R. R.; Javier, A. F. Chemical Characterization of a Hypoglycemic Extract from Cucurbita Ficifolia Bouche that Induces Liver Glycogen Accumulation in Diabetic Mice. *Afr. J. Tradit. Complement. Altern. Med.* 2017, *14*(3), 218–230. DOI: 10.21010/ajtcam.v14i3.24.

[69] Fan, C.; Liang, W.; Wei, M.; Gou, X.; Han, S.; Bai, J. Effects of D-Chiro-Inositol on Glucose Metabolism in Db/db Mice and the Associated Underlying Mechanisms. *Front. Pharmacol.* 2020, *11*, 354. DOI: 10.3389/fphar.2020.00354.

[70] Grzybek, M.; Kukula-Koch, W.; Strachecka, A.; Jaworska, A.; Phiri, A. M.; Paleolog, J.; Tomczuk, K. Evaluation of Anthelmintic Activity and Composition of Pumpkin (*Cucurbita Pepo* L.) Seed Extracts-In Vitro and in Vivo *Studies*. *Int. J. Mol. Sci.* 2016, *17*(9), 1456. DOI: 10.3390/ijms17091456.

[71] Alhawiti, A. O.; Toulah, F. H.; Wakid, M. H. Anthelmintic Potential of *Cucurbita Pepo* Seeds on *Hymenolepis Nana*. *Acta Parasitol.* 2019, *64*(2), 276–281. DOI: 10.2478/s11686-019-00033-z.

[72] Bardaa, S.; Ben Halima, N.; Aloui, F.; Ben Mansour, R.; Jabeur, H.; Bouaziz, M.; Sahnoun, Z. Oil from Pumpkin (*Cucurbita Pepo* L.) Seeds: Evaluation of Its Functional Properties on Wound Healing in Rats. *Lipids Health Dis.* 2016, *15*(1), 73. DOI: 10.1186/s12944-016-0237-0.

[73] Estrella-Mendoza, M. F.; Jiménez-Gómez, F.; López-Ornelas, A.; Pérez-Gutiérrez, R. M.; Flores-Estrada, J. *Cucurbita Argyrosperma* Seed Extracts Attenuate Angiogenesis in a Corneal Chemical Burn Model. *Nutr*. 2019, *11*(5), 1184. DOI: 10.3390/nu11051184.

[74] Can-Cauich, C. A.; Sauri-Duch, E.; Moo-Huchin, V. M.; Betancur-Ancona, D.; Cuevas-Glory, L. F. Effect of Extraction Method and Specie on the Content of Bioactive Compounds and Antioxidant Activity of Pumpkin Oil from Yucatan, Mexico. *Food Chem.* 2019, *285*, 186–193. DOI: 10.1016/j.foodchem.2019.01.153.

[75] Zhao, X. J.; Chen, Y. L.; Fu, B.; Zhang, W.; Liu, Z.; Zhuo, H. Intervention of Pumpkin Seed Oil on Metabolic Disease Revealed by Metabonomics and Transcript Profile. *J. Sci. Food Agric.* 2017, *97*(4), 1158–1163. DOI: 10.1002/jsfa.7842.

[76] Nkosi, C. Z.; Opoku, A. R.; Terblanche, S. E. Effect of Pumpkin Seed (Cucurbita Pepo) Protein Isolate on the Activity Levels of Certain Plasma Enzymes in CCl4-Induced Liver Injury in Low-Protein Fed Rats. *Phyther. Res.* 2005, *19*(4), 341–345. DOI: 10.1002/ptr.1685.

[77] Dash, P.; Ghosh, G. Amino Acid Profiling and Antimicrobial Activity of *Cucurbita Moschata* and *Lagenaria Siceraria* Seed Protein Hydrolysates. *Nat. Prod. Res.* 2018, *32*(17), 2050–2053. DOI: 10.1080/14786419.2017.1359174.

[78] Olatunji, T. L.; Afolayan, A. J. The Suitability of Chili Pepper (*Capsicum Annuum* L.) For Alleviating Human Micronutrient Dietary Deficiencies: A Review. *Food Sci. Nutr.* 2018, *6*(8), 2239–2251. DOI: 10.1002/fsn3.790.

[79] Chaiyasit, K.; Khovidhunkit, W.; Wittayalertpanya, S. Pharmacokinetic and the Effect of Capsaicin in Capsicum Frutescens on Decreasing Plasma Glucose Level. *J. Med. Assoc. Thail.* 2009, *92*(1), 108–113.

[80] Panchal, S. K.; Bliss, E.; Brown, L. Capsaicin in Metabolic Syndrome. *Nutr*. 2018, *10*(5), 1–21. DOI: 10.3390/nu10050630.

[81] Kang, C.; Zhang, Y.; Zhu, X.; Liu, K.; Wang, X.; Chen, M.; Wang, J.; Chen, H.; Hui, S.; Huang, L.;, et al. Healthy Subjects Differentially Respond to Dietary Capsaicin Correlating with Specific Gut Enterotypes. *J. Clin. Endocrinol. Metab.* 2016, *101*(12), 4681–4689. DOI: 10.1210/jc.2016-2786.

[82] Baboota, R. K.; Murtaza, N.; Jagtap, S.; Singh, D. P.; Karmase, A.; Kaur, J.; Bhitani, K. K.; Boparai, R. K.; Premkumar, L. S.; Kondepudi, K. K.; et al. Capsaicin-induced Transcriptional Changes in Hypothalamus and Alterations in Gut Microbial Count in High Fat Diet Fed Mice. *J. Nutr Biochem*. 2014, *25*(9), 893–902. DOI: 10.1016/j.jnutbio.2014.04.004.

[83] Baskaran, P.; Krishnan, V.; Ren, J.; Thyagarajan, B. Capsaicin Induces Browning of White Adipose Tissue and Counters Obesity by Activating TRPV1 Channel-Dependent Mechanisms. *Br. J. Pharmacol.* 2016, *173*(15), 2369–2389. DOI: 10.1111/bph.13514.

[84] Zheng, J.; Zheng, S.; Feng, Q.; Zhang, Q.; Xiao, X. Dietary Capsaicin and Its Anti-obesity Potency: From Mechanism to Clinical Implications. *Biosci. Rep.* 2017. DOI: 10.1042/bsr20170286.

[85] Lavorgna, M.; Orlo, E.; Nugnes, R.; Piscitelli, C.; Russo, C.; Isidori, M. Capsaicin in Hot Chili Peppers: *In Vitro* Evaluation of Its Antiradical, Antiproliferative and Apoptotic Activities. *Plant Foods Hum. Nutr.* 2019, *74*(2), 164–170. DOI: 10.1007/s11130-019-00722-0.

[86] Moriguchi, M.; Watanabe, T.; Kadota, A.; Fujimuro, M. Capsaicin Induces Apoptosis in KSHV-Positive Primary Effusion Lymphoma by Suppressing ERK and P38 MAPK Signaling and IL-6 Expression. *Front. Oncol*. 2019, *9*. DOI: 10.3389/fonc.2019.00083.

[87] Sánchez, B. G.; Bort, A.; Mateos-Gómez, P. A.; Rodríguez-Henche, N.; Díaz-Laviada, I. Combination of the Natural Product Capsaicin and Docetaxel Synergistically Kills Human Prostate Cancer Cells through the

Metabolic Regulator AMP-activated Kinases. *Cancer Cell International*. 2019, *19*(1). DOI: 10.1186/s12935-019-0769-2.

[88] Perveen, R.; Suleria, H. A.; Anjum, F. M.; Butt, M. S.; Pasha, I.; Ahmad, S. Tomato (*Solanum Lycopersicum*) Carotenoids and Lycopenes Chemistry; Metabolism, Absorption, Nutrition, and Allied Health Claims-A Comprehensive Review. *Crit. Rev. Food Sci. Nutr.* 2015, *55*(7), 919–929. DOI: 10.1080/10408398.2012.657809.

[89] Khachik, F.; Carvalho, L.; Bernstein, P. S.; Muir, G. J.; Zhao, D. Y.; Katz, N. B. Chemistry, Distribution, and Metabolism of Tomato Carotenoids and Their Impact on Human Health. *Exp. Biol. Med. (Maywood)*. 2002, *227*(10), 845–851. DOI: 10.1177/153537020222701002.

[90] Agarwal, S.; Rao, A. V. Tomato Lycopene and Its Role in Human Health and Chronic Diseases. *Can. Med. Assoc. J.* 2000, *163*(6), 739–744.

[91] Kamiloglu, S.; Demirci, M.; Selen, S.; Toydemir, G.; Boyacioglu, D.; Capanoglu, E. Home Processing of Tomatoes (*Solanum Lycopersicum*): Effects on *in Vitro* Bioaccessibility of Total Lycopene, Phenolics, Flavonoids, and Antioxidant Capacity. *J of Sci Food Agric.* 2014, *94*(11), 2225–2233. DOI: 10.1002/jsfa.6546.

[92] Yi, B.; Hu, L.; Mei, W.; Zhou, K.; Wang, H.; Luo, Y.; Dai, H. Antioxidant Phenolic Compounds of Cassava (*Manihot Esculenta*) from Hainan. *Mol.* 2011, *16*(12), 10157–10167. DOI: 10.3390/molecules161210157.

[93] Güçlü-Ustündağ, O.; Mazza, G. Saponins: Properties, Applications and Processing. *Crit. Rev. Food Sci. Nutr.* 2007, *47*(3), 231–258. DOI: 10.1080/10408390600698197.

[94] Muzquiz, M.; Varela, A.; Burbano, C.; Cuadrado, C.; Guillamón, E.; Pedrosa, M. M. Compuestos bioactivos en leguminosas: Acciones pronutritivas y antinutritivas. Implicaciones para la nutrición y la salud. *Phytochem. Rev.* 2012, *11*, 227–244. DOI: 10.1007/s11101-012-9233-9.

[95] Latif, S.; Zimmermann, S.; Barati, Z.; Müller, J. Detoxification of Cassava Leaves by Thermal, Sodium Bicarbonate, Enzymatic, and Ultrasonic Treatments. *J. Food Sci.* 2019, *84*(7), 1986–1991. DOI: 10.1111/1750-3841.14658.

[96] Ramos De Robles, S. L.; Garibay-Chávez, G.; Curiel-Ballesteros, A. Identification, Collection and Consumption of Weeds and Wild Vegetables in Mexican Communities: Institutionalized Local Ancestral Indigenous Knowledge as Ecological Literacy, Place and Identity. *Cult. Stud. Sci. Educ.* 2019, *14*(4), 1011–1030. DOI: 10.1007/s11422-017-9852-y.

[97] Jácomo, A. C.; De Andrade Velozo, K.; Lotti, R. G.; Neves, L. M.; De Gaspari De Gaspi, F. O.; Esquisatto, M. A.; Do Amaral, M. E.; Mendonça, F. A.; Dos Santos, G. M. Activity of *Porophyllum Ruderale* Leaf Extract and 670-nm InGaP Laser during Burns Repair in Rats. *BMC Complement Altern Med.* 2015, *15*(1), 274. DOI: 10.1186/s12906-015-0805-2.

[98] Takahashi, H. T.; Novello, C. R.; Ueda-Nakamura, T.; Filho, B. P.; Palazzo De Mello, J. C.; Nakamura, C. V. Thiophene Derivatives with Antileishmanial Activity Isolated from Aerial Parts of Porophyllum Ruderale (Jacq.) Cass. *Molecules.* 2011, *16*(5), 3469–3478. DOI: 10.3390/molecules16053469.

[99] Conde-Hernández, L. A.; Guerrero-Beltrán, J. Á. Total Phenolics and Antioxidant Activity of *Piper Auritum* and *Porophyllum Ruderale*. *Food Chem.* 2014, *142*, 455–460. DOI: 10.1016/j.foodchem.2013.07.078.

[100] Erkan, N.;. Antioxidant Activity and Phenolic Compounds of Fractions from Portulaca Oleracea L. *Food Chem.* 2012, *133*(3), 775–781. DOI: 10.1016/j.foodchem.2012.01.091.

[101] Ramadan, B. K.; Schaalan, M. F.; Tolba, A. M. Hypoglycemic and Pancreatic Protective Effects of Portulaca Oleracea Extract in Alloxan Induced Diabetic Rats. *BMC Complement. Altern. Med.* 2017, *17*(1), 1–37. DOI: 10.1186/s12906-016-1530-1.

[102] Gu, J. F.; Zheng, Z. Y.; Yuan, J. R.; Zhao, B. J.; Wang, C. F.; Zhang, L.; Xu, Q. Y.; Yin, G. W.; Feng, L.; Jia, X. B. Comparison on Hypoglycemic and Antioxidant Activities of the Fresh and Dried Portulaca Oleracea L. In Insulin-Resistant HepG2 Cells and Streptozotocin-Induced C57BL/6J Diabetic Mice. *J. Ethnopharmacol.* 2015, *161*, 214–223. DOI: 10.1016/j.jep.2014.12.002.

[103] Hu, Q.; Niu, Q.; Song, H.; Wei, S.; Wang, S.; Yao, L.; Li, Y. P. Polysaccharides from Portulaca Oleracea L. Regulated Insulin Secretion in INS-1 Cells through Voltage-Gated Na+ Channel. *Biomed. Pharmacother.* 2019, *109*, 876–885. DOI: 10.1016/j.biopha.2018.10.113.

[104] Wang, C.-Q.; Yang, G.-Q. Betacyanins from Portulaca Oleracea L. Ameliorate Cognition Deficits and Attenuate Oxidative Damage Induced by D-Galactose in the Brains of Senescent Mice. *Phytomedicine.* 2010, *17*(7), 527–532. DOI: 10.1016/j.phymed.2009.09.006.

[105] Zhao, C.; Zhang, C.; He, F.; Zhang, W.; Leng, A.; Ying, X. Two New Alkaloids from Portulaca Oleracea L. And Their Bioactivities. *Fitoterapia.* 2019, *136*, 1–5. DOI: 10.1016/j.fitote.2019.05.005.

[106] Maiyo, Z. C.; Ngure, R. M.; Matasyoh, J. C.; Chepkorir, R. Phytochemical Constituents and Antimicrobial Activity of Leaf Extracts of Three *Amaranthus* Plant Species. *Afr. J. Biotechnol.* 2010, *9*(21), 3178–3182.

[107] Tang, Y.; Li, X.; Chen, P. X.; Zhang, B.; Hernandez, M.; Zhang, H.; Tsao, R.; Liu, R.; Tsao, R. Lipids, Tocopherols, and Carotenoids in Leaves of Amaranth and Quinoa Cultivars and a New Approach to Overall Evaluation of Nutritional Quality Traits. *J. Agric. Food Chem.* 2014, *62*(52), 12610–12619. DOI: 10.1021/jf5046377.

[108] Perales-Sánchez, J. X.; Reyes-Moreno, C.; Gómez-Favela, M. A.; Milán-Carrillo, J.; Cuevas-Rodríguez, E. O.; Valdez-Ortiz, A.; Gutiérrez-Dorado, R. Increasing the Antioxidant Activity Total Phenolic and Flavonoid

Contents by Optimizing the Germination Conditions of Amaranth Seeds. *Plant Foods Hum. Nutr.* 2014, *69*(3), 196–202. DOI: 10.1007/s11130-014-0430-0.

[109] Padalia, H.; Chanda, S. Comparative Phytochemical Analysis of Aerial Parts of *A. Procumbeans, F. Dichotoma, S. Sponteneum, S. Nigra* and *T. Angustifolia*. *J. Pharmacogn. Phytochem*. 2015, *4*(2), 11–16.

[110] Román-Cortés, N. R.; García-Mateos, R. M.; Castillo-González, A. M.; Sahagún-Castellanos, J.; Jiménez-Arellanes, M. A. Características nutricionales y nutracéuticas de hortalizas de uso ancestral en México. *Rev. Fitotec. Mex.* 2018, *41*, 245–253.

[111] Miranda-Granados, J.; Chacón, C.; Ruiz-Lau, N.; Vargas-Díaz, M. E.; Zepeda, L. G.; Alvarez-Gutiérrez, P.; Meza-Gordillo, R.; Lagunas-Rivera, S. Alternative Use of Extracts of Chipilín Leaves (*Crotalaria Longirostrata* Hook. & Arn) as Antimicrobial. *Sustainability*. 2018, *10*(3), 883. DOI: 10.3390/su10030883.

[112] Barros, L.; Pereira, E.; Calhelha, R. C.; Dueñas, M.; Carvalho, A. M.; Santos-Buelga, C.; Ferreira, I. C. Bioactivity and Chemical Characterization in Hydrophilic and Lipophilic Compounds of *Chenopodium Ambrosioides* L. *J. Funct. Foods*. 2013, *5*(4), 1732–1740. DOI: 10.1016/j.jff.2013.07.019.

[113] Santiago-Saenz, Y. O.; Hernández-Fuentes, A. D.; Monroy-Torres, R.; Cariño-Cortés, R.; Jiménez-Alvarado, R. Physicochemical, Nutritional and Antioxidant Characterization of Three Vegetables (*Amaranthus Hybridus* L., *Chenopodium Berlandieri* L., *Portulaca Oleracea* L.) As Potential Sources of Phytochemicals and Bioactive Compounds. *J. Food Meas. Charact.* 2018, *12*(4), 2855–2864. DOI: 10.1007/s11694-018-9900-7.

[114] Jia-liang, W.; Dan-wei, M.; Ya-nan, W.; Hong, Z.; Bing, H.; Qun, L.; Zhi-yan, Z.; Jing, F. Cytotoxicity of Essential Oil of Chenopodium Ambrosioides L. Against Human Breast Cancer MCF-7 Cells. *Trop. J. Pharm. Res.* 2013, *12*, 929–933. DOI: 10.4314/tjpr.v12i6.10.

[115] Degenhardt, R. T.; Farias, I. V.; Grassi, L. T.; Franchi, G. C., Jr.; Nowill, A. E.; Bittencourt, C. M. D. S.; Wagner, T. M.; De Souza, M. M.; Cruza, A. B.; Malheiros, A. Characterization and Evaluation of the Cytotoxic Potential of the Essential Oil of *Chenopodium Ambrosioides*. *Rev. Bras. Farmacogn.* 2016, *26*(1), 56–61. DOI: 10.1016/j.bjp.2015.08.012.

[116] Azo-vélez, M. A.; Guajardo-Flores, D.; Mata-Ramírez, D.; Gutiérrez-Uribe, J. A.; Serna-Saldivar, S. O. Characterization and Quantitation of Triterpenoid Saponins in Raw and Sprouted *Chenopodium Berlandieri* Spp. (Huauzontle) Grains Subjected to Germination with or without Selenium Stress Conditions. *J. Food Sci.* 2016, *81*(1), C19–C26. DOI: 10.1111/1750-3841.13174.

[117] Mateos-Maces, L.; Chávez-Servia, J. L.; Vera-Guzmán, A. M.; Aquino-Bolaños, E. N.; Alba-Jiménez, J. E.; Villagómez-González, B. B. Edible Leafy Plants from Mexico as Sources of Antioxidant Compounds, and Their Nutritional, Nutraceutical and Antimicrobial Potential: A Review. *Antioxidants*. 2020, *9*(6), 541. DOI: 10.3390/antiox9060541.

[118] Barrón-Yánez, M. R.; Villanueva-Verduzco, C.; García-Mateos, M. R.; Colinas-León, M. T. Nutrient Value and Saponi Content of Huauzontle (*Chenopodium Nuttalliae* Saff.), Zucchini (*Cucurbita Pepo* L.), Canola (*Brassica Napus* L.) And Amaranto (*Amaranthus Leucocarpus* S. Watson Syn. *Hypochondriacus* L.) Sprouts. *Rev. Chapingo Ser. Hort.* 2009, *15*, 237–243.

[119] Ibarra-Alvarado, C.; Rojas, A.; Mendoza, S.; Bah, M.; Gutiérrez, D. M.; Hernández-Sandoval, L.; Martínez, M. Vasoactive and Antioxidant Activities of Plants Used in Mexican Traditional Medicine for the Treatment of Cardiovascular Diseases. *Pharm. Biol.* 2010, *48*(7), 732–739. DOI: 10.3109/13880200903271280.

[120] Gomez-Chang, E.; Uribe-Estanislao, G. V.; Martinez-Martinez, M.; Gálvez-Mariscal, A.; Romero, I. Anti-Helicobacter Pylori Potential of Three Edible Plants Known as Quelites in Mexico. *J. Med. Food.* 2018, *21*(11), 1150–1157. DOI: 10.1089/jmf.2017.0137.

[121] Jiménez-Aguilar, D. M.; Grusak, M. A. Evaluation of Minerals, Phytochemical Compounds and Antioxidant Activity of Mexican, Central American, and African Green Leafy Vegetables. *Plant Foods Hum. Nutr.* 2015, *70*(4), 357–364. DOI: 10.1007/s11130-015-0512-7.

[122] Reyes-Becerril, M.; Angulo, C.; Sanchez, V.; Vázquez-Martínez, J.; López, M. G. Antioxidant, Intestinal Immune Status and Anti-inflammatory Potential of *Chenopodium Ambrosioides* L. In Fish: *In Vitro* and *in Vivo* Studies. *Fish Shellfish Immunol.* 2019, *86*, 420–428. DOI: 10.1016/j.fsi.2018.11.059.

[123] Assaidi, A.; Dib, I.; Tits, M.; Angenot, L.; Bellahcen, S.; Bouanani, N.; Legssyer, A.; Aziz, M.; Mekhfi, H.; Bnouham, M.; et al. *Chenopodium Ambrosioides* Induces an Endothelium-dependent Relaxation of Rat Isolated Aorta. *Journal of Integrative Medicine*. 2019, *17*(2), 115–124. DOI: 10.1016/j.joim.2019.01.006.

[124] Zhu, H.; Wang, Y.; Liu, Y.; Xia, Y.; Tang, T. Analysis of Flavonoids in Portulaca Oleracea L. By UV–Vis Spectrophotometry with Comparative Study on Different Extraction Technologies. *Food Anal. Methods*. 2010, *3*(2), 90–97. DOI: 10.1007/s12161-009-9091-2.

[125] El-Sayed, M. I. K.;. Effects of Portulaca Oleracea L. Seeds in Treatment of Type-2 Diabetes Mellitus Patients as Adjunctive and Alternative Therapy. *J. Ethnopharmacol.* 2011, *137*(1), 643–651. DOI: 10.1016/j.jep.2011.06.020.

[126] Zamilpa, A.; García-Alanís, C.; López-Arellano, M. E.; Hernández-Velázquez, V. M.; Valladares-Cisneros, M. G.; Salinas-Sánchez, D. O.; Mendoza-De Gives, P. *In Vitro* Nematicidal Effect of *Chenopodium Ambrosioides* and *Castela Tortuosa* N-Hexane Extracts against Haemonchus Contortus (Nematoda) and Their Anthelmintic Effect in Gerbils. *J. Helminthol.* 2019, *93*(4), 434–439. DOI: 10.1017/S0022149X18000433.

[127] Pereira, W. S.; Da Silva, G. P.; Vigliano, M. V.; Leal, N. R. F.; Pinto, F. A.; Fernandes, D. C.; Santos, S. V. M.; Martino, T.; Nascimento, J. R.; De Azevedo, A. P. S.;, et al. Anti-Arthritic Properties of Crude Extract from Chenopodium Ambrosioides L. Leaves. *J. Pharm. Pharmacol.* 2018, *70*(8), 1078–1091. DOI: 10.1111/jphp.12926.

[128] Alvar, J.; Vélez, I. D.; Bern, C.; Herrero, M.; Desjeux, P.; Cano, J.; Jannin, J.; De Boer, M. Leishmaniasis Worldwide and Global Estimates of Its Incidence. *PLoS ONE.* 2012, 1–12. DOI: 10.1371/journal.pone.0035671.

[129] Monzote, L.; García, M.; Montalvo, A. M.; Scull, R.; Miranda, M. Chemistry, Cytotoxicity and Antileishmanial Activity of the Essential Oil from Piper Auritum. *Mem. Inst. Oswaldo Cruz.* 2010, *105*(2), 168–173. DOI: 10.1590/S0074-02762010000200010.

[130] Dominguez-Uscanga, A.; Loarca-Piña, G.; De Mejia, E. G. Baked Corn (*Zea Mays* L.) And Bean (*Phaseolus Vulgaris* L.) Snack Consumption Lowered Serum Lipids and Differentiated Liver Gene Expression in C57BL/6 Mice Fed a High-fat Diet by Inhibiting PPARγ and SREBF2. *J. Nutr. Biochem.* 2017, *50*, 1–15. DOI: 10.1016/j.jnutbio.2017.08.011.

[131] Avila-Nava, A.; Noriega, L. G.; Tovar, A. R.; Granados, O.; Perez-Cruz, C.; Pedraza-Chaverri, J.; Torres, N. Food Combination Based on a Pre-hispanic Mexican Diet Decreases Metabolic and Cognitive Abnormalities and Gut Microbiota Dysbiosis Caused by a Sucrose-enriched High-fat Diet in Rats. *Mol. Nutr. Food Res.* 2017, *61*(1), 1501023. DOI: 10.1002/mnfr.201501023.