



# Edible seeds, leaves and flowers as Maya super foods: function and composition

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## Abstract

Mesoamerica is a megadiverse region where one of the Vavilov center has developed; Guatemala is part of this region, and the heart of the Mayan world. The biodiversity includes the traditional utilization of food (grains, fruits, herbs, flowers and rhizomes), flavors, aromas, condiments, dyes and colorants, medicinal and ritual plants, as well as other products from nature. At least 76 vegetal species were developed as food. In this paper it will be presented the information on seeds and grains (*Amaranthus cruentus*, *Brosimum alicastrum*, *Crescentia alata*, *Cucurbita pepo*, *Phaseolus vulgaris*, *Salvia hispanica*, *Theobroma cacao*, *Zea mays*), herbs (*Amaranthus hybridus*, *Cnidoscolus aconitifolius*, *Crotalaria longirostrata*, *Dysphania ambrosioides*, *Lycianthes synanthera*, *Solanum americanum*, *S. nigrescens*, *S. wendlandii*), and flowers (*Cucurbita pepo*, *Chamedoroea tepejilote*, *Fernaldia pandurata*, *Erythrina berteroana*, *Giricidia sepium*, *Yucca elephantipes*,) traditionally used as food. Other foods include fruits, rhizomes, tubers and condiments. The functional properties and nutritive composition are described for 22 native seeds, leaves and flowers. In comparison with recognized international herbs, it is demonstrated that some native Mesoamerican herbs have an important nutritious and functional composition. A rich traditional culinary heritage is the way that these foods are consumed. The use of traditional dishes and innovative fusions with Maya Super Foods is recommended for economy improvement of the region as well as health and beauty.

**Keywords:** Ancestral foods, Edible flowers, Functional seeds, Nutritious leaves

## Introduction

Mesoamerica is considered to be one of the eight Vavilov centers of the world, which means that the original inhabitants (Toltecs and Mayas) interacted with their environment, collected important seeds, learned how to cultivate them, and provided very important food crops to mankind.<sup>1</sup> Guatemala is an important territory of this region, being considered the 19th megadiverse country, is rich in biological diversity, which means the valorization of these resources from a traditional and integral vision.<sup>2</sup>

Examples of these useful biodiversities are food (grains, fruits, herbs, flowers, rhizomes), flavors, aroma, condiments, dyes, colorants, medicinal and ritual plants, as well as construction and handicraft materials, animals and their products.<sup>3,4</sup> The most important part of this is the cultural diversity that interacts with environment making this integrally useful. Maya descendant populations maintain the knowledge on ancestral foods, mainly through its culinary tradition.<sup>4</sup>

This keynote refers to the ancestral foods consumed by the Mayan population in Guatemala, which accounted for

nearly 80 vegetal species. The most recent and relevant investigation on the chemical composition and biological activity of edible seeds, leaves and flowers will be described in some detail, emphasizing the origin, use, functional activity and composition.

## Ancestral Seeds and Grains

*Amaranthus cruentus* L. (Amaranthaceae) [Amaranth, tzets]. Although there are three main amaranth species with important seeds in the continent, this is the particularly native species of Mesoamerica. It is a pseudo cereal of low gluten content, great protein quality, and it is useful in the management of elevated glycemia, cholesterol and oxidative stress, as well as anti-cancer, hepato- and cardioprotective.<sup>6</sup> Its constituents include protein (albumins, globulins), essential amino acid (lysine, tryptophan), micronutrients (minerals and vitamins), fatty acids (squalene) and tocopherols.<sup>7-9</sup>

*Brosimum alicastrum* Sw. (Moraceae) [Mayan nut, ramon, ujushte]. Native to Yucatan and Peten as a forest resource.<sup>10</sup> It is a fruit of an important tree of hot-humid



tropical forest. It has antioxidant activity, low glycemic index, high nutritional content, and it is gluten free.<sup>11</sup> It has a high content of polyunsaturated fatty acid, ash containing minerals, nutritional dietary fiber and phenolic compounds (higher than walnut, almond and peanut).<sup>12</sup>

*Crescentia alata* HBK (Bignoniaceae) [Morro, jicaro]. It is native dry regions of Mexico and Central America. The seeds are commonly used raw or roasted for preparation of beverages with pleasant sensory properties, and high caloric value.<sup>13</sup> Functional properties include antioxidant and  $\alpha$ -glucosidase activity due to soluble melanins.<sup>14</sup> It contains unsaturated fatty acids, essential amino acids and low anti-nutritional factors.<sup>15</sup>

*Cucurbita pepo* L. and *C. argyrosperma* K. Koch (Cucurbitaceae) [Pepitoria, pumpkin]. The first one is a quite common vegetable from the American continent, but the second is native to Mesoamerica. The pulp is widely consumed worldwide, but the seeds are less consumed. The seed has a great potential for kidney and hepatic damage control, lowering high glucose content, show antioxidant, hepatoprotective, anti-ulcer, anti-inflammatory and anti-tumor activity,<sup>16</sup> as well as contribute to prevent benign prostatic hyperplasia.<sup>17,18</sup> It contains phytosterols, phospholipids, cucurbitosides and minerals (Se).<sup>16</sup>

*Phaseolus vulgaris* L. and *P. dumosus* Macfady (Fabaceae) [Bean, frijol, piloy]. The exact origin is unknown, but evidence place it in Mesoamerica as domestication of wild species<sup>19</sup> or hybridization between other *Phaseolus* species.<sup>20</sup> Both species are fundamental to Mesoamerican nutrition and its composition and functional properties for handling chronic degenerative disease are well known.<sup>21</sup>

*Salvia hispanica* L. (Lamiaceae) [Chia, chan]. Native from Mesoamerica, now cultivated in South America. It is a well-known seed for its functional activity in the nervous system development, combating hyperlipidemia, preventing cardiovascular diseases, and increasing the immune system, being considered a functional nutriceutical.<sup>22,23</sup> Its main constituents are polyunsaturated fatty acids (rich in omega 3, 6 and 9), phenolic compounds (cinnamic acids), coumarins, dietary fiber and proteins (19-23%).<sup>9,23,24</sup>

*Theobroma cacao* L. (Malvaceae) [Cacao]. Originally from the Amazonian basin, but its use was developed in Mesoamerica.<sup>25</sup> It could be prepared as cocoa or chocolate, considered the Food of the Gods,<sup>26</sup> it has important functional activities such as prevention of cardiovascular, neurological, endocrine, immunological and other diseases.<sup>27,28</sup> The main constituents are polyphenolics (epicatechin and proanthocyanidins), theobromine and minerals (Mg).<sup>29</sup>

*Zea mays* L. (Poaceae) [Corn, maize, ixim]. There is a controversy about its origin, but genetic studies place the ancestors in Mesoamerica.<sup>30</sup> Presently cultivated worldwide with an important contribution to human

nutrition, becoming the staple food in many parts of the world, particularly in Mesoamerica where it is fundamental to everyday cuisine as a sacred grain, considering its inhabitants as "hombres de maiz".<sup>31</sup>

### Ancestral Edible Leaves

At least 12 native edible leaves were documented in the Mayan cuisine, although here we present the relevant information of only eight of them, in comparison with most recognized international herbs (*Moringa oleifera*, *Spinacea oleracea*), it is demonstrated that some native Mesoamerican herbs have an important nutritive and functional composition.<sup>32</sup>

*Amaranthus hybridus* L. (Amaranthaceae) [Pigweed, bledo]. Native to Mesoamerica, now distributed in tropical and subtropical regions worldwide, it is widely consumed as a valuable nutritive vegetable. The leaves have antioxidant, antibacterial and xanthine oxidase inhibition activity.<sup>33</sup> It contains most of the essential amino acids, carotenoids, polyphenols, flavonoids, amarantin, betalains and minerals (Cu, Fe, Mn, Se, Zn).<sup>32,34,35</sup>

*Cnidoscolus aconitifolius* Mill. (Euphorbiaceae) [Mayan spinach, chaya]. Domesticated leafy dark green vegetable of the Maya region highly appreciated for its nutritive benefits now cultivated worldwide.<sup>36</sup> It has shown antioxidant, antibacterial, anti-inflammatory, antimutagenic, hepatoprotective, hypo-glycemic and sedative activity.<sup>36-38</sup> It contains flavonoids (kaempferol), protein, tannins, minerals (Fe, Zn),<sup>32</sup> and vitamins (A, C), even though it contains cyanogenic glucosides, so it has to be consumed cooked.<sup>39</sup>

*Crotalaria longirostrata* Hook. & Arn. (Fabaceae) [Chipilin]. Medium-size shrub from lowlands and pine-oak forest in Guatemala and El Salvador, it is consumed as a leaf or aromatic dish due to a particular aroma and flavor.<sup>40</sup> The leaves have antioxidant and sedative activity, as well as antifungal activity to pytopathogens.<sup>40,41</sup> It contains nontoxic alkaloids, polyphenols, flavonoids, minerals (Mg, Fe, Zn)<sup>32</sup>, amino acids and vitamin C.<sup>42</sup>

*Dysphania ambrosioides* (L.) Mosyakin & Clements (Amaranthaceae) [Apazote, wormwood]. Strongly odorous herb aromatic leaves of which are used in Mesoamerican cuisine. Plant extracts and essential oil has demonstrated essential oil which possess amoebic, analgesic, antipyretic, antifungal, antioxidant and anti-tumor activity.<sup>43,44</sup> It contains essential oil (ascaridol, myrcene, safrol), flavonoids, tocopherols, and minerals (Mg, Mn, Zn).<sup>32,44,45</sup>

*Lycianthes synanthera* (Sendtn.) Bitter (Solanaceae) [Quilete, chomté]. Tall shrub abundant in lowlands of Central America; buds and leaves are eaten as green vegetable for local cuisine. It has antibacterial and antifungal activity; possesses some antinutritional factors (hemagglutinin activity) as well as trypsin and  $\alpha$ -amylase inhibiting activity.<sup>46</sup> It contains furostanol saponins,

protein, minerals (Ca, K, Fe, Zn),<sup>32</sup> and vitamins (B2, C).<sup>46,47</sup>

*Solanum americanum* Mill (Solanaceae) [Nightshade, hierba mora]. Wild herb adapted to diverse climates through the American continent at less than 1,500 masl.<sup>44</sup> It is commonly used as green vegetable or for convalescent patients, and as anxiolytic and antimicrobial.<sup>48,49</sup> It contains alkaloids (solanine), polycyclic steroids, glycosides, saponins, phenolics, flavonoids (apigenin), essential amino acids, and minerals (Fe, Zn).<sup>44,50</sup>

*Solanum nigrescens* Mart. & Gal. (Solanaceae) [Makuy, hierba mora]. Wild or cultivated herb from Mesoamerica at higher than 1500 masl. It is consumed as leafy green vegetable in soups, and has proved to be antioxidant and effective against *Candida albicans*,<sup>51</sup> and *Helicobacter pylori* activity.<sup>52</sup> It contains alkaloids (cantalosaponins),<sup>53</sup> coumarins, anthraquinones, minerals (Fe, Mg, Zn),<sup>32</sup> and vitamins.<sup>54</sup>

*Solanum wendlandii* Hook. f. (Solanaceae) [Quixtan, cachanil]. Evergreen woody vine from Central America with recurved spines, it is consumed as vegetable. It is used as galactagogue, mildly sedative and to combat weakness,<sup>55</sup> it has demonstrated antioxidant activity. It contains protein, carotenes, and minerals (Mg, Zn).<sup>32,56</sup>

### Ancestral Edible Flowers

In the Mayan traditional cuisine at least 10 native edible flowers were detected, in this keynote we present the information on six of them.<sup>57</sup>

*Chamaedorea tepejilote* Liebm. (Arecaceae) [Pacaya, tepejilote]. Wild or cultivated palm native from Mexico to Colombia, the flowers are traditionally eaten wrapped in egg or for decorating salads.<sup>58</sup> It has anti-tussive and antidiabetic activity.<sup>59</sup> It contains ash, dietary fiber, minerals (K, Mg, Fe, Zn),<sup>57</sup> and vitamins (A, B2, B3, C).<sup>59,60</sup>

*Cucurbita pepo* L. (Cucurbitaceae) [Ayote, güiocoy, squash]. Creeping monoecious vine native from Mesoamerica cultivated for its fruit, but the flowers are eaten in traditional and innovative dishes. The flowers have antioxidant activity,<sup>57</sup> although female flowers are more active than male flowers.<sup>61</sup> They contain polyphenols, flavonoids (flavanol glycosides), essential amino acids (tryptophan), minerals (Fe, Mg, P, Zn),<sup>57</sup> and vitamins (A, C).<sup>62</sup>

*Erythrina berteroana* Urb. (Fabaceae) [Pito, tzité]. Medium size tree distributed from Mexico to Venezuela, and introduced in the Caribbean. Flowers are added to beans or scrambled eggs, is used for treating nervousness and hemorrhages,<sup>40</sup> and has demonstrated not to be sedative but rather anxiolytic.<sup>63</sup> It contains alkaloids, flavonoids, triterpenes, tannins and minerals (Ca, P).<sup>37,40,63</sup>

*Fernaldia pandurata* (A. DC.) Woodson (Apocynaceae) [Loroco]. Climbing semi-woody vine with white flowers, native from southern Mexico to Costa Rica, it is traditionally consumed as vegetable or condiment, and

has demonstrated moderate antioxidant activity.<sup>57,64</sup> It contains flavonoids, tannins, nutritious fiber and minerals (Ca, Cu, Mn, P) and vitamins (B3, C).<sup>57,64</sup>

*Gliricidia sepium* (Jacq.) Kunth ex Walp. (Fabaceae) [Madre cacao, madriado]. Common tree from Mexico to South America, introduced in the Caribbean, India and Philippines. Flowers are consumed in traditional dishes during season. They were demonstrated to possess anti-inflammatory, antibacterial and antioxidant activities.<sup>65,66</sup> They contain flavonoids (astragaline, robinine, trifoline), essential oils (coumarin, hydroquinone, myrtenol, maltol)<sup>67</sup> saponins, 12-hydroxirotenoids,<sup>69</sup> and minerals (Cu, Fe).<sup>57</sup>

*Yucca elephantipes* Regel (Asparagaceae) [Izote, pasquiy]. Spineless yucca native to Veracruz, Mexico, widely cultivated through Central America; flowers are eaten boiled in different dishes, and medically are used as stomachic, tonic and diuretic,<sup>68</sup> it has been demonstrated antifungal activity.<sup>69</sup> They contain spirostanol glycosides, minerals (Fe, P) and vitamins (carotenes, B1, C).<sup>68</sup>

### Conclusions

Mesoamerica is a megadiverse region from biological and cultural point of view. These conditions generated a rich utilization of the environment, represented by a diverse culinary tradition. Most of the edible vegetal species available demonstrated interesting biological activity and chemical composition, suggesting that their permanent use in the diet might help in alimentary sovereignty as well as behave as a functional food. Some of these vegetables reached the national market, strengthening the traditional cuisine, improving the economic possibilities of peasants, and could be incorporated into national and international culinary fusions. Guatemala has the capacity to produce these innovative Mayan Super Foods with “denomination of origin” seal. It must be remembered that integral wellbeing plus healthy food are the basis for beauty.

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### Competing Interests

None.

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