The Aztec Diet

R. E. Pérez

Keywords: Aztecs; nutrition; plant-based diet; Mesoamerica; agriculture

Abstract

The typical diet consumed by Aztecs during the Pre-Contact period can be reconstructed through a number of primary and secondary sources on ecology, agriculture, history, nutrition, and archaeology. Ecological sources reveal the landscape and available foods. Historical records describe typical Aztec meals. Nutritional sources break down the quality of the staple foods. Finally, archaeological data provides a picture of the general health of the Aztec populace. Together, these resources suggest that the Aztec diet was primarily plant-based, with supplemental inclusion of some animal foods.The geographic region covered by the Aztec Empire is richer in potential plant than animal food sources. Furthermore, records from Spanish chroniclers describe the Aztec diet as being largely based on plant foods. Nutritional sources show that the staple plant foods in the diet are capable of meeting basic human nutritional needs. Archaeological evidence of the Aztecs points to generally well-nourished individuals, further supporting this assessment. The primary limitation in this analysis is a lack of methods to determine the exact quantities of foods available to the general population over long- and short- term periods.

Overview of the Aztec Diet

As a Pre-Columbian New World culture, the Aztecs' diet was composed of food sources available within the Aztec Empire, which spanned modern-day central and southwestern Mexico, northern Guatemala, El Salvador, and Belize. The region's earliest human settlers were nomadic gatherer-hunters relying primarily on gathering wild plant material as the basis of their diet with small-scale hunting and scavenging of animal foods as supplementation. These peoples eventually developed a more sedentary lifestyle, which included a shift to agriculture. This agriculture primarily consisted of crop cultivation, but a limited degree of animal agriculture was also practiced with domesticated varieties of smaller animals such as ducks and dogs grown on a smaller scale, in contrast to the larger livestock produced on a larger scale in Europe. Few if any of the animal flesh consumed by the Aztecs would be classified as red meat. Cultivated crops included species native to the region such as maize, and a variety of beans and squashes. These three staples of beans, corn, and squash were referred to as the three sisters, in reference to both their foundational role in the diet as well as the symbiotic relationship the three crops demonstrated. Chilies, tomatoes, and amaranth also figured largely in the Aztec diet. In addition to cultivated plots, fruit orchards located within cities provided harvests, which included guava, papaya, and plums. (Smith 2002) The development of agriculture did not cause the Aztecs to altogether abandon the food scavenging techniques of their ancestors, particularly in times of scarcity. Wild edible plants were exploited in large quantities, including such staples as the nopal cactus (also called prickly pear), whose fruit, blossom, and fleshy "meat" were consumed raw, cooked and in beverages. There is also evidence that Aztecs scavenged edible aquatic material such as the blue green algae *spirulina,* fungi like the sorrel mushroom, and naturally occurring minerals like salt. (Sahagun 1979)

The quantity, variety, and quality of plants eaten ensured an expansive and nutrient-rich diet for Mesoamerica's Pre-Columbian inhabitants, and cultivation and distribution methods were similarly rich in variety, number and quality. Technology including various irrigation techniques allowed for good agricultural yields even during times of unfavorable growing conditions. Solid astronomical knowledge allowed for the development of agricultural calendars that dictated toptimum planting and harvesting schedules. **Chinampas**, (sometimes called "floating gardens") man-made islands used for agriculture within Lake Texcoco display the Aztecs' proficiency in agro-engineering. Both public and private gardens dispersed throughout cities met additional dietary needs. (Smith 2002) The massive extension of the empire at its peak created a larger and more diverse landscape for agriculture, allowing for an increase in size and variety of the crop supply as well as specialization, and ensuring abundant and varied harvests. Although some plants retained cultivation zones closer to their native regions, only arriving to other

regions via trade post-harvest, others were successfully introduced and cultivated in other areas. Virtually all crop parts (roots, seeds, nuts, skin, flesh/meat, leaves/greens, blossoms) were consumed to maximize their utility. Once harvested or foraged, produce was often distributed through trade and tribute. (Sahagun 1979)

The highly efficient and varied methods used for obtaining food gave the Aztecs an extremely broad diet. Fruits cultivated in gardens and orchards or foraged in the wild included guava, papaya, sugar apples *(Annona squamosa)*, wild black cherries (*Prunus serotina)*, prickly pear fruit, fruits of palm trees, avocados, tomatoes, sapote, chili peppers, plums, sapodillas, pineapples, wild blackberries, **tzápotl, atzáputl, peruétanos, totolcuitlarzáputl, tezontzáputl, eeyotzáputl,** and **aoácatl.** Various root vegetables and bulbs like sweet potatoes, wild onions, and jícama were also consumed as well as roots of various trees like **cimatl** and t**olcimatl**. Staple grains included corn and amaranth. Seeds and nuts of various plants were consumed, including chia seeds, cacao beans, pumpkin seeds, sunflower seeds, peanuts, cherry seeds, eeyotzáputl seeds, palm kernels, papaya seeds, sugar apple seeds, cenizo seeds and amaranth seeds. Legumes included a variety of beans, such as pinto, anasazi and yellow. Leafy greens were consumed in the form of chaya (tree spinach), sorrel, cenizo (purple sage), squash leaves, jicama leaves and sweet potato leaves. Vines of various plants like squash were also eaten, as well as blossoms of foods like nopal cacti, and the flesh of prickly pear, core of agaves and the heart of palms and cacti (both raw and cooked). Foraged foods included fungi like various wild mushrooms and even aquatic "vegetables," such as the blue-green algae spirulina. (Sahagun 1979) Although evidence strongly suggests the Aztec diet was principally plant-based, animal foods had some presence through fishing, raising of livestock like ducks and dogs, foraging insects, and hunting deer and turkeys. Consumption of human flesh from sacrificial victims was occasional and usually limited to upper classes. As time went on, the Aztecs appeared to rely less on animal sources and more on plant foods, particularly valuable ones like the three sisters (maize, beans, and squash), amaranth, chia seeds and prickly pear. The overall diet was extremely diverse, in the number and types of sources, and manners of utilization. Available evidence suggests the majority of the Aztec population adequately meet nutritional needs, better than many Europeans of the same class, through a principally plant-based diet. (Smith 2002)

In addition to boasting a wide range of plant species and parts used for food, Aztec cuisine displayed very creative preparation techniques. Many foods were eaten raw, but cooking techniques as diverse as roasting, grilling, baking, boiling and steaming were employed, along with creative combinations of ingredients, to formulate nutritious and flavorful dishes. Maize, an undeniable dietary staple, had clearly established and time-honored preparation methods. Whole ears were sometimes eaten green, but when allowed to ripen, the toughness of the kernels required processing in order to be suitable for human consumption. Soaking corn in a lime solution was one of the most popular softening methods. The soaked corn could then be ground on a metate and formed into a dough, **masa,** which was used as as base for sweet and savory puddings, porridges,

beverages (such as atole), steamed in the corn husks to create tamales, or flattened into a circular shape and cooked on a special griddle, a **comal**, to make tortillas. Additionally, corn kernels were sometimes cooked into popcorn. Squashes, another of the three sisters, were ingeniously exploited in their entirety, which included flesh, seeds, vines, stems, leaves and flowers. The flesh and seeds were often roasted, ground, and combined with tomatoes and chilies as a tamal filling or mixed into masa to create seasoned tortillas. Although beans had somewhat more limited preparation methods than their "sisters," a variety of breeds and dishes were served, including bean-filled tamales and beans wrapped in tortillas in an early form of enchiladas. (Sahagun 1979)

Another pillar of the Aztec diet, Amaranth seeds, were frequently toasted and mixed into a myriad of dishes. These nutrient powerhouses, often used for tax tributes within the Aztec Empire, are estimated to have composed 80% of the calories of the Pre-Conquest diet. The seeds also played a substantial role in a religious ceremony, in which they were mixed with sacrificial victims' blood, to form a paste, which was shaped into models of gods and then broken and consumed by participants after the festival. (Stallknecht and Shulz-Schaeffer 1993) Chia seeds, yet another staple, were eaten raw and whole or roasted and ground into a flour called **chianpinoll**, which could be mixed into tortillas or tamales or used to create beverages (Cahill 2003). Chili peppers and other fruits were also widely consumed in a variety of ways, which included raw and cooked for both, in sauces for the former and in juices for the later. (Sahagun 1979) Prickly pears and maguey were used to create the alcoholic beverages colonche and pulque, respectively. (Smith 2002) Another much less widespread beverage was hot chocolate, made from toasting cacao seeds in a pan, grinding them into a powder and mixing it into hot water and sometimes chilies or achiote; consumption of this delicacy, however, was limited to the most elite. Seasonings spanning minerals like salt and fruits like chilies as well as preservatives like niter (in the mineral form of potassium nitrate) act as a further testament to the complexity of the Aztec diet. In utilizing a variety of plants and preparation techniques, the Aztecs developed a cuisine anything but tedious or unsubstantial. (Sahagun 1979)

Possible Nutritional Concerns and How They Were Met

A plant-based diet, especially one as expansive and varied as that enjoyed by the Aztecs, can meet and even exceed basic human nutritional needs. Like any diet, it possesses a unique set of concerns, as certain nutrients may be available from fewer sources, and/or in smaller quantities, and/or have lower rates of absorbability in comparison with a diet including a larger proportion of animal foods. Nutrients carrying the greatest risk of deficiency in a plant-based diet include protein, iron, B vitamins, calories, fat (especially amino acids and omega essential fatty acids), salt and calcium. (American Dietetic Association 2009) All of these nutritional needs could have been met within the Aztec diet.

Protein, central to muscle generation, growth, proper neurological function, and bone

strength, is often cited as problematic in a plant-based diet, stemming from the fact that most animal foods are relatively high and many plant foods relatively low in this vital nutrient. Protein is synthesized in the human body through twenty-two amino acids, which act as building blocks, and the proper amount and distribution of each and every amino acid is important for the proper construction of protein. Nine of the amino acids (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) are "essential," meaning they cannot produced by the human body, and so must be attained through diet. Dietary sources of essential amino acids are labeled as "high" or "low" quality proteins based on the quantity and variety of essential amino acids available. Animal food sources contain all nine essential amino acids and are thus considered to be high quality whereas most (but not all) plant food sources display gaps in some of the amino acids and are thus considered to be of a lower quality. Lack of the proper amount of all amino acids prevents the body from properly synthesizing protein, causing symptoms like exhaustion, dizziness or nervousness. Given its significance to basic growth and development, cell multiplication, reproductive, blood, and neurological health and optimal brain health, muscle growth, protein deficiency can be one of the most harmful and visibly manifested nutrient shortages. (World Health Organization 2007) Protein availability can significantly affect populations an a whole through its impact on morbidity, mortality and reproduction. (Santley and Rose 1975) Though a plant-based diet may run the risk of insufficient protein, the nutrient was present in a wide range of quantities and varieties of the foods consumed by the Aztecs. Furthermore, most plants contain some amount of protein, and although they may be minimal sources individually, when large quantities and varieties of these foods are eaten in combination they can provide substantial amounts of all the essential amino acids. Furthermore, many plant foods that held a significant role in the Aztec diet, such as beans, amaranth, chia seeds, pumpkin seeds, sunflower seeds, peanuts and spirulina are individual sources of high quality protein. (USDA)

Adequate intake of iron, a vital nutrient found in all human cell types, is also considered a potential pitfall of a plant-based diet. Among iron's many functions is its role in hemoglobin, which transfers oxygen from the lungs to other tissues. Iron also plays an important part in enzyme reactions within cells. Lack of iron can disrupt or impede these functions causing symptoms like fatigue, pallor, hair loss, irritability, weakness, pica (the eating of non-food items like clay or ice) brittle nails, impaired immune system and ultimately death, among other symptoms. These are all considered side effects, while long term deficiency leads to the direct effect of iron deficiency anemia, whose symptoms include fatigue, anxiety, chest pain, fainting, depression, numbness, and poor appetite. Dietary origins of iron deficiency can be a lack of iron-rich foods or a surplus of foods that impede absorption. Red meat and organ foods are often referenced as ideal sources of iron; however iron exists in most all living organisms, plants, included, making it widely available from a multitude of food sources. Many basics of the Aztec diet, such as beans and amaranth, leafy green vegetables, sunflower seeds, pumpkin seeds, peanuts and other nuts, seeds and cereals were richer in iron than many animal

sources. Although the non-heme variety of iron available from plant sources is less easily broken down and absorbed by the human body, absorbability greatly improves when consumed with vitamin C, which was present in high levels in the Aztec diet from sources including chilies, tomatoes, nopal, papaya, guava and an array of tropical fruits. (American Dietetic Association 2009) (Sahagun 1979). Iron's sensitivity to certain absorption inhibitors can be problematic, but the only inhibitor that the typical Aztec diet would have included in significant amounts is fiber, which interferes only mildly with absorption. Furthermore, legumes and grains were often soaked before cooking, decreasing the levels of the inhibitor phytate and therefore increasing absorption potential. There is even some evidence that the body can adapt to a diet with high levels of non-heme iron through increased absorption efficiency. (American Dietetic Association 2009)

The vitamin B_{12} is yet another nutrient meriting special consideration in the context of a plant-based diet. Eight of the B vitamins are used by humans: B_1 (thiamine), B_2 (riboflavin), B_3 (niacin[amide]), B_5 (pantothenic acid), B_6 (pyridoxine hydrochloride), B_7 (boitin), B_9 (folic acid) and B_{12} (cyanocobalamin). All are water-soluble and used in cell metabolism. B vitamins are essential to healthy metabolism, skin and hair health, muscle, immune and nervous system function, cell growth and division (including red blood cells, which prevent anemia.) (American Dietetic Association 2009) Most of the B vitamins are widely and easily available in a variety of plant foods, including avocados, sweet potatoes, amaranth, sunflower seeds, guava and beans to name just a few. (USDA) B_{12} in particular is often not available in plant sources currently, leading to the misconception that it originates in animal sources, when in fact it is a bacteria based vitamin, so it is not contained in the animal foods themselves, but rather, in the bacteria on them. B_{12} deficiencies can lead to macrocytic anemia, elevated homocysteine levels, neurological, peripheral neuropathy, cognitive disorders like memory loss, sensor/motor deficiencies, decreased sense of touch, weakened reflexes, irritability, difficulty in concentration, fatigue, depression, gastrointestinal symptoms, and in more severe cases, mania, psychosis and paralysis. (American Dietetic Association 2009) Currently, during sanitation processes like washing, plant foods are stripped of soil, and with it bacteria and vitamin B_{12}. As Aztecs predated these technologies and germ theory concerns, vegetables, particularly roots like sweet potatoes, jícama, were consumed with some soil and bacteria, providing a steady source of B_{12}. A biological factor working further in their favor is the ability of the human body to store B_{12} for long periods. (Herbert 1988)

In general, plant foods tend to be very low in fat, especially when compared with animal foods like dairy, eggs and red meats, which tend to be high in saturated fats and cholesterol. The low-fat content of a plant based diet is for the most part considered positive with clear health advantages including improved overall cardiovascular health, lower rates of heart disease and hypertension and healthier cholesterol levels. Plant based diets are also correlated with lower rates of obesity, diabetes, many cancers, and overall

longer life spans. Although a low fat diet has numerous benefits, dietary fat is not entirely negative, and a certain amount is necessary for optimal health. Fat is a valuable source of calories (necessary for expending energy), and also aids in maintenance of healthy body fat, used for energy reserves, insulation from cold, body temperature regulation and protecting organs from shock. It is also important for skin and hair health and required to absorb fat soluble vitamins. Although saturated fat has incontestable negative health effects, unsaturated fat can be beneficial to establishing proper levels of "good" (HDL) cholesterol, which supports healthy blood pressure and reduces risk of hypotension. (American Dietetic Association 2009) The essential fatty acids, so named for the human body's inability to produce them and the resulting necessity to obtain them through diet, in addition to serving the basic purposes of all fats, are required for biological processes like metabolism. These "good" essential fats include the polyunsaturated fatty acids omega 3, 6, and 9. Omega 6 is found in a number of sources that formed part of the Aztec diet, including leafy green vegetables, cocoa and nuts and seeds like pepitas, cocoa beans and palm kernels. Omega 3 acids can be further subdivided into Alpha-linolenic acid (ALA), docosahexaenoic acids (DHA), and eicosapentaenoic (EPA). After consumption, ALA, found in green leaves, fatty fruits and vegetables like avocados, and certain nuts and seeds like chia seeds and cocoa beans, is converted through desaturation and elongation from shorter chains into longer and more unsaturated eicosapentaenoic (EPA) chains and finally into docosahexaenoic acid (DHA) chains. The inefficient conversion rates from ALA to DHA and EPA makes sources where the fat is already in the latter two forms significantly more beneficial. Omega 3, especially in the form of ALA, figures into neurological function, aiding in serotonin production, prevention and management of clinical depression and psychotic disorders like schizophrenia. It also plays a role in boosting cardiovascular health, (seen in reduced rates of cardiovascular death), improving immune function, and decreasing inflammation. Omega 3 and 6 must be consumed through diet, ideally in a ratio of 4 : 1. (Maintenance of this ratio is a common problem area in the current western diet, which often contains an excess of omega 6 and a shortage of omega 3.) The ALA form of omega 3, found in numerous plant sources, occurs in particularly high levels in chia seeds and avocados, amaranth, and cocoa. The EPA and DHA forms are less common. Interestingly, one of the most widely-known sources of these rarer forms, oily fish, does not naturally contain fatty acid through synthesis, but instead acquires it through consumption of algae rich in DHA omega 3. The Aztec diet included the microalgae *Cyrpthecodinium cohnii* and *Schizochytrium*, both excellent and direct sources of DHA. (Crawford et al 2000).

In addition to the vital nutrients of protein, iron, B vitamins and fat, miscellaneous other nutrients can potentially be absent or in insufficient quantities in a plant-based diet. One such nutrient, vitamin D, is essential to proper bone mineralization and prevention of related ailments like rickets. The primary dietary source of Vitamin D is organ foods, but humans are also able to synthesize vitamin D from exposure to sunlight, available in no small quantity in the region of Mesoamerica. A nutrient often correlated with vitamin D, calcium is central to the construction and maintenance of strong bones and teeth and

subsequent reduced risk of ailments like osteoporosis, fractures and low density. Long term calcium deficiency can cause rickets and poor blood clotting. Although dairy is an oft-touted source, it is problematic for the 75% of the world population unable to digest lactose, and many regions, including the Americas, did not historically have many species that would qualify as good potential "dairy animals." (World Health Organization 2007) Furthermore, evidence suggests the body alkalizes animal protein's acidity by leaching calcium from the bones, data supported by lower osteoporosis rates in regions with low dairy consumption and highest in places with high dairy consumption. Excessive calcium can even impair kidney function and hinder absorption of other minerals. (American Dietetic Association 2009) Plant sources of calcium include leafy greens, certain nuts and seeds, amaranth and beans. (USDA) Another potentially problematic nutrient, iodine, which is instrumental in thyroid health and mental development, is found in algae. Choline, needed for cell membrane construction and central nervous system function, is found in amaranth, peanuts, and a variety of beans and leafy greens. (USDA) Deficiency of sodium, which is required for blood volume and pressure regulation, was avoided by Aztecs through consumption of algae and salt. (Sahagun 1979) A concern peculiar to a plant-based diet is sufficient calorie intake, a demand which was partially met through sheer quantity of food. The efficiency, scale, and specialization of the agricultural system (seen in personal gardens, city chinampas, agricultural land and orchards), coupled with the expanse and diversity of terrain and movement of goods through tribute, trade, and religious festivals, allowed for diverse and large harvests. These abundant harvests included many calorie-dense food options, such as amaranth, avocados, and seeds and nuts like pepitas, peanuts, sunflower seeds. Extreme resourcefulness in terms of both methods of obtaining food (which included scavenging and harvesting from a variety of terrestrial and aquatic sources) as well as in efficient utilization of every single part of food items (including flesh, skins, seeds, nuts, roots, flowers, stems vines, and algae) further guarded against the risk of calorie deficiency. The Aztecs also practiced some degree of collection and storage of surplus crops to provide during times of shortage. (Sahagun 1979)

Adequacy and Benefits of the Aztec Diet

A plant-based diet can meet and even exceed human nutritional needs during all life stages, according to both the U.S. and Canadian Dietetic Associations among authorities. Plant foods are rich in a number of nutrients that have been proven to be beneficial to heart and digestive health, cancer prevention, maintenance of healthy body mass index (BMI),increased lifespans, and avoidance of ailments like lactose intolerance. (American Dietetic Association 2009) Many vitamins, minerals and other nutrients like fiber are primarily or solely available in plant foods. Despite the clear benefits of plant-based nutrition, risks arise from nutrients available from fewer sources, in smaller quantities, in a lower "quality" or less absorbable form, or some combination of these aspects. These potential issues can easily be avoided in theory and appear to have been avoided in practice by the Aztecs, particularly in times of plenty. The Aztecs exploited several methods to obtain adequate amounts of nutrients necessary for proper health all within

the context of a plant-based diet. One key technique was consumption of a sufficient quantity of food. The extensive empire's abundance of cultivable land and able-bodied workers, along with agricultural techniques like chinampas allowed large and frequent harvests, thus assuring plentiful amounts of food. (Ortiz de Montellano 1978) The Aztecs' position of authority enabled them to demand tribute in the form large amounts of food, especially such nutrient-dense ones as amaranth, chia, beans, and hauhitli, all of which lend themselves well to long-term storage. (Sahagun 1979) The expanse of the empire created diversity in the landscape available for cultivation and foraging and also meant that adverse weather conditions or poor harvests in one region did not spell disaster for the entire empire. The benefits of the natural diversity were bolstered by the Aztecs' creative capitalization of natural resources, including all available plants and all parts of these plants, such as, skin, flowers, stems, vines, branches, roots, leaves, seeds, and nuts. The Aztecs also proved resourceful in harvest, preparation and consumption practices.

The extreme variety of foods consumed by the Aztecs (grains, roots, leafy greens, squashes, vegetables, fruits, berries, legumes, nuts, seeds, and vines) allowed for the creation of a very balanced diet rich in nutrients including soluble and insoluble fiber, protein, monounsaturated and polyunsaturated fat, vitamins A, C, E, K, the B vitamins, magnesium, manganese, phosphorus, zinc, calcium, iron, sodium, beta carotene, and antioxidants. (USDA) Every part of the diet was a good source of some nutrient. In addition to agriculture, foraging of foods like algae, cactus plants, flowers, fruits, berriers, nuts, seeds and roots, and salt further insured a varied and nutritious diet. Specific staples included maize, beans, squash, amaranth, nopal (prickly pear), chia seeds, chilies, tomatoes and guava. (Sahagun 1979). Pumpkin flesh contains high amounts of vitamin A, beta carotene, fiber, iron, vitamin C, calcium, while the seeds (pepitas) are rich in protein, iron, zinc, manganese, magnesium, phosphorus, copper, potassium. Chilies are full of vitamin C, carotene, B vitamins (especially B_6), potassium, magnesium, iron. Avocados have significant amounts of pantothenic acid (B_5), B_6, folate (B_9), riboflavin (B_2), niacin (B_3) as well as being a good source of omega fatty acids. Chocolate, mostly consumed by nobility, is a good source of antioxidants, fiber, iron, some protein, and the seeds have omega fatty acid. (USDA) Sunflower seeds are low in saturated fat and high in polyunsaturated fat, the essential amino acids linoleic acid and tryptophan, dietary fiber, vitamin E, many B vitamins, especially thiamine (B_1) pantothenic, acid (B_5), B_6, folate (B_9), riboflavin (B_2), niacin (B_3), and minerals like copper, manganese, potassium, magnesium, iron, phosphorus, selenium, calcium, and zinc in addition to containing phytosterols, which can lower cholesterol. Peanuts contain large amounts of essential amino acids, magnesium, phosphorus, zinc, thiamine, riboflavin (B_2), niacin (B_3), folate (B_9), B_6, pantothenic acid (B_5) and iron. Guava is high in fiber, vitamins C and A, potassium, copper, phosphorus, folic acid, beta carotene, some B_3, B_2 and B_1, some and protein. Papaya is full of vitamin C and A, dietary fiber, certain minerals, and has enzymes conducive to digestion. Jícama is high in fiber, vitamin C, A, B, calcium and phosphorus. (USDA) Sweet potatoes are a good source of complex carbohydrates (which

maintain steady glucose levels), beta carotene, Vitamins C and B_6, and some protein, iron, and calcium. Chaya (tree spinach) has good amounts of protein, vitamins, calcium, and iron. Tomatoes contain lycopene, vitamin C, and a variety of antioxidants. A variety of beans like pintos, anasazi, and yellow beans, are all rich in niacin, thiamine, iron, raw protein, and amino acids like lysine and tryptophan (Santley and Rose 196) (Ortiz de Montellano 1978). Prickly pear is full of soluble dietary fiber, vitamins like A, C, B_6, and minerals like magnesium, potassium, manganese and iron and copper, and has also been proven to reduce glycemic effect of other foods because of its low carbohydrate content. (USDA) The Aztecs clearly enjoyed the benefits of a varied and nutrient-rich diet encompassing foods like roots, fruits, vegetables, leafy greens, seeds, legumes, herbs, vines and stems which were eaten cooked, raw and in a variety of other preparation techniques.

Further bolstering the benefits provided by the breadth and depth of the Aztec diet was the consumption of certain nutritionally-dense "superfoods." One such food cultivated by the Aztecs is amaranth, which played an important role in the tribute system and was the primary grain cultivated and consumed in Pre-Contact times. Although the leaves are also edible, the seed was primarily used, standing in as a type of "pseudo-grain." Amaranth was frequently consumed in ceremonies during which priests mixed seeds together with the blood of human sacrifices, fashioned them into images of deities, broke the statues and distributed the pieces to participants for consumption. More mundane uses for amaranth included in the formation of pastes for mole sauces. (Sahagun 1979) (Hindley 1979) Under the colonial Spanish administration, the plant's "heathen" associations led to its illegalization, quite a loss for Aztecs as well as Spaniards as the seed is a powerhouse of nutrients, including many less commonly found in plant foods, such as protein, fats, riboflavin, calcium, phosphorous, lysine, lipid fatty acids (especially linoleic acid) and iron, manganese, magnesium among others. Amaranth also contains moderate amounts of B_6, B_9 (aka folate), and zinc.(Stallknecht and Schulz-Schaeffer 1993) In addition to its nutritional value, the plant is extremely drought resistant and has a very high yields. Chia seeds (*Salvia hispanica*), another vital super-food serving as a tribute crop, was domesticated and cultivated for a the root's medicinal uses, while the seeds were used in beverages and foods (Cahill 2003) The seed of the chia plant is rich in protein, fiber, phosphorus, manganese, calcium, potassium, sodium and omega 3-fatty acids, especially ALA. Yet another significant super-food is the algae spirulina, which grows in aquatic environments high in saline, making it high in sodium. It is also very high in protein, chlorophyll, carotenoids, minerals, vitamins, tryptophan and has a very high leucine/ isoleucine ratio. (Santley and Rose 1975) Spirulina is also high in long-chain polyunsaturated fatty acids. Evidence also reveals it also promotes cardiac health, skin health, the prevention of cancer, and inflammation of joints, mucosa and gastrointestinal tract. (Ötleş and Pire 2001) (American Dietetic Association 2009) Cacao, although reserved only for the elite, is an antioxidant rich in nutrients like theobromine (a mood enhancer) and can have positive benefits on circulatory health and blood pressure. (USDA) The reconstruction of the Aztec diet with quantities of super-foods may run the

risk of assuming ideal conditions, but foresight and planning would have allowed for the inclusion of at least some of the foods under most conditions.

Along with consumption of superfoods, methods of harvesting, preparation, and consumption were key to the maintenance of proper nutrition among the Aztecs. An example of a preparation technique impacting the nutritional status of a food was that used for maize, a good source of calories lacking the essential amino acids lysine and tryptophan and niacin. The variety of maize grown by Aztecs had a very tough outer kernel, and the preferred preparation method was a process called nixtamalization in which the corn was soaked in a solution of lime to soften the kernel, forming a substance called nixtamal, used for grinding into masa dough to form tortillas and other foods. Nixtamalization improves the nutritional profile of maize in multiple ways. It increases the extractable amount of lysine and tryptophan, as well as the leucine/isoleucine ratio, (which aids in the metabolism of tryptophan) and makes niacin and essential amino acids more absorbable for humans, and increases calcium by balancing a phosphorus excess. Additionally, maize protein is stored in two classes, zein and glutelin, the second of which is high quality but can can only be absorbed by the body when exposed to an alkaline solution like the lime water used in nixtamalization. (Santley and Rose 1975) (Ortiz de Montellano 1978) (Rosado 2005) Another example of an important preparation technique was the harvesting of roots, like sweet potatoes, jícama, and tree roots from underground with soil on them, allowing the bacteria based vitamin B_{12} to be retained on the crops. The preparation technique of soaking legumes in water before cooking improves iron absorption by decreasing phytate level and also increases zinc levels. An important consumption method is eating iron rich foods like beans alongside vitamin C rich foods like papaya to make the iron more available. (American Dietetic Association 2009)

Evidence Nutritional Needs Were Met and Conclusions

A surprisingly clear sketch of the Aztec diet can be constructed based on geographical data, material remains, documentary records, and studies of diets of current inhabitants the region.The adequacy of the Aztec diet can be assessed through examination of human remains, which show no evidence of significant malnourishment (including deficiency in plant food “problem” nutrients), especially when taken in historical context. Further evidence of good physical health is seen in birth rates, mortality and morbidity rates, population sizes, and average lifespan. (Ortiz de Montellano 1978) The Aztecs’ successful participation in warfare and creation and maintenance of an empire suggests malnutrition was not a widespread issue. The Spanish found in the Aztecs an opponent fierce enough to merit forging an alliance with other indigenous groups, and to necesitate aid in the form of epidemic disease and vacillating leadership before conquest was possible. Pre-Contact warriors underwent intense and physically demanding conditioning and tests, and engaged regularly in conflict, most frequently employing man to man combat, which required physical fitness. Much of the Aztec economic and political system depended on physical exertion. Talented runners carried messengers throughout

the empire, and **pochtecas** traversed long distances to trade, often accompanied by carriers laden with substantial packs. The lack of wheels or pack animals meant transportation depended almost entirely on human labor. Even many daily activities like food preparation required significant physical exertion. Athletic activities like dancing (practiced recreationally, ceremonially, and as entertainment) and sports like **ullamalitzli (**a type of ballgame) would be unlikely to be developed and practiced by an undernourished populace. (Smith 2002)

Cannibalism within Aztec culture has been explained as a subconscious or more deliberate response to a nutritionally deficient diet. This flawed theory ignores the limited scale and frequency of human flesh consumption. Large scale human sacrifice was limited to special occasions, and not all of the remains were destined to serve as food, and those that were religious and military elites, rather than the common population. The impracticality of distributing meat throughout an empire so large in population and geography further limited its consumption to a more localized population. The minority entitled and able to consume the flesh ate it as more of a condiment or side dish rather than as the main course of a meal, as people suffering a protein deficiency might be more apt to do. It was not a regular component of the standard diet by any means. Patterns of cannibalism appeared to be uninfluenced by periods of drought, famine or other possible causes of food shortages, nor was meat stored as surplus for lean times. Waging war, combat, and transportation of captives demands a far greater amount of calories than are available in the flesh of these victims, making them uneconomical and unlikely responses to calorie deficiency, especially in light of more efficient methods like society-internal sacrifices or performing small-scale, swift raids on nearby states. Wars were often meticulously planned and formally proclaimed, and rarely if ever waged spontaneously, as they more likely would have been if motivated by urgent necessity for food. A serious protein deficiency would more likely have been addressed through intensified exploitation of available plant and animal sources, through means like increased hunting, and scavenging than through cannibalism. Cannibalism among Aztec society seems to have been more motivated by political, social, and religious factors than dietary ones. (Ortiz de Montellano 1978)

Evidence from a number of primary and secondary sources suggests that the people of the Aztec Empire largely consumed a plant-based diet that was sufficiently nutritious to allow the creation of an expansive empire, whose inhabitants often better-nourished than their European counterparts. The adequacy of the diet is demonstrated in present-day dietary practices of the region. Elements of the Aztec diet continue in modern Mexican cuisine and many staples of the Aztec diet are currently held up as nutrient-rich superfoods. Any deficiencies more likely originated from external factors like drought or famine than the inadequacy of the diet as a whole. Such unideal circumstances were precisely when exploitation of animal sources appears to have intensified through practices like hunting and scavenging. Favorable climate conditions, combined with skilled agricultural techniques and resourceful food preparation, ensured the people of the

Aztec Empire enjoyed a highly nutritious diet.