Nutritional Content of Organic Prickly Pads (Opuntia ficus indica) Could be Cure to Different Disease Conditions

Esther Pérez-Torrero, Margarita I. Hernández-Urbiola
Departamento de Posgrado e Investigación, Facultad de Ingeniería
Universidad Autónoma de Querétaro, Querétaro, México

Mario E. Rodríguez-García
Departamento de Nanotecnología, Centro de Física Aplicada y Tecnología Avanzada
Universidad Nacional Autónoma de México, Querétaro, México
1 Introduction

Prickly pads nutritional content is good option between food recommendations for human nutrition and health care maintaining. This requires the use of the best available scientific evidence nutraceutical properties to achieve the goals an expertise team who plays the leading role in providing nutrition in order to prevent degenerative disease such as diabetes (Luo et al., 2010; Musabayane, 2012). Diabetes is a serious degenerative diseases related to metabolic disorder; diabetes mellitus has been defined as a chronic disease of carbohydrate metabolism, but lipid and protein metabolism are also affected (Bailey, 2002; Bennett, 2004).

The consumption of Opuntia cactus is a popular herbal remedy among Mexican American patients in their management of type 2 diabetes mellitus. Animal and human studies have demonstrated the hypoglycemic properties of the Opuntia (prickly pear) cactus that are likely attributable to both its fiber content and specific hypoglycemic molecular agents. Reduction in serum glucose levels are best observed when the cactus cladodes are consumed in cooked form, alluding to heating as a necessary step in attaining its hypoglycemic properties (López, 2007). The Opuntia spp. cladodes and fruits serve as a source of varied number of phytoconstituents, mainly sugar, phenolics and pigments. Although the reported evidences provide the effectiveness of Opuntia spp., active constituents, bioavailability, pharmacokinetics and physiological pathways for various biological actions are not well known in sufficient detail or with confidence. Still more attention is required toward the development of simple, feasible and cost-effective pharmaceutical preparations of Opuntia spp. cladodes and fruit juice, as well as the ethnobotanical approach, if combined with mechanism of action, biochemical and physiological methods, would provide useful pharmacological leads (Chauhan et al., 2012). Other study propose antihyperglycemic effect by protecting the liver from peroxidation damage and by maintaining tissue function, thereby improving the sensitivity and response of target cells in diabetic mice to insulin (Zhao et al., 2011).

The traditional liquefied extract of the cladode of Opuntia streptacantha produces an antihyperglycemic effect when administered before a glucose challenge, and this anti-hyperglycemic effect is maintained after filtering the extract. Administration of both plants can improve glycemic control by blocking the hepatic glucose output, especially in the fasting state (Andrade-Cetto & Wiedenfeld, 2010).

The chronic hyperglycemia of diabetes is associated with long term damage, dysfunction and failure of various organs, especially the eyes, kidneys, nerves, heart and blood. At present, the treatment of diabetes mainly involves the use of plants with hypoglycemic properties. However, due to unwanted side effects the efficacies of these compounds are debatable and there is a demand for new compounds for the treatment of diabetes (Moller, 2001). Hence, plants have been suggested as a rich, as yet unexplored source of potentially useful antidiabetic drugs. These efforts may provide treatment for all and justify the role of novel traditional medicinal plants having anti-diabetic potentials (Kavishankar et al., 2011).

Previous studies reported that the main constituents of dietary fiber or unavailable carbohydrate are non-starch polysaccharides, having physiological actions on gastrointestinal tract and inhibit absorption of glucose and its uptake, also studied the role of viscous and fermentable fibers in the treatment of diabetes mellitus (Cameron-Smith et al., 1994, Eastwood & Morris, 1992 Galibois et al., 1994, Gallaher et al., 1995, Jackson et al., 1999, Johnson & Gee 1986, Moharib, 2000). An increased dietary intake of plant fiber is currently being recommended for lowering of plasma lipids in persons with hyperlipidemia and improving the control (Easwaran et al., 1994).

Dietary fiber has been defined previously as the plant polysaccharides and lignin, which are resistant to hydrolysis by digestive enzymes of man. Dietary fiber has been one of the most enduring die-
tary interests of this decade worldwide. It is a mixture of variety of polysaccharides, cellulose, hemicelluloses, pectin, gums, mucilage, algal polysaccharides and lignin has been found to have hypoglycemic effect (Lafrance et al., 1998, Prasad et al., 1995).

As for the general population, people with diabetes are encouraged to choose a variety of fiber-containing foods such as legumes, fiber-rich cereals (≥5 g fiber/serving), fruits, vegetables, and whole grain products because they provide vitamins, minerals, and other substances important for good health. Moreover, there are data suggesting that consuming a high-fiber diet (50 g fiber/day) reduces glycemia in subjects with type 1 diabetes and glycemia, hyperinsulinemia, and lipemia in subjects with type 2 diabetes (Franz et al., 2002). Palatability, limited food choices, and gastrointestinal side effects are potential barriers to achieving such high-fiber intakes. However, increased fiber intake appears to be desirable for people with diabetes, and a first priority might be to encourage them to achieve the fiber intake goals set for the general population of 14 g/1,000 kcal (Institute of Medicine, 2002).

2 Prickly Pads Characteristics

Organic natural plants are good alternative food sources because they often contribute to human health and its maintenance. It has been demonstrated in several studies that transgenic and cultivated crops have the potential to directly endanger or damage health because of pesticides and insecticide treatments used to enhance and protect these crops many of these foods are generally associated with health issues or for example, the development of allergies from the toxic effects from fertilizers used to enhance such crops nutritional value and also the microbiological safeness of these foods (OMS, 2005).

In Mexico, cactus Opuntia ficus indica have been used since prehispanic times, as an important component of diets and for the agricultural economy. They have also been accompanied with other products such as maize, amaranth and agave to name but a few (Betancourt-Domínguez et al., 2006). Prickly pads are grown throughout Mexico and in all North and South American. This cactus grows in many other regions of the world such as: Africa, Australia and in the Mediterranean (Piga, 2004). Cactus pads are commonly called “nopales” or “nopalitos” when they are fresh young prickly pads from 3-4 weeks of age. Traditionally “nopales” have been consumed in Mexico and Unites States, using several different preparations or cooking methods. Furthermore, the older stage pads are frequently used as forage, especially when there is shortage of fresh forage due to droughts. This plant is cheap, plentiful and sometimes it has also been used for erosion control (Le Houérou, 1996).

3 Health Benefits of Prickly Pads

Dietary fiber is composed of several chemical components that are resistant to digestive enzymes such as cellulose, hemicelluloses, pectin, lignin, gums, etc. (Periago et al., 1993). The fiber content of a food varies according to the species of the plant and its maturity stage. It is noteworthy that plant seeds, berries, fruit skins and the bran layers of cereal grains generally contain large amounts of fiber (Saénz, 1997). The benefits associated with fiber content are well known, especially for the prevention of illnesses such as: diabetes, treatment of gastrointestinal disorders, illnesses associated with low dietary fiber intake, reduction of glucose values in the blood, anti-hyperlipidemic and anti-hypercholesterolemic effects (Palumbo et al., 2003, Feugang et al., 2006, Gebremariam, 2006, Saénz, 1997). Age related differences within the
species can be attributed to the type of *Opuntia*, the climatic conditions where the plants grow as a result of factors such as pluvial precipitation or availability of irrigation.

Regarding the benefit of fiber content in the prickly pads powders, is interesting to remark the relationship between the intake of carbohydrates and the current epidemic of obesity and diabetes as a subject of present interest. Ever since glucose is an essential source of energy, with limited body stores, maintenance of blood levels and changes in its metabolism are strongly determined by the intake of carbohydrates in the diet. Depending on the individual genetic susceptibility and the impact of other risk factors, these metabolic changes can deteriorate and induce abnormalities which increase the risk to develop diseases (Manuel-y-Keenoy & Perez-Gallardo, 2012).

The existing obesity epidemic is becoming a major public health burden for both countries developed and developing. More than ten years ago the World Health Organization estimated that 90% of diabetes mellitus type 2 and 30-40% of cardiovascular disease cases are directly caused by obesity (WHO, 1998). Because has been reported that even small changes in body weight (5 kg) have an impact on health. In particular, a fat excess of abdomen in contrast than peripheral fat, for example, with increases of 5 cm in waist circumference, is associated with increased risk to lead disease. These changes are the inevitable result of an imbalance between energy intake and the expenditure. This imbalance reflects life habits, which include a diet with a caloric content that is excessive for the often low levels of physical activity (Hill & Prentice, 1995; Saris, 2003).

Previous studies demonstrated that young prickly pads are rich in calcium and this increases according to the age of the pads. Most current literature addresses the usefulness of young pads, but does not include data concerning prickly pads in advanced maturity stages (Rodríguez-García *et al.*, 2007, Sáenz, 2000, Stintzing & Schieber, 2001).

*Opuntia* prickly pads are an important source of several nutritional elements like pectin, mucilage and minerals. Currently there is only information related to young stage pads and precious little relating to the nutritional value of older maturity stage pads. The fresh young pads also know as cladodes are an excellent source of proteins including essential amino acids, and vitamins. Several studies have reported that high levels of amino acids especially proline, taurine and serine can also be found in prickly pads (Moreno-Alvarez *et al.*, 2008, Piga, 2004, Stintzing & Carle, 2005 Stintzing & Schieber, 2001). In contrast, not much information is available about the older prickly pads regarding amino acids profile. Also noteworthy, is that there is a gap in studies that have already been published regarding the nutritional and mineral content of the advanced stage pads.

The tannins are amorphous solids, quite soluble in water and alcohol, are virtually insoluble in ether where produce precipitates with alkaloids, jellies and salts of many heavy metals of the group of the alkaline earth metals such as Be, Mg, Ca, Sr, Ba and Ra. It is known that these substances have antinutritional activity, although its mode of action is not well known. Findings suggest that have a role of enzyme inhibition, since they form complexes with protein and human hinder the assimilation of this macronutrient (Jean, 1998). The tannins have little relevance in the human diet and are mainly found in coffee, tea and some fruit (Cervera, 2001).

There is a general consensus among dieticians that diet plays a vital role in the support system of the body. Proper diet provides the strength and nutrition that individuals need to prevent disease; reading up on organic food information will help to build up immunity. Organic production of food includes cultural, biological, and mechanical practices that foster cycling of resources, promoting ecological balance and conserving biodiversity. Comparison studies of health in populations that habitually consume organically- or conventionally-produced foods clearly indicate the potential health benefits of organic foods. In
order to be better supported in the future, more research of better quality is necessary than that which is currently available (Williams, 2002).

4 Materials and Methods

4.1 Sample Preparation

The *Opuntia ficus indica*, var. redonda, were from the experimental field of Universidad Nacional Autonoma de Mexico, located on “Los Lores” farm, in Silao, Guanajuato Mexico were harvested during the summer of 2009 from July to August. The environmental conditions were: an average temperature of 18.4º C and the pluvial precipitation was about 600 mm per year. Each sample was made up of 4 kg of nopal pads which were collected from several plants in the same sampling areas, but were at different maturity stages. In order to know the age of cladodes, new nopal pads were marked and dated as they were sprouting. This was the first day of ten different dates the pads were harvested. The others include day 40, 50, 60, 70, 80, 90, 100, 115, 125, and 135, respectively. The samples were transported to the laboratory and the pads were classified and separated into ten groups according to their age, this being 40, 50, 60, 70, 80, 90, 100, 115, 125, and 135 days, respectively, as has already been mentioned. All samples were analyzed in triplicate.

4.2 Washed and Dry Vacuum Process

The thorns of nopal pads were removed manually then washed with distilled water and disinfected using commercial 10% sodium hypochlorite solution in order to eliminate microorganisms. These samples were sectioned into small slices (3 mm) in order to facilitate the drying process. The prickly pads were then dried using a vacuum system for 12 hours at 10⁻² Torr, and 45 ºC. Vacuum is often employed as a process for removing bulk and absorbed water (or other solvents) from a product. Combined with heat, vacuum can be an effective method for drying. High degrees of dryness can be attained at relatively low temperatures. This allows for fast and effective drying of temperature sensitive products. Lower moisture content can be achieved when using vacuum and heat than can be achieved with heat only. Additionally, drying under a vacuum can prevent oxidation of sensitive product that cannot be dried in the presence of air. Vacuum drying systems can also recover the solvent that is removed from the product, if required. Often the part to be dried is placed into a vacuum drying chamber. However, if the part can withstand, and is designed for vacuum, the inside of the part can be evacuated and dried without the use of a vacuum chamber. Finally, the pads were pulverized in order to obtain a powder using a hammer mill (Pulvex 200, Mexico) equipped with a 0.5 mm screen. These dry vacuum powdered samples were used to determine mineral content by utilizing atomic absorption.

4.3 Chemical Approximate Analysis

The moisture content of the resulting nopal flour was determined by desiccation at 40 ºC for 24 h, according to the 934.01 method as described in the Association of Official Analytical Chemists techniques (AOAC, 2000). The chemical analyses of the prickly pads were carried for ten groups at different maturity stages. This included protein, carbohydrates, fat, non organic components (ash) and humidity. Analyses were done in triplicate according to the AOAC techniques (AOAC, 2000). The evaluation of the flours was performed using specific methods for different components. Explanations of these tests follow.
Mineral ash content was evaluated with the 942.05 method (AOAC, 2000), using 2 g samples, determined at 550 ºC for 24 h in order to remove organic material. The samples were placed in shallow, relatively broad ashing dishes that had been ignited. The samples were then cooled in desiccator, and weighed once they reached room temperature.

Nitrogen (N) concentration was ascertained by applying the Kjeldahl method 2001.11 (AOAC, 2000), using a 0.5 g sample.

The carbohydrate free nitrogen extract, was determined by calculating the differences in 100 g of all the components using AOAC official method 986.25 1986 (AOAC, 2000). Crude fiber was determined according to the 991.42 and 993.19 AOAC methods. Fat was analyzed by petroleum ether extraction using a Soxhlet apparatus according to the 920.39 AOAC methods (AOAC, 2000).

4.4 Determination of Tannins Content

The content of tannins in the nopal powders was measure by colorimetric method using vanillin as reactive chromospheres and catechin as tannin pattern (Jean, 1998). A 0.500 g of sample in assay tubes was extracted with 5 ml of hydrochloric acid in methanol for 20 min at room temperature with constant agitation. After centrifugation for 10 min, 5 ml of vanillin-HCl (2% vanillin and 1% HCl) reagent was added to 1 ml aliquots and the colour developed after 20 min at room temperature was read at 500 nm, using white as a solution prepared by mixing 1 ml of the sample and 5 ml of hydrochloric acid: methanol. Correction for interference light natural pigments in the sample was achieved by subjecting the extract to the conditions of the reaction, but without vanillin reagent. A standard curve was prepared using catechin after correcting for blank and tannin concentration was expressed in g/100 g. The content of tannins obtained through a calibration curve using catechin as standard. The analysis was performed in triplicate.

4.5 Atomic Absorption Spectroscopy (AAS)

The Ca, Mg, K, and Na contents were determined using the dry-ashing procedure 968.08 (AOAC, 2000). The Ca, Mg, K, Na ions concentrations were measured with a double beam atomic absorption spectrometer, a Analyst 300 Perkin Elmer, USA. The organic components were previously eliminated at 550 ºC for 24 h.

4.6 Mass Spectrometry ICP-MS

The mineral elements lithium (Li), vanadium (V), phosphorus (P), manganese (Mn) iron (Fe), cobalt (Co), arsenic (As), zinc (Zn), selenium (Se), cadmium (Cd), and thallium (Tl) of prickly pads powder were quantified by means of mass spectrometry ICP-MS following the Environmental Protection Agency Guidelines (EPA, 1995). The tests were carried out following the method of AOAC (984.27) (AOAC, 2000) using a Thermo Jarrel Ash, Model IRIS/ ICP ICP Spectrophotometer. The IRIS Optical Emission Spectrometer is inductively coupled argon plasma, optical emission spectrometers which uses Echelle optics and a unique charge injection device, solid state detector in order to provide complete and continuous wavelength coverage over the typical analytical wavelength range. The IRIS is equipped with Radial Plasma for the widest range of applications. The unit includes ICP, chiller, power supply, and autosampler, computer with software loaded with no software media, service and operation manual.
4.7 Statistical Analysis

Data, based on three replicates were subjected to analysis of variance. Standard deviation of each individual nutrient regarding maturity stage mean was computed and variations between maturation stages were evaluated by using Tukey test at a 5% level of probability (P = 0.05). All statistical data was calculated using stat graphics.

5 Results and Discussion

5.1 Chemical Proximal Analysis

Prickly pads powders present a large decrement in humidity in relation to the fresh prickly pads which is inherent to the vacuum drying process (Table 1); this procedure prevents the proliferation of microorganisms to render the pads edible (Geankoplis, 2006).

<table>
<thead>
<tr>
<th>Prickly pads age (days)</th>
<th>Prickly pads weight (g)</th>
<th>Moisture (g)</th>
<th>Ash (g)</th>
<th>Fat (g)</th>
<th>Crude Fiber (g)</th>
<th>Protein (g)</th>
<th>Carbohydrates (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>100</td>
<td>5.03cd</td>
<td>17.65a</td>
<td>2.16e</td>
<td>11.00a</td>
<td>7.07b</td>
<td>42.94a</td>
</tr>
<tr>
<td>50</td>
<td>150</td>
<td>8.81e</td>
<td>19.59b</td>
<td>2.37f</td>
<td>13.26b</td>
<td>8.99e</td>
<td>53.04b</td>
</tr>
<tr>
<td>60</td>
<td>200</td>
<td>5.43d</td>
<td>20.64c</td>
<td>2.38f</td>
<td>16.14c</td>
<td>8.39d</td>
<td>53.01b</td>
</tr>
<tr>
<td>70</td>
<td>250</td>
<td>4.85bcd</td>
<td>21.09d</td>
<td>1.62bc</td>
<td>19.03d</td>
<td>8.92e</td>
<td>55.53d</td>
</tr>
<tr>
<td>80</td>
<td>300</td>
<td>4.36ab</td>
<td>21.64e</td>
<td>1.53ab</td>
<td>18.73d</td>
<td>7.25b</td>
<td>53.53bc</td>
</tr>
<tr>
<td>90</td>
<td>350</td>
<td>4.81bc</td>
<td>21.92f</td>
<td>1.50ab</td>
<td>19.12d</td>
<td>7.78c</td>
<td>55.15cd</td>
</tr>
<tr>
<td>100</td>
<td>400</td>
<td>4.08a</td>
<td>22.80g</td>
<td>1.42a</td>
<td>20.11de</td>
<td>8.29d</td>
<td>56.73d</td>
</tr>
<tr>
<td>115</td>
<td>450</td>
<td>4.58abc</td>
<td>22.91h</td>
<td>1.72e</td>
<td>21.48e</td>
<td>8.48d</td>
<td>59.20e</td>
</tr>
</tbody>
</table>

Table 1: Chemical composition of dehydrated prickly pads on 100 g of sample (Opuntia ficus indica). Results for each component versus age followed with the same letter in the column were not different significantly (P < 0.05).

The fat content of the powders decreased as a function of age and not direct relationship related to age-days was observed (R²= 0.3319) (Table 1). The decreases noticed were perhaps due to physiological changes or climatic conditions such as precipitation or irrigation where the plants were grown (AOAC, 2000). For protein, no related changes were observed (Table 1), which was low for all studied ages and similar to those of other vegetables (Lee et al., 2005). Findings suggest that physical conditions such as water availability, temperature, and light/dark periods are primarily implicated in protein synthesis. Several studies demonstrated that protein synthesis increasing as a cellular protection when the soil is too acid or saline (Aguilar & Peña, 2006, Drennan & Nobel 2000, Nobel & Israel, 1994).

Carbohydrate content of old prickly pads showed significant increases from 42.94 mg/g at day 40 to 60.77 mg/g at day 135. Furthermore, they also showed a direct relationship (R²=0.5446) pertaining to age. As with all vegetables, carbohydrates are the main component in prickly pads (Stintzing & Carle, 2005).

The ash content of minerals Ca and Fe were increased from 40 to 135 days old samples, whereas P, Mn and Zn not showed age related changes. The lineal regression analysis showed a positive relation-
ship ($R^2=0.7158$) in regard to prickly pads age. The Ca and Fe content increased from 40 to 135 days samples (Figure 1 A and B, Table 2).

**Figure 1:** Major mineral content (A) and minor mineral content (B), of prickly pads at different maturational stage (Weight). Values are mean from triplicates samples.
Table 2: Mineral composition of prickly pads powder at different maturational stage age-days. Results for each mineral versus age followed with the same letter in the horizontal line were not different statistically significant (P < 0.05). Note that the values marked with de same letter in horizontal way do not showed differences according to age.

The vanadium, cobalt and selenium showed minimal changes in relation to age with maximal content at 80, 90, and 100 age-days. For the lithium, arsenic, cadmium and thallium content, the data revealed minimal content without important changes associated with ages. These findings suggest that the prickly pads powders might be a complement to daily diet due to their essential micro minerals content (Tables 2 and 3). Further suggesting that some elements of ash chemical composition depend on different factors, such as pH, water availability, soil texture and composition where the nopal grow. These results are in line with previous studies which reported that prickly pads contain the main minerals in carbonates, chlorides, sulfates and phosphates (Frati et al., 1991, Granados & Castañeda, 1997).

Table 3: Minor mineral composition, of prickly pads powder at different maturational stage, age-days. Results for each mineral versus age followed with the same letter in the arrow were not different statistically significant (P < 0.05).

5.2 Tannin content

The content of tannins in the prickly pads, modified depending on their stage of maturation, as shown in Figure 2, with statistically significant (p < 0.05) differences between the samples. The behavior of the antinutritional factor in the prickly pads remained undefined, i.e. not maintained a relationship with the maturation state of the prickly pads, as noted in the case of minerals.
In general terms was detected a higher content of tannins in the prickly pads at 500-550 g of weight. In this regard, has established that a high concentration of this antinutritional component in food can give them an astringent taste, clot alkaloids and albumins, in addition to being a chelating agent and sequestrate heavy metals (Otero & Hidalgo, 2004). With regard to content of tannins is observed increase as it increases the age, what suggest that samples of the old prickly pad, being at this age when can play their antinutrient action. In contrast, old prickly pads have the advantage for implement antioxidant action.

![Graph showing tannins content of prickly pads (mg/100 g dry sample), at different developmental stages.](image)

**Figure 2**: Tannins content of prickly pads (mg/100 g dry sample), at different developmental stages.

### 5 Perspectives and Conclusions

The crude fiber showed a positive relationship related to the age, however, the soluble dietary fiber tended to have negative relationship, suggesting than older nopal is better source of insoluble. Several researchers have observed decrements in the LDL-cholesterol and triglycerides when individual dietary intakes were supplemented with prickly pads at 40-50 age-days (Jieun *et al.*, 2011; Junyong *et al.*, 2012; Reid *et al.*, 1995; Sáenz, 1997). The data showed different fiber and mineral content along life cycle of prickly pads, each maturity stages can also be used for distinct purposes (Hernández-Pérez *et al.*, 2005, Lee *et al.*, 2005, Reid *et al.*, 1995). In addition, antioxidant properties are due to the phenols and flavonoids composition in *Opuntia spp* (Feugang *et al.*, 2006, Gallegos-Infante *et al.*, 2009, Guevara-Figueroa, 2010, Medina-Torres *et al.*, 2011, Palumbo *et al.*, 2003).

Because nutritional deficiencies associated to degenerative disease are currently widespread in many poor areas of the world, attention should be focused on inexpensive solutions. Nopal powders can be an economic alternative when used as dietary supplement in all seasons, without the need fresh nopal. The dried products represent certain advantages for transport and preservation for prolonged periods in optimal conditions to ensure maximum nutritional quality and availability (Rodríguez-Félix & Cantwell,
Functional and organic foods that have secondary benefit for health are preferred for human consumption instead of other classic cultivated foods regarding their chemical treatment; often organic foods are preferred for human consumption instead of other classic cultivated foods regarding their chemical treatment (OMS, 2005, Williams, 2002). Prickly pads are good options between food recommendations for people with diabetes and health care providers aware of beneficial nutrition interventions. For achieving nutrition-related goals requires a coordinated team effort that includes the persons with diabetes and involves them in the decision-making process. While the long-term goal of diabetes research must remain the cure and the prevention of the disease and reasonable near-term goals might include amelioration of the symptoms or prevention of complications. Prickly pads can ameliorate the diabetes damage mainly for their soluble fiber content at younger maturity stages. In is well known that surplus calories in the daily diet induce pathological alterations leading to insulin resistance. For this reason the food intake in terms of habit, the individual must be emphasized ingest nutrients discrete so the follow adequate dietary patterns (Mozaffarian & Ludwig, 2010). These directions can then be followed by public health experts, legislators and the food industry in order to ensure correct labeling and information to the consumer. Only extensive multinational studies will be capable of unraveling their relevance and the underlying molecular interactions, not only between the genes themselves but with environmental factors such as diet and healthy lifestyle (Korner et al, 2008). Directions for ameliorate or prevent diseases can be followed by health experts, legislators, and the food managers in order to ensure correct food combination. Only extensive multidisciplinary studies will be capable of give the lines for the adequate pattern of feeding, and together with a good life style based on the diet and exercise.

Acknowledgements

This project was partially supported by the National Council of Science and Technology of Mexico (CONACyT), Grant 91211. The authors want to thank MS Araceli Aguilera Barreiro, and Carolina Muñoz Torres for their technical support.

References


