Human Health Discoveries with *Opuntia* sp. (Prickly Pear)

Donald A. Hegwood
College of Agriculture and Home Economics, Texas A&I University, Kingsville, TX 78363

The leaves (nopales) and tunas (fruit) of *Opuntia* sp. comprise an important nutritious and dietary food source for Hispanics and other groups of Spanish origin (Griffiths and Hare, 1907; Russell and Felker, 1987; Savio, 1989). Their use is increasing, particularly in U.S. cities where Hispanics are concentrated. The nopale is also used in Mexico to treat diabetes mellitus (Ibanez-Camacho et al., 1983). and more recent discoveries suggest additional medicinal benefits. The leaves are consumed as fresh vegetable, canned, added to casseroles and other cooked dishes, and used in salads. Tunas also are eaten fresh, or may be dried or processed into candy-like products and into fermented drinks.

Most of the 1500 species of Cactaceae are in the genus *Opuntia* and are distributed in Europe, the Mediterranean. Africa. Spain. South America. the Southwestern United States, Northern Mexico, and other areas (Russell and Felker. 1987). They thrive in arid and semi-arid regions where the production of more-succulent food plants is severely limited and are used as fodder for cattle during periods of drought *Opuntia* is a genetically diverse genus and has the potential for significant genetic manipulation and engineering. Neither tunas nor nopales have been adequately assessed for their nutrition and human health potential.

Medicinal uses

The use of the nopale to treat diabetes has resulted in increased testing of nopale for medicinal and human health benefits. Various preparations ranging from fresh plant material to broiled leaves were tested on rabbits and human subjects (Frati-Munari et al., 1983; Ibanez-Camacho et al., 1983; Ibanez-Comacho and Roman-Ramos. 1979; Meckes-Lozoya and Roman-Romas, 1986; Fernandez-Harp et al., 1984). Preparations included fresh leaf products (nopal = nopale). broiled leaves. liquified nopal (obtained by removing the epidermis), the juice from liquified nopal. fresh ex - tract from nopal sap, and dialyzed and lyophilized leaf tissue. Orally administered preparations of nopale. including fresh nopale sap, produced hypoglycemic properties in rabbits with experimenrally introduced diabetes or healthy ones with physiologic hyperglycemia (Ibanez-Camacho and Roman-Ramos, 1979). Similar re - sults validating the use of *Opuntia* for the treatment of diabetes were obtained using different animal experimental models in later work by Ibanez-Camacho et al. (1983).

Investigations into the effect of *Opuntia* leaves on the level of cholesterol, triglycerides, and glucose in the blood of human subjects have shown that oral administration of broiled nopales before meals to healthy, obese, and diabetic subjects significantly reduced serum total cholesterol in all groups and beta cholesterol and triglycerides in obese and diabetic patients. Blood glucose levels also were decreased (Frati-Munari et al., 1983; Ibanez-Camacho and Roman-Ramos. 1979). They concluded that intake of the nopales before meals may be useful in management of some hyper - lipidemia, diabetes mellitus. and obesity. Fernandez-Harp et al. (1984) showed that blood glucose and insulin test values were lower in patients treated with nopales. Similarly, a diabetic volunteer given daily administration of *Opuntia streptacantha* nopale sap showed a remarkably improved general symptomatology of the patient. as well as in insulin and glucose blood levels and a reduction of both cholesterol and triglycerides (Meckes-Lozoya and Roman-Ramos, 1986).

The widespread and increasing interest in blood cholesterol and diabetes in relation to diet has focused traditionally on plants and plant products to improve the symptomatology of the diseases asso - ciated with these factors. Prickly pear has largely been ignored in the United States as a potential health-improving plant within this medicinal context. Only recently has it begun to attract increased attention among U.S. scientists, possibly because of the popularity of nopale and tunas among the rapidly increasing Hispanic population and research at a limited number of universities on prickly pear both as a food and fodder crop. Up to this time. virtually all the human health or medicinal research on prickly pear has been conducted in Mexico. Collaboration between U.S. and Mexican scientists promises to lead to increased linkages between the central and southwestern United States and Mexico and to increase the flow of information between these two North American regions.

Opuntia tissue composition

Our understanding of the human health potential of *Opuntia* depends to a large degree on our knowledge of its tissue composition. Most medicinal research reports on nopale tissue rather than tunas, with the *O. streptacantha* being the preferred choice. By contrast. researchers studying tissue composition have used *O. ficus-indica. O. amyclaea,* and *O. inermis,* and have found significant differences between them (Rodriguez-Felix and Cantwell, 1988).

Nopale composition. Amino and organic acids, protein, carotene, crude fiber. ascorbic acid, lipids, and carbohydrates have been determined in the nopale of these varieties. They are relatively low in protein (biological value of 72.6 relative to egg protein), show a significant accumulation of malic and citric acids during the evening, confirming the crassulacean type acid metabolism, and accumulate essential amino acids ranging in concenuation as percent protein from 1.7 for methionine to 6.4 for leucine and only a trace for cystine (Teles et al.. 1984). Rodriguez-Felix and Cantwell (1988) studied the developmental changes in composition and quality of nopale (lengths of 1 to 6 cm) and reported the average composition of 100 g of nopale tissue of the three varieties contained 91.7 g of protein, 0.l g of protein 0.1 g of lipid, 1.3 g of ash 1.1 g of crude fiber, 4.6 g of complex carbohydrates. 0.82 g of simple sugar, 12.7 mg of ascorbic acid and 28.9 µg of carotenes. They also reported that nopale juice has an average pH of 4.6. 0.45% titratable acidity, and 6.9% soluble solids, and moderate amounts of vitamin C and vitamin A precursor compared to other vegetables.

As nopale growth occurred titratable acidity and total carbohydrates increased and protein and crude fiber decreased (Rodriguez-Felix and Cantwell, 1988). This implied relationship raises the question of whether the age factor might be important in harvesting for maximum nutrition potential. Additionally, significant varietal differences in protein. lipid, ash, crude fiber, carbohydrates. ascorbic acid, and carotenes were obtained between *O. amyclaea, O. ficus-indica,* and *O. inermis.* implying a possible relationship between variety and human health potential.

Gregory (1988) working with a large number of *Opuntia* varieties. reported that nopale and *O. inermis* contain significantly higher levels of crude protein than other varieties he tested and as with the findings of Teles et al. (1984). crude protein was higher in younger leaves than older. but showed no interaction between age and variety. However an interaction effect was present in phosphorus level for two intermediate age classes. *Opuntia inermis* showed significantly higher levels of phosphorus at the older age class than any of the other varieties included. At younger ages tissue distinc -

tions between varieties were not as strong, suggesting that some varieties accumulate leaf phosphorus faster than others.

Tuna composition. Traditional usage of *Opuntia* fruit (tuna) uses **a** number of different fruit products. including pasadas (a dry fruit); melcocha **a** molasses-type candy product queso de tuna (tuna cheese), which is a product similar in consistency to melcocha; colonche, a fermented drink made from the fruit of the tuna; and miel de tuna. **a** honey-like product prepared by boiling the juice down. Griffiths and Hare (1907) analyzed protein. sugars, and solids in various tuna products. They showed that total protein ranged from ≈2.4% in melcocha to ≈3.1% in miel. They also showed that acidity was higher in the dried product (pasadas) than in the cooked products made from the juice, such as melcocha, queso and miel. Total solids ranged from ≈70% in miel to >90% in pasadas. while total sugars were lowest in pasadas. at ≈50%, and highest in melcocha and miel at 62% and 61%. respectively. Tunas are widely marketed as fresh fruit in specialty food sections of supermarkets in regions where the Hispanic population is high. It is not uncommon to see them promptly displayed and selling for as much as $1.50 or more per pound. The work on tuna reported by Griffiths and Hare was published in 1907 while the more recent work with *Opuntia* sp., particularly with regard to tissue composition and human health potential. has focused on the nopale. Although their work compares albuminoids, amids, sucrose, and other components in numerous varieties, the human health potential of the fruit appears to have been largely ignored to the present. Consideration needs to be given to the development of tuna products as a food and to determine their human health potential.

Conclusion

The potential of *Opuntia* sp. for human health has a significant implication for it as a horticultural crop. Although demand for *Opuntia* as a vegetable for its fruit and fruit products is increasing as the Hispanic population increases, its current economic value as a crop is much less than it might be if produced for the manufacture of products used in treating hypoglycemia, diabetes, high blood cholesterol and obesity. Such development would transcend ethnic and cultural popularity and create worldwide markets for these products. whether in the fresh vegetable form or altered through processing or manufacturing. The development of such uses would no doubt be associated with product innovations that will make it acceptable to the general public on a global basis.

It is noteworthy that *Opuntia* thrives in semi-arid regions of the northern hemisphere. Possessing crassulacean acid metabolism, this genus of Cactaceae is reported to be. four to five times more efficient in converting water to dry matter than most efficient grasses. Work by Felker and others at Texas A&I Univ.. Kingsville, has demonstrated wide genetic diversity **and** agronomic adaptability of this genus. Their work, along with increasingly frequent research on human health and plant tissue composition. strongly suggests the need for plant breeding and genetic approaches to augment ongoing efforts.

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