This series of essays explores lessons and observations from fieldwork that might be of interest to the integrative medical community. In this context, the authors discuss "new" or less celebrated botanical medicines and unique healing practices that may contribute to the further development of contemporary integrative medical practices. Perhaps this column can facilitate an appreciation for our own roots and those of other cultures, before such ancient wisdom disappears forever.

MACA: FROM TRADITIONAL FOOD CROP TO ENERGY AND LIBIDO STIMULANT

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The 2 students looked at each other and the environment around them in something approaching disbelief. Only a few weeks before, they had been in the verdant Amazonian rain forest, surrounded by trees more than 100 feet tall, bathed in warmth and copious rainfall. Now they had arrived in an area described as one of the most inhospitable places on the planet, in search of the roots and tubers cultivated there by local farmers. They had traveled for days by train, bus, and, finally, in the back of an ancient truck whose driver dropped them off on a dusty road and pointed toward the peak of a mountain with the admonition, "Walk along that trail, and you will find the village of Ninacaca; it is there you will find the plants you are interested in."

The year was 1982, and Harvard PhD student Calvin Sperling and his assistant, Steven King, slowly followed the trail, measuring their steps carefully: the elevation was nearly 13000 feet above sea level. Their cheeks were packed with *coca* leaves and lime, as is the local custom, to ward off *soroche,* or altitude sickness. This part of the world is cold and very windy, and the mountainous environment is barren, covered with rocks and low-growing plants, most less than a foot tall. In Peru, this habitat is known as the *puna,* characterized by freezing temperatures and winds strong enough to knock people off their horses.

Sperling and King had come to Ninacaca not in search of gold, as had the Spanish Conquistadors a half-century before, but to learn about some of the little-known root crops grown by the people of this region. Characterized by a report of the National Research Council as "among the world's worst farmland"[1] because of its climate and terrain, Ninacaca was home to one crop plant that had been cultivated with great success since precontact times. Maca, as it is called by the Quechua-speaking people of the area, is a low-growing perennial plant, forming a mat of leaves that are close to the ground—an adaptation to the climate in which it thrives. Maca is in the mustard family (*Cruciferae*) and is known botanically as *Lepidium meyenii,* first described by the botanist Wilhelm Gerhard Walpers (1816-1853). In its cultivated habitat, 12 to 20 leaves arise from a maroon-brown root that looks somewhat like a radish. The roots can be up to 8 cm in diameter, and when cut open are white. After harvest, roots are dried in the freezing climate, turning grey-black and shrinking in size to take on the shape of a small fig. This crop is only cultivated in the central Peruvian highlands, but its wild forms are found in Peru, Bolivia, and Argentina.[2]

Sperling and King finally reached Ninacaca and began their search for a farmer to teach them about local agriculture and root crops. King recalls that day in a conversation in December 2001:

> We met a man by the name of Lucio Sulfo Cordova Tello in Ninacaca. He lived right next to Lake Junin, a beautiful lake at an elevation of nearly 13000 feet. Legend has it that Lake Junin is one of the epicenters of maca cultivation, which has been going on there for thousands of years. We asked him if we could speak about maca, and, luckily for us, he was delighted to share the details of his cultivation and use of the plant. He was extremely forthcoming. Mr Cordova took us to his maca field and told us that his father had grown this crop, and taught him to do so. "Please come to my home," he said, where he made us a porridge of maca by grinding up the dried roots and mixing them with a little bit of warm water, sugar, and milk—it tasted like butterscotch, was quite delicious, and since it was so cold out, it felt wonderful to share this warm dish with him.... In our interviews with him, Mr Cordova said that people ate this plant on a daily basis in Ninacaca, and laughed when he told us that it was well known that eating maca would help you have more children. After all, he was an elderly gentleman and when asked how many children he had, he replied with a big smile, "Twelve." It seemed like a pretty good testimonial for the virtues of maca!

King, who went on to pursue a doctoral degree in botany, dedicated his studies to maca and other Andean tubers. He was inspired that day by the conversation with Mr Cordova. He continues:

The Spanish who came to the Americas, came first to this part of the continent. As they moved up to colonize the Andes, some 400 years ago, their livestock was not thriving at all, so the local people suggested they feed maca to their animals. The results were so dramatic that the historians of the time wrote of the importance of this plant in their journals. In the 1800s, it was recorded that Indians of the Junin area were required to provide tribute to their Spanish rulers, and Colonial records list an annual payment consisting of 9 tons of maca being given. From our observations in the Junin region, many people knew that the plant was good for increasing potency, and that was in 1982, long before the current wave of interest in this plant.

Distinguished by its ability to thrive in less hospitable high-altitude terrains, maca has important nutritional properties.[3] In 1979, at the Institute of Nutrition in Lima, Peru, maca was studied for its nutritional value. It was found to have high concentrations of protein (11% in the dry root, 14% in whole maca paste).[4] The proteins are mainly in the form of polypeptides: aspartic acid, glutamic acid, serine, glycine, arginine, valine, phenylalanine, tyrosine, and threonine.[5] Maca has been shown to have higher levels of iron, calcium, and amino acids than the white potato.[5]

In addition, maca contains important amounts of the fatty acids linoleic, palmitic, and oleic acid, and is rich in sterols. In 1991, the Food and Agricultural Organization of the United Nations recommended that maca, along with other native Andean foods, be consumed by Peruvians to stave off nutritional deficits, because the diet of approximately 35% of people in rural highland Peru is below accepted standards for healthy populations.[6,7] The remaining nutritional components of the root are 59% carbohydrate and 8.5% fiber. Maca's overall nutritional status is similar to cereal grains such as maize, rice, and wheat.[8]

Maca* (Lepidium meyenii) *freshly harvested from a field in highland Peru. Photo courtesy of Dr Steven K

In a feeding trial, 2 generations of albino Swiss mice (parents and breeding) were fed cooked powdered maca (30% of the regular feed), raw powdered maca (30% of the regular feed), or regular feed. Growth curves for both generations were taken. In addition, serum albumin and protein were measured. Although all 3 groups grew, the growth curves were the best in the group that consumed cooked maca, with more significant differences in growth seen in the second generation. Serum protein and albumin levels in the cooked maca group were significantly better—proof of maca's positive nutritive potential.[4]

Maca is prepared by baking in ground pits *(panchamancas*) or eaten as a porridge (*mazamorra*). There is a fermented drink, *macha chicha,* made from the roots that flavor a native cane rum (*aguardiente*).[9]

Traditionally, maca has been used for medicinal purposes and as a source for energy, stamina, and endurance. It also has been used as an aphrodisiac and tonic for postmenopausal problems.[10] The latter use has generated a resurgence of interest in this plant. The fertility-enhancing properties partially have been substantiated in rat studies. Chacon, the biologist at the University of San Marcos in Lima, Peru, who is credited with initiating groundbreaking work on this plant, isolated 4 alkaloids from the maca root. These alkaloids, purified and blended together or fed as powdered root, were given to female and male rats. The females who received either form developed increased maturation of egg follicles. In both preparations, the males had significantly higher sperm counts and motility. Chacon concluded that the activity of the alkaloids affected the hypothalamic-pituitary axis, which explains why maca has the ability to induce effects in both sexes.

In addition, Chacon[11] suggested that maca influenced the adrenal axis. Johns[12] suggested that the root's aphrodisiac qualities may be attributed to the biologically active aromatic isothiocyanates: benzyl isothiocyanate and *p*-methoxybenzyl isothiocyanate. He also noted that the positive effects on fertility are attributed to the glucosinolates present in the root. Dini et al[5] reported that the aphrodisiac properties are linked to sterols and prostaglandins in the roots.

Another study aimed at determining the effect of an aqueous portion of the roots on spermatogenesis showed maturation and acceleration of spermatogenesis in its initial stages, with increased testicular and epididymal weights in rats given extract for 15 consecutive days.[13]

Cicero et al[14] published a study evaluating sexual behavior in rats given pulverized maca root. Activity was measured on day 1 (acute exposure) and day 15 (chronic exposure), at lower doses (15 mg/kg) and higher doses (75 mg/kg). The following sexual performance parameters were observed: first mounting (ML), first intromission (IL), ejaculation latency (EL), postejaculatory latency (PEL), intercopulatory interval (ICI), and copulatory efficacy (CE). (Who would have guessed that sex was so complicated in rats?) At both lower and higher doses there was acutely decreased ML, IL, and ICI ($P < .05$). Only the higher dose acutely decreased PEL. After 15 days both doses decreased ML, IL, EL, and PEL. In addition, there seemed to be an overall increase in "rat aspecific" activity (general activity) after chronic treatment.

We also contacted Ms Natalie Koether and Dr Qun Yi Zheng of Pure World Botanicals, a company that has developed commercial extracts of maca and subjected them to animal studies. We asked about their interest in maca, how they learned about it, in what form it was sourced, and their perspective on its attributes.

"We first learned about maca in 1997, from a friend who traveled to the Peruvian highlands," noted Dr Zheng. "He was looking for plants with interesting properties, when local people told him about this plant. This plant is very nutritional, high in protein, and it grows only in high altitudes—perhaps that is why the plant's biosynthetic pathway created a species with very strong self-defense. There are many research papers being published on this plant now, many more than when we first started. I predict that more research will be undertaken on this important remedy."

When asked whether there were contraindications, Dr Zheng replied, "None that we know of. Today, it is used as a food, in soup, and even the roots are chewed on the street."

"Are you positioning this plant as an herbal Viagra?" we asked. Ms Koether replied, "Not so much as that it acts more on the libido, whereas Viagra acts more on mechanical function. Response to the extracts of maca has been terrific, and while men report it works, we have also gotten some good feedback from a physician who uses it with success for menopausal women."

Dr Zheng continued: "We also have reports from the physician that the plant seems to have other properties, such as enhancing energy, and reducing depression. This herbal product seems of great potential utility, which we are going to explore."

Finally, because there are numerous brands on the market, we wondered whether the type of maca made any difference, as some products claim. According to Dr Zheng, all of the species are similar in terms of their pharmacology and chemistry, as long as they are processed correctly.

The studies undertaken by Dr Zheng's research group, in collaboration with academic research groups in China, have evaluated both a lipidic and aqueous extract of maca finding different physiological effects to each. Zheng et al[15] evaluated the endurance and energy capabilities in a series of aqueous extracts of maca by measuring the swimming activity of mice. Four doses of aqueous extract (4, 10, 20, and 40 mg/g) were prepared and given to mice in 4 proprietary mixtures of maca (*Maca* Force™ AQ-1, AQ-2, AQ-3, and AQ-4). AQ-3 and AQ-4 contained significantly smaller amounts of polysaccharide than did the aqueous extracts AQ-1 and AQ-2. In addition, small amounts of Siberian ginseng (*Eleutherococcus senticosus*) and *Rhodiola*—known botanical remedies that increase endurance—were placed in AQ-3 but not in AQ-4. The results revealed that increased swim time was directly related to the increased content of polysaccharides in the aqueous extracts. Furthermore, recovery from muscle fatigue (measured by lactic acid and malonic acid production) during strenuous physical activity was demonstrated in mice given the AQ-1 and AQ-2 (the higher polysaccharide extract samples). The recovery from fatigue also was correlated to dosing.

In another study done by Zheng et al,[16] lipid extracts of maca were given to mice and rats to evaluate sexual behavior. Results showed that oral administration of these preparations increased the number of complete intromissions and decreased latent period erection. This work was consistent with studies showing aphrodisiac activity as discussed earlier.

One of our neighbors is from Peru, and her food pantry is stocked with several different brands of ground maca roots. Sold in bags and plastic jars in Peru, the powder is yellow-brown, with a strong, deep odor. She starts her day with a spoonful of maca powder mixed in a glass of orange juice, and swears by it as the source of her energy. Her boyfriend agrees with this sentiment and, with a smile, confirms the power and magic of maca.

This tenacious and unassuming ancient root crop, able to flourish in a most stressful habitat, finally seems to have attracted the attention of the herbal medicine community. Ongoing in vivo studies should show whether this nutritious food, rich in ethnomedical lore, has value in today's integrative medical practice. From our initial survey of the literature—as well as information from our friends—it certainly seems that way. However, it also may be worthwhile to temper our quest for youthful energy and libido by remembering the words of an ancient sage: "What was, *was*; and what is, *is*."

Acknowledgments

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