Freeze-dried but Always Peeled: Anthropological Approaches to Food Processing, Preparation, and Consumption of the Andean Potato

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The "white" potato (*Solanum tuberosum*) is an indigenous crop to the Andes and grows both at elevations above 10,000 feet and at lower elevations. The potato is the world's fourth largest food crop (CIP 2002; Messer 2000). Since its domestication 8,000 years ago on the Andean *altiplano* (high plateau), potatoes—raw, boiled, roasted or freeze-dried—have had central roles in indigenous Andean culture and cuisine (Hawkes 1990; Werge 1979; Woolfe 1987). Initially introduced to Europe by the Spanish conquistadors in the mid-1500s, it has circled the globe and more than 4,000 varieties are now grown and consumed in about 150 countries (Messer 2000; Roach 2002; Salaman 1949; Tannahill 1973). The Centro Internacional de la Papa (CIP or the International Potato Center)—indisputably the world's most important institution concerned with the potato—has with other scientific institutions increasingly recognized and supported the role of indigenous knowledge and biodiversity in alleviating food scarcity in the Andean region and elsewhere (CIP website).

Potato production in 2003, according to the Food and Agricultural Organization, was 310.8 million metric tons (FAOSTAT 2004) (see Figure 1). Surprisingly, those countries and regions with the greatest production (China, the Russian Federation, Poland, the United States, and India) are geographically dispersed and have vastly different climates. These four countries and one region accounted for more than 50% of the worldwide potato production in 1995–97 (153/295 million metric tons) (FAOSTAT 2002; CIP 2002).

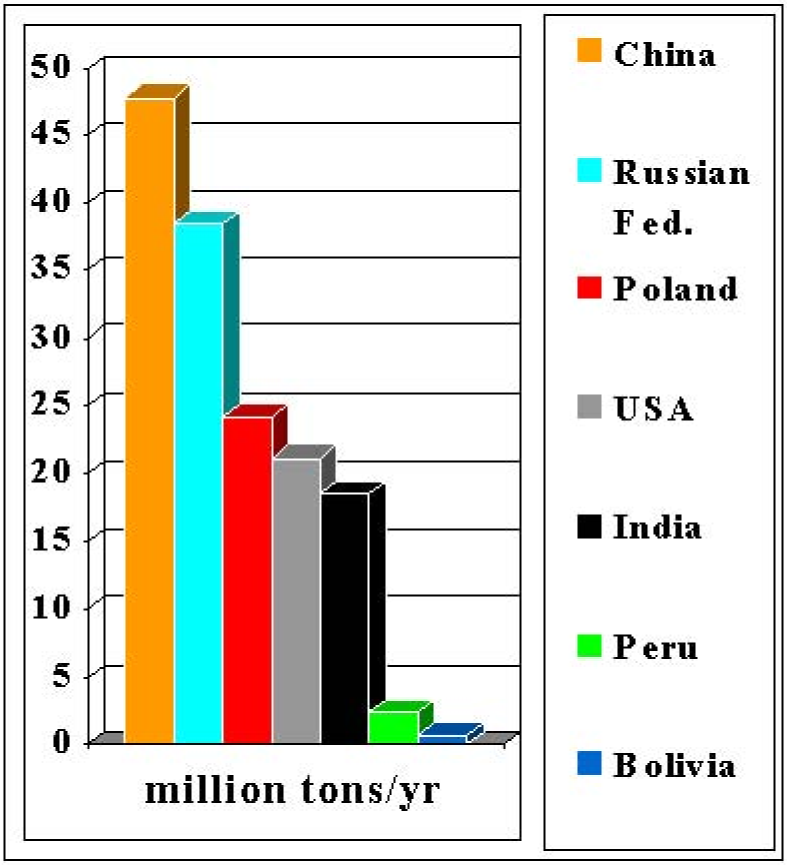

Figure 1. Worldwide potato production 1995–97. Source: Maldonado, FAOSTAT (1998).

Contrary to expectation, those countries with the highest potato production are not the same countries with the highest per capita consumption (see Figure 2). As anticipated, Andean consumption is estimated to be the highest at 150–200 kg per person per year, followed by Poland and the Russian Federation all averaging more than 120 kg per person per year. In the United States annual consumption is about 60 kg per person, although this has declined in very recent years because of the current diet fad of low carbohydrate diets (Sterling 2004). Potato consumption in China and India has always been low, with annual per capita consumption of about 14 kg (CIP 2002a).

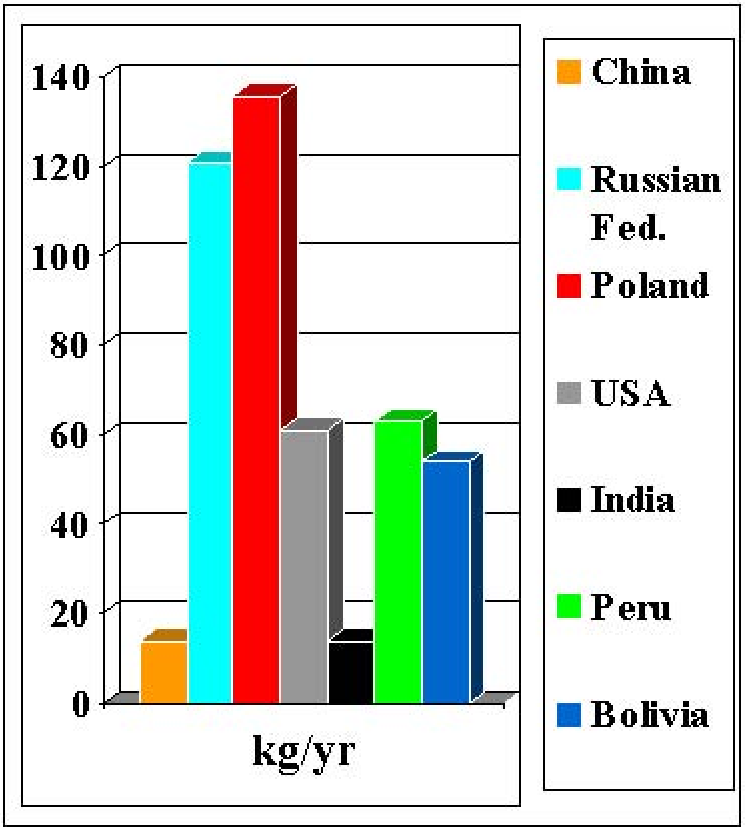

Figure 2. Per capita worldwide potato consumption 1994–96.
Source: Maldonado, FAOSTAT (1998).

The potato (*Solanum tuberosum)* belongs to the diverse Family Solanaceae (but see Vasquez, 1996, on Andean versus scientific names for potatoes). This Family includes tomatoes, chili peppers, eggplant, tobacco, and many of the nightshade species, such as belladonna and jimsonweed, which have been used as medicinal plants (Hawkes 1990; Howard 1970; Johns 1990). The International Potato Center (CIP) and other groups have described the evolution and genetic diversity of the Andean potato *Solanum tuberosum* ssp. *andigena*. They have characterized a number of subspecies and identified nearly 1,500 wild types and 5,000 cultivars worldwide (CIP 2002; Hawkes 1990; Messer 2000; Woolfe 1987). Generally, andigena varieties are predominant in the highlands, growing at 1,000–3,900 meters above sea level (Tapia n.d.), and tuberosum varieties (*S. tuberosum* spp. *tuberosum*) in the valleys (CIP 2001). The bitter varieties with high levels of potentially toxic protein-sugar compounds, the glycoalkaloids, are grown in the Andean altiplano (3,900–4,200 meters above sea level; Tapia n.d.) and serve as an important food source. The bitter species, planted in the highest zones most subject to frost, are *S. juzepzuckii*, *S. curtilobum*, and *S. ajanhuiri* (CIP 2001). Cultivars grown in other regions of the world have lower glycoalkaloid levels (Johns 1990; Messer 2000, Woolfe 1987).

Nutritional Value and Indigenous Processing

Although there is a wide range of nutrient concentrations—depending on variety, climate, soil conditions, and processing—potatoes are a good source of calories, carbohydrates, dietary fiber, potassium, phosphorus, magnesium, iron, thiamin, niacin, pyridoxine, folic acid, and particularly vitamin C (Brown 1999; Hall n.d.; Messer 2000; Woolfe 1987) (see Figure 3). The starch is easily digested and the protein content is comparable by dry-weight to cereals. The protein is high in the lysine and low in sulfur-containing amino acids. However, potatoes are very watery, with dry matter comprising only about 20% (range 18–34%) of the weight on the average. Therefore, a number of processing techniques that preserve potatoes post-harvest are used to reduce the water content and increase nutrient concentration (Messer 2000; Woolfe 1987). Native Andean varieties are more "floury" and "have more dry matter than commercial potatoes" (W. Amorós in Portillo, 2004:3), offering greater nutritional value since they contain less water (*ibid.*). Potatoes also contain a number of pigments that act as antioxidants, including the yellow carotenoids and the red and purple anthocyanins (Messer 2000; Woolfe 1987).

Like other tubers, such as bitter cassava or manioc, that require processing to reduce the concentrations of cyanogenic glycosides, potatoes also require processing to reduce the concentrations of potentially toxic glycoalkaloids (Guido, Esprella, Aguilera and Devaux 2002; Jackson 1996; Johns 1986, 1990; Woolfe 1987). High levels of glycoalkaloids inhibit the neurotransmitter cholinesterase and injure the lining of the gastrointestinal tract, leading to nausea, vomiting, diarrhea, headaches, and dizziness. Death can ensue at very high levels (Johns 1990; Woolfe 1987). However, glycoalkaloids and other potato constituents such as the lectins and proteinase inhibitors protect the plants, conferring resistance to cold stress, as well as being toxic to insects, other vertebrates, and fungi (Woolfe, 1987).

There are many glycoalkaloids, but the most common one is alpha-solanine. These are found in higher concentrations in the rapidly growing parts of plants such as the sprouts, flowers, and the peel. Concentrations are affected by light, soil conditions, maturity, and genes. Sunlight increases the production of solanine and storage in light increases the concentration in the flesh of the potato. Recommendations are to avoid harvesting and storage on sunny days (Werge 1979; Woolfe 1987). Glycoalkaloid concentrations less than 10 mg/100 g of potato are generally imperceptible to taste. A hot, burning sensation with persistent irritation and metallic aftertaste is characteristic of bitter potatoes with concentrations of 20-30 mg/100 g. (Johns 1986; Messer 2000; Woolfe 1987).

Allelochemicals are common in domesticated plants and many have a dose-dependent toxicity for humans. These toxic properties of foods play a role in the identification and processing of foods to increase palatability and nutrient quality and to decrease adverse physiological effects (Jackson 1996; Johns 1986, 1990). Unlike the proteinase inhibitors and the lectins that are destroyed on heating, glycoalkaloids do not dissipate with standard cooking techniques. In traditional Andean cultural practice, potatoes are always peeled, eliminating much of glycoalkaloid content. For most potatoes the peel contains 60–80% of the glycoalkaloids, but for the bitter varieties, only about 30–35% of the glycoalkaloids are in the peel (Woolfe 1987). Therefore, a number of other drying, freezing, and leaching techniques are employed to reduce the glycoalkaloid content (Messer 2000; Werge 1979). These techniques are particularly important because these processed potatoes are often the foods

NUTRIENT	AMOUNT/ UNIT	% RECOMMENDED DAILY VALUES
Calories	110 Kcal	10
Protein	3 g	6
Carbohydrate	23 g	8
Fat	0 g	0
Dietary Fiber	2.7 g	10
Sodium	10 mg	0
Potassium	750 mg	20
Iron	2 mg	8
Iodine	10 mcg	15
Phosphorus	60 mg	8
Magnesium	32 mg	8
Copper	0 .32 mg	8
Vitamin C	30 mg	50
Thiamin	0 .06 mg	8
Niacin	2 mg	10
Folic Acid	32 mcg	8
Vitamin B-6	0 .45 mg	15

Kcal = kilocalories mg = milligrams
g = grams mcg = micrograms

Figure 3. Averaged percentages of U.S. Recommended Daily Values for an Adult contributed by one medium potato (150g). Sources: Brown (1999); Hall (n.d.); Sun Spiced (2002).

consumed in high quantity when little other food is available (Jackson 1996; Johns 1986, 1990; Messer 2000; Salaman 1949; Tannahill 1973; Werge 1979).

Fermenting and then drying is used in the production of *tocosh* (*togosh*). Drying is used in the preparation of *papa seco* ("dehydrated potato"), and freeze-drying in the production of *chuño* (*ch'uñu*). Tocosh is prepared in several Andean countries by fermenting potatoes for several weeks or months, then drying them in the sun (Cruz n.d.; Patiño 1992). *Chuño* is prepared in the highland regions that formerly were part of the Inca empire (especially Peru and Bolivia). *Papa seco* is prepared on the Peruvian coast by first cooking, then peeling and drying the cooked potatoes in the sun (CIP 2002). Two varieties of chuño are made: *chuño negro* (black) and *chuño blanco* (white) (see Figure 4). Chuño negro (or simply, chuño) is made from bitter and/or small, irregular, poor quality potatoes and has an average concentration of 16 mg of glycoalkaloids/100 g of potato. Chuño blanco is made from large, regular potatoes and has an average of only 4 mg of glycoalkaloids/100 g of potato (Woolfe 1987).

Figure 4. Aymara-speaking women display chuño blanco (far left, right), chuño negro (center), and grains (far right) for sale or trade in the Sunday market of Ilave, Peru. (Photo © E. Zorn 1978.)

The freeze-drying processes take advantage of the tropical mountain ecology with warm daytime temperatures and freezing nights during the dry winter season (June–July). This process is well-documented in the ethnography by Mauricio Mamani (1978) [for photos of post-harvest processing including freeze-drying, see REDEPAPA (website), and Jacobs (2003) for a description in Quechua of a regional variant in Ancash, Peru]. The production of chuño negro involves placing the potatoes on a bed of straw, freezing them for one or several nights, and then drying them in the sun. Before drying they are gently stepped on to squeeze out the water. After drying thoroughly in the sun, a process that can take two weeks, the potatoes are rubbed to remove the peel and stored away from sunlight. Two varieties of chuño blanco are made. The processes show regional variation in production and terminology (Arnold and Yapita eds. 1996; Guidi, Esprella, Aguilera, and Devaux 2002; INCOPA 2003; Mamani 1978; Patiño 1992). After freezing, the potatoes are soaked in a running stream for approximately two weeks to make *tunta* or soaked in stagnant water to make *moraya*.

The processes of creating chuño blanco and chuño negro significantly alters the nutritional content of the potatoes, in part by decreasing the moisture content from an average of 83–78% to 14–18%. One hundred grams of chuño has a four-fold increase in energy from an average of 75–80 kcal to 300–350 kcal and a four-fold increase in carbohydrate from 18.5g to 78g when compared to 100g of raw potato. Freeze-drying markedly increases calcium from approximately 8 mg in the raw potato to 100 mg in chuño blanco and 50 mg in chuño negro. However, there is a reduction in vitamin C from 20 mg to 1–2 mg. Chuño negro when compared to chuño blanco shows a two-fold increase in protein, a four-fold increase in phosphorous, and two-fold increase in niacin. Chuño blanco exhibits a three-fold increase in iron. In addition, chuño can readily be transported because of its light weight and stored for many years: three years is average but there are many ethnographic reports of storage for ten years or more. Long periods of subsistence on chuño as the primary food source are legendary (Tannahill 1973:256-58).

Culturally, chuño has an extremely strong racialized association. Produced and consumed primarily in highland Peru and Bolivia, chuño is considered “Indian food.” Since native peoples continue to have very low social status in Andean countries (Albó 1999), despite chuño’s nutritional value and its use in some regional dishes it is generally spoken of pejoratively. Zorn, during eight years of ethnographic fieldwork, frequently heard chuño described by some non-Andeans as “tasteless” or “dirty.” An anecdote clearly illustrates the racialization of chuño: Zorn notes that during her fieldwork in Taquile Island, Peru, she was introduced in Quechua to a native Andean by being described as someone who ate chuño, which she later understood had meant that she wasn’t prejudiced against native peoples.

The vast system of Andean indigenous or traditional knowledge of potato cultivation, storage, marketing, and “processing for traditional uses” (Thiele and Devaux 2002) is associated with other domains of life through metaphor and analogy to describe values and ways of thinking in Andean ethics and philosophy (Arnold and Yapita eds. 1996). Andean indigenous or traditional knowledge is increasingly recognized for its potential to restore ancient Andean farming systems to help solve local food scarcity (Arnold and Yapita eds. 1996; CIP 2001, 2002; Cruz n.d.; Guido, Eprella, Aguilera, and Devaux 2002; Hobhouse 1985; National Research Council 1989; Portal Agrario n.d.; Roach 2001; Tapia n.d.; Thiele and Devaux 2002). For example, this knowledge is being used globally in the developing world in applications such as the technology of storing potatoes away from light to improve retention of nutrients and sprouting (CIP website). Furthermore, as researchers such as Arnold and Yapita eds. (1996) at the Institute of Aymara Language and Culture (ILCA) in La Paz have shown, the study of indigenous knowledge in relation to the potato provides significant insight into Andean thought and logic.

Traditional Andean knowledge about the potato has considerable time depth. Extremely complex civilizations developed in the high tundra grasslands of the southern Andes more than a thousand years ago with a subsistence base of tuber agriculture and camelid herding of llamas and alpacas (Moseley 2001). Potatoes were the major high-altitude crop, along with other Andean tubers. Then as now, camelids transformed inedible high-altitude grasses into meat and fleece, and their dung fertilized the fields. Llamas were the pack animals that Andean peoples used to obtain products from lower-altitude zones through exchange. This permitted the growth of dense populations and major civilizations, notably Tiwanaku outside La Paz, Bolivia, on the Andean altiplano (*ibid.*), and subsequently the Inca civilization centered at Cuzco, Peru.

Today, the most important components of contemporary Andean life are agriculture (especially potatoes), animals (notably camelids), textiles, and humans (Arnold and Yapita eds. 1996). An elaborate vocabulary exists for cultivating potatoes, drawing on their inherent properties, including color, and reproduction (Apaza 1996). Ideas about what to do and not to do in terms of technology are encoded in language and concepts shared across multiple semantic domains, which function through metaphor and analogy.

Cloth as a tangible representation of these domains has been the single-most important expressive medium in the Andes for 5,000 years (Zorn 2004; Zorn and Quispe, these Proceedings; Zorn 2004). Weaving provides the structuring principle for understanding other aspects of life, including agriculture. The ILCA team has found multiple examples of a system of analogies between textiles and agriculture by Aymara-speakers in Bolivia (Arnold and Yapita eds. 1996), as well as among Quechua-speakers. Potatoes are the first crop planted in Andean crop rotation systems, and this is symbolized by textile designs (see Figure 5). In some regions, the furrows of the potato fields are compared to the lines (*listas*) in the textiles that women weave (Arnold and Yapita with Apaza 1996). Furthermore, the images growing in the textile as it is woven are like potato flowers growing in the fields and the tubers growing underground. As well, the process of warping the loom is compared to inserting seed in the open plain area field of textiles. In addition, the stripes in some textiles are the same colors as potato flowers in fields, and so on (*ibid.*).

Figure 5. The hexagons in this handwoven coca leaf purse represent flowers (roses) and the crop rotation system (*suyus*) in Taquile Island, Peru. The upper right triangles of each hexagon represent potatoes, which are the first crop in the rotation cycle. (Photo © E. Zorn 2002.)

Gender permeates all aspects of Andean life, and in pre-Conquest times women and men lived, according to Irene Silverblatt, in two separate but inter-related gendered worlds (1995). Gender permeates Andean knowledge. Women are responsible for seed selection and storage, management of ecology, and potato biodiversity (Arnold and Yapita eds. 1996; Tapia and De la Torre 1998), and thus must be central to scientific efforts to improve food security through sustainable agriculture (FAO n.d.). In the Andean sexual division of labor, men break open the earth and women plant the seed, so both genders are essential. The ILCA team points out how the potato seed is related to female fertility, but the potato flower is symbolic of the human head and the masculine power of war (Arnold and Yapita eds. 1996).

Stories about the origin of potatoes vary according to region and ethnic group. The supernatural power of special stones or *illas*, considered ancestors turned into stone (Apaza 1996), link the power of the dead and the ancestors to the agricultural cycle of death and the regeneration of life. This cycle is a common organizing principle for many agricultural peoples and in Andean life it is extended to animals, notably the condor, yet ultimately dominated by the "maternal principle" (Arnold 1996).

Potatoes are animate beings with social lives, and their growth is understood by analogy with humans and animals. For example, potatoes are carefully sorted after the harvest according to variety, size, and future use, but two or more varieties are always sown together in a single field. According to Domingo Jiménez, an elderly ritual leader in Bolivia, potatoes "compete" with one another when planted in Mother Earth as to which variety will produce more: "I will win," "No, I will win," each variety proclaims (Jiménez and Yapita 1996).

Perhaps of greatest interest to outsiders is the complex system of classification that Andeans apply to potatoes, based on color, gender, shape, use, frost resistance, and so on (Arnold and Yapita eds. 1996; Vasquez 1996). Given potato diversity, not surprisingly numerous regional and ethnic group variations exist, with the greatest variation in the Peruvian and Bolivian altiplano, where the potato originally was domesticated. In Aymara, the indigenous language spoken primarily around Lake Titicaca, popular varieties include *Janq'u Imilla* (White Girl), *Wila Imilla* (Red Girl), *Saq'ampaya* (Long Male Potato), and many others. In Quechua (Inca), names of popular varieties include *Yana Imilla* (Black Girl), *Puka Imilla* (Red Girl), *Illa Pilpintu* (Shining Butterfly), *Kusi Sonq'o* (Happy Heart) (CIP 2001), and many, many more (also see Vasquez 1996). Like animals and humans, the tubers (which do not reproduce sexually) are gendered (Apaza 1996; Arnold 1996; Arnold and Yapita eds. 1996; Jiménez 1996). Red potatoes are female, and white potatoes are male. Potatoes also have nuclear family kinship relations: a husband and wife, and their babies (Jiménez 1996).

Another way that Andeans apply metaphors and analogies involving potatoes to other domains of life can be seen in the relationship between agricultural crops—especially potatoes—and music. In northern Potosi, Bolivia, the *pinkillu* flute is played between San Sebastian on January 20 through Carnival in the rainy season, when potatoes flower above ground (Stobart 1996). The flutes have openings like the "eyes" of potatoes and are alive. In the *q"ata* dance, females encircle the male flute players, hiding them from view and preventing them from "escaping." Similarly, the earth envelops the potato seed, as the peel wraps the potato, and textiles envelop newborn babies. In contrast, the panpipe, which has no openings, is "dead" like chuño and cannot grow, and is played in the dry season at harvest.

In summary, potatoes are a crop fundamental to the daily lives of Andean peoples. As a food crop they provide a nutritional staple. As a plant they provide the basis for organizing lives around agricultural cycles, designs for textiles and metaphors for human kinship and social relationships. Although low-carbohydrate diets have reduced potato consumption in the United States, potatoes remain the vegetable consumed in highest frequency and amount (Stirling 2004). Potatoes offer increasing nutritional value to tropical regions of the developing world. The indigenous knowledge of Andean peoples, developed through thousands of years of cultivation of this major world crop has been and continues to be used to improve the lives of people worldwide. There is much hope, too, that Andeans will see improvement in their lives both economically—through sustainable development and commercialization of diverse, colored potato varieties—and nutritionally with improved food security (CIP n.d., INCOPA 2003; National Research Council 1989; Portillo 2004).

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Centro Internacional de la Papa (CIP, International Potato Center)
http://www.cipotato.org

Red Electróbuca de la Papa (REDEPAPA, Electronic Network about Potatoes)
http://www.redepapa.org/index.html

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