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Chapter 1

CHUÑO AND TUNTA; THE TRADITIONAL ANDEAN SUN-DRIEDPOTATOES

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ABSTRACT

It is believed that the chuño and tunta procedures, sun drying while allowing the potato to freeze, were introduced by the population of the Andean highlands between 2000 and 3000 years ago. There are clear evidences that the methods were employed during thepre-tiwanakanChiripa culture period (aprox. 400 B.C.) when potato growing was the base of the agriculture in the Lake Titicaca western region (presently Bolivia and Perú). The production of potato was one the most important targets for the "sukakollos", a system of irrigation trenches surrounding the flat cultivation beds providing them with a mild micro-climate during cold nights providing frost protection (references). The transformation of potato into "chuño"(black sun-dried potato) and "tunta"(white sun-dried potato) gave the community the possibility to store crops over the seasons.

Chuño andtunta during the times have been and are currently widely used in traditional cooking in the Andean region. Due to their historical and cultural, and indeed economical importance, these products deserved a scientific approach regarding their chemical composition and nutritional worth. For example, after decoction ofchuño it has been found that it possesses high contents of some minerals such as calcium and iron. Also a slight to moderate loss of antioxidants namelyphenolic compounds in comparison with fresh potatoes has been previously reported. Thus, these products can be considered as a source of nutrients and antioxidants. However, most of the available scientific information about these products is published in the Spanish language. This fact makes difficult the diffusion of the qualities of these foods overseas. On the other hand, it is necessary to further investigate them as an alternative component for healthy diets.

This chapter presents a thorough review of the existing literature, both in English and Spanish, onchuño and tunta, with respect to their nutritional and chemical properties and their applications as food ingredients in the Andean cuisine.

INTRODUCTION

The traditional methods for preserving potato (and other tubers) based on sun drying while allowing the tubers to freeze and thaw are termed Chuño and Tunta. It is believed that these preserving processes were employed during the pre-TiwanakanChiripa culture (400 B.C.)[1] and it is still practicing nowadays.

The foods selected for this process were in particular potato cultivars (various *Solanum*species) and it is also occasionally applied using oca tubers (*Oxalis tuberosum*).

Chuño (in English known as chuno) as well as tunta are sun dried while exposed to freezing and thawing dried potatoes traditionally produced by the Aymara and Quechua communities at the Bolivian and Peruvian Altiplano. Chuño and tunta are words from the aymara language used to define black and white sun-dried potatoes respectively. These food processing methods were practiced for centuries for preserving potatoes over the seasons and contributed in making potatoes one of the main crops of the Andean people [2]. Nowadays, there is still a significant chuño and tunta production in the Altiplano and both (chuño and tunta) are important ingredients of the Andean cuisine being part of many local dishes and they are considered an important national heritage. For instance, the saying “to be more Bolivian than chuño” is common to describe a strong nationality and it is heard in the Bolivian cities.

During the winter time (June-August) in Altiplano (aprox. 4000 above sea level) the environment conditions are suitable for sun-dried foods. Low relative humidity (30 -40%) and sunny conditions followed cold nights creates perfect conditions for the process.

There is a shortage of scientific information regarding the chemical and nutritional composition of these products and about the possibilities to use them as food ingredients. We think that chuño and tunta apart to be considered as “exotic” food products developed by native cultures of South America can be consider as alternative ingredient in the international cuisine in the same way as quinoa (*Chenopodium quinoa*) is considered today.

Another important aspect of the present chapter is the inclusion of descriptions of the processes of producing chuño and tunta, as these processes not are completely described in the literature, maybe because the knowledge is based on the oral tradition rather than on written documents.

This chapter presents the history, the process description, the actual production and the economical importance,the nutritional and chemical properties of chuño and tuntaand their possible applications as food ingredients in the Andean cuisine.

THE CHUÑO AND TUNTAPROCESS

In the case of chuño the process consist in at least four steps, stating during the winter time in particular between June and July [3].

1. The first step consists in the selection of potatoes at harvest (April-May) where small bitter potatoes tubers are preferred over sweeter tubers.
2. The potatoes are spread early in the morning a day in June when the temperature still is aprox.-5°C. The intention is to allow the tubers to freeze before being exposed to sunlight during the middle of the day (Figure 2).
3. Remaining water and also the skin is removed mechanically by pressing and by abrasive action, usually performed by stepping on the potatoes several times a day (Figure 3).
4. After approximately three weeks the potatoes are completely dry. Eventually remaining skin is removed and the chuño is ready to be used or stored.

The tunta production process has been described by Paz, [4] interviewing people of Chullina village, BuatistaSaavedra province in Bolivia.

The potatoes for the tunta production are selected similarly as for the chuño process. The potatoes are allowed to freeze during the night, but during the days they are covered by blankets to avoid a direct sunlight exposure when drying which is the essential difference from the chuño production. After three or four days the farmers step on the potatoes removing the moisture and skins, always keeping the potatoes away from sunlight. Afterwards the semidried potatoes are stored for around three weeks in a hole called “tajana” by the aymara language.

The tajana is an approximately 5 m deep hole at the side of a river and lined by stones and straw (particularly strong grass called pajabrava which includes for instance *Stipaichu*).[5].The potatoes are deposited there until the tajana is full and finally sealed with straw and stones. The intention is to have a cold and humid environment surrounding the place.After some time tuntas are dried spreded in the land always covered by blankets.

After three weeks the dry white tuntas (Figure 1) are ready to use.

Figure 1.Chuño and tunta (white chuño).

Figure 2. Step 2, potatoes spread on the BolvianAltiplano.

Figure 3. People stepping on chuños.

The final chuño and tunta products are dehydrated. The composition of typical chuño, tunta and potato samples are given in Table 1. During the dehydration water soluble (minerals (ash), proteins, ascorbic acid, etc.) may partly be lost. Oxidative processes may lead to loss of ascorbic acid, oxidation of lipids and other components. The freeze and thaw processes destroy the vacuoles in the cells and release the phenoloxidase which may lead to loss of phenolic antioxidants. In parallel some phenolic material is released during the decomposition of lignins.

Most of the minerals follow the water pressed out of the potato during the chuño process as can be seen by the decrease in ash content. However, Burgos et al.[6] showed that chuño increase calcium content (aprox. 1-2-fold), iron is partly lost and 90% of the zinc is lost during this process. In the particular case of tunta (where only one calcium determination is available) showed to have 2-fold calcium content than chuño. We may speculate if these data reflects the true condition and in that case why.

One important aspect is that the chuño and tunta process drastically decrease (almost 50%) the content of glycoalcoloids and thereby reducing toxicity and allowing for the consumption of more bitter varieties than otherwise [7].

Table 1. The chemical composition of chuño and tunta and their comparison with potatoes

	Chuño	Tunta	Potatoes
Water/(% [fresh weight])	14-20[3,7,9,10]	13-18.1 [3,10]	68-84%[9,10,11,12]
Energy (Kcal/100 g dry matter)	375-400[3,10,11,12]	400[10,11]	351-400[9,10,11]
Proteins (% [dry matter])	0.6-4,5[6,10,11,12,13]	1,3-3,2[10,11]	7-14d,g,h[,10,11,13]
Carbohydrates(% [dry matter])	92-95[9,10,12,13]	94-96 [10,11]	79-87d,g,h[9,10,11]

Fibre(% [dry matter])	2,5d[13]	2,4[10,11]	3,5[11]
Lipids (% [dry matter])	0,2-1,5[9,10,12,13]	0,2[10]	0,4-1,5[9,10,,13]
Iron (mg/100g dry matter)	0.4-7[6,9,10]	5[10]	1-8,5[6,9,10]
Calcium(mg/100g dry matter)	19-110a[6, 9,10,11]	83-120[10,11]	13-38[6,9,10]
Zinc (mg/100g dry matter)	0,05-0,14[6]	nd	1,2-2,3[6]
Phophorus (mg/100g dry matter)	60-240[9,10]	120[10]	170-190[9,10]
Ash (% [dry matter])	2,0-3[9,10,12]	0,5[10]	2-5,8[9,10,12]
Antioxidants (µmol TE /100g dry matter)	150 -180[3]	nd	100 – 470[3]
Glycoalkaloids (mg/100g dry matter g)	16[11]	4[11]	20-30[11]
Vitamin C (mg/100g dry matter)	1-2[9,10,11,13]	nd	30-100[7,9,10]
Thiamin(mg/100g dry matter)	0,06-0,15[9,10]	0,02[10]	0,2-0,6[9,10]
Riboflavin(mg/100g dry matter)	0,02-0,06g,h[9,10]	0,02[10]	0,2-0,7[9,10]
Niacin(mg/100g dry matter)	0,5-4g,h[9,10]	1[10]	4-9[9,10]
Chlorogenic acid (mg/100g dry matter)	90[3]	nd	100 [3]
Syrinaldehyde (mg/100g dry matter)	<0.1 [3]	nd	1 [3]
Protocatechuic acid (mg100g dry matter)	1.0 [3]	nd	2 [3]
Gallic acid (mg/100g dry matter)	60 [3]	nd	110 [3]
Epicatechin (mg/100g dry matter)	460 [3]	nd	200 [3]

Peñarrieta et al., [3].;Burgos et al., [6].; Zorn and Lieberman, [7].; Peruvian Tables of food composition[9].; Bolivian tables of food composition. [10].;Woolfe, [11].;Quispe, [12].dHorkheimer, [13].

The total antioxidant capacity and the phenolic and flavonoid content were measured during chuño production [3].The total antioxidant capacity (TAC) measured by two methods FRAP (ferric reduction antioxidant power) and ABTS[2,2'-azino-bis(3-ethylbenzotiazoline-6-sulphonic acid)]. TAC showed that chuño decreased 70% by the FRAP method while it was almost constant by the ABTS in comparison with their correspondent potatoes. Five individual phenolic compounds were indentified and quantified during this process showing the chlorogenic acid one of main phenolic compounds present in the potatoes remains almost constant the same results were also observed in the protocatechuic acid content while gallic acid and epicatechin varied strongly before and after the process and syringaldehyde decreased.

HEALTH ASPECTS OF CHUÑO AND TUNTACONSUMPTION

Chuño and tunta can be considered as a source of carbohydrates (Table 1).

Regarding the high number of potato cultivars present in the Altiplano the chuño and tunta process result an innovative alternative to control the glycoalkaloid content in bitter potatoes making these cultivars edible.

It is well known that potatoes can be consider an important source of antioxidants and phenolic compounds to the human diet [8] and most of these materials remain in the chuño although the composition is somewhat changed.

BRIEFHISTORICREMARKS OF THE POTATO CHUÑO AND TUNTA

Wild and semi-wild potatoes are spread from Venezuela, Colombia, Ecuador, Peru, Bolivia, Argentina, and Chile through the Pampa and Chaco regions of Argentina, Uruguay, Paraguay, and southern Brazil and northward into Central America, Mexico, and the southwestern United States. [14].

Several researchers assert that the potato primarily originates from the Andean Altiplano, particularly fromendorheic basin region, between Lake Titicaca and Lake Poopó in Bolivia. A key argument is the high biological diversity.

It is believed that potato was domesticated probably 10,000 and 7,000 years agoin the Titicaca Lake region. Early archaeological remains are food garbage from about 600 BC and originates from the Chiripa culture (present in the Lake Titicaca region between 1500 BC until 200 BC) [15].

In the Andean region it had been shaped two agricultural complexes. In temperate ecological zones, both in the mountains and on the coast, the corn (*Zea mays*) was the main crop while in the ecological region of the Altiplano the main crops were quinoa (*Chenopodium quinoa)*, cañiwa (*Chenopodiumpallidicaule)*, the lupine tarwi (*Lupinusmutabilis*)and tubers (potatoes (*Solanumtuberosum*), root vegetables and rhizomes).The Tiwanaku civilization (five phases comprising 200 BC to 1000 AD aprox.) grew based on the Altiplanoagriculture and in particular the potato production. For this reason we may call the Tiwanaku civilization as "the potato culture". The process of producing sun dried potato exposed to freezing and thawing was developed for preservation of tubers during the Tiwanaku I and IIcivilisations (between 200 BC and 500 AD)[16].

During the Inca empire (1438 AD) (1200 AD to 1572 AD) most of the potatoes harvested in the "Land of the Incas ", was transformed into chuño flour, and shipped and preserved in the imperial stores, to be distributed from there to regions in need or for maintenance of the troops. The production of chuño flour destined to the masses, while the tuntaproduction was reserved for the Inca elite [17]

Chuño and tunta was described by early Spaniard chroniclers. For instance, Pedro Cieza de León [18] wrote that “many Spaniards become rich and prosperous solely by sending this chuño to be sold in the mines of Potosí”. José de Acosta (1590) mentioned in his accounts of minesthat Spanish mine managers of Potosí complained about its high price of chuño. It is also curious that one seventeenth-century information source [19] mentioned chuño as a origin of fine white flour for cakes and other delicacies, although it was usually considered to be a lower-class native food. Antonio Vázquez de Espinosa in 1622[20]mentioned that a kind of porridge based on chuño was prepared and that it was highly prized. Inca Garcilaso de La Vega, born in Cusco, son of the spanish captain SebastiánGarcilaso de La Vega and of the Inca princess Isabel ChimpuOcllo of Cuzco, capital of the Inca Empire, in his "ComentariosReales" also wrote about importance ofchuño in society[21].

John V. Murra, one most important specialist of the Inca Empire and history seeking a way to explain the importance of chuño in the Andean civilizations drew the “glove metaphor”: “I see here an Army General. You, Mr. General, will agree with me when I say that is impossible to put an army in the field without a good system of logistics and food supply. What happens -still- is that Andean farmers have taken the harsh, aggressive conditions of the highlands, where no one would have suspected that it was possible to survive ... and like a glove, they have inverted it, and they have converted them into a source of wealth and prosperity, achieving food, -including chuño, precisely, sustainable food supplies for the military -and over-all, surplus accumulated in the family, ethnic and state

stores named “colcas” and “pirhuas”, and also extracted by a state that recognized the differences, taking into account the bad years in one community and the good years in another community, calibrating productions, taking percentages of the populations to serve as mitayos, or shiftworkers, and recording the results in their register system using colored ropes called qiposquipos” (quoted by [22]).

CHUÑO PRODUCTION

Modern Production

A modern definition of chuño and tunta has been proposed as: “Chuño is a food product of dark coloration, obtained out of native sour potato entire tubercles, themselves made throughout freezing, dehydration and exposing-to-sun drying processes. Tunta is a whitey product obtained out of native potato entire tubercles, themselves made throughout freezing, washing and exposing-to-sun drying processes”.[23]As a potato derivative product the modern production of chuño-tunta can be directly linked to the economy of potato. Hence, an approach to the modern chuño-tunta production is the published statistics on potato production. The most recent published statistical data [23] report two modern periods to be considered in the production of potato in Bolivia, 1980 to 1990 and 1991 to 2007. For the first period (1980 to 1990) the potato production in Bolivia was ascendant from 1980 to 1983. These years yielded an average of 850 kilotons (800 to 900). Then in 1983 a rapid fall was experimented because of the extreme climatic conditions due to the “El Niño” phenomenon. This year the dramatic number of 300 kilotons was reached. The 1984 to 1988 was again an increasing production period, giving rise to a total of 3800 kilotons (ranging from 700 to 800 kilotons). Nevertheless in 1989 production falls down again with a permanent diminishing tendency until 1995, the production in 1990 is about 600 kilotons. From 1996 to 2002 the production rises and in 2003 it reaches 900 kilotons. In the period 2004-2007 the production is stabilized in about 750 kilotons per year. This information is global and allows estimating the economy of potato in the last approximately three last decades in Bolivia. The complementary concept to production is consumption. Thus we can find in the same bibliographic source [23] information regarding the usual destination of the production of potato. For instance the triennium 2005-2007 potato was destined to a variety of uses. The approximately 761 kilotons produced in these years, were disseminated in 99.6 kilotons for self-consumption (the potato producer’s consumption). 195 kilotons were destined to self-consumer seed. Some 5 kilotons of certified seed were separated for export. 0,350kilotons were injected into the national market. The losses for diverse causes were about 0,117kilotons. Some interesting information to be deduced from these data is the fact that the addition of self-consumption and sells in the local markets gives a total of 0,449kilotons. This numbers divided into a population of 9,500,000 gives a consumption of 47.24 kg per capita per three years or 15.8 kg per capita per year. This reveals a tendency of lowering potato production in recent times in Bolivia.

Table 2. Fraction of various potato varieties converted into chuño and tunta. Data from the department of Potosi, Bolivia, 2008 by Zeballos,[23]

Potato variety	Commercialized chuño (% of total production)	Self consumedchuño (% of total production)	Total fraction of the production that is converted into chuño. (% of total production)
Mateo pintado	0	5	5
Pukaqoyuqoyu	10	27	37
Chutainñaqa	0	5	5
Tanta papa	0	5	5
Puka taka	0	5	5
Yurajpali	10	27	37
Yana amajana	0	5	5
Yana saq'ampaya	15	30	45
Papa Durazno imilla	0	10	10
Alqaimilla	0	5	5
KhuchiK'orota	0	5	5
PukaAjawiriLuk'i	50	27	77
Pukaluk'i	30	40	70
Pukapituwayaqa	0	5	5
Mama thalla	10	30	40

Statistical information about the production of chuño and tunta, it is practically inexistent. Even though some tentative statistical information can be extracted from thework by Zeballos et al.[23]. "The estimated production of chuño and tunta would be 2,469 and 1,938 tons respectively with its origin in the central altiplano, or the Loayza, Aroma, Vilarroel, Ingavi, Inquisivi and Los Andes provinces. These quantities come from some 20,000 tons of potato produced by about 5600 family units. The corresponding revenues reach an average sum of 550 US dollars per family per year". According to the same authors, "the brut value of this production at the farmers markets is approximately US$ 1 700 000 for 2 500 tons of chuño, and US$ 1 600 000 for 2 000 tons of tunta". It is interesting to note that tunta is mostly produced for the market while chuño is mainly produced for self consumption. The formal industrial sector produces chuño and tunta in bags, potato starch, canned tunta, peeled refrigerated potato, potato chips. The formal industries are settled in the capital cities of the departments of Bolivia.

Zeballos et al.[23] also reports data on the grooving of native potato varieties in northern Potosi (2008) (Table 2). Fifteen varieties of potato are also reported as source of chuño [24]. The fraction of the potato production converted into chuño can be obtained by summarizing commercialized and self-consumption.The conclusion from these data is apparently that some potato varieties are mainly used as raw material for chuño.

CHUÑOAND TUNTAAT THE MARKET

A rapid development of the quinoa at the world market has shown that the culinaric heritage of the Altiplano may be appreciated even in the modern context. Important aspects are intrinsic product properties like, taste, nutritious value, usability, cost as well as extrinsic factors like the identity and provenance. We have tried to summarize the gastronomical properties in Table 3. We may note that the character obviously is similar to potato flakes and

face similar problems with oxidation, although due to its origin in the traditional handcraft, the oxidized flavour may be considered a characteristic feature rather than a processing damage.

The commercial use of chuño and tunta in Bolivia today is summarised in Table 4. From this table we may notice that the use is as a source of carbohydrate or as a thickener in soups. We also notice the presence of pre-soaked products aimed to eliminate the soaking as well as pre-cocked products eliminating the cocking. In several of the products the chuño or tunta is providing the final dish with character and thereby adding to its identity.

An evaluation of the export potential of chuño and tunta is obviously very speculative. It is clear that the health arguments based on the nutritional value are weak. The gastronomical based values depend very much on the strength of the provenance. However, as the history of Andean kingdoms and empires is fascinating and the landscape glorious we may expect that these values may be powerful, particularly when combined with other characteristic already accepted components such as corn and quinoa.

Table 3. Gastronomic and culinaric properties of chuño and tunta

Property	Chuño	Tunta
Preparation	Soaking 24 h. Cocking in water 20-30 minutes.	Soaking 24 h. Cocking in water 20-30 minutes.
Color	Grey to light brown.	White to light grey
Consistency	Soft, thickening to the liquid.	Soft, thickening to the liquid.
Taste	Mild taste, slightly bitter	Mild taste, less bitter than chuño.
Flavor	Mild odor. Slightly oxidized.	Very mild odor. Less of the oxidized flavor.

Table 4. Inventory of final products based on chuño and tuntain Bolivian economy and kitchen

Product	Description
Chuño and tunta bulk product	Dry standard product, classified by size.
Chuño or tunta soup or porridge	It is the milled chuño or tunta, with addition ofsalt, pepper, chili, onion powder and garlic, bagged in polyethylene containers and distributed dry (several suppliers?).
Canned tunta	The previously rehydrated tunta by soaking, was packed with a brine (salt content?) in cans. CorporacionIndistrialDillman, Cordill, Bolivia).
Chuño cookies	Cookies obtained with flour of chuño(50%) .
Bagged “chairo” soup	Driedchairo soup ingredients
“Frozen”chuño	Frozen and thawed (but not dried) potato that is peeled and sold directly in the markets.
Pinched chuño	It is the soaked chuño pinched in small pieces that is sold in the market.
Dried tunta shells	A powder of peels is obtained after processing of tunta and it is used to form a starch rich flour that is used as a human food as well as

	ananimal feed.

Source: Modified from Guidi et al. [25].

Considering the high number of potato cultivars present in the Altiplano the chuño and tunta processes result in an innovative alternative to control the glycoalkaloid content in bitter potatoes making those cultivars ediblethrough the conversion of potato in chuño and tunta.

It is well known that potatoes can be considered an important source of antioxidants and phenolic compounds for the human diet [8]. Chuño can also be considered as an important source of antioxidants and phenolic compounds in particular chlorogenic acid. Peñarrieta et al. [3], mentioned that a portion consisting of 100 g of chuño provides a total antioxidant capacity comparable to 200 g of cauliflower.

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