A microethnographic and ethnobotanical approach to Llayta consumption among the Andes feeding practices

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Abstract: Llayta is a dietary supplement used by rural communities in Perú and northern Chile since pre-Columbian days. Llayta is the biomass of colonies of a Nostoc cyanobacterium grown in wetlands of the Andean highlands, harvested, sun-dried and sold as an ingredient for human consumption. The biomass has a substantial content of essential amino acids (58% of total amino acids) and polyunsaturated fatty acids (33% total fatty acids). This ancestral practice is being loss and the causes were investigated by an ethnographic approach to register the social representations of Llayta, to document how this Andean feeding practice is perceived and how much the community knows about Llayta. Only 37% of the participants (mostly adults) have had a direct experience with Llayta; other participants (mostly children) did not have any knowledge about it. These social responses reflect anthropological and cultural tensions associated to lack of knowledge on Andean algae, sites where to find Llayta, where it is commercialized, how it is cooked and on its nutritional benefits. The loss of this ancestral feeding practice, mostly on northern Chile, is probably associated to cultural changes, migration of the rural communities, and a very limited access to the available information. We propose that Llayta consumption can be revitalized by developing appropriate educational strategies and investigating potential new food derivatives based on the biomass from the isolated Llayta cyanobacterium.

Keywords: Andean microalgae consumption, Atacama, cyanobacteria, Llayta, microethnography, Nostoc

1. Introduction

Members of microalgae and cyanobacteria genera (i.e., *Chlorella*, *Dunaliella*, *Arthrospira* and *Nostoc*) have been part of the human diet in North and South America, Asia and Africa, based on their nutritional and digestive benefits. Also, some of them are natural resources from which a variety of organic molecules can obtained, with high interest to the biotechnological industry (proteins, amino acids, vitamins, poliinsaturated fatty acids, pigments [1-4].

The high levels of desiccation and ultraviolet light irradiation severely limit the abundance and diversity of organisms at the Atacama Desert [5,6]. In contrast, biodiversity increases near and at the Andes Mountains highlands, from where Andean plants have been obtained and used historically by local communities for feeding, foraging and ethnomedicine [7-10]. In this context, Llayta is an indigenous foodstuff consumed by rural Andean communities in a practice that can be traced back to pre-Columbian times and still used today as a food additive at Arica y Parinacota and Tarapacá Regions in northern Chile, and at Tacna City in southern Peru (Figure 1) [7-13]. Llayta is the dry

biomass of colonies of a cyanobacterium of the genus *Nostoc*, and information on its isolation, taxonomy and biochemical composition is available (Figure 2) [4,13].

The *Nostoc* colonies are harvested manually, sun-dried, and sold at food markets in Tacna, Peru, and Arica and Iquique, Chile (Figure 1) and used as an ingredient in local dishes [4,13]. Our preliminary information indicated that this ancient culinary legacy is disappearing or it is already unknown by the urban communities from other areas of the region, especially among children; for example, at Antofagasta, the major coastal city in northern Chile, nearly 400 km south of Iquique (Figure 1). This apparent loss may be explained by considering the impact of new technologies on rural life, cultural changes and migration of young Atacameños people from rural regions into urban centers, as described for the Aymara people in northern Chile [14,15]. Thus, efforts to recover such old and nutritional food resource is in line with the worldwide need and search of new foodstuff, considering the increased demand for health foods, hunger in the underdeveloped world, low food production and the anthropogenic impact on environmental changes (global climatology, desertification, loss in biodiversity and degradation of ecosystems); in this context, FAO has projected an increase of 5% on the prevalence of undernourishment on South America [16]. Considering the biochemical information available on Llayta, we have conducted a complementary microethnographic study in order to learn how much people know about Llayta and about their perception on this ancestral Andean ingredient.

Ethnographic registries allow the collection of evidence and social representations from people on a particular subject; in turn, social representations can be considered appropriate approaches to discover what people think, believes, and know about their surroundings [17]. They also provide the opportunity to understand the interactions between how people see and fit in their particular interpretations of realities [18]. Thus, the knowledge people may have on a particular natural situation is a good example where social representations can be collected and interpreted from social and cultural perspectives [19]. Also, descriptions and references from participants are essential on the fields of representation for an event of ethnographic interest [20].

The ethnographic registry for the Llayta feeding practice can be supported by anthropological, socio-cultural and nutritional referents [21]. The first two referents would provide information on the meaning(s) of the term Llayta, the identification of sites where Llayta grows naturally, and where it is commercialized and consumed. This information should provide descriptions of their representations and evidence of direct or indirect knowledge about Llayta. The ethnographic goal for this study was to document the anthropological and cultural tensions found in these social representations and relate them to the knowledge the communities have of Andean algae and how they are valued. We propose that this approach will help us to begin to understand why Llayta has been consumed for centuries without untoward effects on human health, to suggest explanations for an apparent decrease in Llayta consumption, and to provide arguments and suggestions for the revitalization of this feeding practice.

2. Materials and Methods

The ethnographic study

The Theory of Social Representations and the construction of social worlds was the framework for the collected information, using heuristic criteria that support the subjectivity of participants [22], with respect to the type of knowledge and the social representations they have about Llayta.

The microethnographic study on Llayta collected social representations from interviewing participants and also drawings prepared by children. The main expressions about Llayta provided by participants were ethnographically registered and analyzed in order to explain the social worlds built by persons about their understanding of the surrounding natural, social and cultural environment [23]. Llayta pertinence and context were described, Llayta social representations were documented and direct or indirect knowledge on Llayta was analyzed from the social representations.

The sample for the ethnographic study

Observations were carried out during the first half of 2014, with participants from Putre (Chile) and Tacna City (Peru) (Figure 1). Putre is a rural village in northern Chile and near sites where Llayta grows and it is harvested. The participants selected were active members of their community, they were previously informed about our study and invited to participate anonymously in the interviews. The participants were 12 children (seven boys and 5 girls) and 7 middle age adults (four males and three females). In addition to an adult woman and a professional cook, twelve fourth-grade students (9-10 years old) and three teachers (two males and one female) were interviewed at a school in Putre. In Tacna, Peru, two salespersons at the food market were also included as participants in this study. The interviews and observations were conducted at sites normally used by the participants (street, market place, school, and hotel).

3. Results

3.1. The vocable Llayta: alternative names and their meaning.

Llayta is the Aymara name that refers to colonies of a cyanobacterium that grows in the Andes highlands and is consumed by rural and urban communities in South America (Figure 2). Alternative names for Llayta can be found in several languages: Spanish, Quechua, Kunza and Mapudungun (Table 1). The variety of names for the vocable Llayta stresses the cultural and anthropological diversity of representations associated with this feeding practice.

Table 1. The Llayta vocable: alternative names, their ethnic origins and meaning.

Name	Language	Comments	Reference
Cushuro Llullucha Murmuta Crespito Yrurupa		The author did not indicate the language of origin of the words.	[13]
Chuncoro Murmunta	Aymara	"Vna yerua negra de comer, frutilla fe llama Chun- coro,o Murmunta" (*edible black herb called Chuncoro or murmuta*)	[11]
Murmunta Chuncuru	Aymara	"(Prunus capulí Cav.) Cerezo. La infusión de las hojas de esta planta se usa como laxante. Sus frutos en Aymara se llaman". (*The leaves infusion is used as a laxative. Their fruit are named in Aymara*)	[25]

Cerezo	Aymara	"s. Cerezo. Plumas coloridas (10)" (*Colored feathers*)	[26]
Quchayuyo Murmunta	Aymara	"Bot. Cerezo. 2. Plumas coloridas, en Bolivia. Bot. Cochayuyo de agua dulce y del mar (p.e. alga comestible). Vte. QUCHAYUYU, MURMUNTA" (*Colored feathers in Bolivia. Bot. Macroalga from freshwater and sea water) (edible alga)*)	[27]
Chungullu	Quechua	"una cianobacteria comestible, se encuentra en riachuelos y lagunitas del bofedal ubicado entre Isluga y Colchane, en las cercanías de la frontera entre Bolivia y la Región de Tarapacá en Chile". (*an edible cyanobacterium, found in small rivers and lakes of wetlands located between Isluga and Colchane, near the border between Bolivia and the Tarapacá Region in Chile*)	[7]
Murmunta, Chuncuro	Aymara Quechua	"…, probablemente derivado de su morfología, hábitat y uso. En Aymara: hierba de las ciénagas como granillos negros". (*… derived probably from its morphology, habitat and use. In Aymara: black grain herb from wetlands*)	[7]
Luche (lucha)	Mapuche	"…, es un símil de una alga roja, marina y comestible". (*..., is like a marine edible red alga*)	[7]
Yullucha	Aymara	"De llullu para referirse a formas vegetales que empiezan a desarrollarse o se pasman". (*from llullu, to refer to plants starting or have stopped their growth*).	[8]
Tchuckula Chucula	Kunza	"Nombre atacameño de la cianobacteria comestible *Nostoc*. Planta acuática que hay en la cordillera". (*Name given by the Atacameños people to the edible cyanobacterium Nostoc. Aquatic plant found in the Andes Range*).	[8]
Yoyo	Aymara Quechua	"Cianobacterias del género *Nostoc*" (cianobacteria from the genus *Nostoc*).	[9]
Chungulle, chungullo	Quechua	"Cianobacteria acuática de bofedales, procedentes de Chela. Se usa para la comida (caldo con papas chuño). Se indicó que "hay uno que se come, es	[9]

		especial. Se lava y se seca". (*Aquatic cyanobacterium from Chela wetland. It is used as food, in soups with potatoes. It was mentioned that there is an edible one which is special. It is washed and dried*).	
Luche	Mapuche	"Símil de un alga roja comestible para designar a un alga verde-azulada de agua dulce, también comestible (*Nostoc*)". (*Similar to a edible red alga, it is used to indicate an edible, freshwater blue-green alga, (Nostoc)*).	[9]
Yoyo	Aymara	"Nombre de la cianobacteria *Nostoc* en Ollagüe, posiblemente aludiendo a su carácter comestible. Planta acuática comestible". (*Name given in Ollagüe to the cyanobacterium Nostoc, possibly due to its edibility*).	[9]

3.2. How much people know about Llayta?

All participants were interviewed to assess the type and level of knowledge they have on Llayta. Table 2 provides extracts of the answers given by 10 participants (7 adults and 3 students). Only 8 of the 19 participants had some perception about Llayta; the others (58%) lack any knowledge about it. The extracts in Table 2 corroborate that 7 participants have had personal experience of Llayta, i.e., direct knowledge with the colonies. Only one teacher expressed indirect knowledge about Llayta since the information was second-hand (Table 2). Compared with adult participants, the oral expression of knowledge used by the fourth-grade students from Putre to refer to Llayta were few or absent. When asked to draw an image of Llayta, 11 out of 12 students were willing to participate and their drawings were far from a correct depiction of the colonies (Figure 3). As an exception, one student emphasized that his mother used to cook Llayta and her drawing was the closest image to it (drawing K in Figure 3). Another student said: "*no, yo no*" (No, I do not [know Llayta]). A third student asked: "¿*Esa es la Llayta*? (Is this Llayta?), referring to a drawing made by another student. Table 2 and Figure 3 are compilations of the representations of Llayta obtained.

Table 2. Transcripts of interviews conducted to adult and students participants about their knowledge on Llayta

Informant	**Type of knowledge about Llayta**
	DIRECT KNOWLEDGE:
Saleswoman at the food market, Tacna, Peru.	"Ahí huapé súcuros; de Súcuro se trae; de súcuro de ahí al fondo pues; ahí arriba de Puno. Otros caballeros traen y ahí compramos; para picante. Si, picante prepara rico ahí comen". (*There, huapé súcuros; it is brought from Sucuro; down there; there, above Puno. Other people bring it and we buy it to make "picante" – a local dish; yes, a tasty picante is*

	prepared up there).
Salesman at the food market, Tacna, Peru.	"Esta es nacional; ésta la traen de Camaná. Esta es de río muestra -y muestra Llayta-, es más rica y esa es de mar -muestra cochayuyo; a tres soles. Esto jefe chángalo, muélelo, jugo". (*This is peruvian; it is brought from Camaná. This from a river, it is better and this one is from the sea; it is worth three peruvian new sols. Cut it and grind it for juice, boss*).
Professional cook, Chile.	"Para el consumo lo comemos eh; la Llayta es un tipo de alga de mar, de agua dulce y de mar también hay. Lo traen y lo hacen secar, y seco lo venden en los negocios; para cocinarlo se la remoja. Los peruanos los comen la Llayta y el cochayuyo. De la altura, de Puno, de Juliaca, bofedales eso está en la altura, en agua dulce en los ríos crece por ahí, bueno acá en la frontera con Perú, tripartito, Visviri, ahí también crece". (*We eat it for consumption, eh!; Llayta is a kind of marine alga; it is from freshwater and also marine. They bring it, dry it and sell it dried; They soak it before cooking. Peruvians eat Llayta and cochayuyo. From the highlands, from Puno, from Juliaca, from wetlands, which are in the highlands, in fresh water rivers, it grows around; right here, at the three parties' border, it also grows at Visviri*).
Middle age woman, Putre, Chile.	"Llayta, arriba hay, arriba; Parinacota, ahí si hay Llayta; Llayta come..., el segundo come bonito, así que coce para…, es como carne para…, se prepara eso como carne, como picante cocino acá. Ahí no se pa' qué sea, en Parinacota hay río de esa, ahí florece". (*Llayta is from up there; Llayta is at Parinacota; Llayta is eaten…, nice as a second dish…, it is cooked…, it is like meat…, it is prepared as meat…, I cook it here as picante. I do not know what it is used for over there; in Parinacota there is a river where it grows*).
Director, school at Putre, Chile.	"La Llayta es de por acá también. La Llayta se usa para el picante. La he comido no más, pero no sé qué me ha hecho; acá hacen mucho picante de pata con guata y Llayta. Hay en las lagunas, en Caqueña, en Tacna y aquí arriba Caquena". (*Llayta is from here too. Llayta is used in picante. I have only eaten it; I do not know the effects on me; people right here prepares a lot of picante with meat and Llayta. There are some ponds, in Casqueña, in Tacna and up here in Caquena*).
Teacher 1, at school in Putre, Chile.	"¡no! y los picantes de guatita, ahí le ponen la Llayta… es un musgo que se trae de Caquena; es un musgo parecido al cochayuyo, es la misma que venden en el agro". (*No! Llayta is added at the picante dishes…, it is a moss brought from Caquena; it is a moss similar to cochayuyo -marine macroalga, it is the same one that is sold at the food market*).
Student 1, at school in Putre, Chile.	"Ah! yo sí, porque mi mamá cocina. En Caquena". (*Mm! I do, since my mother cooks it. At Caquena…*).
	INDIRECT KNOWLEDGE:
Teacher 2 at school in Putre, Chile.	"Eh…Yo no las he visto pero sí me han dicho que ahí en la laguna está la Llayta" pero de verla no. En Caqueña en Tacna y aquí arriba Caquena". (*Eh…, I have not seen it, but I have been told that Llayta is at the pond, but I have not seen it. At Caquena, in Tacna and up here in Caquena*).

	WITHOUT KNOWLEDGE:
Student 2, at school in Putre, Chile.	"No, yo no". (*No, I do not… – know Llayta*).
Student 3, at school in Putre, Chile.	"¿esa es la Llayta?" (*Is that Llayta?*)

3.3. Fields of representations for Llayta

Table 2 shows the extracts from the ethnographic registries. These are the descriptions and references that sustain the field of representation of Llayta for 7 adult participants, which can be organized in the following 3 semantic fields:

3.3.1. What is it?

"Es un musgo que se trae de Caquena"; "es un musgo parecido al cochayuyo, es la misma que venden en el agro". "Ésta es nacional"; "la Llayta es un tipo de alga de mar, de agua dulce y de mar también hay".

"It is a moss brought from Caquena"; "it is a moss similar to cochayuyo [seaweed], it is the same that is sold at the market", "This is national"; "Llayta is a kind of marine alga; from fresh water and also from the sea".

3.3.2. Where is it from?

"De súcuro se trae", "De súcuro de ahí al fondo pues"; "Ahí arriba de Puno"; "ésta es de río"; "en Parinacota hay río de esa, ahí florece"; "la Llayta es de por acá también"; "Hay en las lagunas, en Caqueña en Tacna y aquí arriba Caquena"; "de la altura, de Puno, de Juliaca, bofedales eso está en la altura, en agua dulce en los ríos crece por ahí, bueno acá en la frontera con Perú, tripartito, Visviri, ahí también crece"; "Llayta, arriba hay, arriba"; "Parinacota, ahí si hay Llayta"; "la Llayta es de por acá también"; "en Caquena"; "Eh…Yo no las he visto pero sí me han dicho que ahí en la laguna está la Llayta, pero de verla no"; "en Caquena".

"It is brought from Sucuro"; "from Sucuro, back there"; "from Puno, up there"; "this is from a river"; "at Parinacota, there is a river where it blooms"; "Llayta is from here too"; "it is from ponds, at Caquena, in Tacna, and up here in Caquena"; "from highlands, at Puno, Juliaca, wetlands, this is at the highlands, it grows in freshwater rivers, well, here at the border with Peru, Visviri, where it also grows; "Llayta, it is up there, up high"; "Llayta is at Parinacota, for sure"; "Llayta is from here too"; "at Caquena"; "Eh…, I have not seen it but I was told that over there at the pond, there is Llayta, but I have not seen it"; "at Caquena".

3.3.3. What is it for?

"Para picante"; "si picante prepara rico ahí comen"; "los peruanos los comen la Llayta y el cochayuyo"; "Llayta come... el segundo come bonito, así que coce para… es como carne para… se prepara eso"; "como carne, como picante cocino acá"; "la Llayta se usa para el picante"; "la he comido no más, pero no sé qué me ha hecho"; "¡no! y los picantes de guatita"; "ahí le ponen la Llayta…"; "lo traen y lo hacen secar, y seco lo venden en los negocios para cocinarlo se la remoja"; "ah yo sí, porque mi mamá cocina".

"For making picante dish"; "yes, picante dish is good, they eat it"; "Peruvian people eat Llayta and cochayuyo"; "Llayta is for consumption…, so you cook it…, it is like meat…; like meat, like picante I cook it here"; "Llayta is used for picante"; "I have eat it but I do not know how to prepare it"; "it is brought here, it is dried and it is sold dry to restaurants"; "it is soaked before cooking"; "yes I know it, my mother cooks it.

When asked for places where Llayta can be found, one informant from Tacna, Peru, used the vocable "*chuncuru*" (an Aymara synonym for Llayta) instead of using "*Sucuru*", the right geographic site to where Llayta can be found. This mistake can be explained by the phonetic similarity between both words.

4. Discussion

4.1. Biochemical characterization of Llayta.

Future attempts to rescue and revitalize Llayta feeding as a traditional cultural practice can be supported by the ethnographic registries on the provided in this work, along with the available evidence on the biochemical composition and nutritional quality of Llayta; thus, a positive evaluation will give it value and it may revitalize its consumption [4]. The first contributions on the nutritional evaluation of colonies of *Nostoc* cells from Peruvian wetlands were published by Aldave-Pajares [11,12]. Later, Gómez-Silva et al. [13] registered a proximal composition and additional information for both the Llayta colonies, sold and consumed in Chilean territory, and also for the biomass from the cyanobacterium isolated from Llayta grown in the laboratory. Both studies are in agreement on the total protein and carbohydrate contents of the Andean *Nostoc* biomasses (30-35% and 50-60% of the dry weight, respectively). Also, the partial chemical content of *Nostoc* species found in Andean wetlands provided by Ponce [28] was similar to previous reports. More recently, Galetovic et al. [4] categorized 60% of Llayta aminoacids as indispensable. Also, the biochemical characterization of the Llayta biomass informed that 2% of dry weight were total lipids, 32% of total fatty acids were polyunsaturated fatty acids, the most abundant vitamin was vitamin E (4.3 mg%), the total polyphenols was 64 mg (as equivalent to galic acid), its antioxidant activity was 17.4 µmoles (as equivalent to Trolox), and total fiber content of 56% of dry weight [4]. Also, a genomic approach showed that the *Nostoc* species isolated from the Llayta colonies did not have a key gene needed for the biosynthesis of the cyanotoxin microcystin [4]. However, total arsenic content in Llayta biomass (9.2 ± 5.4 ppm) was a disturbing finding and these authors also stressed the need of further studies to evaluate other potentially toxic secondary metabolites on Llayta [4]. In fact, the growth of the isolated *Nostoc* strain from Llayta for massive production under controlled conditions will provide an arsenic-free biomass for new food products [29].

4.2. Microethnographic aspects

Nearly 40% of the participants declared they knew of Llayta and described it as a moss or an alga, without clarifying whether it grows in fresh water or seawater (Table N° 2). They also provide names for the sites of origin of Llayta: Parinacota, Putre, Caquena and Visviri in Chile, and Sucuro, Juliaca and Puno in Peru (Table 2, Figure 1). The participants knew that Llayta is used to prepare "*picante*", a typical dish from rural areas in the Andes. However, they were unaware of the nutritional properties of Llayta. The other 58% of the participants of this study, all fourth-grade students, did not know Llayta (11 out of 12 students). It is of considerable concern to confirm that a large proportion of the participants, all young people, did not know Llayta.

The cultural and anthropological tensions observed in this study stemmed from a lack of knowledge on the following subjects: (1) the conceptual limitations to explain what is an Andean alga or a microalga, (2) the geographic locations where Llayta can be found and commercialized, and (3) the weak descriptions used to explain how Llayta is cooked and on the benefits obtained from its consumption. This lack of knowledge on Llayta refers also to the way on how people perceive and

relate to the world around them, and to a probable extinction of an Andean cultural practice. The massive ignorance about Llayta found in discussions with children in Putre is a clear example of it.

Llayta is commercialized at food markets in Arica and Iquique, two major coastal cities in northern Chile; however, is not sold in Putre, a village at 2,500 m altitude and closer to sites where Llayta colonies are harvested. People in the coastal city of Antofagasta, nearly 400 km south of Iquique, completely lack knowledge about Llayta and its consumption as a food, as it was found with most of the children interviewed in Putre.

These anthropological tensions are indication of a paucity of information on Llayta. We urgently need to educate people about all the cultural and nutritional knowledge accumulated on Llayta, so that it can be properly valued as a safe, nutritional foodstuff.

5. Conclusions

Llayta consumption is a feeding practice with a know-how that has been transmitted through generations in the rural Andean world of South America. Nevertheless, this ancestral feeding legacy is being lost in young generations from northern Chile. New educational and anthropological strategies must be developed if there interest in promoting the preservation and value of this traditional feeding practice and a Andean cultural legacy.

Llayta is a nutritious dietary ingredient for human consumption. This is supported by centuries without negative epidemiological evidence and interdisciplinary studies that have combined biochemical information and microethnographic records. However, caution on the amount of Llayta consumed daily must be stressed, based on its arsenic content.

Under controlled conditions, the massive growth of the cyanobacterium isolated from Llayta would provide arsenic-free biomass for the formulation of new food products. This biotechnological approach would revitalize the use and add value to this ancestral food ingredient for the benefit of not only the Andean communities, but also making it available to whole population of South America and the world.

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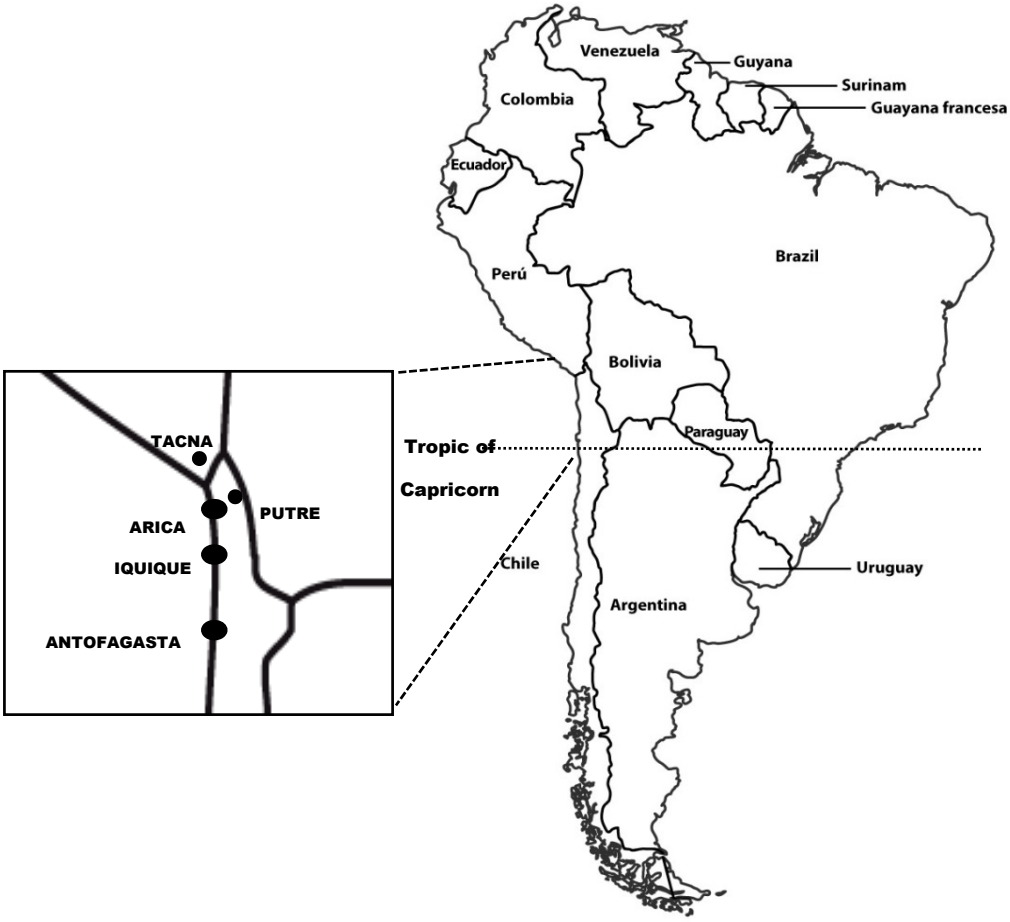
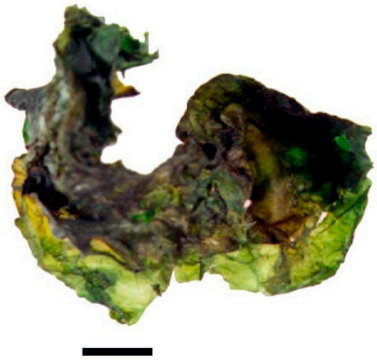


Figure 1. Locations, in southern Peru and northern Chile, where information on Llayta was acquired.



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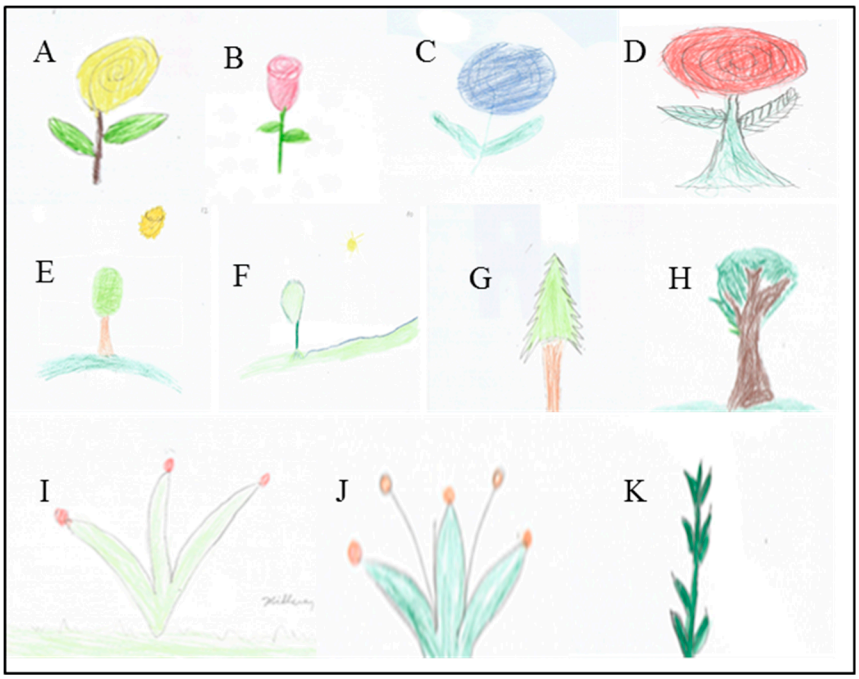
361 **Figure 2.** A dry colony of Llayta obtained at a major food market in Arica, Chile. (Bar: 1 cm).



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363 **Figure 3.** Drawing prepared by 11 fourth-grade students at a school in Putre, Chile, who were asked
364 to portray Llayta. Descriptions given by each student were A: a yellow flower; B: a rose; C: a flower;
365 D: a red and green flower; E: a tree; F: a tree; G: a pine; H: a tree; I: a flowering cactus; J: a cactus with
366 flower; K: a cactus.