

SCREENING OF YACON (*Smallanthus sonchifolius*) IN THE BILBAO RIOJA AND CHARCAS PROVINCES OF DEPARTAMENT POTOSÍ IN BOLIVIA

FERNÁNDEZ C.E., PÉREZ V.W., ROBLES C.H., VIEHMANNOVÁ I.

Abstract

The major objective of this work was to complement the existing studies of yacon (*Smallanthus sonchifolius*) in Bolivia. We have made a screening of the actual situation of the crop (population, exploitation, commerce) in the Bilbao Rioja and Charcas provinces of department Potosí; a total area of 656 sq.km including 16 villages in above the sea height ranging from 2 680 to 3 776 m.

Of the total 2 435 families in the 16 villages, 51 families grow yacon in small areas and for their own needs. The local people recognize two local cultivars of yacon: *k'ellu* (yellow) and *yurak* (white). Depending on major colour of cortical part of tuberous root (of pulp), the classification into 5 morphotypes was made: white, crystal white, clearly violet, orange and yellow. The white morphotype was the most spread one in the monitored areas; it is grown in 13 villages of the total 16; the yellow ecotype is grown in 10 villages; the crystal white one in 3 villages, the orange and the clearly violet ones in 1 village.

Key words: Screening, yacon, *Smallanthus sonchifolius*, growth, morphotypes, Potosí, Bolivia

INTRODUCTION

Ands represent one of the most plentiful genetical world's centres, their fytogenetical biodiversity results from various climate environments existing in this large mountain system; the Ands area offers hundreds of original plants species, which were domesticated by Ands farmers during recent years. Some of them, eg. potatoes (*Solanum tuberosum*), corn (*Zea mays*) and others are known all over the world and plays the general role in nourishment of many inhabitants. However, most of them, and typically also yacon (*Smallanthus sonchifolius*), is not known outside the Ands area.

Presently, yacon is grown in regions from Venezuela (Mérida area) down to North Argentina (Jujuy, Salta); between 1.000 and 3.750 above the sea height. In era of Inks it was probably one of the most grown crop (Rea, 1997). In Bolivia and Peru is known under various names, yacón, llakjum (Quechua), aricoma (Aymara), in Equador as jícama or yacón, in Colombia as arboloco and jiquimilla, in Venezuela jíquima and jikimilla, at North Argentina (Jujuy, Salta) as llacjon and llag'on.

In 1981 yacon was declared an endangered species by FAO (Food and Agriculture Organization), because until the year it was permanently close to disappear likely to other crops. From this point FAO decided to support research and development of yacon through ICFR (International Council for Fitogenetic Resources).

Interest in yacon was driven by discovering saccharides in tuberous roots (mostly fructans) and an alleged medicinal ingredient in leaves. That is why there is so much attention payed to yacon as a source of material for production of natural sweetener and syrup

convenient especially for diabetics – as increases number of people suffering from civilization diseases (diabetes, overweight etc.). Besides that, yacon could be useful as a feeding crop, for its leaves contains 11-25 per cent of nitrogen dry matter.

Outside the Ands area, yacon is grown in New Zealand, where it is commonly sold in supermarkets (Endt, 1983). Yacon was introduced to Japan in two ways: first, in 70s through Korea, where yacon is exploited as a resource for reaching high age; and the second way led from New Zealand in 1985 (Anonym). The total area under cultivation is over 100 ha (Frček, 1996). At beginning of 90s yacon was introduced in Brasil, state Sao Paulo, as an „*in natura*“ nourishment with probably significant medicinal consequences; while at present fresh tuberous roots are sold as freeze-dry „chips“ and dried leaves for preparation of medicinal antidiabetic tea are sold as well (Grau et al, 2001). Yacon has also been introduced in the Czech Republic, where it has been grown since 1994 at two sites; at the experimental farm of Czech Agricultural University in Prague and at the Research Insitute in Havlíčkův Brod. Growing yacon has also been extended in the United States, Russia, Estonia and Taiwan. Focus on its growing technologie has been other matter of researchers' interest (Havrland, 2002).

In Bolivia, the highest concentration of yacon finds out at 2.500 m. above the sea level. It is grown in departments La Paz (provinces Camacho, Inquisivi, Larecacha, Loayza, Muñecas, Murillo, Nor Yungas, Saavedra, Sud Yungas), Cochabamba, Chuquisaca, Santa Cruz and Tarija (Rea, 1994). It is recommended to continue mapping the area where it is grown or grows uncultivated to conduct more quality inventory

making the research easier. From this point, our objective was focused to complete existing studies of this kind in Bolivia. Screening current situation about this crop (population, exploitation, commerce) was made in the Bilbao Rioja and Charcas provinces of department Potosí.

MATERIAL AND METHODS

Plant materials

Yacon (*Smallanthus sonchifolius* Poeppig & Endlinger) H. Robinson of Asteraceae family is a perennial plant. The stem is created by the perennial underground part and part of above-ground one year shoots which dries after fading away. The underground part of the stem is a very irregular, very branched mass which in case of older plants can be as wide as 0.5 m. Numerous roots grow from this part as well as above-ground shoots, while some of them strengthen and form the most important, eatable part. Some of the roots begins to increase from the central part already when they reach as short as 10 mm length and continue to be longer and wider until they create a spindle-shaped body 100-200 mm long and 30-80 in diameter. At the beginning, the tuberous roots have a sharp ending and they are connected with the stem by a very narrow neck while the peak is conical, gradually it fills up and after a certain period the tuberous root is elipsoidal or nearly spherical.

Above ground cylindrical stems of green colour with irregular dark violet marks reach height up to 3 m and are covered by mild and rare fledge. During maturity they are hollow. Two narrow and soft leaves lead from each node of the above ground stem. Lower leaves are broadly ovate and hastate or subhastate, connate and auriculate at the base; upper leaves are ovate-lanceolate, without lobes and hastate base; upper and lower surfaces are densely pubescent.

The inflorescence is terminal, composed of 1-5 axes, each one with 3 capitula; peduncles densely pilose. Phyllaris 5, uniseriate and ovate. Flowers are yellow to bright orange; ray flowers are 2 or 3-toothed, depending on the clone, to 12 mm long x 7 mm broad, pistillate; disc flowers about 7 mm long, staminate. Immature cypselas are purple, and turn dark brown or black at maturity (Grau & Rea, 1997).

Project Methodology

The methodology of the project was based on:

- a) Obtaining direct information about morphotypes of yacon from local farmers growing yacon (maintaining *in situ*), about way of growing (planting and harvesting period), use, way of consuming and commerce.
- b) Direct evaluation of yacon; evaluation of tuberous root (skin colour – epidermis, pulp, number of roots per plant), the above ground part of the plant (plant height). The evaluation was made within the period of flowering (in May) of randomly chosen plants, average 3-10 plants at each family growing yacon.
- c) Monitoring, eg. sites where yacon is grown (garden, kanchón – the bordered field etc.), species which are grown together with yacon, types of yacon – eg. classified according to taste.

General characteristics of the researched area

The project methodology was undertaken at the north of Potosí department, in villages of Bilbao Rioja and Charcas provinces. Geographically they are located between 65° 45' 31" and 66° 03' 29" East longitude, and between 18° 01' 01" and 18° 08' 47" geographical North, on the average above sea level of 3097 m, in agroecological area called Quechua. The average annual environmental temperature in the area ranges between 10°C and 20°C. The rainy spell begins in November and lasts till March. The annual precipitation are between 500 and 600 mm.

Researched villages

The screening yacon was conducted on the total area of 656 sq. km. Of this 432 sq. km in the Bilbao Rioja province including 10 villages, and 224 sq. km in the Charcas province including 6 villages (tab. 1)

Tab. 1: Researched villages

Area (Province)	Village	height (above sea level)	No. of families
BILBAO RIOJA	Carpacayma	3 352	21
	Collpa Pampa	2 775	20
	Challa Villque	2 978	32
	Lujuni	3 378	52
	Niño Kollu	2 964	25
	Quirusillani	3 312	44
	Tuquiza	2 989	35
	Villa Paraíso	2 815	20
	Yanayu Chico	2 834	22
	Yanayu Grande	2 680	24
CHARCAS	Ararian	3 075	20
	Estrillani	3 085	20
	Hacienda Loma	2 748	15
	Vaquería	3 616	20
	Villa K'asa	3 179	30
	Yunguma	3 776	20
Total	16 villages	av. 3097 m	420

Source: The own project of the authors

RESULT

The species of *Smallanthus sonchifolius*, is widespread heterogenously in 16 researched villages of the Bilbao Rioja and Charcas provinces. It is known as yacones, but we may consider this name as a locally adopted plural name herited from the Spanish name of yacón . The highest number of plants was identified in village of Ararian (tab. 2), with 370 plants. Tuquiza is a village with the highest number of families growing yacon, with 7 families. The local farmers witnessed that in the past the cultivated areas of yacon were larger, but gradually they decrease, because growing yacon has not been a priority.

Local people recognize two local cultivars: k'ellu (yellow) and yurak (white), which are grown for own consumption on small fields; in gardens (50 %) and on kanchones (fields bordered with stone walls), 50 %; mixed crops (81 %) with vegetables (onion, beetroot, salad, radish, cabbage a carrot), cereals (barley, wheat and corn) and fruit trees (peach and opuntia); only approximately 19 % farmers grow yacon without mixing it with other crops. Depending on taste there are two types of yacon (sweet and dim). Generally sweet yacon is connected with yellow and the dim one with the white cultivar.

Yacon reproduces vegetatively through rhizom, which is left in the soil after harvest of the tuberous roots. The roots are harvested gradually, according to consumption needs, from June, mainly in July and at the beginning of August. Fields are not prepared specifically for

planting; similarly to other tubers and root crops they are planted in ridges; they are fertilized with organical dung. The whole system of growing is organical. The early growing is fast and except for weeding out, which is done in a period of emergence, and spudding, when the plants reach 30 cm of height, it requires just a little attention. Irrigation is limited to lack of water in the area; this factor is one of major reasons for no further extention of the cultivated areas.

Yacon has been recognized by local people as fruit, a delicasy for children. Generally it is used as a enfreshing food, mainly during long journeys; in several villages a powdered wheat flour, called pito, is mixed up with cutted tubers to make chewing easier for people without teeth – mainly older persons; other way of using is not known. Farmers of the researched villages did not know of benefits of yacon. They consume raw and striped tuberous roots; before eating the root are displayed onto the sun for 4-7 days to increase their sweetness (Enzymatic processes in tuberous root ferments a content of fructose nearly ten times, glucose three times, while saving content od saccharose similarly to freshly harvested roots and lowering of water contents by 8 %), but roots harvested later are not necessary to display onto the sun. Yacon is grown for own consumption mainly, its commerce potential is minimal; only occasionally it serves as a product for exchanging with another products, for example potatoes, wheat, vegetables etc. Of 51 families growing yacon, only one family (a farmer) grows it commercially, in Ararian village (the Charcas province); the same family maintains the highest

number of plants (tab. 2). The family sells yacon in Toro Toro town, during the celebration of Saint Santiago (July 25), priced at 0,8 Bs (bolivianos, 7,5 = 1 USD) per 1 kg (approx. 3,2 Kč per 1 kg). The yellow cultivar is the most popular for its sweetness.

From evaluation we received the following results:

According to a cortical part of the tuberous root (pulp) there was determined 5 morphotypes (tab. 2):

1. Morphotype white
2. Morphotype crystal white
3. Morphotype clearly violet
4. Morphotype orange
5. Morphotype yellow

The white morphotype has the highest ratio in the researched areas; it is grown in 13 villages of total 16; the yellow morphotype is grown in 10 villages; The crystal white one in 3 villages, the orange and clearly violet ones in one village (tab. 2).

Brix grades (⁰Bx) at each morphotype: yellow (av. 12,00), orange (14,00), white (11,50), crystal white (10,50), clearly violet (12,00); give us information about soluble matter (saccharides) in tuberous roots. Based on this data we can identify two groups of morphotypes: sweet (with content of soluble matter higher than or equal to 12⁰ Brix) and dim group (with the content lower than 12⁰ Brix), according to classification used for fruits (Anonym 1999). Yellow, orange a clearly violet morphotypes would be identified in the „sweet“ group, while white and crystal white morphotypes in the „dim“ group.

Number of tuberous roots per one plant differs across various morphotype and in the frame of one morphotype from 7 to 15 pieces (tab. 2, 3).

Based on total number of plants (2,435) and distance of planting (60 x 60 cm), commonly used at all 16 villages, the total area under cultivation was estimated to 877 sq. m.

Tab. 2: Evaluation of yacon

Prov.	Village	No. of families (a)	No. of plants (b)	Morphotypes (c)	No. of roots (d)	⁰ Bx (e)
BILBAO RIOJA	Carapacayma	3	108	Yellow	7	11,50
				White	9	10,50
	Collpa Pampa	2	100	Yellow	7	11,25
				White	8	10,75
	Challa Villque	6	60	White	8	12,50
				Lujani	1	50
	Niño Kollo	1	70	White	7	11,25
				Quirusillani	3	160
	Tuquiza	7	248	Yellow	12	11,00
				White	9	10,50
	Villa Paraíso	3	250	Crystal White	9	10,25
				Clearly Violet	11	12,00
	Yanayo Chico	5	120	Yellow	9	12,00
				White	10	11,50
Yanayo Grande	6	300	Yellow	12	13,00	
			Orange	14	14,00	
Ararian	1	370	Yellow	9	12,00	
			White	10	11,75	
CHARCAS	Estrillani	3	150	Yellow	15	11,50
				White	10	10,25
	Hacienda Loma	3	170	White	9	11,75
				Yellow	8	12,25
	Vaquería	2	90	White	9	11,50
				Crystal White	12	10,50
	Villa K'asa	3	69	Yellow	8	12,25
				Crystal White	10	10,50
Yunguma	2	120	Yellow	12	11,75	
			White	11	11,00	

total	16 villages	51	2 435	Yellow (10x)	7-15	11,00-13,00
				Orange (1x)	14	14,00
				White (13x)	6-11	10,25-13,00
				Crystal White (3x)	9-12	10,25-10,50
				Clearly Violet (1x)	11	12,00

Notes:

- (a) Number of families in a village growing yacon.
- (b) Total number of plants grown in a village.
- (c) Morphotypes of yacon, according to pulp colour
- (d) Average number of tuberous root on a plant.
- (e) °Bx (Brix grade) determines a concentration of soluble matter (sacharides) in yacon's tuberous root.

Tab. 3: Differences in botanical characteristics and Brix grades among morphotypes.

Morphotypes	Plant height (m)	No. of roots per plant	Root size (length/width) (mm)	Brix grades (°Bx)
1 White	1,26	10,10	15,4/6,0	11,50
2 Crystal white	1,05	10,40	14,2/6,0	10,50
3 Clearly violet	0,93	11,00	14,4/8,3	12,00
4 Orange	1,68	14,00	20,7/13,5	14,00
5 Yellow	1,19	10,80	15,0/8,8	12,00

Notes: The evaluation was made within the period of full flowering (May).

CONCLUSION AND RECOMMENDATIONS

In the researched area yacon is considered a fruit and is grown for own needs on small fields (family gardens). It is in danger of possible disappearance, because its cultivated area has been gradually decreasing and for local farmers it does not represent a priority crop – mainly for poor knowledge of its nutrition, medicinal and feeding significance.

Five morphotypes have been identified based on pulp colour of tuberous root, which is a genetic characteristics enabling to receive local names for individual morphotypes: white, crystal white, clearly violet, orange and yellow.

Based on a taste the local farmers recognize two groups of yacon: sweet and dim. Mostly, the sweet yacon means the yellow morphotype (k'ellu yacón) and the dim one means the white morphotype (yurak yacón). According to classification based on a content of soluble matter (Brix grades), we came to the same conclusion: yellow, orange and clearly violet morphotypes are classified into the sweet group, while white and crystal white into the dim group.

Generally in Ands as in the place of its origin and especially in the researched area, there might be morphotypes with unexpected quality. So far there has been no knowledge of improved cultivars, and that is why the local cultivars might be declared as the best ones. Undoubtedly, the major priority in researching

yacon is to maintain it (*in situ* growing) and re-introduce local cultivars into a crop.

Firstly, growing yacon must be supported through distribution of knowledge about significance of the crop. Training agricultural technical workers must be supported as well, consulting should be realized directly in production family units (father, mother, son) for better effectiveness.

It is recommended to add further research and systematical collection of wild (if exist) and cultivated forms of yacon.

Yacon has a chance to become an alternative crop, not only in the researched area, but also in the whole Ands area.

ACKNOWLEDGEMENT

Research Project MSM 51130-51-3201 of the Tropical and Subtropical Institute of the Czech University of Agriculture in Prague supported this work.

REFERENCES

ANONYM, 2002: Informe sobre el uso del yacón en Japón. <http://www.yaconcha.com>
 ANONYM, 1999: Mora. Boletín CCI:SIM. Perfil de producto. No 4. Abril-junio 1999.

- <http://www.cci.org.co/publicaciones/perfil%20de%20producto/perfilmora4.html>
- ENDT A., 1983: Two new vegetable crops from the babaco enthusiasts. Landsedt New Crop Development, Oratia.
- FERNÁNDEZ C. E., 1997: Utilización del cultivo de tejidos en el yacón (*Polymnia sonchifolia* Poeppig & Endliger). Trabajo doctoral. Universidad checa de agricultura de Praga – Instituto de agricultura tropical y subtropical, República Checa. En idioma checo.
- FRČEK J., 1996: Jakon (*Polymnia sonchifolia*) – nová kořenová zelenina v dietě diabetiků. Seminář: Alternativní a maloobjemové plodiny pro zdravou lidskou výživu. Listopad, 1996. Praha – Ruzyně.
- GRAU A., REA J., 1997: Yacón – *Smallanthus sonchifolius* (Poepp. & Endl.) H. Robinson. In Hermann M., Heller J., 1997: Andean roots and tubers: Ahipa, arracacha, maca and yacon. Promoting the conservation and use of underutilized and neglected crops. 21. Institute of Plant Genetic and Crop Plant Research, Gatersleben/ International Plant genetic Resources Institute, Rome, Italy.
- GRAU A., KORTSARZ A. M., AYBAR M. J., SÁNCHEZ R. A., SÁNCHEZ S. S., 2001: El retorno del yacón. Ciencia Hoy, Revista de Divulgación Científica y Tecnológica de la Asociación Ciencia Hoy. Volumen 11 – No 63 Junio/Julio 2001.
- HAVRLAND, B., KAPILA, P., 2002: Agricultural Technology Management Program „AGRO-EXPERT“. Agric. Trop. Subtrop. 35, p. 3 – 14.
- INE (Instituto Nacional de Estadística), 1992: INE, 1992. <http://www.ine.gov.bo/cgi-shl/PIWDGEO.EXE/GEONIVEL>

*Received for publication on February 9, 2004
Accepted for publication on November 16, 2004*

Corresponding author:

Ing. Eloy Fernández Cusimamani, PhD.
Czech University of Agriculture, Prague
Institute of Tropics and Subtropics
165 21 Prague 6 – Suchbát, Czech Republic
e-mail: eloy@itsz.czu.cz

