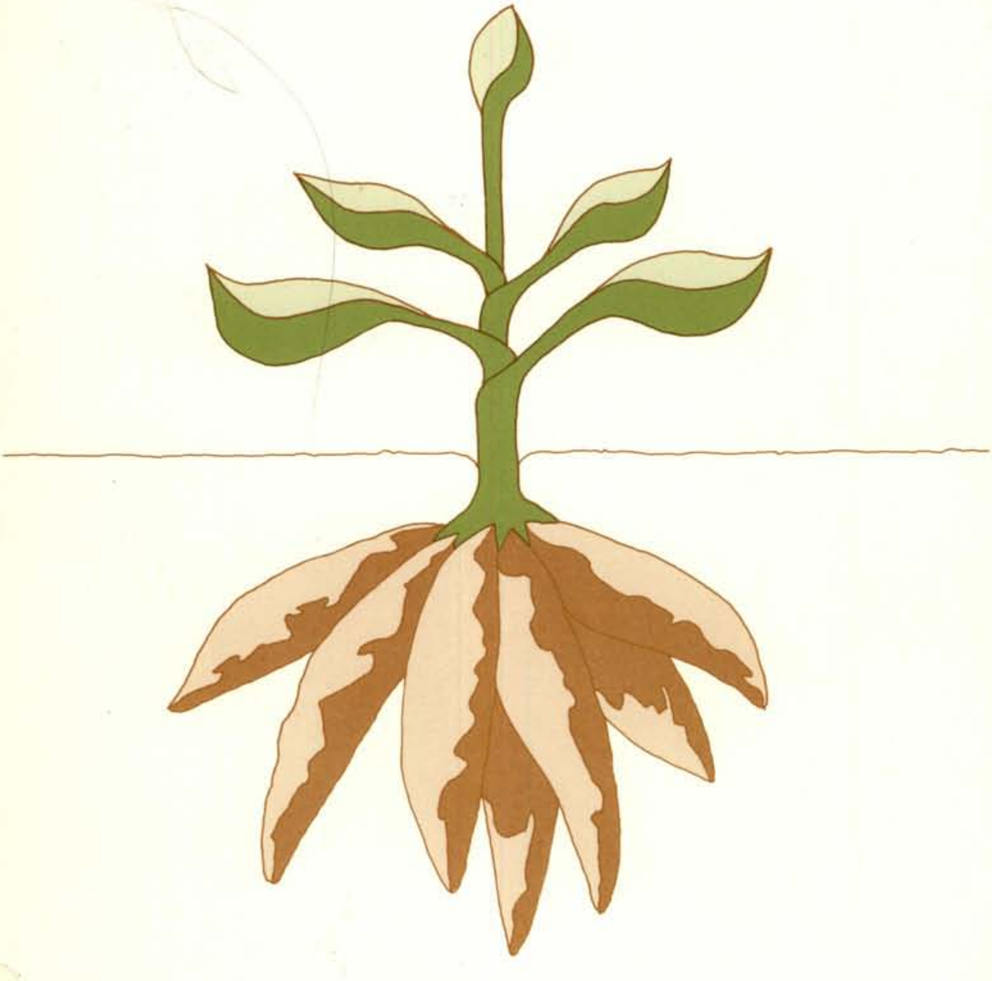
IDRC-080e

edings of the Fourth Symposium of the ational Society for Tropical Root Crops

Held at CIAT, Cali, Colombia, 1-7 August 1976

Edited by James Cock, Reginald MacIntyre, and Michael Graham



The International Society for Tropical Root Crops in collaboration with
Centro Internacional de Agricultura Tropical
International Development Research Centre
United States Agency for International Development

IDRC-080e

PROCEEDINGS

of the

FOURTH SYMPOSIUM

of the

INTERNATIONAL SOCIETY FOR TROPICAL ROOT CROPS

held at CIAT, Cali, Colombia, 1–7 August 1976

Edited by
James Cock, Reginald MacIntyre, and Michael Graham

The International Society for Tropical Root Crops
in collaboration with
Centro Internacional de Agricultura Tropical
International Development Research Centre
United States Agency for International Development

Postal Address: Box 8500, Ottawa, Canada K1G 3H9
Head Office: 60 Queen Street, Ottawa

Cock, J.
MacIntyre, R.
Graham, M.
International Society for Tropical Root Crops
CIAT
IDRC
USAID IDRC-080e
Proceedings of the Fourth Symposium of the International Society for Tropical Root Crops held at CIAT, Cali, Colombia, 1–7 August 1976, Ottawa, IDRC, 1977. 277 pp.

/ IDRC pub CRDI /. Proceedings of a symposium on / root crop / / plant production / in the / tropical zone / – includes / list of participants /, / bibliography/s, and / statistical data /.

UDC: 633.4(213) ISBN: 0-88936-115-0

Microfiche Edition $1

CONTENTS

The Utilization of "Bitter" Potatoes in the Cold Tropics of Latin America

J .A. Christiansen and N. R. Thompson[1]

This report is part of a study started with "bitter potatoes" in 1971. It was completed in the Physiology Department of the International Potato Center in 1976. The purpose of the investigation was to identify: (1) the yield potential of "bitter potatoes"; (2) the nutritional value of "chuño" (dry potato); and (3) its use as a source of protein and calories in the countries of Latin America.

Potatoes are an important part of the diet in the Andean zone. The per capita consumption in Peru reaches 142 kg/year. In the high mountain plains, the consumption of potato increases to 288 kg/year, including the use of chuño.

These high mountain plains are considered to be the centre of origin of the potato and it is in this area that the greatest variability of cultivated and wild potato species is found. Among the cultivated species are found the bitter potatoes, *Solanum juzepczukii* and *S. curtilobum*, a group in which little work on genetic and nutritional aspects has been done. They are planted at altitudes of 3500–4500 m, in areas of deep frost.

The bitter taste of the roots results from their high glycoalkaloid content. Bitter potatoes are resistant to low temperatures and are used by farmers only for making chuño. Cultivation of this crop goes back to the pre-Inca period and is continued today by farmers, who generally obtain low yields due to a lack of technology. These varieties respond favourably to fertilizer application.

The method for processing chuño was well known by the Inca culture. They used it as their main source of protein and calories. In 1550, Cieza de León wrote that many Spaniards became wealthy by transporting and selling chuño in the Potosí mines of Bolivia. Cobo, in 1653, mentioned that there were bitter potatoes that were not acceptable for consumption fresh, but that they were good for chuño and were so hardy that even though they were stored for many years they did not rot or deteriorate. In 1925, Saffort reported that he had found chuño, in perfect condition, in some pre-Inca tombs in the coastal region.

Pre-Spanish Peruvians had a very rich diet from plant sources, consisting of 88 g of protein and 2400 calories/capita per day. Included in this diet were both fresh and dried potato.

The possibility of storing "bitter potatoes" for several years in the form of chuño makes them an important source of proteins and calories. They are therefore more important than corn and wheat, which cannot be cultivated at high altitudes. Chuño, stored from the previous year, may make up close to 80% of the diet of the inhabitants of the high Andean zone if heavy frosts damage other crops.

Preparation

Chuño preparation requires the climatic conditions that exist in the higher plains of the Andes, with very low night temperatures (−15 to −20 °C), very high daytime temperatures (20–25 °C), and a low relative humidity (30–40%), especially during the months of June and July.

After harvesting, the potato is allowed to freeze and thaw alternatively, during 3 nights and 3 days. The roots are then squeezed to extract as much water as possible (eliminating a large percentage of the harmful gly-

[1]Visiting Scientists from Ministry of Nutrition, National Potato Program, Lima, Peru, and from Michigan State University, Department of Food Science, East Lansing, Michigan, USA, respectively, to The International Potato Center (CIP), Apartado Postal 5969, Lima, Peru. Research carried out as part of the PhD thesis of the senior author.

Table 1. Effect of fertilizer on the yields of white chuño, black chuño, and dry potato from clones 702445, 702443, and 702444.

Fertilizer (N-P-K)	Fresh potato (t/ha)	White chuño (t/ha)	White chuño (%)[a]	Black chuño (t/ha)	Black chuño (%)	Dry potato (t/ha)	Dry potato (%)
702445							
0-0-0	12.5	2.5	20	2.6	21	3.0	24
80-80-50	23.0	4.6	20	4.8	21	5.5	24
160-160-100	28.4	6.0	20	5.9	21	6.8	24
240-240-150	34.0	7.0	20	7.1	21	8.1	24
702443							
0-0-0	8.0	1.8	20	1.9	24	2.0	25
80-80-50	18.0	4.0	20	4.3	24	4.5	25
160-160-100	20.0	4.4	20	4.8	24	5.0	25
240-240-150	21.0	4.6	20	5.0	24	5.2	25
702444							
0-0-0	8.8	2.5	29	2.6	30	2.6	31
80-80-50	20.5	6.0	29	6.1	30	6.3	31
160-160-100	23.4	6.8	29	7.0	30	7.3	31
240-240-150	24.0	7.0	29	7.2	30	7.5	31

[a]Percentage production of processed product starting from fresh potato.

coalkaloids). At the same time, however, part of the protein value is also lost by leaching.

After 15 days of natural drying in the field, black chuño is obtained. It is a dried, brown, almost black, root with a very strong flavour. To obtain white chuño it is necessary to soak the roots in running water, after an alternate freezing and thawing for 4 weeks. The roots are then washed and peeled in the river. After drying in the sun for 15 days the final product is obtained, which has a lower protein content than black chuño.

To obtain dry potato, the harvested roots are boiled for 25–30 min, peeled, and then dried in the sun for 12–15 days. They are ground before use. For dry potatoes in chip form, after cooking and peeling, the roots are cut into 1- to 2-mm thick slices that are dried in the sun for 10–12 days.

Results

Table 1 shows the effect of fertilizers on yield. Fertilization does not influence the relative proportion of the production of chuño and dry potato. It only increases as a direct consequence of the effect of the fertilizer on the production yield of fresh potato. A higher percentage of yield is found in dry potato, processed from fresh potato.

Table 2 shows the result of chemical analysis of the processed products from bitter potatoes. A difference in crude protein content with regard to true protein can be seen.

In white chuño there was a loss in total protein of 67–83%, in black chuño this loss ranged between 18 and 30%, and in dry potato there was a loss of only 1–20%. These results show that loss of nutritional value depends on the processing system and on the variety. A positive constant tendency is noticed in the yield of clone 702444 for the processed products, with the exception of white chuño.

Table 3 shows the biological and nutritional value contained in 1 kg of each of the processed products in dry matter, crude protein, calories, and usable protein, as well as the amount (g), that should be consumed to acquire the daily nutritional requirement of 37 g of protein and 3000 calories.

Comparing the nutritional value produced by 1 kg of each of the processed products, it can be seen that all three have a considerable amount of dry matter, but in crude protein, black chuño and dry potato have four times as much as white chuño. All three products have more than 3000 calories; however, in usable protein, white chuño has a low content (14 g), whereas dry potato has a high content (66 g). To obtain 37 g of protein daily, one must consume 1502 g of white chuño, 414 g of black chuño, or 376 g of dry potato. Dry potato and black chuño are the products that have the best balance of nutritional value al-

Table 2. Chemical analyses of processed bitter potatoes.

Clone	Dry matter (%)	Total nitrogen (%)	Crude protein	True protein	Biological value
Fresh potato					
702445	21.0	2.14	13.7	5.3	45
702443	21.0	2.22	13.9	6.2	48
702444	33.0	1.54	9.8	5.2	45
White chuño					
702445	90.2	0.37	2.4	2.0	55
702443	89.5	0.45	2.8	2.5	54
702444	89.8	0.50	3.1	2.6	58
Black chuño					
702445	94.6	1.52	9.5	3.1	42
702443	94.7	1.79	11.2	4.7	54
702444	95.0	1.30	8.1	4.1	63
Dry potato					
702445	90.7	1.83	11.4	5.6	68
702443	92.1	1.86	11.1	6.1	63
702444	95.3	1.52	9.5	5.7	71

NOTE: Clone = entry number of material cultivated in the Germplasm Bank of the International Potato Center, Lima, Peru; dry matter = weight of freeze dried sample; total nitrogen obtained by micro-Kjeldahl; crude protein = total nitrogen × 6.25; true protein = residue of alcohol washing at 80% of total nitrogen; and biological value obtained by the *Stroptococcus zymogenes* microbiological method taking as reference the biological value of casein (100).

Table 3. Nutritional value of 1 kg freeze dried sample of products processed from bitter potatoes.

	Biological value	Dry matter (g)	Crude protein (g)	Calories[a]	Usable[b] protein (g)	Amount (g) needed for dietary requirements[c]	
Fresh potato	49	250	79	840	14	1231	3571
White chuño	56	900	25	3597	14	1502	834
Black chuño	53	950	90	3797	48	414	791
Dry potato	67	930	98	3708	66	376	809

[a]Obtained by ((yield × % solids × 4)/100).
[b]Obtained by ((crude protein × B.V.)/100).
[c]Dietary requirements = 37 g of protein and 3000 calories.

though dry potato has the largest protein content.

The processing of potatoes, cheaply and at the small farmer and community level, is extremely important in cold tropical regions to help relieve the problems of storage, transportation, and marketing, and consequently of food supply. The nutritional aspect of these products is very important in the cold regions of the tropics because the intake of proteins and calories must be increased.

In the processing of white chuño, losses of 7.7–14.7 mg of total glycoalkaloids occur during freezing and thawing. During soaking, losses of between 14.4 and 22.2 mg glycoalkaloids are recorded.

Table 4 shows the total glycoalkaloids content in milligrams per 100 grams fresh potato contained in each of the products processed from bitter potatoes. The low content of glycoalkaloids in white chuño and dry potato is shown. Considering the maximum tolerance for human consumption, fresh potato of this species cannot be eaten. Even black chuño would barely be palatable. On the other hand, dry potato is well within the limit of palatability.

During the processing of black chuño, losses

Table 4. Total glycoalkaloid content[a] in products processed from bitter potato clones.

	702443	702444	702445
Fresh potato	30.4	34.3	30.0
White chuño	4.2	4.4	2.5
Black chuño	18.0	16.5	14.9
Dry potato	6.0	6.6	6.1

[a]Expressed as milligrams of total glycoalkaloids per 100 g of fresh potato. The maximum tolerance for human consumption is 20 mg glycoalkaloids per 100 g fresh potato.

are produced during freezing and thawing of 9.2–10.4 mg of glycoalkaloids, and, during drying, between 3.3 to 8.3 mg. It is thought that this is due to an enzymatic process. During the processing of dry potatoes, losses during cooking of the root vary between 23.9 and 27.7 mg of total glycoalkaloids.

The processing of chuño requires special climatic conditions, such as those found in the Andean highlands. However, dry potato can be produced in almost any potato producing area in the world. It thus has a tremendous potential as a source of protein and calories. The cheap processing of potatoes is very important in helping to relieve problems of storage, transportation, and marketing and, consequently, the problem of food in developing countries.

Cassava Utilization in Agro-Industrial Systems

D. J. McCann[1]

Cassava is an ideal crop for use in agro-industrial systems, where agriculture and industry combine to achieve the greatest efficiency in utilization. The basic concepts for a correctly designed agro-industrial system based on cassava are explained, and those industrial processes with the greatest potential are discussed. If research and development on both the "agro" and "industrial" fronts can proceed together, then cassava could be a major provider of food, chemicals, and energy within a decade.

Over the past few years considerable resources have been allocated to research on cassava agronomy (at CIAT, IITA, CTCRI, etc.). This has resulted in a yield potential of 40–50 t/ha even on rather infertile soils with limited inputs and without irrigation. Although research on cassava utilization has unfortunately lagged behind these agronomic developments, nonetheless there is every indication that cassava could become a major provider of food, energy, and chemicals throughout the tropical world once these yield potentials are achieved in normal farming practice.

Cassava is the highest known yielder of starch and is in the top rank of crop biomass producers. However, unlike other high yielding crops (such as elephant grass), the major component of the biomass is starch, which is far easier to chemically process than cellulose. Consequently cassava is well-suited as an agro-industrial crop, that is, one that is grown primarily for processing into industrially useful products.

The importance of cassava as an agro-industrial crop has been further enhanced by the recent change in the world energy price structure. All of the chemicals that can be produced from cassava starch are currently manufactured from petrochemicals derived from oil. Many of these processes also require large amounts of energy, normally provided in the form of fossil fuels; as a result chemical prices have risen drastically. Although cassava processing also requires significant amounts of energy (usually in the form of heat and electricity), this can be provided from crop residues. For example, the leafy tops could be burned to provide steam or combined with tuber waste streams to provide methane by anaerobic fermentation. This approach is very important, particularly for developing countries where there are little or no indigenous fossil fuels.

The processing of cassava by utilizing crop residues to provide the energy leads to the concept of an "agro-industrial system." Here there

[1]Department of Chemical Engineering (and Energy Research Centre), University of Sydney, Sydney, Australia 2006.