8 Successes and pitfalls of linking nutritionally promising Andean crops to markets

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Introduction

This chapter focuses on three native plant species from South America that have provided food to native Amerindian populations since time immemorial (Table 8.1). They are all fully domesticated crops. Maca and yacon produce edible underground storage organs whereas quinoa is a chenopod grain. These plants represent the vast range of many thousands of species of local edible plants that have been used and/or domesticated since pre-history all over the world, but have lost ground in terms of production and dietary significance to a limited number of globally significant crops that nowadays dominate agriculture and food systems (Mayes et al., 2011). However, the three species covered in this chapter have seen in recent years a remarkable, in the case of maca and yacon even meteoric, rebound from nearly exclusive subsistence uses toward steeply increased commercial production, which in turn has generated the incentives for product development and scientific enquiry into the benefits of such previously “underutilized” species.

Key to this development has, in all three cases, been the discovery or substantiation and the growing consumer awareness of specific nutritional attributes. In striking contrast, those native edible species from the same geographic area that have not achieved as much “nutritional notoriety” because of unknown nutritional traits or lack of awareness thereof continue to linger in neglect. Examples include a range of Andean roots and tubers (mashua, mauka, ahipa) and a large number of New World fruits.

The approach taken in this chapter is to examine the three successful cases and tease out the factors that have shaped the re-emergence of these species from oblivion. This seems to be a more insightful and rewarding procedure than developing a “conceptual framework” for the promotion of such species on nutritional grounds.

The chapter will first narrate the recent re-emergence of the three species from neglect and underuse, and then it will examine the players and processes involved. While nutritional messages played a prominent role in raising awareness and the development of markets, the way these messages were brought to bear in the three cases are quite heterogeneous. As will be seen in

Table 8.1 Use attributes of quinoa, maca and yacon

Common and scientific name	*Plant characteristics*	*Traditional use*	*Salient nutritional properties of commercial interest*
Quinoa (*Chenopodium quinoa*, Chenopodiaceae)	Herbaceous annual crop (seed-propagated)	Edible seeds, cooked for a variety of dishes, Bolivia and Peru	Balanced protein, high iron content, gluten-free
Maca (*Lepidium meyenii*, Brassicaceae)	Herbaceous annual crop (seed-propagated)	Edible root, used as tonic at high altitudes, Peru	High in mustard oils, isothiocyanates, anti-oxidants
Yacon (*Smallanthus sonchifolius* Asteraceae)	Herbaceous annual crop (vegetatively propagated)	Edible root, eaten raw, Northern and Central Andes	High in fructans in roots, presence of hypoglycaemic principles in leaves

the following section, product characteristics, indigenous knowledge, crop dispersals outside the Andes, the opportunities afforded by export markets, food science research and food safety-inspired concerns of regulators intertwine to produce a complex picture. Based on these narratives commonalities will be determined and broader lessons will be determined for the promotion of nutritionally relevant agricultural biodiversity.

The transition from subsistence to commercial production

Quinoa

Quinoa is a small-grain staple of the Chenopodiaceae, which has been in cultivation for at least 5,000 years BP in its native range in the Andean highlands (Chepstow-Lusty, 2011; Oelke et al., 1992), predominantly around Lake Titicaca. Quinoa is adapted to the relatively cold conditions at high altitudes (3,500–4,000 masl) and this in combination with the plant's drought resistance and nutrient efficiency (facilitated by a deep root system) make quinoa production competitive vis-à-vis other starchy grains (mostly introduced Old World cereals) under the harsh climatic and poor soil quality of the Andean highlands (Aguilar and Jacobsen, 2003; Oelke et al., 1992). Although quinoa leaves are tasty and very similar in texture and flavour to amaranth leaves, they are rarely used in the Andes.

Recent archaeological work (Chepstow-Lusty, 2011) assessing ancient pollen abundance suggests that quinoa disappeared from mid-elevations in the Peruvian Andes after the introduction of maize – presumably from the Pacific lowlands to which maize had been introduced a few millennia earlier. This coincided with a relatively warm period and increased availability of animal dung, factors that appear to have boosted the evolution and productivity of locally adapted maize and possibly made it the preferred staple. The pollen record unveiled by Chepstow-Lusty (2011) suggests that quinoa's importance was much reduced by 2500 BP and that the crop found a refuge from maize competition at higher altitudes, in particular in the high Andean plains around Lake Titicaca, where the crop has remained unrivalled by other starchy grains to this day. It is here where nearly all quinoa in Bolivia and Peru is grown today.

Nutritional quality and importance of quinoa

Several sources stress the higher quantity and better quality of the quinoa protein versus other starchy foods (Repo-Carrasco et al., 2003), and this message has also been effectively communicated to consumers in both producer countries and export markets, where quinoa has acquired a reputation as a health food. The quinoa protein has indeed a desirable composition of essential amino acids, similar to the protein of milk (Oelke et al., 1992), and hence very good nutritional value as compared with other plant proteins, but total protein content in quinoa is not much higher than that of the cereals (Repo-Carrasco et al., 2003). In addition quinoa has good iron and calcium contents – for a plant food – further adding to the perception as a "superfood". To the best of my knowledge, there is no literature assessing the nutritional advantage arising from quinoa's superior protein. In any case, it is well known that proteins of lesser quality from different plant foods complement each other's nutritional value in that they mutually contribute limiting amino acids.

Authors frequently make misleading claims as to the high nutritional importance of quinoa to contemporary native communities, when indeed several lines of evidence suggest quite the opposite. For example, according to Rojas et al. (2004), Bolivia's production in 1999 of barley, wheat and rice exceeded that of quinoa by factors of three, six and nine, respectively. These ratios would be even more unfavourable for quinoa if the large quantities of cereals imported into Bolivia were taken into account, and the fact that a large proportion of quinoa is being exported to the USA, Europe and other health food markets. Field work undertaken by Astudillo (2007) shows that both the frequency and quantity of quinoa consumption in poor communities in Southern Bolivia is quite low, and seems to be further diminished in households producing quinoa for the market.

Quinoa production and demand constraints

In Bolivia, the most important quinoa-producing country, average quinoa yields were around 500 kg/ha in the 10 years to 2001 (Rojas et al., 2004), an average unlikely to have increased because of the predominant production for "organic" export markets and the concomitant avoidance of mineral fertilizers and resulting soil mining (see below). Recent data suggest that yields in many areas are actually declining (Rojas et al., 2004; Astudillo, 2007). Virtually all quinoa production is by manual labour and uses ancient technologies, including ploughing, sowing, harvesting, threshing and winnowing. What may appeal to the visitor as picturesque scenery in fact involves a lot of drudgery and production inefficiencies.

Quinoa grain as sold by farmers is still coated with saponin, which protects the plant from insect pests, but needs to be removed prior to consumption, either by washing or polishing the grain in machines specifically developed for that purpose (Fujisaka et al., 2006). Another inconvenience and additional post-harvest production cost of quinoa for urban or export consumption is the removal of black grains, which result from cross-pollination with wild *Chenopodium* species. Black grains are innocuous and account for less than 1 per cent of total grain but deter consumers, who perceive such grains as contamination. Grain separation technology could probably be adapted from high-accuracy cereal cleaning machines, but is prohibitively expensive in the context of the ubiquitous small-scale quinoa processing. Therefore, grains with undesirable colours are removed manually by workers, further adding to processing costs (2007, field observations).

The above-described constraints make the production, processing and marketing of quinoa quite inefficient, and result in production costs and quinoa prices that are much higher at wholesale and retail levels than for quinoa's starchy substitutes, such as wheat, rice, maize and derivatives from these grains. According to Astudillo (2007) quinoa in rural markets in Bolivia costs twice as much as rice. While a surprisingly large degree of awareness of quinoa's nutritional properties amongst the rural poor with little formal education was uncovered, Astudillo also found in the three communities in Southern Bolivia that price of food is the overriding criterion in food choice decisions, and much more important than nutritional properties and flavour. In 2011, press reports picked up by international media (Romero and Shahriari, 2011) suggested that soaring quinoa prices have made this ancient staple unaffordable for urban Bolivians as well, with the retail value of quinoa being five times that of noodles or rice, quinoa's main substitutes. Even before the recent price hikes, Iparuna, a La Paz-based processing firm specializing in native grain products, could not afford to include quinoa as an ingredient in products tendered for Bolivian school feeding programmes and relied entirely on imported raw materials in order to be able to offer an affordable product (Ms Martha Cordera, personal communication, 2007).

Quinoa enthusiasts often point to the nutritional qualities of quinoa and demand policies in producer countries to discourage the consumption of its main competitors, wheat and rice (see, for example, Jacobsen 2011). As Table 8.2 shows, quinoa is indeed superior to rice and wheat products for protein content and a number of other nutrients, although the raw grain of certain wheat varieties can have equally high protein content. Quinoa's nutritional superiority is partially attributable to the fact that its whole grain is consumed whereas the outer, nutrient-rich, layers of wheat and rice are typically removed (although some of the lost minerals are added in the customarily enriched derivatives such as flour, bread and noodles).

Table 8.2 Comparison of the content of selected nutrients in quinoa grain versus rice and wheat products (uncooked except for bread)

Nutrient	*Quinoa grain (20035*)*	*Rice, white, short grain (20052)*	*Wheat grain, hard, spring (20071)*	*Wheat flour, white, unenriched (20481)*	*Wheat flour, white, enriched (20381)*	*Wheat noodles, enriched (20120)*	*Wheat bread (18064)*
Water (g)	13.3	13.3	12.8	11.9	11.9	9.9	35
Protein (g)	14.1	6.5	15.4	10.3	10.3	13.0	10.4
Carbohydrates (g)	64	79	68	76	76	75	49
Energy (kcal)	368	358	329	364	364	371	270
Iron (mg)	4.6	4.2	3.6	1.2	4.6	3.3	3.5
Zinc (mg)	3.1	1.1	2.8	0.7	0.7	1.4	1.2
Calcium (mg)	47	3	25	15	252	21	138

Source: United States Department of Agriculture, National Nutrient Database, http://ndb.nal,usda.gov, rounded figures, per 100 g, *NDB number (USDA).

If we conservatively assume a price ratio of quinoa to wheat products of about three, which has been typical at the retail level prior to the current export boom, and if the approximate contents of key nutrients in quinoa versus wheat as shown in Table 8.2 are taken into account, it can easily be deduced that a dollar spent on unenriched (native) wheat flour buys three times as much food energy, twice as much protein and only slightly less calcium, iron and zinc than quinoa. For bread and noodles made from whole-wheat grain or enriched flour, the comparison is even more favourable for wheat. Even rice with its comparatively low protein content will provide 40 per cent more protein per food expenditure. As quinoa prices have climbed to new heights in 2010 and 2011, providing much opportunity for income generation, there will be increased incentives for quinoa producers to trade their precious commodity rather than consume it in pursuit of intangible benefits as proposed by a majority of authors that emphasize the importance of nutritional diversity and strengthened cultural identity.

Quinoa marketing

In light of the poor competitiveness and resulting high consumer prices for quinoa, it is no surprise that quinoa consumption has increased in the past 20 years predominantly amongst affluent consumers, a development that has initially been limited to the European health food scene, but has gained momentum in other export markets as well. Quinoa's fame as a "superfood" produced under "organic" conditions eventually also reached an affluent urban clientele in quinoa producer countries, although the consumption there is still dwarfed by export markets.

In addition to the celebrated nutritional qualities of quinoa (protein quality; high contents of calcium, magnesium, phosphorus, iron, zinc and vitamins B6 and E; low glycaemic index), it is its lack of gluten that is having the greatest impact on demand growth. Gluten is a storage protein of cereals causing allergy in many people in developed countries. In Germany alone an estimated 100,000 gluten intolerance sufferers are in need of substituting wheat, rice and maize with gluten-free starchy products such as quinoa.

Expansion of quinoa production and soil mining

Astudillo (2007) has described how the lure of high quinoa prices in the wake of the export boom has led to the growing investment in quinoa cropping by absentee landlords relying on hired labour and with little regard for communal action to maintain sustainability practices. In 2011, Bolivia had registered some 70,000 producers on an estimated total area of 50,000 ha. In the same year, the export FOB value was US$46 million, up from US$2 million in 2000,[1] translating into an average annual growth rate of 33 per cent.

Although there is a dearth of substantiating quantitative data, several sources report a tendency of declining quinoa area yields (Rojas et al., 2004; Astudillo, 2007). Based on production statistics from the Bolivian Ministry of Rural Development, Jacobsen (2011) calculated that average quinoa yields declined by 20 per cent in the 10 years to 2009. Local informants throughout the quinoa production zone consistently report reduced soil fertility, reduced fallow periods and the expansion of quinoa into steep and erosion-prone land to compensate for reduced area productivity (Medrano and Torrico, 2009; Jacobsen, 2011). Most of this expansion is on account of the demand for organically certified produce under various private and public labels, which invariably allow the application of locally available animal dung only. However, animal dung in the Altiplano is scarce, and there is circumstantial evidence for persistent net extraction of nutrients from the soil, a process also referred to as soil mining that leads to soil degradation.

Despite growing awareness for the decline in soil fertility (Ms Martha Cordera, personal communication, 2007; Medrano and Torrico, 2009) commercially motivated demands abound that the "purity" of quinoa production and organic quality standards be maintained.[2] Thus, the application of rational and science-based fertilization practices, including the use of mineral fertilizers to replenish nutrients removed by harvested produce, is being prevented and leads to the degradation of the resource base – all in the name of "organic" production methods so dear to distant quinoa consumers. Characteristically, Jacobsen (2011), in his discussion of sustainable soil management in quinoa cropping in the Southern Bolivian Altiplano, fails to even mention the option of using mineral fertilizers while giving much consideration to the improved use of animal dung and green manure, a proposal that seems of limited practical value in the context of the much needed "sustainable intensification", particularly in locations where "organic" sources of nutrients are either inaccessible or unaffordable.

Maca

Traditional uses

Maca (*Lepidium meyenii* Walpers) is a fully domesticated, seed-propagated root crop of the crucifer family. It is endemic to the high Andes around Lake Junín in Central Peru, a chilly plateau at 4,000 m altitude. In locations where temperatures range during the crop's growing season from 0°C to 12°C, maca presents one of the few cropping options, apart from other cold-adapted domesticates such as quinoa, and certain varieties of bitter potatoes (Tello et al., 1992).

Prior to the late 1980s, maca was estimated to be grown on no more than 15 ha, an area so small as to raise concerns that the crop might become extinct (IBPGR, 1982). The traditional cropping area is circumscribed by the shores of Lake Junín and adjacent slopes, with any two cropping sites not further apart than some 100 km as the crow flies. Such a restricted and "insular" distribution is remarkable for a crop plant, and all the more so when considering that suitable high altitude habitats extend for thousands of km south and north of the traditional distribution of the crop.

Claims about maca having been much more widely distributed across Peru and even other Andean countries in the past 500 years therefore seem plausible, and indeed abound in the maca literature. However, a thorough examination of historical production and trade records going back to the 16th century as well as the absence of archaeological evidence outside the crop's place of domestication – both in terms of plant remains and phytomorphic pottery – strongly suggest that maca, in pre-Hispanic and colonial times, never extended beyond the above-mentioned Lake Junín area (Hermann and Bernet, 2009).

Food value

Traditionally, maca roots are dried after harvest and remain edible for several years. Drying diminishes pungency owing to the significant reduction of the content of glucosinolates. Traditional drying, apart from reducing pungency, presumably converts some starch into free sugars and it also brings out the typical flavour of maca, which is peculiar and difficult to describe. Maca is typically rehydrated before being boiled and then blended into a range of dishes or potions to which the maca imparts a characteristic flavour.

One often-quoted botanist praised the maca aroma as reminiscent of butterscotch but according to Torres (1984) most maca novices find maca rather repulsive, and acceptance of maca was very low in a focus group recruited from Lima with no previous exposure to this food. Maca quite obviously is an acquired taste, and this must have been a major use constraint and is likely to be one of the reasons for the failure of this crop to expand beyond its narrow geographic distribution in the past.

In any case, traditional beliefs suggest that maca consumption improves human fertility, and physical stamina (Leon, 1964; Locher, 2006). Maca has high nutritional density (in root dry matter: 55–65 per cent highly digestible carbohydrates, 2.2 per cent lipids, 10–13 per cent protein) and it is particularly rich in iron, zinc and potassium. Maca protein is high in essential amino acids (Dini et al., 1994).

Maca contains high concentrations of isothiocyanates, which are the compounds responsible for the pungent flavour of raw maca (Johns, 1981), and other secondary metabolites, but it is not clear what their biological activity is and whether they are responsible for the reported pharmacological effects of maca in mammals (see below).

The transition from subsistence use to Internet notoriety

Beginning in the late 1980s maca experienced a meteoric rise from an obscure botanical curiosity to Internet notoriety with the total area cropped to maca extending across Peru and neighbouring countries and increasing in the 15 years to 2005 by a factor of at least 60 to some 3,000 ha. What had happened?

In the early 1980s, different local actors started to promote maca on the grounds of its locally perceived health benefits, with a small rural road-side restaurant playing a key role. Located on the heavily transited road between Lima and Huanuco, it marketed a "trade-mark", maca-fortified, hot drink to a clientele of truck drivers and travellers who conveyed a tale of increased sexual stamina and fertility to the nearby capital city of Lima. To this day, the little store serves the hot maca beverage to travellers, and numerous postcards on display thank the manager for restored marital lives and the arrival of desperately wanted children. The traditional beliefs of maca as a "strong food" had mutated into a more effective marketing message (Vilchez, 2001).

Emerging commercial interest on the part of local traders, and small Lima-based processors, was further stimulated by reports in national newspapers and TV channels of maca's miraculous properties, leading to supply shortages, higher prices and the expansion of production to satisfy an increasing demand from outside the crop's native highland range. It was also at that time that the first convenience products containing maca began to appear, using the root at lower concentrations or with ingredients that mask its strong flavour, thus improving its acceptance among urban consumers (Torres, 1984; Vilchez, 2001).

The 1990s saw an unprecedented expansion of the production of maca. Four factors were responsible for this:

1 Product development and diversification have been key in the expansion of maca demand, particularly the development of convenience products for urban consumption that mask the maca flavour, typically by limiting maca's share of total product weight to under 20 per cent (Figure 8.1).
2 Growing demand from export markets, particularly in Japan and the USA, based on Internet marketing stressing the purported aphrodisiac qualities of maca as the "natural alternative to Viagra", the "Peruvian ginseng", a rejuvenating tonic, or a "wellness" product.

Figure 8.1 The variety of maca-based convenience foods developed have increased the demand for the root crop

3 A growing body of knowledge, as evidenced by the exponentially growing number of university theses and publications, was instrumental in the promotion of maca, particularly research dealing with maca food composition, nutritional studies with animal models, and product development. Private sector-funded research papers sought to substantiate traditional beliefs in the capacity of maca to increase fertility (Hermann and Bernet, 2009).
4 The intensification of maca production, notably through the use of mineral fertilizers, resulted in a significant increase of area yields (Hermann and Bernet, 2009).

Problematic maca marketing

The frivolous Internet marketing of maca as a libido booster quickly propelled it to international notoriety in the mid-1990s. Maca pills containing the crude flour became increasingly available in Europe by mail and over the counter, and were openly touted for their alleged pharmacological effects. The fact that none of these products had gone though internationally accepted registration procedures mandated for pharmacological products did not escape the attention of the regulatory entities in target markets. Particularly in the EU, an increasing number of maca shipments were confiscated in the 1990s and maca marketing became increasingly limited to informal distribution channels including sales through the Internet (Hermann and Bernet, 2009).

Peruvian exporters and their EU importer counterparts reacted by toning down advertisements and/or by removing health claims from their product labels, but this invariably resulted in reduced demand. It was also at this time that a sense of the need for scientific substantiation of maca's "invigorating" effects emerged, leading to research, which was eventually published in university theses and in peer-reviewed journals from 1999 onwards. However, the frequently reported enhanced sexual function following maca administration in rodents was observed at intake levels several orders higher than those recommended in commercial maca "nutraceuticals", casting doubt on the efficacy of commercial products. Also, authors of peer-reviewed articles reporting such effects mostly failed to disclose the private sources of funding for their research and the links of their work to commercial product development and promotion (Hermann and Bernet, 2009).

Specific market access barriers

Some maca suppliers, however, began to pursue a different marketing strategy aimed at the promotion of maca as a food or food ingredient consistent with the root's traditional use in its native area. This strategy was beset with two difficulties. One was the de facto positioning of maca as a drug in the Internet, which was further accentuated by the appearance of scientific papers suggesting the efficacy of maca's action on reproductive parameters in animals and humans. This necessarily led to concerns about possible toxicological effects at the much higher doses implied in consumption of maca as a food.

A second problem of this approach was that maca suppliers were unprepared to respond adequately to food safety concerns, particularly those embodied by the EU Novel Food Regulation (NFR). This regulation requires food safety assessments of traditional foods (viewed as novel from a European perspective) for pre-market approval. The NFR arbitrarily defines novel food as food or food ingredients that have not been used widely within the EU before 15 May 1997, an arbitrary cut-off date. If viewed as novel, market authorization needs to be preceded by a food safety assessment under the NFR that typically requires scientific data with regard to food composition, suggested intake levels, toxicological assessments and allergenic potential. Such a food safety assessment was not available and at any rate required resources, expertise and a degree of determination not possessed by the dispersed community of value chain stakeholders (Hermann, 2009).

The non-authorization of maca under the NFR resulted in the confiscation of numerous consignments and explicit prohibitions in several EU countries discouraged investment in export-oriented maca supply chains, and particularly in product and market development for the most attractive export market for natural products, the EU. This constraint in combination with the incoherent and even confusing use of product names, the widely varying product quality and frequent adulteration (especially at times of low supply) became a problem and compromised the reputation of maca (Hermann and Bernet, 2009).

Impact of the expansion of maca production on rural livelihoods and maca diversity

Despite marketing problems, maca remains an important local crop in a small area of Central Peru, because the roots can be stored and sold for cash, providing more income security to smallholders. With farm-gate prices over three Soles (ca. US$1) per kilogramme of dehydrated maca roots for several years, and conservatively estimating average dry matter yields of one tonne per hectare, the revenue from a two-hectare field of maca (typical of a smallholding), is likely to have exceeded US$2,000 in most years. This is by far more than farmers could expect from any other agricultural activity under the harsh conditions of the Puna, and significant income effects are evident from the display of greater wealth in terms of vehicles and new homes in production areas. Maca has become a source of self-employment and income for the rural poor, many of which have only recently started growing maca. Moreover, expanded maca production has triggered the development of a number of small-scale businesses related to maca processing and commercialization, which has allowed farmers to diversify activities and lower income risks (Locher, 2006).

Yacon

Origin and traditional uses

Yacon is another minor root crop domesticated in the Andes. It is a herbal species of the sunflower family with perennial rhizomes from which the edible storage roots emerge. In contrast to maca, the starch-free yacon roots are eaten raw and function as "fruits" in traditional diets. Farmers in the subtropical inter-Andean valleys and on the eastern slopes of the Andes, which descend toward the Amazon used to grow this plant more commonly in the past along field borders where the juicy roots provide a welcome source of refreshment during field work (Grau and Rea, 1997).

There is a dearth of information on indigenous knowledge surrounding the use of yacon. The extensive monograph of Grau and Rea (1997) based on a thorough review of the literature on the economic botany of this crop is silent on traditional beliefs as to its food qualities and uses. There is also no mention of medicinal properties in the limited number of early yacon publications that predate the fairly recent scientific discovery of yacon's dietary qualities. The apparent absence of significant indigenous knowledge and the use of yacon exclusively in the raw (uncooked) state, however, is consistent with the marginal significance of the crop in subsistence and trade throughout its traditional range in Ecuador, Peru, Bolivia and Argentina.

Until as late as in the early 2000s, yacon was mostly unheard of by the large majority of the people in the crop's native range, except for cultivators and occasional consumers in remote rural areas apt for its cultivation. Yacon was rarely offered in rural markets, and if so, mostly during the religious festival of "Corpus Christi", the celebration of which includes the serving of traditional foods rarely eaten during the non-festive season. This rather marginal use changed in a rather dramatic fashion in 2001, principally because of the crop's distribution outside the Andes, which will be examined in the following section.

International dispersal and discovery of food value

In 1979, Dick Endt, a renowned plant collector from New Zealand, while on a collecting mission to Ecuador, took yacon planting material from a "town garden" in Loja, Ecuador to New Zealand (D. Endt, personal communication). New Zealand has been successful with the introduction and development of Andean crops (such as tree tomato, babaco and oca), and yacon is still available from Endt's nursery, but yacon remained a garden curiosity in that country. However, yacon found much greater acceptance in Japan to which the first plants appear to have been introduced in the mid-1980s from material in Endt's collection. Within the space of some 20 years after its introduction in Japan, successful yacon cultivation and trade has been reported from a range of Asian countries. Various sources (Asami et al., 1989; Doo et al., 2000) suggest that the origin for the crop's dispersal in Asia, as shown in Figure 8.2, was indeed Japan. Incipient yacon cultivation has recently been observed in the Cameron highlands of Malaysia (Paul Quek, personal communication, 2011) suggesting that the crop's expansion in Asia continues in full swing.

It was in Japan in the 1980s where yacon food use, product development and its culinary discovery really "took off". In light of the many creative uses that the product has found in that country and elsewhere in Asia, we can surmise that yacon appeals much more to its new Asian consumers than to its original domesticators in the Andes. The succulent and crunchy texture of yacon roots

Figure 8.2 Origin and dispersion paths for yacon

is similar to radish or apple, and this as well as a mildly resinous but pleasantly sweet taste reminiscent of the peculiar texture and flavour of other plant foods popular in East Asia, probably explains its success there. Yacon also retains desired crunchiness after stir-frying, an added advantage for its use in Asia, but not exploited in the cuisine of Andean countries. Use of yacon in South Korea in a variety of dishes, including iced noodles, chopped noodles, fries, pancakes and dumplings (Doo et al., 2000) illustrates the versatility of yacon use in Asia.

With an estimated area of some 100 ha by the early 2000s (more recent data not available), yacon remained insignificant economically in Japan, but interest in the crop – as evidenced by the formation of a very active Japanese yacon association – led to research unravelling the plant's chemical composition. Most importantly, it was found that two-thirds of yacon carbohydrates, which account for about 90 per cent of the root dry matter, consist of fructo-oligosaccharides (FOS) (a polymer made up of fructose units) of a low degree of polymerization (Ohyama et al., 1990; Wei et al., 1991; Asami et al., 1992).

The nutritional significance of the sweet-tasting FOS is that the human small intestine has no enzyme to hydrolyse its glucosidic bonds. FOS are thus largely indigestible, but there is much literature suggesting benefits for gut health from the increased ingestion of FOS which stimulate the growth of bifidobacteria and suppress putrefactive pathogens in the human colon. They are thus increasingly added to pastry, confectionery, and dairy products (Geyer et al., 2008).

Apart from the content of FOS, the nutritional value of yacon is rather limited: the energy content ranges from 148 to 224 kcal/kg per root fresh matter and is several times lower than for comparable foods. Yacon is a reasonably good source of potassium (1.8–2.9 g/kg fresh matter), but low in protein (2.7–4.9 g/kg) and lipids (112–464 mg/kg) (Hermann et al., 1999).

First reports of additional hypoglycaemic properties of the leaves of yacon, which have only recently been confirmed in animal models (Genta et al., 2010), prompted the commercial development of yacon tea in Japan in the 1990s for use by type 2 diabetics. Recently, Habib et al. (2011) demonstrated lipid lowering principles of yacon roots in diabetes-associated hyperlipidemia, thus identifying another property to position yacon as a functional food.

In 1991, Mr Sergio Kakihara, a Japanese-Brazilian immigrant farmer, introduced yacon planting material from Japan to Capão Bonito, near Sao Paulo. Starting from a single propagule brought to Brazil more by chance than intent, he multiplied enough over the ensuing five years to comprise a total area of four hectares when the author of this chapter visited him in 1996. Initially marketed to Japanese-Brazilians at the Liberdade market in Sao Paulo (Kakihara et al., 1997), the crop eventually spread across Brazil, and has since become a standard item on offer in retail grocery stores, especially in Southern Brazil (Fenille et al., 2005).

The incipient use of yacon in Brazil and in Japan, the plant's salient attribute of being a prime source of short-chained FOS as well as anti-hyperglycaemic properties for innovative use as a product for diabetics, which has no parallel in traditional knowledge, remained unnoticed in the crop's native range throughout the 1990s. Ironically, a comprehensive priority-setting exercise led by the International Potato Center in Peru and relying on canvassing expert opinion, to assign priorities for research and development attention to a range of nine species of minor Andean root crops, was oblivious to yacon's potential, given the marginal use of this crop in traditional and modern food systems. A very large majority of urban people in the Andes had never heard of the product.

Yacon in the headlines

Yacon would probably have continued to linger in oblivion in the Andean countries for some more years, had it not been for Peruvian press reports that first appeared in August 2001, and eventually catapulted yacon into the limelight of markets and "put it on the map" of researchers and regulators. These reports referred to a 1999 incident, when Victor Aritomi, the former Peruvian ambassador to Japan and member of the meanwhile discredited Fujimori administration, on official diplomatic mission had carried yacon propagules to Japan, however without going through proper export procedures and the required material transfer agreement. Nothing could have more effectively enhanced public awareness for a hitherto underutilized crop than its name being brought into association with a much-despised former political regime. The apparent act of self-inflicted biopiracy fuelled national headlines for several weeks (Figure 8.3) and introduced a national audience to a genuine Peruvian crop which was highly appreciated on the opposite side of the world but unheard of in Peru itself. Once the scandal subsided, media reports – which Reuters and CNN eventually took up – began to cover the medicinal properties of yacon, as reported from Japan. These media reports tended to wildly exaggerate benefits, even suggesting yacon as a cure for diabetes, and were the basis for the emerging national interest in growing the crop, which has been sustained until the present day.

Ten years have passed since yacon was in the headlines. The "hype" surrounding yacon in Peru has subsided, but the fresh roots are now firmly established as a regular and year-round product in the fruit sections in urban markets and sought out by health-conscious consumers throughout the

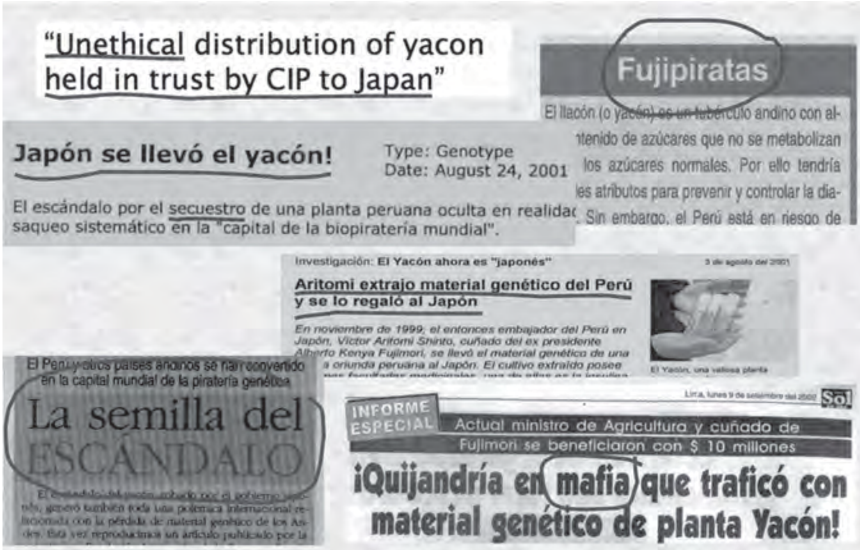

Figure 8.3 Biopiracy allegations referring to the use of yacon in Japan hit national headlines in Peru in 2001

country. Smallholder associations in some rural parts of Peru have established a reputation for growing yacon, but seed continues to be sourced through informal channels, and the lack of varietal performance guarantees, particularly in relation to the highly variable FOS content, has meant a constraint to large-scale cultivation for industrial processing (Seminario et al., 2003; Graefe et al., 2004; Manrique et al., 2005).

The last decade has also seen the development of a variety of convenience products motivated by the need to transform the perishable root into standardized products with export potential. According to statistics of PromPeru,[3] the value of total Peruvian yacon exports was US$1.1 million in 2011, up from US$0.2 in 2007, with the bulk of the produce going to Japan and the USA. In the EU, yacon requires authorization under the Novel Food Regulation, since it was not used as a food or food ingredient before 15 May 1997.[4] Therefore, an extensive food safety assessment under the Novel Food Regulation is required before it can be placed on the market in the EU as either a food or a food ingredient. Presumably, yacon sales in the EU, as evident from Internet marketing, are through informal and "under-the-counter" channels, which have not yet come under the scrutiny of EU regulators.

Discussion and conclusions

Re-emergence of underutilized food crops

A few dozen crops account for most of global food production, while the vast majority of food species are falling into disuse or reduced to subsistence systems. Much of the neglect of so many species is put down to the ongoing globalization of diets, the erosion of local food cultures, and the greater competitiveness of commodity crops ever more replacing traditional foods. However, the examination of the natural histories of the three food crops covered by this chapter reveals that the marginal or declining importance of food species – while being accentuated in the recent past – is not necessarily a modern phenomenon as often stated, but can have its roots in the very distant past.

Quinoa's importance began to erode in pre-Hispanic times. The pollen records unveiled by Chepstow-Lusty (2011) suggest that, as early as 2500 BP, quinoa was being replaced by maize in mid-elevation valleys in the Andes. It is reasonable to assume that quinoa retreated to the Altiplano, an ecologically narrowly circumscribed high-altitude plateau to which quinoa is supremely adapted, and where the crop is grown to this day. Based on a review of colonial and modern literature, Hermann and Bernet (2009) conclude that the production and consumption of maca never exceeded its very limited production area in a small mountainous region of central Peru. Maca was declared to be under threat of extinction in 1982. The early Spanish chroniclers, our only historical source on the economic botany of pre-Hispanic Andean civilizations, are either silent or provide only brief mention of yacon, suggesting that the crop was of much lesser use than other roots and tubers native to the Andes (Garcilazo de la Vega, 1609; Patiño, 1964; Antunez de Mayolo, 1981). As recently as 10 years ago, yacon's significance had declined to the status of a botanical rarity known only by a few specialists and occasional indigenous cultivators.

In conclusion, none of the three species have in the past been consumed by a large proportion of the population at substantial intake levels, and hence the often stated nutritional importance of these species is at odds with the marginal role of these crops in traditional food systems as evident from several sources. Moreover, restricted geographic distribution made these crops almost "invisible" to most Andean consumers and resulted in a lack of familiarity.

It was the discovery and communication of nutritional attributes that catapulted the three species into the minds of consumers in urban and export markets. The resulting demand expansion made all the difference. Seventy per cent of the Andean population is now urban, with a growing middle class and purchasing power. Importantly, the interest of export niche markets (fair trade, organic, health and ethnic food) provided key incentives for novel product development and diversification in order to overcome demand constraints.

Lessons for the development of minor food species

One often stated cliché is that minor food species are held back by the stigmata of "poor people's food" and "backwardness" associated with their rural producers. No evidence of this notion was found, and even if reputational problems existed, these would likely not be the cause of limited use but rather consequence and expression of objective demand constraints such as the inconvenience of use of (traditionally) unprocessed quinoa, and unappealing aspect and taste of maca and yacon. It is implausible how the promotion on nutritional grounds would be effective, unless accompanied with efforts to lessen or remove demand constraints as happened with the three crops of this study through the development of a diversity of appealing and novel products.

A variety of factors, however, made the products of the three species of this study prohibitively expensive for poorer sectors in producer countries. Growing consumer demand quickly exceeded supplies, and low productivity and predominantly manual production methods added to production costs and price pressures. For poorer people, whose food choices are strongly influenced by price, it would seem that costs have to come down to include these products in their diets. This can only be achieved by increasing area productivity, improved plant types and agronomic management as well as greater economies of scale through appropriate processing and more efficient value chain management.

Thus, this chapter provides a number of pointers for research investment in order to remove or lessen constraints that act on the supply (low productivity, narrow ecological adaptation) or the demand (lacking knowledge and consumer awareness of nutritional benefits, unavailability of convenience products, marketing inefficiencies) of these "neglected" crops. By comparison, globally established food crops have enjoyed vastly greater research and development efforts by both private and public entities. For example, many thousands of person-years must have been invested world-wide over past decades in the breeding of any of the major cereals. This has decisively contributed to their greater competitiveness vis-à-vis minor crops.

Communication of nutritional attributes to consumers

The communication of nutritional attributes was found to have been of key importance for the increased awareness of the food value of the three crops, although nutritional claims were often made in a sensationalist manner, exaggerating the significance of emerging scientific results, and in violation of Codex Alimentarius rules. However, it appears that focusing on key properties helped to position the products in the minds of consumers.

Access of quinoa to the EU market has not been a problem because of the long use tradition in some European countries; however, the lack of food safety documentation for maca and yacon has prevented the market authorization of these species under the EU Novel Food Regulation and discouraged investment in export value chains (Hermann, 2009). There is a need for authoritative species and food dossiers that substantiate the food value of traditional food products in new markets. These must provide details on food composition, traditional intake levels, and discuss potential hazards from processing or lack of familiarity of use. Recent EU market authorizations obtained for a range of traditional foods such as baobab and the Allanblackia tree provide models for the required procedures.

The role of indigenous knowledge

The importance generally attached to the role of indigenous knowledge in the continued use of agricultural biodiversity is clearly at odds with the findings of this chapter. Traditional beliefs about fertility-enhancing effects did indeed provide pointers for the modern use of maca, and recent research results appear to bear out certain pharmacological effects.

However, authentic indigenous knowledge surrounding the use of maca is very limited (Locher, 2006). As with other nearly forgotten foods subject to renewed commercial interest, what is described as "indigenous knowledge" actually has been enmeshed with attributions from press reports and contaminated with the hype associated with Internet claims. Genuine traditions are thus difficult to disentangle from modern product promotion, especially when they relate to the "immune system", better "concentration and memory", "lowered cholesterol" and other modern medical jargon (Hermann and Bernet, 2009).

None of the very limited traditional knowledge associated with the use of quinoa and yacon has had much bearing on the marketing and expansion of consumption of these products. Scientific research uncovered the previously unknown hypoglycaemic and bifidogenic properties of yacon, as well as the nutritional excellence of quinoa, particularly its potential as a starchy food for gluten intolerance sufferers. Moreover, awareness of the nutritional properties of quinoa and yacon as revealed by scientific methods has stimulated the interest of rural producers.

Likewise it has not been culinary traditions, but rather the ingenuity of modern product development and the versatility of food processing techniques that have helped overcome a number of use constraints, through the development of products that are more convenient to use, have longer shelf-life and better consumer acceptance.

The exaggeration and sensationalist use of indigenous knowledge in marketing maca paid quick dividends for some companies, but it eventually brought maca into ill repute, particularly in the EU, where regulators banned maca from the market for several years because of food safety concerns and the predominance of unsubstantiated product claims. Typically, indigenous knowledge on traditional food is silent on potential food hazards and even where it provides details on health and nutritional benefits, regulators will not allow its use in product claims, unless these are substantiated by scientific methods. This is often overlooked in discussions of the "complementarities" of "scientific" and "traditional knowledge". In recording indigenous knowledge greater emphasis needs to be placed on the documentation of traditional intake levels, frequency and distribution of use, data that are of great relevance to food safety assessments.

Multilateral access and benefit sharing of underutilized plant genetic resources

Current project funding and development priorities involving minor food species are posited on the widely held belief that these hold the greatest potential in their native range to benefit indigenous cultivators and consumers. On the surface, this appears to be a plausible proposition, but the lessons from this study suggest otherwise. All the three species have re-emerged from oblivion because of the discovery of nutritional properties outside the Andes following informal introductions[5] of germplasm to Brazil, Japan and a range of Asian countries. The case of yacon and quinoa is particularly interesting, as novel modes of preparations and the marketing in response to new demands outside the Andes (avoidance of gluten intolerance, interest in gut health, culinary interests) facilitated the diversification of crop uses. For instance, Japanese and Korean culinary techniques applied to yacon have hugely expanded its perceived food value and sparked scientific enquiry.

Unfortunately, myopic media opinion makers and misguided anti-biopiracy advocates have failed to realize that all three crops would most likely continue to be under-exploited had they not been taken out of the context of the demand constraints in their native agricultural and food systems.

Expansion of yacon and maca consumption in export markets has provided income opportunities for producer countries with benefits not only to poor farmers but also to processors and other value chain participants. Of course, increasing yacon production in Asia and Brazil is bound to curtail foreign currency revenues for Andean producers to some extent, but much of the understanding of yacon's and maca's nutritional properties have essentially been developed in these countries, and have hugely benefited product development, consumer interest and market development in the Andes as well.

The conclusion is that informal benefit-sharing mechanisms associated with the global dispersal of indigenous crops are still effective, although the time-scales involved exceed the short-term quid pro quo attitudes of post-CBD policy makers. The phenomena described are not applicable to every local food crop, but the number of crops being moved through informal seed systems across borders is substantial, and many more crop examples from the recent past support the chapter's conclusions. The implications are that the unfettered sharing of plant genetic resources for food within a multilateral access system not only benefits the use of global crops, but that the interdependence of countries with regard to minor species may be similarly high.

Notes

1 Unidad de estadísticas agropecuarias y rurales (MAGDER), Bolivia.
2 Associated Press, 10 January 2011. Quinoa's popularity boon to Bolivans. http://thedailynewsonline.com/lifestyles/article_10f5ef38-1d28-11e0-bf68-001cc4c002e0.html
3 http://www.siicex.gob.pe/siicex/apb/ReporteProducto.aspx?psector=1025&preporte=prodpres&pvalor=1953
4 http://ec.europa.eu/food/food/biotechnology/novelfood/novel_food_catalogue_en.htm
5 No evidence was found for negotiations or material transfer agreements related to these crop introductions as mandated by international agreements and recognized best practices.

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