Mashua

By Travis A. Clark

Mashua (*Tropaeolum tuberosum* Ruiz & Pavón 1802), also known as *isanu*, *cubio*, *añu*, *ysaño*, or *puel*, is a tuber crop indigenous to the Andean highlands and is of economic value as a food and medicinal crop. This root crop ranks fourth in importance in the Andean region after potato, oca, and ulloco (NRC, 1989). Of the Andean tubers, mashua is one of the highest yielding, easiest to grow, and the most frost resistant.

Mashua is cultivated in the Andes of Bolivia, Peru, Ecuador, Columbia, and Venezuela (Gibbs *et al*., 1978). It is currently being grown experimentally in New Zealand and the Pacific Northwest to evaluate its potential for worldwide cultivation (Soria *et al*., 1998). The tubers of *T. tuberosum* are an important source of food for around 9 million people living at elevations of 2500 to 4000 m throughout the Andes mountains (King and Gershoff, 1987).

Mashua is an annual, herbaceous climber that belongs to the family Tropaeolaceae which includes about 100 species. *Tropaeolum tuberosum* is closely related to the garden Nasturtium, *Tropaeolum majus* L. (Vaughn and Geissler, 1997). *Tropaeolum tuberosum* grows to over 1-1.5 m in diameter and 0.5-0.8 m high with slender and cylindrical aerial stems. Both erect and prostrate forms of mashua are known.

Mashua has alternate, circular, peltate, 3- to 5-lobed leaves, and glaborous, twining stems that attach themselves to other plants by tactile petioles (NRC, 1989). The flowers are long-stalked, solitary, axial, bisexual. The color of the flowers range from dark yellow, orange, and scarlet. The fruit is a schizocarp with three indehiscent carpels that contain joined seeds lacking endosperm (NRC, 1989, Torres et al., 1992). The seeds are abundant and viable at maturity although since mashua is propagated asexually many asexual forms have arose which occasionally set seed.

The tubers of *Tropaeolum tuberosum* are produced on axillary stolons which enlarge to form terminal, elongate tubers which are slightly roughened from enlarge scale leaves (Sperling and King, 1990). The tubers vary in color from white to yellow with occasional variants that are purple or red. They are often striped or mottled red or purple, especially underneath the eyes. The flesh of the tuber is yellow (NRC, 1989).

History

Mashua has been cultivated since ancient times and tubers are often found in archeological sites (NRC, 1989). Pre-Incan pictograms representing potato, ulluco, oca, and mashua have been found which show evidence the importance of these tubers even in those times (Hodge, 1946). The exact date of domestication is not known but estimated at around 5500 B. C. (Flannery, 1973). The ancestral origin of mashua is yet undetermined. Weedy types of mashua exist in moist, wooded, brushy areas around 3000 m in elevation in Peru and Ecuador and may represent the ancestral type (Gibbs et al., 1978).

The geographic origin of *Tropaeolum tuberosum* appears to have been in the highlands of the central Andes in the vicinity of the Titicaca basin (Hodge, 1946). It is a polyploid species that has a relatively stable chromosome number of $2n = 52$ in a $x = 13$ series (Gibbs *et al*., 1978). Due to multivalent formation and the occurrence of other meiotic abnormalities suggest a possible autoploid origin. Mashua could have been protected from sterility problems through asexual tuber propagation.

Other theories of the origin of polyploidy in *T. tuberosum* such as segmental allopolyploidy following hybridization with other closely related *Tropaeolum* species such as *T. cochabambae* and evolution at the homoploid level have not been discounted (Gibbs *et al.*, 1978). Future research on the origin of *T. tuberosum* is needed to help clarify these questions.

Cultivation

Mashua is adapted to high Andean altitudes which are typified by steep terrain, strong winds, shallow soil, and bare rock surfaces with a high water run-off. Low minimum temperatures and large ranges or diurnal temperatures impose severe stress on the plants (Sperling and King, 1990). Introduced Old world crops are not well adapted to this ecosystem.

Mashua is cultivated in the Andean highlands from 2600 to 4000 m with the best yields of 30,000 kg/ha a year obtained at 3000 m altitude (Torres *et al.*, 1992). A single plant can yield 4 kg of tubers (NRC, 1989). Yields have reached as high as 70 tons per hectare on experimental plots. Annual production figures are hard to determine as much of mashua is cultivated in small fields in remote areas. Mashua has a short life cycle of 5-6 months which allows two harvests per year (Sperling and King, 1990).

Mashua is propagated vegetatively using whole tubers selected from storage. Small tubers are preferred for planting in Peru because they are less valuable for food use (Sperling and King, 1990). Mashua has been vegetatively propagated for thousands of years and viable seeds are only occasionally produced. Mashua is planted in rows or hills 800-100 cm apart with plants spaced 40-60 cm apart in the rows. Planting and harvesting is done by hand with mechanization rare or unknown (Sperling and King, 1990).

Mashua is a favored tuber crop in some Andean farm communities because it is the easier and less labor intensive root crop to grow, and is almost unaffected by poor management (NRC, 1989). In the higher, colder altitudes mashua can be stored in the ground and harvested when needed.

Mashua is also a valuable crop because it is resistent to many insects, nematodes, fungi and other pathogens. It is also resistent to the Andean weevil which attacks potatoes and other tuber crops (NRC, 1989). This disease resistance makes mashua a valuable crop to intercrop with other cultivated species as an efficient and cost effective way to control pests and diseases without using costly chemicals. In the Peruvian highlands, mashua is often grown with maize, oca, ulluco, potatoes, legumes and grains. High levels of compounds with insecticidal properties explain the virtual absence of pests and diseases in the crop.

Although few pests or diseases effect mashua, it is often heavily infected with plant viruses. These viruses effect its productivity and has led to a recent drastic decline in yield (Soria *et al*., 1998). Viruses are a problem in many clonally propagated crops (Sperling and King, 1990). The *Tropaeolum* mosaic potyvirus found affecting mashua has recently been described and traced throughout the whole range of the cultivated tuber. The virus is often spread through the tuber propagation. Elimination of viruses will dramatically increase plant vigor and yield (Stone, 1982). There are a few virus resistant varities of *T. tuberosum* being grown experimentally and their success will determine if mashua will be a crop more widely accepted worldwide for cultivation.

Mashua is a short day length plant requiring 11-13.5 hours of day length for stolon formation and tuberization (Sperling and King, 1990). Tubers fail to form under longer days. Daylight sensitivity may limit its widespread adoption until insensitive strains can be further cultivated.

Nutrition

The nutritional value of mashua is high. Dry tubers may contain 14-16 percent protein, almost 80 percent carbohydrate, about 9 µg/100g ß-carotene, and almost 480 mg Vitamin C/100g (Vaughn and Geissler, 1997). They also contain all of the essential amino acids and posses high levels of asorbic acid (King and Gershoff, 1987). The nutritional content of mashua is good when compared with other staple root and tuber crops eaten around the world.

Although the tubers of mashua have a high nutritional content it is not as palatable as other tubers and tends to be abandoned more readily when people have access to other foods. Because the tubers of mashua are rich in carbohydrates as well as other nutrients and the foliage has a high protein content, it has been suggested that it could be grown for livestock feed (NRC, 1989).

Food uses

Mashua tubers contain isothiocyanates (mustard oils) that give them a sharp, peppery taste reminiscent of hot radishes when eaten raw (Soria *et al*., 1998). The preparation and consumption of mashua vary within countries and cultural groups. The tubers become mild and in some instances sweet when boiled.

The tubers are often boiled with meat, green vegetables, corn, potatoes, and herbs to form a stew or eaten alone as a baked or fried vegetable (King and Gershoff, 1987).

The tubers are also soaked in molasses and eaten as sweets. In Bolivia and some parts of Peru the tubers are coated with molasses and frozen to make a special dessert (NRC, 1989). In addition, the tender young leaves can be eaten as a boiled green vegetable and the flowers are also eaten (NRC, 1989). It has also been suggested that mashua be grown as feed for livestock because of its highly nutritious vegetation (NRC, 1989).

Medicinal uses

Mashua traditionally has many medicinal uses in the folk medicine of the Andean region, and its domestication may have related to its importance as a medicinal agent (Johns et al., 1982). Many of the medicinal uses of mashua relate to the presence of p-methoxybenzyl isothiocyanate, which has been used in Andean ethnomedicine (Johns and Towers, 1981) Mashua is considered an antiaphrodisiac and many Andean men refuse to consume it because they believe it produces impotence and infertility (Johns *et al*., 1982). The Spanish chronicler Cobo stated that the Inca emperors fed their armies mashua, "that they should forget their wives" (1956). Studies done on male rats fed a diet of mashua tubers showed a 45% drop in the levels of testosterone/dihydrotestosterone (Johns *et al*. 1982). In modern Bolivia *T. tuberosum* is believed to induce menstration and are employed in popular medicine as emmenagogues (Johns *et al*. 1982).

Other medicinal properties are also attributed to *T. tuberosum*. The tubers are used to treat kidney ailments, to break bladder and kidney stones, to treat kidney pain, and other kidney diseases. Mashua is also regarded as a diuretic (Johns *et al*. 1982). It is also reported to treat skin ulcers and kill lice.

Recent scientific studies have isolated compounds that are antibiotic, diuretic, and that effect testosterone levels in males and estrogen levels in females (Johns *et al*., 1982). The effect on testosterone level appears to be related to the isothiocyanates in the tubers. Preliminary results suggest that N, N-di-(methoxy-4-benzyl) thiourea competitively inhibits estradiol binding and may have estrogenic activity in human females (Johns *et al*., 1982). The antibiotic, insecticidal, nematocidal, and diuretic properties of isothiocyanates substantiate several uses of mashua in Andean folk medicine.

Potential

Mashua has the potential to become a major food plant around the world. The pest and pathogen resistance, high yield, nutrient content, and ease of cultivation make mashua an excellent candidate for further research. Possibilities exist for cultivating mashua in other regions of the world with similar growing conditions and also for treating the tubers as winter crops in mild climates.

The success of introducing mashua to other regions of the world will depend on careful selection of germplasm adapted to specific environments (Sperling and King, 1990). The current requirement for short days for tuber formation may limit potential cultivation areas, but existing variations in different clones in response to day length show promise in producing new cultivars adapted to long days or being day neutral (Sperling and King, 1990). The Andean potato was originally adapted to the same environment and had the same day length requirements as mashua, and there is a strong possibility of introducing mashua into new growing regions as has been done with the potato.

The insecticidal, nematocidial, bacteriocidal, pharmacological, and other medicinal effects should be investigated further. Mashua may also be suited for industrial production. These properties of mashua along with the continually expanding food needs of a growing population suggests a greater demand and market for this useful crop. Increased research attention to the production of mashua can improve the potential for cultivation of mashua in other regions as well as increase the use of mashua in its native Andean range, providing food for increasing Andean populations. Research towards the improvement of *Tropaeolum tuberosum* may yield a crop plant that will someday rival its companion in origin, the potato.

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