



"The potato eaters" (1885)
by Vincent Van Gogh

Diffusion

The diffusion of the potato from the Andes to the rest of the globe reads like an adventure story, but it began with a tragedy. The Spanish conquest of Peru between 1532 and 1572 destroyed the Inca civilization and caused the deaths – from war, disease and despair – of at least half the population.

The conquistadores came in search of gold, but the real treasure they took back to Europe was *Solanum tuberosum*. The first evidence of potato growing in Europe dates from 1565, on Spain's Canary Islands. By 1573, the potato was known to be cultivated on the Spanish mainland. Soon after, tubers were being sent around Europe as exotic gifts – from the Spanish court to the Pope in Rome; from Rome to the papal ambassador in Mons; and from there to a botanist in Vienna. Potatoes were grown in London in 1597 and reached France and the Netherlands soon after.

But once the plant had been added to botanical gardens and herbalists' encyclopaedias, interest waned. European aristocracy admired its flowers, but the tubers were considered fit only for pigs and the destitute. Superstitious peasants believed the

potato was poisonous. At the same time, however, Europe's "Age of Discovery" had begun, and among the first to appreciate potatoes as food were sailors who took tubers to consume on ocean voyages. That is how the potato reached India, China and Japan early in the 17th century.

The potato also received an unusually warm welcome in Ireland, where it proved suited to the cool air and moist soils. Irish immigrants took the tuber – and the name, "Irish potato" – to North America in the early 1700s.

Long summer days. The widespread adoption of the potato as a food crop in the northern hemisphere was delayed not only by entrenched eating habits, but by the challenge of adapting a plant grown for millennia in the Andes to the temperate climate of the north. Only a drop of the rich potato gene pool had left South America, and it took 150 years before varieties suited to long summer days began to appear.

Those varieties arrived at a crucial time. In the 1770s, much of continental Europe was devastated by famines, and the potato's value as a food security crop was suddenly recognized. Frederick the Great of Prussia ordered his subjects to grow potatoes as

insurance against cereal crop failure, while the French scientist Parmentier succeeded in having the potato declared “edible” (around the same time, on the other side of the Atlantic, the President of the United States, Thomas Jefferson, served French fries to White House guests).

After initial hesitation, European farmers – even those in Russia, where the potato was called the “devil’s apple” – began growing potatoes on a large scale. The potato became Europe’s food reserve during the Napoleonic wars, and by 1815 it had become a staple crop across northern Europe. By then, the Industrial Revolution was transforming agrarian society in the United Kingdom, displacing millions of rural people into crowded cities. In the new urban environment, the potato became the first modern “convenience food” – energy-rich, nutritious, easy to grow on small plots, cheap to purchase, and ready to cook without expensive processing.

Increased potato consumption during the 19th century is credited with helping to reduce the scourge of diseases such as scurvy and measles, contributing to higher birth rates and the population explosion in Europe, the United States and the British Empire.

“Potato famine”. But the potato’s success proved a double-edged sword. For the tubers that were being cloned and cultivated across North America and Europe belonged to a few, genetically similar varieties. That meant they were highly vulnerable: a pest or disease that struck one plant could spread quickly to the rest.

The first sign of impending disaster came in 1844-1845, when a mould disease, late blight, ravaged potato fields across continental Europe, from Belgium to Russia. But the worst came to Ireland, where potato supplied 80 percent of calorie intake. Between 1845 and 1848, late blight destroyed three potato crops, leading to famines that caused the deaths of one million people.

The Irish catastrophe led to concerted efforts to develop more productive and disease-resistant varieties. Breeders in Europe and North America, drawing on new potato germplasm from Chile, produced many of the modern varieties that laid the foundation for massive potato production in both regions for most of the 20th century.

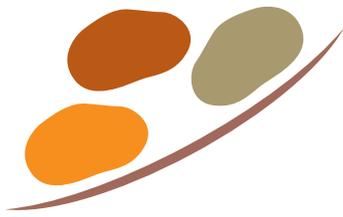
Meanwhile, European colonialism and emigration were taking the potato to all corners of the globe. Colonial governors, missionaries and settlers introduced potato growing to the floodplains of Bengal and Egypt’s Nile delta, the Atlas Mountains of Morocco, and the Jos plateau in Nigeria. Emigrant farmers took the potato to Australia and even to South America, establishing the potato in Argentina and Brazil.

In the Asian heartland, the tuber moved along more ancient routes, finding its way from the Caucasus to Turkey’s Anatolian

Papa, patata, potato...

While the Incas called it *papa* (as do modern-day Latin Americans), the Spaniards called the potato *patata*, apparently confusing it with another New World crop, the sweet potato (known as *batata*). In 1797, the English herbalist Gerard referred to the sweet potato as “common potatoes”, and for many years *S. tuberosum* was known as the “Virginia potato” or “Irish potato” before finally displacing *batata* as *the* potato.





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plateau, from Russia to western China, and from China to the Korean Peninsula. In the mountain valleys of Tajikistan, some potato types have been grown long enough to be considered “old local varieties”.

The 20th century saw the potato finally emerge as a truly global food. The Soviet Union’s annual potato harvest reached 100 million tonnes. In the years following the Second World War, huge areas of arable land in Germany and Britain were dedicated to the potato, and countries like Belarus and Poland produced – and still do – more potatoes than cereals.

The potato came into its own as a snack food. The invention in the 1920s of the mechanical potato peeler helped make potato crisps America’s top-selling snack. A restaurant chain founded by the McDonald brothers in the United States in 1957 spent millions of dollars to “perfect the French fry”. A Canadian firm, McCain, that began making frozen French fries in 1957, expanded to open 57 production facilities on six continents and now supplies one third of all French fried potatoes produced internationally.

Exploding demand. From the 1960s, cultivation of the potato began to expand in the developing world. In India and China alone, total production rose from 16 million tonnes in 1960 to almost 100 million in 2007. In Bangladesh, potato has become a valuable winter cash crop, while potato farmers in Southeast Asia have tapped into exploding demand from food industries. In sub-Saharan Africa, potato is a preferred food in many urban areas, and an important crop in the

highlands of Cameroon, Kenya, Malawi and Rwanda.

The potato has an extraordinarily rich past, and a bright future. While production in Europe – the potato’s “second home” for four centuries – is declining, the potato has ample room for expansion in the developing world, where its consumption is less than a quarter that of developed countries.

Today in mountainous Lesotho, many farmers are shifting from maize to potato, assisted by an FAO project for production of virus-free seed tubers. In China, agriculture experts claim that a staggering 30 percent increase in potato yields is within reach.

And in the Andes, where it all began, the Government of Peru created in July 2008 a national register of Peruvian native potato varieties, to help conserve the country’s rich potato heritage. That genetic diversity, the building blocks of new varieties adapted to the world’s evolving needs, will help write future chapters in the story of *Solanum tuberosum*.



HARJONO DJOYOBISONO

Potato fields in central Java, Indonesia

Cultivation

Potato is grown in more than 100 countries, under temperate, subtropical and tropical conditions. It is essentially a “cool weather crop”, with temperature being the main limiting factor to production: tuber growth is sharply inhibited in temperatures below 10°C and above 30°C, while optimum yields are obtained where mean daily temperatures are in the 18 to 20°C range.

For that reason, potato is planted in early spring in temperate zones and late winter in warmer regions, and grown during the coolest months of the year in hot tropical climates. In some sub-tropical highlands, mild temperatures and high solar radiation allow farmers to grow potatoes throughout the year, and to harvest tubers within 90 days of planting (in temperate climates, such as in northern Europe, that can take up to 150 days).

The potato is a very accommodating and adaptable plant, and will produce well even without ideal soil and growing conditions.

However, it is also vulnerable to a number of pests and diseases. To prevent the build-up of pathogens in the soil, farmers avoid growing potatoes on the same land from year to year. Instead, they grow potatoes in rotations of three or more years, alternating with other, dissimilar crops, such as maize, beans and alfalfa. Crops susceptible to the same pathogens as the potato (e.g. tomato) are avoided, in order to break the development cycle of potato pests.

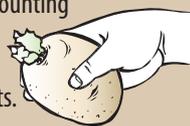
With good agricultural practices, including irrigation when necessary, a hectare of potato in the temperate climates of northern Europe and North America can yield more than 40 tonnes of fresh tubers within four months

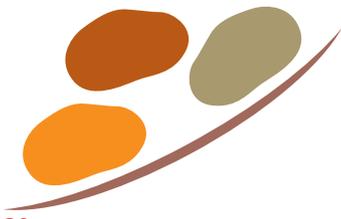
of planting. In most developing countries, however, average yields are much lower – ranging from as little as 5 to 25 tonnes – owing to lack of high quality seed and improved cultivars, lower rates of fertilizer use and irrigation, and pest and disease problems.

Selecting seed potato

Seed potato is usually the most expensive input to potato cultivation, accounting for from 30 to 50 percent of production costs.

In areas of developing countries where no formal seed supply system exists, farmers have devised their own *ad hoc* method for selecting seed tubers: they sell the largest potatoes for cash, eat the medium-sized ones at home, and keep the smallest as future planting material.





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Soil and land preparation

The potato can be grown on almost any type of soil, except saline and alkaline. Naturally loose soils, which offer the least resistance to enlargement of the tubers, are preferred, and loamy and sandy loam soils that are rich in organic matter, with good drainage and aeration, are the most suitable. Soil with a pH range of 5.2 – 6.4 is considered ideal.

Growing potatoes involves extensive ground preparation. The soil needs to be harrowed until completely free of weed roots. In most cases, three ploughings, along with frequent harrowing and rolling, are needed before the soil reaches a suitable condition: soft, well-drained and well-aerated.

Planting

The potato crop is usually grown not from seed but from “seed potatoes” – small tubers or pieces of tuber sown to a depth of 5 to 10 cm. Purity of the cultivars and healthy seed tubers are essential for a successful crop. Tuber seed should be disease-free, well-sprouted and from 30 to 40 g in weight. Use of good quality commercial seed can increase yields by 30 to 50 percent, compared

to farmers’ own seed, but expected profits must offset the higher cost.

The planting density of a row of potatoes depends on the size of the tubers chosen, while the inter-row spacing must allow for ridging of the crop (*see below*). Usually, about two tonnes of seed potatoes are sown per hectare. For rainfed production in dry areas, planting on flat soil gives higher yields (thanks to better soil water conservation), while irrigated crops are mainly grown on ridges.

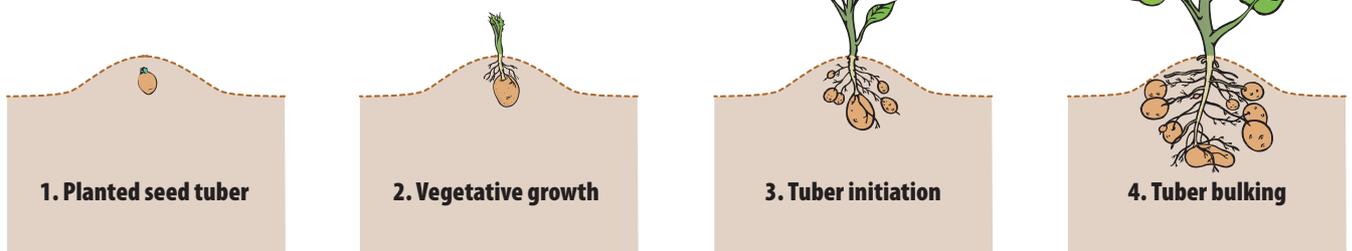
Crop care

During the development of the potato canopy, which takes about four weeks, weeds must be controlled in order to give the crop a “competitive advantage”. If the weeds are large, they must be removed before ridging operations begin. Ridging (or “earthing up”) consists of mounding the soil from between the rows around the main stem of the potato plant. Ridging keeps the plants upright and the soil loose, prevents insect pests such as the tuber moth from reaching the tubers, and helps prevent the growth of weeds.

After earthing up, weeds between the

Stages in crop development

BRITISH POTATO COUNCIL



Potato varieties

Although the potato cultivated worldwide belongs to just one botanical species, *Solanum tuberosum*, the tubers come in thousands of varieties with great differences in size, shape, colour, texture, cooking characteristics and taste. Here is a small sample of potato diversity:



1. Atahualpa
Bred in Peru, a high yielding variety good for both baking and frying



2. Nicola
Widely grown Dutch variety, one of the best for boiling, also good in salads



3. Russet Burbank
The classic American potato, excellent for baking and French fries



4. Lapin puikula
Grown in Finland for centuries, in fields bathed in the light of the midnight sun



5. Yukon Gold
A Canadian potato with buttery yellow flesh suitable for frying, boiling, mashing



6. Tubira
CIP-bred variety grown in West Africa. White flesh, pink skin



7. Vitelotte
A gourmet French variety prized for its deep blue skin and violet flesh



8. Royal Jersey
From the Isle of Jersey: the only British vegetable with an EU designation-of-origin



9. Kipfler
Hails from Germany. Elongated with cream flesh, popular in salads



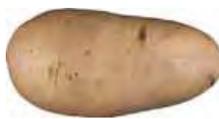
10. Papa colorada
Brought to the Canary Islands by passing Spanish ships in 1567



11. Maris Bard
Bred in the United Kingdom, a white variety with a soft waxy texture good for boiling



12. Désirée
Red-skinned, with yellow flesh and a distinctive flavour



13. Spunta
Another popular commercial tuber, good for boiling and roasting



14. Mondial
A Dutch potato with smooth good looks. Boils and mashes well



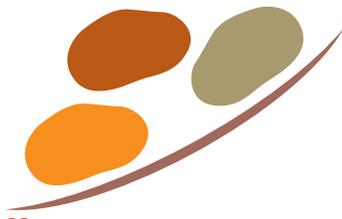
15. Unknown
One of more than 5 000 native varieties still grown in the Andes

growing plants and at the top of the ridge are removed mechanically or by using herbicides. Ridging should be done two or three times at an interval of 15 to 20 days. The first should be done when the plants are about 15-25 cm high; the second is often done to cover the growing tubers.

Manuring and fertilization

The use of chemical fertilizer depends on the level of available soil nutrients – volcanic soils, for example, are typically deficient in phosphorus – and in irrigated commercial production, fertilizer requirements are relatively high. However, the potato can benefit from application of organic manure at

CIP [1,6], NIVAP HOLLAND [2,12,13,14], CANADIAN FOOD INSPECTION AGENCY [3,5,11], LAPIN KEITTIÖMESTARIT [4], ABSTRACT GOURMET [7,8,10], J-L GONTERRE [15]



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the start of a new rotation: it provides a good nutrient balance and protects the structure of the soil. Crop fertilization requirements need to be correctly estimated according to the expected yield, the potential of the variety and the intended use of the harvested crop.

Water supply

The soil moisture content must be maintained at a relatively high level. For best yields, a 120 to 150 day crop requires from 500 to 700 mm of water. In general, water deficits in the middle to late part of the growing period tend to reduce yield more than those in the early part. Where supply is limited, water should be directed towards maximizing yield per hectare rather than being applied over a larger area.

Because the potato has a shallow root system, yield response to frequent irrigation is considerable, and very high yields are obtained with mechanized sprinkler systems that replenish evapotranspiration losses every one or two days. Under irrigation in temperate and subtropical climates, a crop of about 120 days can produce yields of 25 to 35 tonnes/ha, falling to 15 to 25 tonnes/ha in tropical areas.

Pests and diseases

A few basic precautions against diseases – crop rotation, using tolerant varieties and healthy, certified seed tubers – can help avoid great losses. There is no chemical control for bacterial and viral diseases but they can be controlled by regular monitoring (and when necessary, spraying) of their aphid vectors. The severity of fungal diseases such as late blight depends, after the first infection, mainly on the weather – persistence of favourable conditions, without chemical spraying, can quickly spread the disease.

Insect pests can wreak havoc in a potato patch. Recommended control measures include regular monitoring and steps to protect the pests' natural enemies. Even damage caused by the Colorado potato beetle, a major pest, can be reduced by destroying beetles, eggs and larvae that appear early in the season, while sanitation, crop rotations and use of resistant potato varieties help prevent the spread of nematodes.

Harvesting

Yellowing of the potato plant's leaves and easy separation of the tubers from their stolons indicate that the crop has reached maturity. If the potatoes are to be stored rather than consumed immediately, they are left in the soil to allow their skins to thicken – thick skins prevent storage diseases and shrinkage due to water loss. However, leaving tubers for too long in the ground increases their exposure to a fungal incrustation called black scurf.

To facilitate harvesting, the potato vines should be removed two weeks before the



Potatoes awaiting sale
in La Plata, Argentina

potatoes are dug up. Depending on the scale of production, potatoes are harvested using a spading fork, a plough or commercial potato harvesters that unearth the plant and shake or blow the soil from the tubers. During harvesting, it is important to avoid bruising or other injury, which provide entry points for storage diseases.

Storage

Since the newly harvested tubers are living tissue – and therefore subject to deterioration – proper storage is essential, both to prevent post-harvest losses of potatoes destined for fresh consumption or processing, and to guarantee an adequate supply of seed tubers for the next cropping season.

For ware and processing potatoes, storage aims at preventing “greening” (the build up of chlorophyll beneath the peel, which is associated with solanine, a potentially toxic alkaloid) and losses in weight and quality. The tubers should be kept at a temperature of 6 to 8°C degrees, in a dark, well-ventilated environment with high relative humidity (85 to 90 percent). Seed tubers are stored, instead, under diffused light in order to maintain their germination capacity and encourage development of vigorous sprouts. In regions, such as northern Europe, with only one cropping season and where storage of tubers from one season to the next is difficult without the use of costly refrigeration, off-season planting may offer a solution.

Uses of potato

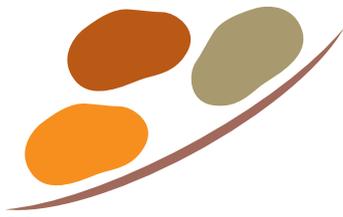
Once harvested, potatoes are used for a variety of purposes, and not only as a vegetable for cooking at home. In fact, it is likely that less than 50 percent of potatoes grown worldwide are consumed fresh. The rest are processed into potato food products and food ingredients, fed to cattle, pigs and chickens, processed into starch for industry, and re-used as seed tubers for growing the next season’s potato crop.

Food uses: fresh, “frozen”, dehydrated

FAO estimates that just over two-thirds of the 320 million tonnes of potatoes produced in 2005 were consumed by people as food, in one form or another. Home-grown or purchased in markets, **fresh potatoes** are baked, boiled or fried and used in an astonishing range of recipes: mashed potatoes, potato pancakes, potato dumplings, twice-baked potatoes, potato soup, potato salad and potatoes *au gratin*, to name a few.

However, the global consumption of potato as food is shifting from fresh potatoes to added-value, **processed food products**.





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UJAMAI

One of the main items in that category goes by the unappetizing name of *frozen potatoes*, but includes most of the *French fries* (“chips” in the United Kingdom) served in restaurants and fast food chains worldwide. The production process is fairly simple: peeled potatoes are shot through cutting blades, parboiled, air dried, par fried, frozen and packaged. The world’s appetite for factory-made French fries is estimated at more than 11 million tonnes a year.



M. ALVES

Another processed product, the *potato crisp* (“chips” in the United States), is the long-standing king of snack foods in many developed countries. Made from thin slices of deep-fried or baked potato, they come in a variety of flavours – from simple salted to “gourmet” varieties tasting of roast beef and Thai chili. Some crisps are produced using a dough made from dehydrated potato flakes.



JIANGSU CORP.

Dehydrated potato flakes and granules are made by drying a mash of cooked potatoes to a moisture level of 5 to 8 percent. Flakes are used in retail mashed potato products, as ingredients in snacks, and even as food aid: as part of its international food assistance, the United States has distributed potato flakes to more than 600 000 people. Another dehydrated product, *potato flour*, is ground from cooked, whole potatoes and retains a distinct potato taste. Gluten-free and rich in starch, potato flour is used by the food industry to bind meat mixtures and thicken gravies and soups.



JIANGSU CORP.

Modern starch processing can retrieve as much as 96 per cent of the starch found in raw potatoes. A fine, tasteless powder with “excellent mouth-feel”, *potato starch* provides

higher viscosity than wheat and maize starches, and delivers a more tasty product. It is used as a thickener for sauces and stews, and as a binding agent in cake mixes, dough, biscuits and ice-cream.

Finally, in eastern Europe and Scandinavia, crushed potatoes are heated to convert their starch to fermentable sugars that are used in the distillation of *alcoholic beverages* such as vodka and *akvavit*.

Non-food uses: Glue, animal feed and fuel-grade ethanol

Potato starch is also widely used by the pharmaceutical, textile, wood and paper industries as an adhesive, binder, texture agent and filler, and by oil drilling firms to wash boreholes. Potato starch is a 100% biodegradable substitute for polystyrene and other plastics and used, for example, in disposable plates, dishes and knives.

Potato peel and other “zero value” wastes from potato processing are rich in starch that can be liquefied and fermented to produce **fuel-grade ethanol**. A study in Canada’s potato-growing province of New Brunswick estimated that 440 000 tonnes of processing waste could produce 4 to 5 million litres of ethanol.

One of the first widespread uses of the potato in Europe was as **farm animal feed**. In the Russian Federation and other East European countries, as much as half of the potato harvest is still used for that purpose. Cattle can be fed up to 20 kg of raw potatoes



C. FROGENHALL

a day, while pigs fatten quickly on a daily diet of 6 kg of boiled potatoes. Chopped up and added to silage, the tubers cook in the heat of fermentation.

Seed potatoes: renewing the cycle...

Unlike other major field crops, potatoes are



D. MARJINE

reproduced vegetatively, from other potatoes. Therefore, a part of each year's crop – ranging from 5 to

15 percent, depending on the quality of the harvested tubers – is set aside for re-use in the next planting season. Most farmers in developing countries select and store their own seed tubers. In developed countries, farmers are more likely to purchase disease-free “certified seed” from dedicated suppliers. More than 13 percent of France's potato growing area is used to produce seed potatoes, and the Netherlands exports some 700 000 tonnes of certified seed a year.

OSCAR MARIN REPELLER

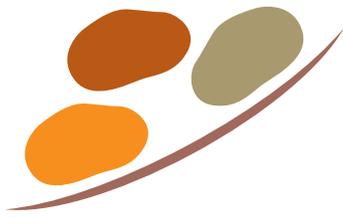


Traditional dish
of the Canary
Islands

Potatoes in the kitchen

What has made the “humble tuber” the world's No. 4 food crop is not only its nutritional value but its amazing versatility in the kitchen. Potatoes are the world's most popular vegetable, and have been welcomed into the cuisines of countries around the globe. Potatoes are used in curries in India and in pasta in Italy, stewed with bananas in Costa Rica, baked with rice in Iran, stuffed with liver in Belarus, stir-fried with green beans in Ethiopia, and simmered with smoked haddock in winter soups in Finland.

The secret of the potato's success is its great diversity: in Peru, a potato salad may include three or four different types. While the choice of tubers is more limited elsewhere, modern varieties of *Solanum tuberosum* offer a wide range of cooking characteristics suitable for hundreds of different dishes. Some give soups a creamy density, providing a delicate taste that highlights other ingredients. Other potatoes are great when baked, served as a simple snack or with a filling as a complete meal. Roast potatoes – crisp and golden outside and fluffy inside – are the perfect



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accompaniment to roast meat. Smooth, creamy, mashed potato is said to be the “ultimate comfort food”, while “new” potatoes, steamed or boiled, are considered a special delicacy.

Most potato recipes are easy to prepare. But choosing the right potato variety is essential for a successful potato dish – in the kitchen, potatoes are classified according to their starch content, which determines how they react to cooking. Basically, the more starch they contain, the more easily the tuber’s starch cells burst when heated.

Choosing the “right potato”

High-starch potatoes, also called “floury” potatoes, generally have coarse, corky skin and a dry texture (due to lower levels of moisture). Boiled, they tend to fall apart. But they are unbeatable for baking, making French fries, and yielding light, fluffy mashed potato. Common high-starch varieties are Russets, Bintje, King Edward and Maris Piper.

S. GILBERT



J. JULIAN

Medium-starch (or “all purpose”) potatoes include long white, round white and yellow potatoes, such as Yukon Gold, German Butterball and Nicola, as well as purple-fleshed tubers. They are more moist than baking potatoes, but – some say – have a blander taste. Ideal for steaming, they go well in stews and in baked, roasted, pan-fried and *au gratin* dishes.

Low-starch potatoes are called “waxy” for their glossy skins. These moist tubers keep their shape during cooking, making them the best choice for boiling, sautés, stews and salads (in France, waxy varieties are preferred for making thick mashed potato). Use fingerling and round reds, or “new” (immature, of any variety) potatoes.



K. PUGH

Factsheets. To deepen understanding of the potato’s role in world agriculture, the economy and global food security, FAO specialists compiled a series of factsheets on key issues in potato development.