



POTATOES - STORAGE AND PROCESSING

Introduction

The potato (*Solanum tuberosum*) is a starchy tuber of the Solanaceae family. It is thought to have originated in the Andes region, where there are other closely related cultivated potato species. Potatoes were introduced outside the Andes 400 years ago, and are now an integral part of the world's cuisine, being the fourth-largest food crop after rice, wheat, and maize. Following centuries of selective breeding, there are now over a thousand different types of potatoes and nearly 4000 different varieties (Figure. 1).



Figure 1: Potatoes on display at the festival of native potatoes in Peru. There are 256 varieties of potato that can survive the harsh conditions of the high Andes. Practical Action is helping families living at altitudes of 3800ft to maintain this crucial biodiversity by developing varieties of local potatoes, as well as improve technical aspects of production. Photo: Soluciones Prácticas.

Approximately 80 varieties are commercially available in countries outside Latin America, and these are grouped either according to their colour (e.g. russets, reds, whites, yellows and purples), or for culinary and processing purposes, varieties that are described in terms of their texture: flourey potatoes that are baked or roasted have more starch (20–22%) compared to waxy boiling potatoes (16–18%). There are also differences in the type of starch present in each type: amylose, a long-chain molecule, diffuses out of the starch granule when flourey types are cooked in water, whereas waxy varieties that contain a higher amount of highly-branched amylopectin molecules retain their shape when boiled. Different types of potatoes are described on the European Cultivated Potato Database at www.europotato.org/menu.php

Potatoes contain toxic compounds known as glycoalkaloids; the most common being solanine. The toxin affects the nervous system, causing headaches, diarrhoea, cramps, weakness and confusion. Solanine content in potato tubers is increased by exposure to light, physical damage, and age, and the highest concentrations occur just underneath the skin. However, exposure to light also causes greening due to chlorophyll production, which gives a visual warning that these areas of the tuber may have become more toxic.

Storage

Storage facilities for potatoes need to be carefully designed to slow the natural process of decomposition, and it is essential that the storage area is dark and well-ventilated. New potatoes are sensitive to chilling injury and should be stored at 13 - 15°C with 85-90% relative humidity for up to a few weeks. For short-term storage of mature potatoes, temperatures of 7 - 10°C are preferred. If potatoes are stored above approx. 10°C they sprout

and shrivel. For long-term storage (up to twelve months), the optimum conditions are a temperature near to 4°C. Commercial storage of potatoes involves first drying them to remove surface moisture; then storage at 85 - 95% relative humidity and below 25°C to heal any wounds and toughen the skin; a cooling phase to 4°C; holding at this temperature for the storage period and then a conditioning phase before use, during which the tubers are slowly warmed.

Potatoes should not be stored below 4°C because dark spots and internal discoloration can occur. Low storage temperatures, below 10°C, also cause starch to be converted into sugar and this increase in sugar content is undesirable if potatoes are used in fried products because they darken excessively during frying. This also produces higher levels of acrylamide in fried products (see below).

For artisan or small-scale storage, potatoes can be stored in cellars or underground pits. In a lined pit, potatoes are piled on a bed of straw and the pile similarly covered with straw and soil. This type of pit can only be used in areas where groundwater and rodents are not a problem. The pit protects crops from sub-zero temperatures during the winter in temperate regions or at high altitudes, or it protects them against heat in tropical climates. Provided that any damaged or diseased pieces are removed before storage, they can remain in good condition for several months. Another low-cost storage method is a buried barrel (Fig. 2a), which is sealed against groundwater and rodents. Potatoes are placed in the barrel and the lid is fitted loosely to allow for air movement. It is then covered with up to a thick layer of straw and a layer of soil. A storage mound (Fig. 2b) is similar to an unlined pit and is used where there is groundwater or a shorter storage period is required. Potatoes are piled on a layer of straw on the ground and then covered with a layer of straw and soil.

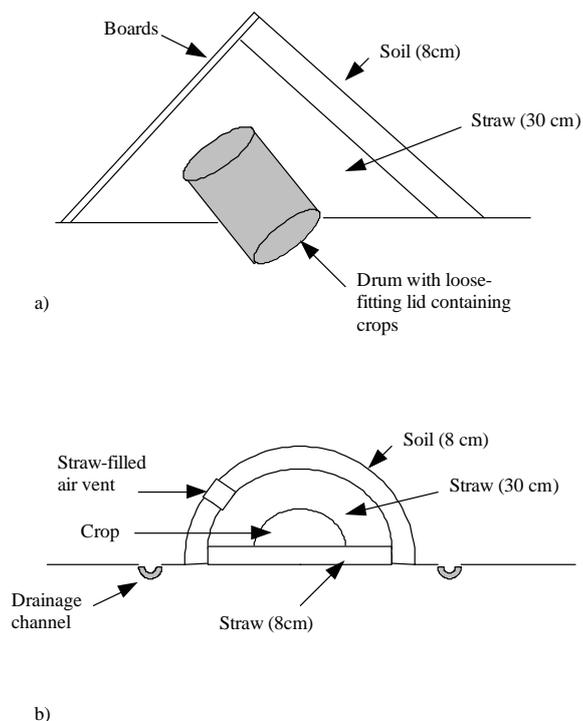


Figure. 2. Low-cost potato storage, a) buried drum, b) storage mound (Adapted from Ells et al, 2011)

Processing

Potatoes are prepared in many ways as components of meals and a selection of these products is included here as many are processed for food service outlets or as street foods. All involve

cooking the potatoes to gelatinise the starch and make them more digestible. Most potato dishes are served hot and they include unpeeled baked potatoes; boiled or steamed potatoes; peeled roast potatoes; mashed potatoes from peeled boiled potatoes with milk, yoghurt and/or butter, also used a component of traditional dishes such as shepherd's pie, fish pie, and Colcannon or 'bubble and squeak' (mashed potato fried with a shredded leafy vegetable); hash browns (grated into small thin strips and fried). Boxyt pancakes are traditionally made with soaked grated potatoes mixed with flour, buttermilk and baking powder. Acadian poutine is a ball of grated and mashed potato, salted, sometimes filled with pork, and boiled. In India, potato is used in Aloo ki sabzi (potato curry), alu paratha, a type of stuffed chapatti, and in puri snacks. Masala dosa is a thin pancake of rice and pulse paste with spicy mashed potato filling. Other dishes are alu tikki and pakodas. South American cuisine contains potatoes as a main ingredient in many dishes (e.g. Fig. 3), often with chilli-based sauces (papa a la huancaína), or Carapulca with dried potato (papa seca). Bryndzové halušky in Slovakia is made of a batter of flour and finely grated potatoes boiled to form dumplings. Puddings (kugel, kugelis and potato babka) are made from grated potatoes in Lithuania and Belarus. Mashed potatoes or potato flour are used in dumplings eaten with meat dishes throughout central and eastern Europe and in Italy potatoes are used to make a type of pasta named gnocchi.



Fig. 3. Papa rellena - a South American potato product (from http://en.wikipedia.org/wiki/Papa_rellena) Peruvian stuffed potatoes are mashed potatoes that are shaped around a center of seasoned ground beef and then fried golden brown.

One of the most important derivatives of the potato in Peru is the dried potato known as Papa Seca, a product that requires little preparation. Soluciones Practicas has written about the processing of Papa Seca.

Potato flour is made in some countries by grinding potatoes to a paste and drying and milling it to the flour. Chuño is freeze-dried potato, traditionally produced in mountainous regions of Peru and Bolivia, where the low temperatures and low air pressure allow the process to take place naturally. In other areas, freeze drying requires equipment and this process is too expensive.

Frying

The most widespread type of potato processing that is used by small-scale processors is frying and the two most common products are potato chips (or 'French fries' in USA) and potato crisps (or 'chips' in USA). These products are made from peeled potatoes that are cut into slices or scallops and fried. Other fried potato products include aloo chaat; patatas bravas, a dish of fried potatoes in a spicy tomato sauce; potato samosas made from spicy mashed potato mixed with vegetables, stuffed into dough and deep fried. Each of these products offer the opportunity to add considerable value to basic ingredients using relatively inexpensive equipment, and as a result frying is a popular and potentially profitable business at all scales of operation.

Potatoes first require cleaning by soaking them in water to remove soil, and then sorting and peeling. Potatoes can be sorted according to differences in density by flotation in brine that has a specific gravity of 1.1162–1.1362. Potatoes that are suitable for crisp-making have high solids content, which makes them denser and they sink in the brine, whereas less dense potatoes float. For economical peeling, potatoes should have a uniform oval or round shape without any protuberances. Peeling by hand is laborious and time-consuming, and causes excessive loss of potato along with the skins. Machine peeling is preferable in even micro-scale operations, and the most common type of peeler is an abrasion peeler (Fig. 4). This has a

rotating bowl that is lined with an abrasive material such as carborundum, and a supply of fresh water to wash away the peels.



Fig 4. Potato peeler (Courtesy of Stigwood and Sons)

Potatoes are cut to size using a number of methods: chopping, dicing and chipping large to medium sized pieces for French fries and slicing to medium/small pieces for crisps. Small manual or powered machines are available to cut uniform sized chips and a mandolin may be used to may uniformly thick slices (Fig. 5).



Fig. 5. Chipping and slicing machines, a) and b) manual potato chippers, c), powered potato chipper (from Metcalfe Catering at www.metcalfecatering.com/products/metcalfe/potato-chippers), d) mandolin slicer (from Fantes at www.fantes.com/images/23712mandolines.jpg)

technical brief

When potatoes are peeled and sliced, browning of cut surfaces takes place due to a natural enzyme in the potatoes. This can be reduced or prevented by immersing the slices under water with or without the addition of a small amount (e.g. 2%) of citric acid (lemon or lime juice can also be used but these flavour the products, which may be unacceptable). Blanching can also be used to prevent browning of potatoes before they are fried. The slices are heated in steam or in hot water for a few minutes.

Potato slices are fried in a deep-fat fryer (Fig. 6) at 185-190°C for 3 min for crisps and 4 - 6 min. for French fries.

Fig. 6. Deep fat fryer (photo from Deep Fat Fryer Shop at <http://fryershop.co.uk>)



There are a large number of blended oils available for different applications, but many processors use sunflower, peanut or palm oils for frying potato crisps and French fries.

Potentially carcinogenic (cancer causing) acrylamide is produced in foods at the high temperatures used in frying. It can be reduced by selecting potatoes that have low levels of sugar or by dipping the cut potatoes in citric acid solution before frying. Less commonly, lower temperature frying or vacuum frying can also reduce the formation of acrylamide.

French fries are consumed shortly after frying and are packaged in simple wraps to keep them clean. Potato crisps require packaging to protect them against breakage; to prevent them picking up moisture that would lead to softening; and exposure to heat, light and oxygen that would lead to development of rancid off-flavours. To give a long shelf life, they should be packed into individual packs made from moistureproof, lightproof and airtight plastic films. Many small-scale processors attempt to use polythene bags, but these are not sufficiently airtight and polypropylene is preferred. Packs should be heat-sealed and not tied, and ideally the packs should be printed to exclude light. They are then contained in corrugated cardboard boxes or other containers to protect them against breakage and light and stored in a cool place.

A note on other potato products

Potato pulp may be fermented with malted barley or other grains and then distilled to make a variety of vodka-like drinks (e.g. Cocoroco (Bolivian brandy) and Irish Poteen). Production of alcoholic spirits requires a special licence in most countries and is illegal in others. Starches made from potato flour are also used to make a wide variety of extruded breakfast cereals, snackfoods, pasta and biscuits. The starch is extracted by soaking potato pulp in water and separating the starch by sedimentation and/or filtration. However, this is not widely done at a small-scale. Potato chips may also be frozen, either before or after frying (the latter producing 'oven ready' chips) and have a storage life of two years when held frozen at a temperature of minus 18 - 20°C.

Reference

Ells, J.E., Jorgensen, C.J. and Whiting, D., 2011. Storage of Home-Grown Vegetables, Colorado State University Extension, available at www.ext.colostate.edu/pubs/garden/07601.html

Further information

- *Deep-Fat Frying Basics for Food Services*, Kerr R.M., 2006, FAPC 126, Oklahoma Cooperative Extension Service Division of Agricultural Sciences and Natural Resources, available at www.fapc.okstate.edu/news/factsheets.html
- *Frying of Food*, Boskou, D. and Elmadfa, I. (Eds.), 1999, Technomic Publishing, Lancaster.
- *The Complete Manual of Small-scale Food Processing*, Fellows, P.J., 2012. Practical Action Publishing, in preparation.

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