Green Bean and Pea
Harvest & Post-harvest Handling Handbook
May 2011

Submitted to:

Imani Women Group
c/o CNFA-Tanzania
Summit Centre, Block B, 5th Fl.
P.O. Box 16449, Arusha
Tanzania

Submitted by:

Jeffrey E. Engels, Ph.D.
International Development Specialist
59 Church Street
Hawthorn, VIC, 3122
Australia

USAID
FROM THE AMERICAN PEOPLE

Table of Contents

Table of Contents **i**

1 Introduction **1**

2 Green Beans **1**
2.1 Production overview 2
2.2 Harvesting 3
2.3 Grading and packing 4
2.4 Storage 4

3 Peas **7**
3.1 Production overview 8
3.2 Harvesting 10
3.3 Grading and packing 12
3.4 Storage 12

References **13**

1. Introduction

The Imani Women Group (IWG) in Siha district, Kilimanjaro province, Tanzania, is comprised of seventy (70) active members who grow fresh beans and peas to supply to Home Vegetable Limited (HomeVeg). HomeVeg is a local fresh vegetable exporting company that ships high quality vegetables to EU customers. HomeVeg would like to expand their operations to more EU buyers, but to do so HomeVeg requires from small-scale grower groups like IWG to increase their knowledge and experience in harvesting and post-harvest handling of their crops. For IWG to sell more of their production to HomeVeg, the group needs to adopt good agricultural practices and meet export standards. Once done, it is anticipated IWG will be able to reduce the amount of their post-harvest losses from the current 20-40% to 10-15%. This will significantly increase their sales and income and help to reduce poverty among IWG members (Kissinga, 2011).

Citizens Network for Foreign Affairs (CNFA), a USAID-funded international development organization, is providing technical support to IWG on harvesting and post-harvest handling through this 'Green Bean and Pea Harvest & Post-harvest Handling Handbook'. This Handbook has been specifically complied for IWG and acts as a guide to good agricultural practices addressing harvesting, grading, packing, and storage of fresh green beans and peas. Further, this Handbook accompanies harvesting and post-harvest handling training conducted for IWG in May 2011.

2. Green Beans

The bean (*Phaseolus vulgaris*) is known by several names, including such names as kidney bean, navy bean, pinto bean, snap or string bean, black bean or white bean. Over 14,000 cultivars of common bean are known to exist. The common bean (genus *Phaseolus*) includes 150-200 species of plants, many of which are cultivated as food.

Beans are one of the longest-cultivated plants. Broad beans, with seeds the size of a small stone, were gathered in their wild state in Afghanistan and the Himalayan foothills thousands of years ago (Kaplan, 2008). In ancient Egypt, beans were buried with the dead. In the Second millennium BC, beans appeared in Greece, Spain, and middle-Europe. Beans were first seen by a European when Christopher Columbus, during his exploration of what might have been the Bahamas, found them growing in fields (Wikipedia, 2011).

Bean is used as a green vegetable, shelled, or dry. In temperate regions, green mature pods are cooked and eaten as a vegetable (Salunkhe, Sathe, & Deshpande, 1989). Immature pods are marketed as fresh, frozen, or canned, whole or cut. Mature dry beans known as navy beans, white beans, northern beans, or pea beans are widely consumed. Green beans are one of the most valuable vegetable crops grown by market gardeners for shipping and canning. The name snap bean is applied to beans at a young growth stage when the pods are eaten.

Green beans, while low in calories, are full of nutrients—an excellent source of vitamin K, vitamin C, manganese, vitamin A, potassium, folate, and iron. Green beans are also a good source of thiamin, riboflavin, copper, calcium, phosphorus, protein, omega-3 fatty

acids, and niacin. Beans have significant amounts of fiber and soluble fiber, with one cup of cooked beans providing between nine and thirteen grams of fiber. Soluble fiber can help lower blood cholesterol. (Mayo Clinic, 2011).

Beans, average	
Nutritional value per 100 g (3.5 oz)	
Energy	334 kJ (80 kcal)
Carbohydrates	10.5 g
Fat	0.5 g
Protein	9.6 g

Source: USDA Nutrient Database, 2011

According to the website *The World's Healthiest Foods*, few foods compare to green beans in the number of nutrients they contain for diabetic heart disease. They prevent cholesterol from becoming oxidized and hence reduce the chance of heart attack or stroke (A2Z of Health, Beauty, & Fitness, 2001).

2.1 Production overview

Green beans can be both stringless and colored other than green—such as yellow and purple. Green bean varieties have been bred especially for freshness, flavor, or for the sweetness of their pods.

Green beans are found in two major groups, bush beans and pole beans. Bush beans are short plants, growing to approximately two feet in height, that do not require supports. Bush beans generally reach maturity and produce all of their fruit in a relatively short period of time, then cease to produce. Over 130 varieties of these beans are known. Their pods can be either flat or round (oval) in cross section. Pole beans are beans that climb supports and are easily harvested. Pole beans, like bush beans, are picked young and tender, before the seeds inside have fully developed (University of Illinois Extension, 2011).

Like other vegetables, green beans grow and yield best on loamy or sandy-loamy soils. However, green beans can also be grown on many other soil types. Well-drained soils are preferred. Excessively wet soils encourage root diseases and nutrient problems. Bean do not tolerate salinity (Adsule, Deshpande, & Sathe, 1998).

Bush bean seeds should be planted at a depth of 2.5 cm./1 inch. The seeds should then be covered with soil to fill the furrow. They should be planted 2.5-5 cm./1-2 inches apart in rows that are 60 cm./2 feet apart. Pole beans are ideally planted on hills or mounds. These mounds should be 1 meter/3 feet apart with rows 1 meter/3 feet wide (Green Beans N'More, 2011).

In some production areas, fields are irrigated prior to planting and the seed is placed into moist soil (or mulch). If fields are not pre-irrigated, water is necessary immediately after sowing. Subsequent irrigations should occur at 5- to 10-day intervals, generally furrow-

irrigated. Drip systems can also be an excellent method of irrigating beans. Precautions should be taken to avoid root injuries at the time of hoeing and weeding. The pole type varieties need support for proper growth and fruiting. When rains are heavy, additional drainage facilities may be needed to prevent water logging. Poor water drainage leads to yellowing of leaves and new growth (Vegetable Research & Information Center, 2011; Adsule, Deshpande, & Sathe, 1998).

Green beans are a warm-season crop and are frost-sensitive plants. The optimal temperature for seed emergence is 25º C/77º F. The optimal temperature for plant growth is 18.3-29.4º C./ 65-85º F. Most varieties mature in 50 to 60 days. Temperatures above 32.2º C./90º F cause blossoms to drop. Botanists believe fluctuations in moisture (rain) and temperature cause blossoms to drop. As a precaution, along with keeping plants evenly watered and only watering at the roots, adding mulch will help keep soil temperature evenly regulated (Vegetable Research & Information Center, 2011; Green Beans N'More, 2011).

2.2 Harvesting

Green beans should be harvested before reaching maturity, usually 2-3 weeks after blooming, but the time required varies with weather conditions. When ready, the pods are fully grown but the seeds are small. Ideally, green beans should be harvested before the seeds become large enough to cause the pod to bulge around the seeds. Marketable pods are fleshy, tender, and green for only a short period. Most varieties become tough and stringy if left on the plants until the seed develops to a considerable size (Thompson & Kelly, 1980). Beans should be picked after any morning dew is off the plants and they are thoroughly dry. Picking beans when wet can spread bean bacterial blight, a disease that seriously damages the plants.

Harvesting can be done by hand or by machine, though picking by hand is preferable. Hand-harvesting allows for multiple harvests of a field. Beans should be removed from the plants cleanly without tearing them or causing undue damage to the pods or plants. Over-handling or rough handling of the pods will result in both visible and latent damage. In addition, harvested pods should never be tightly packed into harvesting containers or allowed to remain in the sun for extended periods.

Basic rules for manual harvesting

1. Keep your hands clean. Remember that you are handling a food product. You should wash your hands after each visit to the rest station;
2. Pick all mature pods on the bush before moving on to the next bush;
3. Harvest only those pods that are ready. Leave immature pods for the next harvest;
4. Avoid overfilling your hands; do not squeeze or roll the pods;
5. Do not put trash or cull pods into the container;
6. Never allow harvested pods to remain in the sun (North Carolina Cooperative Extension Service, 2011).

Machine-harvesting, a one-time operation because the plants are destroyed in the process, usually follows after the first hand-harvest. Mechanical harvesters must be carefully adjusted and operated to reduce the amount of trash and unacceptable pods. Most

harvesters have no means of discriminating between quality levels and will harvest immature, over mature, diseased, or damaged pods that would ordinarily be discarded during hand-picking. Eliminating large quantities of unacceptable pods and foreign matter in the packing house is difficult, expensive, and requires the harvested crop to be handled excessively. Under the best circumstances, a mechanical harvester and the required sorting machines subject bean pods to some damage. Any additional handling can so adversely affect the shelf life and appearance of the product that it will be discounted or refused by buyers (North Carolina Cooperative Extension Service, 2011).

2.3 Grading and packing

Regardless of the harvest method used, minimal handling of bean pods is desirable. Careful supervision of labor is the key to ensuring uniform cleaning, sizing, and packing of hand-harvested green beans. Smaller-acreage growers may use a grading table or belted conveyor located at a packing shed to remove trash and culls. Spreading in-shell beans on a belt or flat surface helps to dissipate field heat before packing and shipping.

Pod diameter, not length, is the best indicator of quality. Buyers prefer pods with no bulge or only a slight bulge, indicating tender, young seeds. Over mature green beans with bulging pods are tough and fibrous, while immature pods (pin beans, sieve sizes one and two) are more susceptible to wilting.

Uniform sizing of beans in the crate or carton is critical for acceptance by fresh market buyers. The shape must be fairly straight, the color bright, and the appearance fresh and without blemishes. Freshness is evidenced by a distinct, audible snap when the bean is broken (North Carolina Cooperative Extension Service, 2011).

Different growers take different approaches to packing. Some growers conduct field packing so that the beans can be quickly moved from field to cooler with minimal handling. Some growers use 13.5 kilo/30 pound (net weight) waxed or unwaxed cartons, depending on the grower or shipper requirement. Other growers use smaller wire-bound wooden or cardboard cartons (Adsule, Deshpande, & Sathe, 1998; Vegetable Research & Information Center, 2011).

2.4 Storage

Green beans are highly perishable and should be cooled quickly after harvest, preferably to 4-5º C./39-41º F. Cooling greatly maintains quality and substantially lengthens shelf life. In addition, prompt and thorough cooling can reduce the effects of dehydration and lessen damage caused by decay-producing organisms. Still, while post-harvest cooling is essential for maintaining quality, it will not improve the quality of a poor product (North Carolina Cooperative Extension Service, 2011).

Beans may be room cooled or forced-air-cooled, but hydro-cooling is preferable not only because cold water cools beans rapidly but also because the moisture helps to prevent wilting or shriveling (Gorini, Borinelli, & Maggiore, 1974). A delay in post-harvest cooling and exposure to the sun leads to quality deterioration, resulting in shriveling and weight loss. Therefore harvested beans should be shaded while they are held in the field.

Limiting the time between harvesting and cooling to no more than 1 or 2 hours will help maximize shelf life.

Effect of delayed cooling on Snap Bean quality	
Delay time (hours)	Weight loss (%)
1	2.2
3	2.8
5	10.0

Source: North Carolina Cooperative Extension Service, 2011

If refrigeration is not immediately available, alternatives such as shade, harvesting during the coolest part of the day, and drenching the produce with cold well water after harvesting should be employed. Field-packed containers, if properly cleaned and destined for immediate sale, may be cooled with well water. Wetting may also initiate evaporative cooling if sufficient air circulation is present. Once the beans have been packed in cartons and wetted, air circulation must continue until the products are properly refrigerated.

The placement of field-warm beans in a refrigerated space, known as room cooling, may be used but it is only recommended as a last resort. Room cooling may be of some benefit but is slow because it relies only on natural conduction and convection to transfer heat. Palletized and bulk containers of snap beans may require more than 16 hours to cool sufficiently in cooling rooms. To promote cooling and prevent the buildup of respiration heat, the green bean containers should be loosely stacked, leaving space between the pallets for air circulation.

In forced-air cooling systems, circulating fans are used in a cooling room to pull refrigerated air through produce containers, greatly improving the cooling rate. Experiments have shown that forced-air cooling is five to eight times faster than standard still-air room cooling (North Carolina Cooperative Extension Service, 2011).

Hydro-cooling, the process of bringing large quantities of chilled water into contact with the produce, is the preferred method for cooling green beans. It is particularly useful where large volumes of beans must be cooled quickly for shipment to distant markets. Because water is a much better heat transfer medium than air, hydro-cooling is very rapid. In this process, the produce is wetted either with a commercial hydro-cooler that rains the water onto the produce containers as they pass on a conveyor or by immersion into a tank of chilled water.

The disadvantage of hydro-cooling is that the beans are wetted. Significant post-harvest disease problems will inevitably occur if the produce is allowed to re-warm after hydro-cooling or if the water is not properly chlorinated. Warm, wet beans are particularly liable to develop any of a host of post-harvest diseases. These include nesting (caused by Pythium species or Rhizopus species), gray mold (caused by Botrytis cinerea), and watery soft rot (caused by Sclerotinia species). Although hydro-cooling is the preferred cooling method, it should not be used unless adequate refrigeration facilities are available for continuous cooling and storage (North Carolina Cooperative Extension Service, 2011).

Although the skin of beans offers considerable protection against infection, pathogens (disease-causing organisms) can enter the produce through a variety of openings. Wounds such as punctures, cuts, and abrasions as well as stems and stem scars provide potential points of entry. The probability of pathogens entering the produce increases with the size of the opening, the depth of submergence, the length of time in the water, and the water temperature (North Carolina Cooperative Extension Service, 2011).

Always use chlorinated water when washing and hydro-cooling beans and peas. Chlorine is a germicidal agent that can control decay-causing organisms found on produce. A free chlorine concentration of about 55 to 70 ppm at pH 7.0 (neutral) is recommended for sanitizing most fruits and vegetables. It may be necessary to add chlorine to the solution more often if the pH is higher and if the temperature of the solution is more than 27º C./80º F. In practice, free chlorine concentrations of 150 ppm and more have been used.

Practical rules for successful chlorination

1. Closely evaluate the need to wet the produce. Wetting the produce greatly increases the likelihood of infection and spread of post-harvest diseases;
2. Monitor the condition of the water. Check the chlorine concentration and pH frequently using test papers or electronic equipment;
3. Avoid overexposure. Do not allow the produce to remain in contact with the solution longer than necessary;
4. Change the water frequently. Chlorination efficiency is poor in very dirty water. If the produce is very dirty, wash it with clean water before it comes into contact with the chlorinated water;
5. Dispose of wastewater properly. Before you install chlorination equipment, plan how you are going to dispose of the wastewater safely;
6. Practice good sanitation. Hose off the packing equipment and floors daily and remove the dirt and trash that may have settled in the chlorination tank. Sanitize equipment with a spray of 4 pints of 5.25 percent sodium hypochlorite solution in 10 gallons of water (North Carolina Cooperative Extension Service, 2011).

Green beans should be stored at 3-7º C./37-45º F. and 95% relative humidity. Under these conditions, green beans will maintain quality for 4-10 days. However, temperatures of 3º C./37º F. and lower may cause significant chilling injury to beans. Chilling injury may appear later during distribution as obvious surface pitting and make beans unmarketable. Equally, chilling injury can occur when beans are stored for longer than 5-6 days, resulting in a general opaque discoloration of the entire bean. The most common symptom of chilling injury is the appearance of discrete rusty brown spots which occur in the temperature range of 5-7.5º C./41-45º F. These lesions are very susceptible to attack by common fungal pathogens. Beans can be held about 2 days at 1ºC./34º F., 4 days at 2.5º C./36º F. or 8-10 days at 5º C./41º F. before chilling symptoms appear (Postharvest Technology Research Center, 2011).

When beans are to be stored or transported in mixed loads with other commodities, it is important to consider the compatibility of the produce in regard to temperature, humidity, and the presence of ethylene gas. Ethylene is given off by some fruits (apples, cantaloupes, bananas, and tomatoes) and will hasten the maturity and decline in quality of green beans. Storing beans with ethylene-producing items is discouraged. Beans also

readily adsorb the odor of peppers, onions, and cantaloupes. Common storage and shipment with these items should also be avoided (Postharvest Technology Research Center, 2011).

3. Peas

The pea is a small spherical seed or seed-pod of the legume *Pisum Sativum*. Each pod contains several individual peas. While pea pods are botanically a fruit (since they contain seeds developed from the ovary of a pea flower), they are considered a vegetable for cooking (Rogers, Hubbell, & Byers, 1942).

Peas are thought to have originated in Middle Asia and the central plateau of Ethiopia. Many kinds of peas were known to the ancient Greeks and Romans. Burned peas have been found in the ruins of lake dwellings in Switzerland and in Turkey in the ancient city of Troy, which was first built during the Bronze Age. Archaeological findings of carbonized pea seeds in western Asia and Europe have been dated to 7000 BC. Peas were supposedly brought to the West Indies by Christopher Columbus in 1493 and planted on Isabela Island. During the reign of Queen Elizabeth I, peas were imported from Holland and were considered a great delicacy because they were so expensive. By 1614, they were being cultivated in Jamestown, Virginia.

Peas of early times were small and were dried before cooking. They belonged to the variety now called field peas. Europeans found the garden pea to be much more appealing for use as a green vegetable than other varieties of peas. The world's first sweet tasting pea was developed in the 18th century by amateur plant breeder Thomas Edward Knight of Downton, near Salisbury, England. Modern garden pea varieties may be traced back to Knight's selection, which explains why garden peas were known around the world as 'English peas' up until the early years of the 20th century. By the end of the 19th century many cross-breeding trials had been made, the most notable of which were those conducted by the Austrian monk Gregor Mendal which provided the foundation of the modern science of genetics (Yes, Peas!, 2011; Deshpande & Adsule, 1998). Today Peas are a major crop produced on over 18 million acres around the world.

Most pea varieties are classified by criteria such as growth habit, leaf type, and the color, size, and shape of the seed. HomeVeg Tanzania works with growers who produce both snow peas and sugar snap peas.

Snow peas (*Pisum sativum var. saccharatum*) are a variety of pea eaten whole in its pod while still unripe. The name *mangetout* is French for 'eat all' and this term can be applied to both snow peas and snap peas. It is speculated that the name comes from the whitish tint reflected from the pods. The name may also come from the pea's tendency to grow at the end of winter, just before the last spring freeze. Snow peas may be covered with snow—hence the name—and during these times still keep growing well.

Snap peas (*Pisum sativum var. macrocarpon*) or 'sugar snap' peas are also edible-podded peas but they differ from snow peas in that their pods are round as opposed to flat. Sugar snap peas, like snow peas, are an edible podded pea similar to a garden, or English, pea, but the pod is less fibrous, and edible when young. Snow peas and Sugar snap peas do

not have a membrane and do not open when ripe. At maturity, pods grow to around 4-8 cm. in length and each pod contains three to 5 peas.

Peas are an excellent source of dietary protein, and pea flour is an important component in the food industry. About 1 cup of cooked peas provides an amount of protein (8 g.) equivalent to 1 oz. (28 g.) of cooked lean meat. However, peas contain about twice as many calories per gram of protein.

Raw Green Pea	
Nutritional value per 100 g (3.5 oz)	
Energy	339 kJ (81 kcal)
Carbohydrates	14.5 g
Sugars	5.7 g
Dietary fibre	5.1 g
Fat	0.4 g
Protein	5.4 g
Vitamin A equiv.	38 µg (4%)
- beta-carotene	449 µg (4%)
-lutein and zeaxanthin	2593 µg
Thiamine (Vit. B1)	0.3 mg (23%)
Riboflavin (Vit. B2)	0.1 mg (7%)
Niacin (Vit. B3)	2.1 mg (14%)
Panothenic acid (B5)	0.1 mg (2%)
Vitamin B6	0.2 mg (15%)
Folate (Vit. B9)	65 µg (16%)
Vitamin C	40.0 mg (67%)
Calcium	25.0 mg (3%)
Iron	1.5 mg (12%)
Magnesium	33.0 mg (9%)
Phosphorus	108 mg (15%)
Potassium	244 mg (5%)
Zinc	1.2 mg (12%)

Source: USDA Nutrient Database, 2011

Peas also contain substantial amounts of vitamins A and C and are rich in calcium, potassium, phosphorus, and iron. Fresh green peas are low in sodium.

3.1 Production overview

The pea is an annual herbaceous plant with a one-year life cycle. Pea is considered a cool season crop with planting taking place from winter to early summer depending on the

location. Seeds may be planted when the soil temperature reaches 10º C./50º F., with plants ideally growing at temperatures of 13-18º C./55-64º F. Peas do not thrive in summer heat nor lowland tropical climates, but they do grow well in cooler high altitude tropical areas. Many reach maturity about 60 days after planting. The plant and the stems grow to a length of 2-4 feet. A leaf consists of one to three pairs of leaflets with a terminal, branched tendril. Leaves are pale green with a whitish bloom on the surface (Oelke, et. al, 1991).

Generally, peas are grown outdoors and not in greenhouses. Peas can be grown in a wide range of soil types—from light sandy loams to heavy clay. In any soil, however, there should be good drainage since the pea does not tolerate soggy or water-soaked conditions.

Pea seed germination rate increases with increasing temperature, but at temperatures greater than 18º C./64º F., the percentage of seeds germinating decreases. The percentage of seedlings that emerge is also dependent on soil environment.

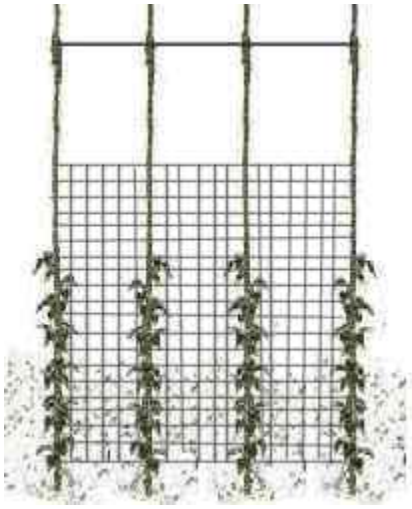
Emergence of field pea seeds at different soil temperatures

Soil Temperature (°F)	41	50	59	68	77	86	95
Percent Normal Seedlings	89	94	93	93	94	89	0
Days to Emergence	36	14	9	7	6	6	--

Source: Harrington & Minge, 1954

Considerable research has been conducted on different seed treatments and treatment methods. For example, seed treatment with the fungicide Baytan has shown to significantly improve emergence (Deshpande & Adsule, 1998). Baytan is a member of the DMI group of fungicides and is a Group C fungicide produced by Bayer CropScience Pty. Ltd.

Virtually all pea plants require some type of support. An easy method of support is to erect canes in a row, tying the plants as they grow. Netting tied to the canes will provide extra support. Each plant can then grow on its own individual cane and can spread accordingly (Garden Action, 2011).



Source: Garden Action, 2011

Peas usually require the same growing season as spring wheat. Bloom generally occurs about 60 days after seeding and maturity occurs at about 90 days. High temperatures during flowering (>32.3º C./90 Fº.) can cause flowers to blast, and reduces seed yield. Peas respond well to good moisture at emergence until bloom, then dry, warm weather for pod filling and ripening.

3.2 Harvesting

The time to harvest peas depends largely on the appearance of the pods. Peas do not ripen as uniformly as other crops, therefore it may be necessary to harvest while the green leaves and pods remain. Ideally, the pods should be filled with tender young peas and change in color from dark to light green. In this way the peas are slightly immature—when fully mature they become hard and lose their sweet taste. If harvested too late, seeds may shatter in dry pods. Harvesting at night or early morning, when pods are wet with dew will also reduce shattering (Oelke, 1991; Desphande & Adsule, 1998).

The harvest should be made when the peas are still in prime condition. There is an inverse relationship between yield and quality after the peas reach a certain maturity. If the harvest is delayed, the proportion of small peas decreases steadily, thereby increasing the yield of the crop. However, this greatly reduces the quality and total value of the harvested peas.

Snow peas should be harvested before the individual peas have grown to the size of BBs (buckshot), when the pods have reached their full length but are still quite flat. This stage is usually reached 5-7 days after flowering. Snow peas must be picked regularly (at least every other day) to assure sweet, fiber-free pods. As soon as overgrown pods missed in earlier pickings are discovered, these pods should be removed from the plants to keep the plants blooming and producing longer. Enlarging peas inside these pods may be shelled and used as garden peas. Fat snow pea pods (minus the pea enlarging inside) should be discarded. Fibers that develop along the edges of larger pods, along with the stem and blossom ends, are removed during preparation (University of Illinois Extension, 2011a).

Sugar snap peas, depending on the variety, ripen at different times. For example:

Snowbird (58 days; 18 inches tall; double or triple pods in clusters)
Dwarf Gray Sugar (65 days; 24 to 30 inches)
Snowflake (72 days; 22 inches to harvest; high yield)

Snap peas should be harvested every 1 or 3 days, similarly to snow peas to get peak quality. Sugar snap peas are at their best when the pods first start to fatten but before the seeds grow very large. At this point, the pods snap like green beans and the whole pod can be eaten. Some varieties have strings along the seams of the pod that must be removed before cooking. Sugar snaps left on the vine too long begin to develop tough fiber in the pod walls. These must then be shelled and used as other garden peas, with the fibrous pods discarded (University of Illinois Extension, 2011a).

High quality garden peas are generally associated with tenderness and high sugar content. Tenderometers or similar instruments are used to measure the toughness of the seed coat and the firmness of the pulp. The tenderometer is used by most canners to assess quality—a high value indicates low quality. The highest price is paid for peas with a low tenderometer value. In some growing areas, the emphasis is on size, and the price paid to the growers is based on the sieve size of garden peas (Deshpande & Adsule, 1998).

In common practice, the appropriate maturity of peas for harvesting is determined by (Salunkhe, Kadam, & Deshpande, 1993):

(1) use of physical instruments like the tenderometor, maturometer, or shear press;
(2) ratio of peas to pods;
(3) content of alcohol-insoluble solids (AIS);
(4) starch content; or
(5) floating in 5% brine solution.

Recommended ranges are 11-16% AIS for canning, less than 11% for fancy grade, 11-15% for extra standard grade, and more than 15% for standard grade canned peas. Using the tenderometer technique, peas used for canning fresh, quick-freezing, or artificial drying are ready when the crop is just starting to lose its green color and the peas are still soft. The reading for freezing peas is about 100, and for canning they can be slightly firmer at 120. When ready, the crop must be cut as soon as possible and shelled peas rushed to the processing plant for further processing. Alternatively, the seeds are graded by floating on a 5% brine solution—the sinkers are taken for canning while the floaters are used for freezing.

Peas grown for fresh market are usually picked by hand. Peas must be picked at just the right stage of maturity because premature picking yields small-sized seeds whereas delayed pickings lowers quality. Some growers make two or three pickings, while others make only one. In the latter case, the vines are pulled and all the pods are picked off. Although it costs less to harvest peas by this method, the quality of the product is better and the yield higher when two or more pickings are made.

Peas intended for commercial processing are harvested with machines of various types. The vines are cut with a mowing machine and loaded on trucks with a hay loader. Pea

harvesters which mow the peas and load directly into a truck are commonly used in main growing areas. The vines are hauled to a vining station, where the peas are removed from the vines and pods by machinery. In some areas, self-propelled combines are used for harvesting pea vines. The combines sweep over previously laid pea vines, engulf the vines, gently separate the tender vegetable from their pods, and convey the product into trucks while moving at about an acre an hour (Woodroof, 1988). The average yield of shelled peas in developed countries is about 5500 kg./ha. (Ensminger, et. al., 1994; Deshpande & Adsule, 1998).

3.3 Grading and packing

When peas are intended for fresh market, it is necessary to cull the over-matured yellow pods, the flat pods, and diseased and insect-injured pods, and the trash from the harvested peas before they are packed. Peas are commonly packed for shipment in baskets, hampers, and boxes of various types.

Peas for processing are graded into four grades based on the size of shelled peas. The smaller sizes are considered to have the best quality and fetch the highest prices from canners. The sieves used for separating the sizes have mesh ranging from 18/64 to 24/64 inches in diameter. Some processors also buy peas based on tenderometer readings rather than sieve size. Such quality measures are much better than size alone for grading peas. For example, small peas are sometimes over mature and of poor quality, while large peas may be tender and not yet mature (Deshpande & Adsule, 1998).

3.4 Storage

Peas need to be promptly cooled to near 0º C. after picking or they lose their sugar content on which much of their flavor depends. Peas should be packed with crushed ice to maintain their freshness and turgidity. Even at an ideal holding temperature of 0º C. peas cannot be kept in saleable condition for more than 1-2 weeks unless they are packed in crushed ice. Peas keep better shelled than in their shells (Wager, 1964).

Some of the common methods for extending the shelf life of garden peas are as follows.

Low-temperature storage: Peas can be stored for 2 weeks at 0º C./32º F. Peas that are to be shipped for export should be kept cool if they are to reach their markets in edible condition. Peas pre-cooled by immersing in water (hydro-cooling) must be kept under refrigeration until they reach their destination. Pre-cooling can also be done by placing crushed ice in or over the top of the package. Peas should be shipped in refrigerated trucks. A temperature of -1º/32º F. to 0º C./32º F. with 90% relative humidity is recommended for storage of peas in marketable conditions for up to 2 weeks (Ryall & Lipton, 1972; Pantastico, Chattopadhyay, & Subramanyam, 1975; Salunkhe & Desai, 1984).

Controlled-Atmosphere storage: Ordinary refrigeration at 0º C./32º F. can hold green peas for only 7-10 days. Controlled atmosphere storage with 5-10% O^2 and 5-7% CO^2 at 0º C./32º F. can extend the storage life of green peas for up to 8-10 weeks (Wager, 1964; Ryall & Lipton, 1972; Salunkhe & Desai, 1984).

References

A2Z of Health, Beauty, & Fitness (2011) *Green Beans Nutrition Facts*, http://health.learninginfo.org/green_beans.htm, viewed 15 March.

Adsule, R., Deshpande, S., Sathe, S. (1998) 'French Bean' in Salunkhe, D. & Kadam, S. (eds.) *Handbook of Vegetable Science and Technology: Production, Composition, Storage, and Processing*, New York: Marcel Dekker, Inc.

Deshpande, S. & Adsule, R. (1998) 'Garden Pea' in *Handbook of Vegetable Science and Technology: Production, Composition, Storage, and Processing*, New York: Marcel Dekker, Inc.

Ensminger, A., Ensminger, M., Konlande, J., Robson, J. (1994) *Foods and Nutrition Encyclopedia*, Boca Raton, Florida: CRC Press.

Garden Action (2011) 'Care of Your Peas', http://www.gardenaction.co.uk/fruit_veg_diary/fruit_veg_mini_project_april_1a_pea.asp, viewed 1 March 2011.

Gorini, F., Borinelli, G., & Maggiore, T. (1974) 'Studies on precooling and storage of some varieties of snap beans' in *Acta Horticulture*, Volume 38.

Green Beans N'More (2011) *Growing Green Beans*, http://www.greenbeansnmore.com, viewed 16 March.

Harrington, J. & Minge, P. (1954) 'Dry field peas' cited in Oelke, E. et al.'s *Alternative Field Crops Manual*, Cooperative Extension, University of Minnesota and University of Wisconsin.

Kaplan, L. (2008) 'Legumes in the history of human nutrition' in Dubois, C., Tan, M. & Mintz, C. (eds) *The World of Soy*, Chengdu, China: Papers from the Soybean Conference at the 8th Symposium of the Foundation Chinese Dietary Culture.

Kissinga, A. (2011) *HomeVeg Tanzania Scope of Work*, developed 13/01/2011, Arusha, Tanzania: CNFA.

Mayo Clinic (2001) *Beans and other legumes: types and cooking tips* and *Health recipe: mix bean salad*, http://www.mayoclinic.com/health/healthy-recipes/NU00410, viewed 16 March.

North Carolina Cooperative Extension Service (2011) *Postharvest Cooling and Handling of Green Beans and Field Peas*, http://www.bae.ncsu.edu/programs/extension/publicat/postharv/ag-413-8/index.html, viewed 16 March.

Oelke, E., Oplinger, E., Hanson, C., Davis, D., Putnam, D., Fuller, E., Rosen, C. (1991) *Alternative Field Crops Manual*, Madison, Wisconsin: Cooperative Extension Service University of Wisconsin-Madison.

Pantastico, E, Chattopadhyay, T., & Subramanyam, H. (1975) 'Storage and commercial storage operation' in Pantastico, E. (ed) *Postharvest Physiology, Handling and Utilization of Tropical and Sub-tropical Fruits and Vegetables*, Westport, CT: AVI Publishing.

Postharvest Technology Research Center (2011) *Snap Beans: Recommendations for Maintaining Postharvest Quality*, Davis, California: Postharvest Technology Research Information Center, Department of Plant Sciences.

Rogers, J., Hubbell, T., & Byers, C. (1942) *Man and the biological world*, New York: McGraw-Hill.

Ryall, R. & Lipton, W. (1972) ' Handling' in *Transportation and Storage of Fruits and Vegetables*, Vol. I, *Vegetables and Melons*, Westport, CT: AVI Publishing.

Salunkhe, D. & Desai, B. (1984) *Postharvest Biotechnology of Vegetables*, Vol. I, Boca Raton, Florida: CRC Press.

Salunkhe, D., Kadam, S., Deshpande, S. (1993) 'Peas and lentils' in MaCrae, R., Robinson, R., & Sadler, M. (eds) *Encyclopaedia of Food Science, Food Technology and Nutrition*, Academic Press: London.

Salunkhe, D., Sathe, S., Deshpande, S. (1989) 'French Bean' in *Handbook of World* Food *Legumes: Nutritional Chemistry, Processing Technology and Utilization*, Vol. II, Boca Raton, FL: CRC Press, Inc.

Thompson, H. and Kelly, W., (1980) *Vegetable Crops*, 5th ed., Nagpur, India: Agri Horticultural Publishing House.

University of Illinois Extension (2011) *Beans*, http://urbanext.illinois.edu/veggies/beans.cfm, viewed 15 March.

University of Illinois Extension (2011a) 'Peas: Harvesting', http://urbanext.illinois.edu/veggies/peas.cfm, viewed 2 March.

USDA Nutrient Database (2011) 'Beans, average', USDA Agricultural Research Service Nutrient Data Laboratory Database for Standard Reference, http://www.nal.usda.gov/fnic/foodcomp/search/, viewed 15 March.

USDA Nutrient Database (2011) 'Pea, Green Raw', USDA Agricultural Research Service Nutrient Data Laboratory Database for Standard Reference, Release 23, http://www.nal.usda.gov/fnic/foodcomp/search/, viewed 1 March 2011.

Vegetable Research & Information Center (2011) *Snap Bean Production in California*, Publication 7240, Oakland, California: University of California, Division of Agriculture and Natural Resources.

Wager, H. (1964) 'Physiological studies of the storage of green peas' in *Journal of the Science of Food & Agriculture*, Vol. 14, Issue 4.

Wikipedia (2011) Bean-History, http://en.wikipedia.org/wiki/Bean, viewed 17 March.

Woodroof, J. (1988) 'Preparing vegetables for processing' in Luh, B. & Woodroof, J. (eds) *Commercial Vegetable Processing*, New York: Van Nostrand Reinhold.

Yes, Peas! (2011) Facts & Figures, http://www.peas.org/factsandfigures.php, viewed 1 March 2011.