2008 STATE PRODUCTION SUMMARY TABLE (lbs)

	Green Peas	Yellow Peas	AWP	Lentils	Chickpeas
Idaho	51,438,505	5,618,151	3,314,520	36,473,879	31,764,807
Washington	87,425,346	14,386,888	2,065,338	58,569,960	39,626,844
Oregon	984,456	370,260	767,448	0	0
California	0	0	0	0	13,662,000
North Dakota	277,853,365	323,256,327	0	93,072,310	10,219,340
Montana	39,501,000	188,647,200	5,508,000	57,061,125	5,035,000
Others	3,082,618	4,534,730	2,966,565	1,962,575	5,415,000
Total	460,285,290	536,813,556	14,621,871	247,139,850	105,722,991

Small Lentils - Pardina, Morton, Eston Varieties
Medium Lentils - Brewers, Richlea, Merrit, Varieties
Large Lentils - Mason, Pennell, Palouse, VanGard, Laird Varieties
Red Lentils - Red Chief, Red Robin, Crimson, Morton

Notes:
This report contains yield and acreage data from industry processors, the Farm Service Agency, and the National Agricultural Statistics Service.
Acreage data for 2008 has been amended since posting of the Industry Seeded Acreage Report, July 2008.

4

CHAPTER

Processing Methods for Dry Peas, Lentils & Chickpeas

USA DRY PEA & LENTIL COUNCIL

Once legumes have been harvested and precautions taken to ensure safe storage, processing is conducted before they are shipped and ultimately find their way onto grocery shelves and dinner tables.

The processing of dry peas, lentils, and chickpeas is a specialized and important part of the production process and is designed to ensure a consistent, high-quality product. This has led to the establishment of standards meant to guide producers, processors, and vendors around the world.

Compliance with these standards is achieved by subjecting the legume seeds to an elaborate series of cleaners, separators, splitters, dryers, polishers, graders, and color sorters. The goal is to provide food manufacturers and their consumers with top-quality dry peas, lentils, and chickpeas every time a purchase is made.

Having passed through processing, the seeds proceed to packaging, which helps ensure that a wholesome product is delivered to the distributor and, ultimately, to the consumer. Overseas shipments are normally packaged in large 100-pound polypropylene or jute sacks for easy bulk handling. Almost any combination of grade and package is available from processing plants.

How and Why Legumes Are Used

In recent years, legumes have in recent years attracted increasing interest as useful ingredients in a range of prepackaged and processed foods in the U.S. and abroad, generally in canned or dehydrated form.

Researchers have found that legume flours can be used to fortify foods that have typically been fortified with wheat and other traditional flours. Depending on the variety and the way in which they are processed, legume flours may show unique properties in complex systems.

Pea flour, for example, is now used widely in the processed meat industry where heat and mechanical stability are important. It has also had excellent results in canned foods, cooked sausages, pâtés, and other items.

Processing can enhance the functional characteristics of legumes as well. A mixture of cellulose and enzymes has, for example, been used to augment important details like the mouthfeel and smoothness of products. The unique properties of legume starch, including good stability at high temperatures and high viscosity compared with cereal or tuber starches, can be further improved by processing.

Pea starch has become popular as a thickening agent in soups, sauces, and many other products. Until recently, the main limitation of the use of pea starch has been the relatively high cost of its isolation.

The bulk of the research on pulses has concentrated on the effects of processing on the protein quality of legumes. Changes in protein brought about by processing are, to many processors, more important than other changes in nutritional value. The protein can absorb water or fat, be soluble under certain conditions, and maintain foaming and emulsification properties. This helps processors achieve the desired texture and quality (e.g., chewiness) for foods. The goal is to employ processing to minimize the loss of nutritional value while maximizing protein quality.

Despite the fact that there is a large amount of information available on the effects of processing on various components of grain legumes, interpreting this data has proven challenging. Among the difficulties is the fact that even varieties of the same legume species differ in their content and availability of specific components, such as protein and lysine.

After legumes have been processed and converted into primary products, they can be cooked and then used for a variety of purposes. Many are processed to make different products for use in the home or in commercial enterprises. Food developers commonly incorporate processed legumes into soups, including canned soup, frozen soup, shelf-stable mixes, "instant" dry soups and others, as well as extruded and puffed snacks and breakfast-cereal-type foods. ***See Appendix C for a collection of sample formulations.***

The processing industry uses various quality checks, kinds of equipment, and processes to ensure buyers a clean, wholesome product that conforms exactly to the grade ordered. The consistent, industry-wide grading standards, established by the Federal Grain Inspection Service of the U.S. Department of Agriculture, help achieve this end by facilitating accurate communication among all parties in a trading transaction. Each variety of pea and lentil has precise standards for size, color, and other factors. Storing each crop type separately from the others results in better quality and uniformity. Food safety is a primary concern for both processors and customers, so there are processors that carefully segregate product preserve the identity of product and may provide traceability to the exact origin of the crop.

Although all products must conform to these minimum standards, some processors use additional methods to guarantee superior quality for their customers. These processors customize orders to reach the customer's desired level of quality.

Processing Legumes

Legumes go through several processes before they are ready to be used either as a plated item or as an ingredient in food preparations. These processes can include cleaning, drying, sorting, splitting, milling, and fractionating. Depending on the pulse and its intended use, other steps like dehulling (decorticating), puffing, roasting, and grinding may be included as well.

Once the field-dried pulse product is received at the processing facility it is visually inspected for color and general quality and then loaded into storage bins. Storage of the newly received product is key to quality and optimum preservation of the crop.

Each crop requires slightly different storage conditions, so humidity and temperature are controlled to maintain the best conditions for preservation and to eliminate the possibility of pest or fungal infestation.

As the product is dropped from the receiving bins for initial air cleaning, magnets are used to attract and remove any metal debris or stones from the product. In addition, many processors conduct a second and final screening with rare earth magnets to ensure removal of metal before after the product has been bagged.

After completion of processing, the product is bagged and shipped to the customer. Quality checks vary from one processor to another, including inspection and packaging methods used before shipment.

In most cases, pulses are first soaked in cold water overnight for 4 to 12 hours. Hydration can be enhanced by using warm/hot water; this also helps prevent seed hardness. Heating is more costly for processors and can trigger an unwanted increase in microbial growth. Pulses with thick, tough seed coats are often first abraded and mechanically cracked before soaking to help facilitate moisture uptake. If the seed coats are unpalatable, they can be removed by hand from soaked seeds. This also promotes faster cooking and more digestible cotyledons.

Asian producers often hold their food legumes at ambient temperatures for several days after soaking. This enables them to germinate, which activates certain enzymes that then partially *hydrolyze* (i.e., digest) the proteins, starch, and oligosaccharides. It also inactivates tannins, releases minerals, and synthesizes many vitamins. The sprouted grains are then consumed directly or dehulled, roasted, and ground for use in blends and other foods.

Whole food legumes or hulled splits are either ground dry into a flour or ground wet into a batter for other food uses, often in combination with cereal and millet. The properties of the product, such as mouthfeel, texture, and others are impacted by the composition of the flour, the fineness of the grinding, the ratio of particle size grades, and the cooking conditions.

Cleaning

The first step in the processing regimen of a legume is cleaning. Processors run the pulses over gravity tables, which act as a filter to rid them of foreign material like pebbles, dirt and any undeveloped, broken, damaged, or shrunken pieces.

For split peas, initial cleaning and de-stoning is performed after receipt of the dried product, followed by steaming and tempering. These processes prepare the dry peas for a uniform split in the pea splitter and minimize shattering and other product loss issues. Sometimes, steaming and tempering is done just prior to splitting.

Sorting

By forcing air through the gravity table, products of the sought-after size are effectively separated out, while outsized product and foreign material fall below into a separate area. The sorted product is then air-cleaned again to eliminate dust.

Cleaned legumes are graded according to their seed size using separators. For chickpeas, the separators usually employ five sieves varying in dimension from 6 mm to 10 mm. Legumes can be processed through an electronic color sorter to ensure uniform coloration.

The product will then often proceed to a metal detection system prior to a final air-blast cleaning and bagging. Sending products through additional magnets that act as prescreeners enables processors to help ensure absolute food safety prior to final packaging.

Dehulling or Decortication

The dehulling of legumes generally consists of two steps: 1) loosening the hull (by the dry or wet method), and 2) removing the hull and cleaning. Loosening the hull can be done by a variety of means, including:

- Prolonged sun drying until the hull is loosened
- Applying small quantities of edible oil, followed by sun drying and tempering
- Soaking the legumes in water for several hours, followed by coating them with red-earth slurry and sun drying
- Soaking in water for several hours to loosen the hull before manufacture of food products
- A combination of the above

Dehulling (decortication) produces refined cotyledons with good appearance, texture, and cooking qualities. Legumes that have gone through this process are more easily digested and efficiently utilized by the body.

The process can be a time-consuming procedure depending on how tightly the legume hull wraps around the *endosperm* (i.e., the nutritive matter in the seed), because of the thin layer of gums and *mucilages* (i.e., the gummy secretions or gelatinous substances present in plants).

The success with which a legume can be dehulled is influenced by the variety, season when harvested, and location of cultivation. Larger or bold-grain varieties are easier to dehull and give a higher yield, making them the preferred variety among millers. Smaller varieties, meanwhile, require repeated pre-dehulling treatments and other complex procedures. Because their hulls are comparatively easy to remove, dry peas, lentils, and chickpeas require less drying and fewer oil or water treatments.

Freshly harvested legumes are more difficult to process, likely because of their higher moisture content. Legumes of this kind are either stored for some period of time to reduce moisture, or are treated with lime water or a solution of sodium carbonate to loosen the hull.

There are a variety of ways to decorticate food legumes. The oldest and most common technique involves spreading out the seeds to dry in the sun or mixing them with a bit of water before pounding them in a mortar with a pestle. The hull is winnowed off to get the clean cotyledons. Similar methods are used in commercial mills, though being much larger in scale they are adapted for greater yield and operational efficiency. The dehulling of legumes on a commercial scale is generally based on dry-processing techniques.

Smaller processors can expect about 50 percent removal with the first effort. The process is then repeated several times until almost all the grain is converted into dehulled, split cotyledons. It can be difficult with this approach to achieve complete removal of the hull from the grain. Breakage is also a common downside.

Another method for dehulling is based on adjusting the moisture of the grain to loosen the hull. The grain is first exposed to heated air in a tempering bin, for a pre-determined time based on the variety. Through gradual aeration it reaches a critical moisture level. The hull is then removed in an abrasion-type hulling machine, while efforts are made to minimize scouring or breaking the endosperm. If it is to be split, the whole dehulled grain is then ready to proceed to a splitting machine.

Splitting

Many of the operations, particularly decorticating and splitting, are mechanized. Splitting is often carried out in parallel with dehulling, though both are more effective if undertaken as independent operations.

Adding water prior to dehulling helps bring about splitting. Such a step does, however, often leave portions of hull on the split cotyledons (dhal) that then have to be removed by polishing machines. During splitting, the germ, which forms about 2 percent to 5 percent, is typically lost.

After drawing or winnowing off the hull, the split cotyledons are separated by sieving. Any leftover whole grains that have not been split are similarly processed until as much of the grain as possible is dehulled.

Milling

Once splitting has been completed, the material moves on to the milling stage, a critical step in legume processing. Reduction of the particle size must be undertaken to expand the surface area of the material, thereby increasing its availability or drying efficiency.

The bulk density of the material is controlled by creating a particle size distribution consisting of a matrix of larger particles the gaps between which are filled by smaller particles. Success here helps ensure a free-flowing material for maximum milling efficiency and contributes to end-product functionality.

Four Milling Techniques

There are four principal techniques used to bring about the size reduction necessary for processing. These are impact milling, attrition milling, knife milling, and direct-pressure milling.

Impact Milling

Impact milling involves use of a hard object to strike a wide area of the particle to fracture it. A rotating assembly then uses blunt or hammer-type blades, such as with hammermills, pin mills, cage mills, universal mills, and turbo mills. The impact technique is recommended for pulse milling applications due to particle size variability.

Attrition Milling

By contrast, attrition milling relies on a horizontal rotating vessel filled with a size-reduction solution. Treated to grinding media, the materials tend to be turned into free-flowing, spherical particles. This method, which includes the ball mill, can reduce 1,000-micron (20-mesh) particles of friable materials down to less than 1 micron.

Knife Milling

With knife milling, a sharp blade applies high, head-on shear force to a large particle, cutting it to a predetermined size, while also minimizing fines. A rotating assembly of sharp knives or blades is used to cut the particles. Examples like knife cutters, dicing mills, and guillotine mills can reduce two-inch or larger chunks or slabs of material, including elastic or heat-sensitive materials, to 250 to 1,200 microns.

Direct-Pressure Milling

Direct-pressure milling occurs when a particle is crushed or pinched between two hardened surfaces. This can involve two rotating bars or one rotating bar and a stationary plate and can typically reduce one-inch or larger chunks of friable materials down to 800 to 1,000 microns. Examples include roll mills, cracking mills, and oscillator mills.

Process Features

The rotor speed, feed rate, screen size, screen type, and moisture content of peas all affect pea milling quality. Rotor speed is the primary factor and can significantly impact the milling process.

Feed Throat

The feed throat introduces material into the milling chamber. A gravity feed throat delivers material tangentially to the rotation of the blades.

Blade profile

The type, quantity, and shape of a milling blade helps determine the degree of reduction achieved. The blade profile offers the flexibility of a knife on one side and an impact tool on the other, with the former being used for gentle granulation and latter for more aggressive reduction.

Feed Rate

Milling is most effective if the product is fed uniformly into the feed throat using a variable feed system (15 to 60 rpm). It should be noted that high feed rates increase energy consumption.

Rotor Speed

The rotor speed affects particle size distribution and as a general rule, and with all other variables remaining constant, the faster the rotor speed, the finer the grind.

Two Types of Food Milling

Impact milling

- The particle is fractured after being hit by a hard object that applies a blunt force across a wide area.
- The particle passes through a rotating assembly that uses blunt or hammer-type blades.
- Examples: hammer mills, pin mills, cage mills, universal mills, and turbo mills

Direct-pressure milling

- The particle is crushed or pinched between two hardened surfaces.
- Two rotating bars or one rotating bar and a stationary plate generally produce this milling action.
- Examples: roll mills, cracking mills, and oscillator mills

Rotor speeds of 3000 to 7200 rpm are used with flat blades in fine-grinding applications such as with coarse and fine pea flour and other legume flours, while speeds of 1000 to 3000 rpm are used with sharp blades in coarse grinding applications.

Screen

The screens can be round or rectangular, with screen thickness and the total open surface area of the screen affecting the *comminuting* (i.e., pulverizing) operation. The diameter of the screen holes doesn't necessarily designate the particle size of the finished product as impacted particles follow a tangential trajectory from the blades and approach the screen at a shallow angle. The higher the rotor speed, the smaller the angle under which the particle approaches the screen and the smaller the screen openings appear to the particle.

Fractionating

In the search for new food protein and fiber resources, commercial facilities have begun focusing on extracting protein concentrates from pulses via a process called fractionation that allows researchers to separate out component ingredients to obtain the desired concentrates and isolates.

Dietary fiber in legumes is actually captured as a byproduct of the process by which protein and starch concentrates are acquired from legume seeds. The results are generally richer in fiber when obtained from the hulls.

The separation of pure legume starch is difficult because of the presence of a highly hydrated fine fiber (cotyledon cell wall material) and the strong adherence of large amounts of insoluble proteins.

Fractionation typically takes the form of a dry or wet method: air classification or wet milling. Dry and wet separation processes have been used for some time to fractionate grain legumes for both experimental purposes and industrial applications.

Wet Method

The traditional wet process is intended for food applications. Using this method, the hulls are removed from the seeds and then milled or ground into flour. The legume flour is pulped using a decomposing agent like an alkaline solution to pull out the protein, which is then dried. The solid matter left after the protein has been separated out is screened through a series of sieves to recover the starch. Like fiber, pea starch is usually made available as a byproduct of protein extraction.

Another wet approach includes soaking the whole grain, followed by straining the result, now a slurry, through a cloth. This is common in Thailand, the Philippines, and other Southeast Asian countries as a means for removing the hull to extract the starch. In some West African countries, whole peas, or the remains from stone grinding, are soaked in water and agitated until the hull separates and is then captured by sieving.

For chickpeas and dehulled split yellow peas, starch fractionation involves steeping the seeds in warm water with *toluene* (i.e., a colorless, water-insoluble, flammable liquid often used as a solvent) to prevent fermentation. This is followed by wet grinding and repeated screening.

Lentils are better served by a similar method that also includes resuspension in a 0.2 percent sodium hydroxide (NaOH) solution, which dissolves most of the protein.

The wet method is particularly useful if the pulse is to be ground into a paste for further processing. On the other hand, if it is to be dried, the wet method can be difficult and time consuming, often involving the loss of nutrients in the soak-water.

Dry Method

The dry method uses a mill and air classification process to break down the dehulled seeds and separate out the starch and protein fractions. Dry processes have been employed more successfully with grain legumes than with other legume varieties because in legumes starch is the principal storage compound rather than oil.

"In India, the grains are oil treated and sun dried before being mixed with two percent to three percent stone powder."

Removal of the loosened hulls from the grain in the dry-milling technique is commonly done in small machines. These usually take the form of under-runner disc-shellers or grinders with emery or stone contact surfaces. A plate mill is sometimes used to both hull and split the soaked and dried grains.

In India, the grains are oil treated and sun dried before being mixed with two percent to three percent stone powder. They are then hulled in a rice-huller. The usable pieces are removed by sieving, while the hull, powder, and small bits remain in the stone powder.

Wet Versus Dry

In a comparative study of dry and wet milling, dry air classification of pea flour containing 22 percent protein and 55 percent starch yielded fractions containing 53 percent protein and 83 percent starch. The protein fraction also contained some broken starch granules in addition to most of the lipid, ash, sugars, flavor, and color compounds in the flour.

The protein isolated from wet milling contained 88 percent protein and refined starch contained less than 1.0 percent protein. The refined fiber was light colored and relatively free of other constituents. The main drawback of the wet milling method is the resulting loss of protein and starch in the whey and washes, as well as the expensive effluent recovery requirements.

Puffing

Puffing of legumes has been practiced in Asia, Africa, and Latin America for years. It is achieved by first subjecting the pulse to high temperatures, about 176 degrees F (80 degrees C), for a short time. Water is then added and allowed to absorb overnight. The grain is finally roasted, which prompts the cotyledons to expand, thereby splitting the hull so that it can be more easily removed.

Studies show that in addition to moisture conditioning or moisture addition prior to heating, puffing can be improved by certain hardening agents such as calcium phosphate, egg white, gums, calcium, or sodium caseinate.