Peanut

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Scientific Name and Introduction

Arachis hypogaea L., the peanut or groundnut, is an annual herb of the Leguminosae family. Two subspecies are grown commercially, and four market types are of greatest economic importance. *A. hypogaea* subsp. *hypogaea* includes the market types "runner" and "virginia," and *A. hypogaea* subsp. *fastigata* includes the market types "spanish" and "valencia." In the United States in the 1980s, 70% of the peanuts grown were runners, while 20, 10, and <1% were virginia, spanish, and valencia market types, respectively (Knauft and Gorbet 1989). According to the USDA national peanut tonnage report, U.S. production in 1999 included 78% runners, 18% virginia, 3% spanish, and 3% valencia.

The edible portion is a seed which develops underground inside a pod containing two to four seeds. Peanuts originated in South America and are now cultivated worldwide, with the majority of production in India, Asia, and the United States. In the United States, about 60% of peanuts are used in a variety of food products, with the reminder used in approximately equal proportions for export and for production of edible oil. Major chemical constituents of peanuts are oil (44 to 56%) and protein (22 to 33%), with large influences by environment, genotype, and maturity on their concentrations (Holaday and Pearson 1974).

Quality Characteristics and Criteria

Shelled peanuts should be properly sized to meet market type, be free of misshapen or underdeveloped kernels, and be free of any shell or foreign material and off odor or flavor. Raw peanuts should be surrounded by a tan, pink, or red seedcoat (testa) that fully encapsulates the seed, and the interior color of each half-seed should be ivory. Moisture content for in-shell peanuts should be <10% to prevent mold growth (Diener and Davis 1977). Prior to shelling, peanuts should contain 7 to 10% moisture to reduce splitting and kernel breakage during milling. After milling, moisture content for maximum shelf-life is ≤7%. Seed may be stored at ambient temperature for up to 11 years with good viability if seed moisture content is <3.3% (Cheng et al. 1997). Peanuts marketed without seedcoats (blanched) should have an ivory-colored raw kernel. Peanuts are most commonly consumed following roasting, which may be accomplished in-shell or after shelling. Roasted peanut kernels should be light yellow in color, free of external oil, contain <6% moisture, and be free of dark-colored kernels.

Peanut seed, and particularly peanut seedcoats, are a source of resveratrol, a compound that reduces cardiovascular disease and cancer incidence. Resveratrol ranges from 0.02 to 1.79 $\mu g\ g^{-1}$, compared to 0.6 to 8.0 $\mu g\ mL^{-1}$ in red wines (Sanders et al. 2000). Fatty acid composition of peanut oil is predominantly oleic and linoleic acids, found in roughly equal amounts and making up 80% of total fatty acids. Certain genotypes may contain substantially more oleic than linoleic acid, with ratios as high as 40:1 (oleic:linoleic). Peanuts with a high oleic:linoleic ratio are less susceptible to oxidative deterioration and off flavor development caused by oxidative cleavage of polyunsaturated fatty acids. The ratio of oleic to linoleic is influenced primarily by genotype, but interactions exist between genotype and the environment.

Horticultural Maturity Indices

Peanuts are an indeterminant plant, with flowering followed by underground seed development over a range of time. Assessment of peanut maturity should be conducted using multiple plants at various locations within a field. Peanut maturity may be judged by the shell-out procedure, involving separation of peanut seed into mature or immature categories. Using the shell-out procedure, a peanut is considered mature if the inner hull is brown and the seed coat is pink to red. Optimum maturity is reached for runner and spanish types when 75 to 80% of the inner hull has turned brown and for virginia types when 65% of the seed coat has turned deep pink. Runner peanut maturity can be determined by a hull-scrape method, in which maturity profiles for samples are estimated based on degree of change in pod mesocarp from white to brown to black (Williams and Drexler 1981).

Grades, Sizes, and Packaging

U.S. grade standards and industry grade standards from the American Peanut Shellers Association exist for shelled spanish, shelled runner, shelled virginia, and in-shell virginia peanuts. A comparison of tolerances as provided by the American Peanut Shellers Association fficial Trade Rules for shelled peanuts based primarily on size, peanuts of other types, amount of split or broken kernels, freedom from foreign material, damage, minor defects, and in some cases moisture percentage are presented in tables 1 to 4. Tolerances for in-shell virginia peanuts based on maturity; freedom from loose shelled peanuts; discoloration of shell; presence of dirt, shell, and other foreign material; and degree of kernel fill inside the shell are compared.

Table 1. Comparison of screen sizes and tolerances (by weight) for American Peanut Shellers Association (APSA) and USDA Grades for shelled spanish peanuts.

Grade & minimum screen size	Fall-thru prescribed screens	Other types	Splits	Damage	Damage and minor defects	Foreign material	Moisture
				%			
No. 1 (15/64 x 3/4" Slot)							
APSA	2.00	1.00	3.00	0.75	1.25	0.10	9.00
US	2.00	1.00	3.00	1.50	2.00	0.10	-----
Splits (16/64" Round)							
APSA	*	2.00	----	1.50	2.00	0.20	9.00
US	**	2.00	----	2.00	2.00	0.20	----
No. 2 (16/64" Round)							
APSA	6.00***	2.00	----	1.00	2.00	0.20	9.00
US	6.00***	2.00	----	----	2.50	0.20	----

* (APSA) 2.00% sound portions of peanuts which pass through the prescribed screen; and 4.00% for sound whole kernels, not over 3.00% which will pass through a 13/64×3/4 in screen. This fall-through combined with percentage of sound portions shall not exceed 4.00%.

** (US) 2.00% sound portions of peanuts which will pass through the prescribed screen; and 4.00% for sound whole kernels.

*** Combined fall-through of sound portions through a 16/64 in round screen and sound whole kernels through a 13/64×3/4 in screen shall not exceed 4.00%

Table 2. Comparison of screen sizes and tolerances (by weight) for American Peanut Shellers Association (APSA) and USDA Grades for shelled runner peanuts.

Grade & minimum screen size	Fall-thru prescribed screens %	Fall-thru 16/64 x 3/4" Slot screen	Other types	Splits	Damage	Damage and minor defects	Foreign material	Moisture
Jumbo 38-42 ct. per oz.*** or 21/64 x 3/4" Slot	5.00	3.00	1.00	3.00	1.00	2.00	0.10	9.00
Medium 40-50 ct. per oz.*** or 18/64 x 3/4" Slot (Report % Riding 21/64 x 3/4" Slot)	5.00	3.00	1.00	3.00	1.00	2.00	0.10	9.00
Select 16/64 x 3/4" Slot (Report % Riding 21/64 x 3/4" Slot)	----	3.00	1.00	3.00	1.00	2.00	0.10	9.00
No. 1 16/64 x 3/4" Slot (Report % Riding 18/64 x 3/4" Slot)								
APSA	----	3.00	1.00	3.00	1.00	2.00	0.10	9.00
US	----	3.00	1.00	3.00	1.50	2.00	0.10	----
Mill run 16/64 x 3/4" Slot	----	3.00	1.00	3.00	1.00	2.00	0.10	9.00

Splits 17/64" Round								
APSA	*	*	2.00	----	1.50	2.00	0.20	9.00
US	**	**	2.00	----	2.00	2.00	0.20	----

* (APSA) 2.00% sound portions pass through 17/64 in round screen. 4.00% for sound whole kernels, not over 3.00% which will pass through 14/64×3/4 in slot screen. This fall-through combined with sound portions passing 17/64 in round not to exceed 4.00%.
** (US) 2.00% sound portions pass through 17/64 in round. 4.00% for sound whole kernels.
*** American count per ounce shall be within the specified range.

Each of the above grades may be certified “with splits” providing all requirements of the grade are met, except that a tolerance of 15% is allowed for split kernels of which not more than 3% will pass through 17/64 in round screen.

Table 3. Comparison of screen sizes and tolerances (by weight) for American Peanut Shellers Association (APSA) and USDA Grades for shelled Virginia peanuts

Grade and minimum screen size	Fall-thru prescribed screens	Other types	Sound split or broken kernels	Damage	Damage and minor defects	Foreign material	Moisture	Count per pound maximum
	%							
Extra large 20/64 x 1" Slot APSA & US	3.00	0.75	3.00	1.00	1.75	0.10	----	**512
Medium virginia 18/64 x 1" Slot APSA & US	3.00	1.00	3.00	1.25	2.00	0.10	----	**640
No. 1 virginia 15/64 x 1" Slot APSA & US	3.00	1.00	3.00	1.25	2.00	0.10	----	**864
Virginia splits 20/64" Round APSA & US	*3.00	2.00	Not Less Than 90.00	----	2.00	0.20	----	----
No. 2 virginia 17/64" Round APSA & US	*6.00	2.00	As Graded	----	2.50	0.20	----	----

* (APSA & US)—Includes both sound split and broken and sound whole kernels which pass through prescribed screens.
** Unless otherwise specified.

Each of the above APSA whole grades may be certified as “with splits” providing all requirements of the grade are met, except that a tolerance of 15% is allowed for split kernels of which not more than 3% will pass through 17/64 in round screen.

Table 4. Comparison of screen sizes and tolerances (by weight) for American Peanut Shellers Association (APSA) and USDA Grades for in-shell Virginia peanuts.

Grade and minimum screen size	Fall-thru prescribed screen	Cracked or broken shells, pops, paper, and foreign material	Damaged kernels	Count per pound
	%			
Jumbo 37/64 x 3"				
APSA	5.00	*10.00	3.50	**176 (U.O.S.)
US	5.00	*10.00	3.50	**176 (U.O.S.)
Fancy 32/64 x 3"				
APSA	5.00	*11.00	4.50	**225 (U.O.S.)
US	5.00	*11.00	4.50	**225 (U.O.S.)

* (APSA & US) Not more than 0.5% shall be allowed as dirt or other foreign material.
** Unless otherwise specified.

Raw in-shell peanuts are typically stored as "farmer stock peanuts" in flat, ventilated warehouses or grain bins in bulk or, less commonly, in 50-lb (23 kg) burlap bags for a week to 10 mo prior to shelling (Smith et al. 1995). After shelling, raw peanuts are often shipped in bulk containers but may be packaged in burlap or nylon tote bags of various sizes. Peanuts for human consumption must be free of visible *Aspergillus flavus* mold, containing less than 15 ppb (nL L^{-1}) aflatoxin. Lots imported into the United States may be designated "segregation 1" or "segregation 2" depending on degree of kernel damage and concealed damage from rancidity, mold, or decay. Segregation 1 peanuts may *not* contain more than 2.00% damaged kernels nor more than 1.00% concealed damage, while segregation 2 peanuts *may* contain more than 2.00% damaged or more than 1.00% concealed damage. Segregation 3 peanuts are those which contain visible *Aspergillus flavus* mold or 15 ppb (nL L^{-1}) or more aflatoxin.

Optimum Storage Conditions

In-shell farmers-stock peanuts should be dried to about 7.5% moisture. If stored at 10 °C (50 °F), these can be stored for up to 10 mo without significant quality loss (Davidson et al. 1982). High losses in milling quality may occur if peanuts are dried to below 7% moisture or if kernel temperature is below 7 °C (44.6 ºF) during shelling (McIntosh and Davidson 1971). Peanut moisture content >10% should be avoided to prevent mold growth (Diener and Davis 1977). Adequate ventilation in a warehouse storage facility, preferably providing one air change every 3 min, is also desirable to prevent excess moisture and heat from accumulating in the storage facility (Smith and Davidson 1982).

Quality of raw shelled peanuts can be maintained for at least 1 year at 1 to 5 °C (34 to 41 °F) with moisture content of <7%, or for 2 to 10 years at -18 °C (0 °F) and <6 % moisture. Maintaining RH between 55 and 70% at 1 to 5 °C (34 to 41 °C) will maintain peanut moisture content at 7 to 7.5%. Careful handling of peanuts equilibrated to <5 °C (41 °F) is necessary to prevent bruising and subsequent oil seepage from damaged cells within the cotyledon. Upon removal of raw shelled peanuts from refrigerated or frozen storage, equilibration to ambient temperature should be gradual in conditioning rooms, with RH, temperature, and air-flow adjusted to prevent moisture condensation onto peanuts.

Controlled Atmosphere Considerations

Low-O_2 storage shows promise for delaying rancid flavor development and insect infestation (Slay et al. 1985). High-CO_2 storage appears to limit growth of *Aspergillus flavus* in short-duration storage of high-moisture, noncured peanuts. Peanuts at 20% moisture stored at 0.6 to 3 °C (33 to 37 °F) in a high-CO_2 environment had acceptable quality for 4 days but deteriorated after 8 days of storage (Moseley et al. 1971). For longer-term storage of high-moisture, shelled peanuts under ambient temperature conditions, <1.5% O_2 was required to slow *Aspergillus flavus* growth; but no CA totally eliminated aflatoxin production (Wilson and Jay 1976).

Retail Outlet Display Considerations

Peanuts are normally marketed at ambient temperature. Using low O_2 and preventing excessive exposure to light is recommended. In-shell peanuts may be displayed and marketed in bulk containers. Exposure to moisture or high RH should be avoided.

Chilling Sensitivity

Prior to or during harvest and prior to postharvest drying, exposure to chilling temperatures of 0.9 to 1.6 °C (33.6 to 35 °F) caused increased ethanol production, and the effect was greater for small seeds than for large seeds within a genotype. This was accompanied by increased seed leachate, suggested by the authors to be indicative of induction of anaerobic respiration and cell membrane damage (Singleton and Pattee 1989). Following postharvest drying and during storage, peanuts do not appear to be sensitive to chilling and may be stored at or below freezing.

Ethylene Production and Sensitivity

Peanut seeds exhibit dormancy periods following harvest of 63 to 84 days, varying with genotype and temperature during pod maturation and storage. Soaking seeds in GA3 or ethephon at 50 to 200 µg mL^{-1} was effective in breaking dormancy (Kapur et al. 1990). Nondormant peanuts exhibit a climacteric-like rise in ethylene production during seed germination (Whitehead and Nelson 1992).

Respiration Rates

Properly cured peanuts in storage exhibit a relatively low rate of respiration. During harvest and prior to curing, especially for high-moisture peanuts, respiration rates may be substantial and significant losses in quality can ensue. Freshly harvested peanuts should be dried soon after harvest to <10% moisture to assure optimum quality.

Physiological Disorders

Shriveled seed trait has been identified as a heritable condition for peanuts. Seed mature normally but appear shriveled and thus appear to have been harvested while immature. Seeds of shriveled lines exhibit up to 67% less oil and double the amount of sucrose, and defatted meal contained less protein (Jakkula et al. 1997). Improper curing of peanuts results in loss of quality and off-flavor development.

Fermented, fruity off flavor is caused by freezing temperatures during harvest while peanuts are still windrowed (Singleton and Pattee 1991) or by too high a temperature during curing (Sanders et al. 1989). Effects of improper curing are greatest on smaller seed, perhaps indicating greater effect on immature seed (Sanders et al. 1990).

Postharvest Pathology

Peanuts are susceptible to infection by various molds and fungi, and a combination of storage at 1 to 5 °C (33.8 to 41 °F) and reduction of moisture content to <7.5% may be effective in reducing mold and fungi growth in storage. The presence of toxic fungal metabolites (mycotoxins) are a particular concern. The name “aflatoxin” refers to four metabolites found in contaminated peanuts and designated aflatoxin B1, B2, G1, and G2. Aflatoxins B1 and B2 are metabolites of *Aspergillus flavus*, and all four aflatoxins may be produced by *Aspergillus parasiticus* (Cole et al. 1995). A fifth mycotoxin, cyclopiazonic acid, is somewhat less toxic than aflatoxin and is produced by *Aspergillus flavus*, other *Aspergillus* species, and several species of *Penicillium* (Dorner et al. 1985).

Preharvest conditions favoring aflatoxin contamination are high temperatures and drought stress during the last 3 to 6 weeks of the growing season (Cole et al. 1989). Late-season irrigation may be effective in reducing aflatoxin contamination (Dorner et al. 1989). When aflatoxin contamination occurs, it is common for most of the harvested seed to be free of contamination with only a few highly contaminated seeds. Although monitoring at the point of sale for *Aspergillus flavus* is mandated by the USDA Peanut Marketing Agreement, and detection of ≥15 ppb (nL L^{-1}) aflatoxin leads to positive aflatoxin identification, the irregular distribution of infection may lead to false negative designations.

Storage conditions to deter growth of the causal organisms and subsequent metabolic production of the mycotoxins primarily involve prevention of rehydration during storage. Decontamination of contaminated lots is most effectively done with electronic color sorting, although size and density separation may also be effective in removal of the most susceptible underdeveloped seed.

Quarantine Issues

Importation of peanut seed into the United States for planting is prohibited from Burkino Faso, the People’s Republic of China, Cote d’Ivoire, India, Indonesia, Japan, the Phillipines, Senegal, Thailand, and Taiwan because of peanut stripe virus. During import of peanuts, all lots must be labeled with a positive lot identification and must meet the requirements for segregation 1 peanuts if used for human consumption. Peanuts with visible *Aspergillus flavus* mold, or those containing≥15 ppb aflatoxin, may not be used for edible purpo ses; they may be used for oil stock. Such peanuts may be blanched and reseparated into aflatoxin-negative lots, which may be used for edible purposes.

Special Considerations

Peanuts are a major allergenic food among adults and children in the United States (Taylor 1992). Allergen activity has been identified for at least six allergens by phage display technology and is known to be in association with the two major storage proteins, arachin and conarachin, and in profilin (Kleber et al. 1999). Allergens may also be present in refined peanut oil (Olszewski et al. 1998). Due in large part to allergenicity, any food product containing peanuts or peanut oil must be labeled as such.

Careful handling of cured farmers-stock peanuts to prevent breakage of shells reduces the risk for spread of fungal contamination and maintains the grade. Conveyors, cleaners, sizers, and other handling equipment should be padded where appropriate and properly maintained to prevent excessive breakage during handling. Once shelled and roasted, peanuts should be handled carefully to prevent separation of the half kernels and breakage since splits and pieces are more susceptible to oxidative deterioration and rancidity development. Peanuts will absorb lipophilic volatiles from their surroundings or from inappropriate packaging that can induce off flavors. Absorption of ammonia can cause darkening of nutmeats.

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