Food Uses of Peanut Protein

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ABSTRACT

Approximately 19 million metric tons of peanuts *(Arachis lypogae L.)* are harvested annually, and contribute over 3.5 million tons to the world's protein pool for food and feed uses. Peanut is the world's fourth most important source of edible vegetable oil and the third most important source of vegetable protein feed meal. About 70% of the U.S. Crop is consumed domestically or exported as peanut kernels, peanut butter, and confections. Crushing is limited primarily to culls and kernels containing aflatoxin; and to stabilize the market. However, in countries such as India, Senegal, Brazil and Argentina, 75 to nearly 100% of the crop is crushed or exported for use as oil and livestock meal. The peanut is perhaps the world's most widely researched food protein oilseed. Advantages over other oilseeds include relatively bland flavor, minor color problems, and minimal preparation requirements. Products in use throughout the world include boiled peanuts, roasted full-fat or partially defatted peanuts, peanut butters, grits and flours (full-fat or defatted), defatted peanuts, protein concentrates, and protein isolates. Compounded food applications include fortified breads and bakery products, snacks, meat products, extended milks, cheese and curd type products, and various mass-feeding foods in developing countries. Challenges encountered in peanut utilization include improvement of flavor levels and stability, identification of nutritional adequacy and fortification requirements, elimination of antinutritional factors, development of new products and improved processes, and elimination of aflatoxin problems.

INTRODUCTION

The peanut *(Arachis hypogae L.)* is also known throughout the world as: groundnut, earthnut, pistache de terre, goober, monkey nut, Manilla nut, ground beans, and pindar (1). Man's experience in learning to use this oilseed is an exciting story. The plant is believed to have been cultivated first in the upper Plata basin of Bolivia over 3,800 years ago. By the time of the Spanish and Portuguese explorers, it was being grown in Peru, Mexico, Brazil, and the West Indies. The peanut was distributed throughout the world by explorers, colonists, and missionaries, and brought to the United States from Africa by slave traders (2). Broad cultivation in the South did not occur until the 1920s, when farmers were forced to find a substitute crop for cotton because of the boll-weevil (3).

Approximately 19 million metric tons of peanuts are produced on about 18 million hectares, and contribute ca. 3.5 million tons to the world's food and feed protein pool. Peanuts are the world's fourth most important source of edible vegetable oil and contribute ca. 14% of the world's annual production. Also, they are the third most important source of vegetable protein meal and provide ca. 11% of the world's supply (4-6). Peanuts are grown in more than 50 countries. Although acreage and yields vary from year to year, the relative standing of the world's 10 leading peanut-producing nations in 1976 is summarized in Table I. The major recent change in this list is Nigeria, a leading exporter of peanuts and peanut oil in the 1950s and 1960s, which now exports only small amounts of meal and has become an importer of peanut oil

Many varieties of peanuts are grown throughout the world, with the choice in any locality dependent upon adaptability to climate and soil, and needs of the marketplace. Uniform-size long kernel varieties like Virginia and Valencia types, and small seed Spanish types, are primarily used for the whole nut market. Runner types are more variable in size and are mostly used for processing, but have also been size graded for the whole nut market.

The peanut is an annual herbaceous plant belonging to the suborder *Papilonacea* of the order *Leguminoseae.* After fertilization of the flower, the stalk (peduncle) elongates, drops to the soil, and pushes the ovary 7 to 10 cm below the surface where the pods are formed. Pods are cylindrical and 1 to 8 cm in length. The shell comprises 20-30% of the pod and may easily be separated from the kernels (1,3). The kernels consist of two halves (cotyledons), a "heart" (germ) weighing ca. 4% of the kernel, and a "skin" (testa) weighing ca. 3%(7). A ton of farmer's stock peanuts yields ca. 58% shelled edibles, 17% oil stock, and 25% hulls (8). Composition of the various fractions of the peanut pod is summarized in Table II. About 10 to 12% of the nitrogen content of peanuts is usually reported as non-protein nitrogen (9).

Processing of peanuts varies broadly depending upon use, and typically includes removal of the shell to reduce fiber content, and of the skin through various processes called "blanching" to eliminate off-color problems. The hearts contain high levels of vitter tannin-like compounds, and are frequently removed in the production of mild flavored products. Most processes also include one or more heating steps to inactivate antinutritional factors and spoilage enzymes.

USES OF PEANUTS

The peanut has some very important advantages over the other major oilseeds. It can be prepared in many food forms with only simple roasting and grinding processes. Its products are pleasantly flavored, and do not require severe refining. This is especially significant in today's emphasis on conservation of energy, minimization of food processing waste by-products and pollution, and interest in natural foods. With peanuts it is not necessary to first extract and purify constituents such as protein, oil, and carbohydrates for later recombination into compounded foods. The peanut already is a naturally compounded food, ready to eat with minimim preparation.

About 60% of the peanuts harvested outside the United States are crushed (3), while about 70% of the U.S. crop is used for food purposes (10). Edible grades of peanuts are

TABLE I

1976 Acreage, Production and Processing of Peanuts in Selected Countries and the World (4)

Country and Continent	Acreage (1,000 hectares)	Production[a] (1,000 metric tons)	World production (%)	Estimated commercial crop crushed and/or exported (%)
Ten countries				
India	7,500	5,800	32.4	75
China, People's Republic	2,200	2,900	16.2	---
United States	616	1,701	9.5	29
Senegal	1,181	1,182	6.6	100
Sudan	745	839	4.7	90
Brazil	367	514	2.9	80
Burma	668	450	2.5	---
Indonesia	411	450	2.5	---
Nigeria	970	350	2.0	100
Argentina	309	338	1.9	94
Continents				
Asia	11,297	10,338	57.9	---
Africa	6,049	4,714	26.4	---
North America	731	1,846	10.3	---
South America	732	915	5.1	---
Oceania	27	37	.2	---
Europe	12	25	.1	---
World total	18,849	17,246	100.0	---

[a]Farmer's stock (in shell).

TABLE II

Approximate Composition of Peanut Pod Components

Analysis:	Peanut shells[a,b] %	Red peanut skins[c] %	Peanut hearts[a,c] %	Raw peanut kernels[c] Range %	Average %
Moisture	---	9.0	---	3.9-13.2	5.0
Protein	5.0-7.3	12.2	28.3	12.0-36.4	28.5
Fat	1.2-2.1	1.2	42.4	35.8-54.2	47.5
Crude fiber	66.0-80.0	19.3	1.8	1.2-4.3	2.8
Ash	3.0-4.6	2.1	3.1	1.8-3.1	2.9
Nitrogen-free extract	10.6-21.2	---	---	60.0-24.9	13.3
Carbohydrates	---	49.2	---	---	---
Total sugars	---	---	12.0	---	---
Reducing sugars	0.6	---	7.9	0.1-0.3	0.2
Disaccharides	1.7	---	---	1.9-5.2	4.5
Starch	0.7	---	---	1.0-5.3	4.0
Pentosans	18.0	---	---	2.2-2.7	2.5

[a]Moisture-free basis.
[b]See reference 1.
[c]See reference 7.

used in the U.S. as follows: peanut butter, 52.7%; peanut butter sandwiches, 2.0%; salted (nut uses), 23.3%; candy, 20.7%, and others, 1.4% (10). Disposition of the total U.S. peanut crop is summarized in Table III. Compositions of peanut products are shown in Table IV.

Nut Products

Nut uses of peanut contribute over 125,000 tons of food protein to the American diet alone, and deserve mention in this review. Forms in which peanuts are used without significant extraction of refining include the following.

Boiled fresh peanuts. Freshly dug, unshelled immature peanuts boiled in a medium brine (26 salimeter), are eaten as a delicacy in some areas (3). Canned and frozen boiled peanuts are sold commercially.

Roasted peanuts in the shell. Barnum's circus has been credited for having introduced peanuts to New York City and throughout the United States (11). Sales by street vendors, and at ball games and other public outings have introduced many persons to the desirable fresh roasted flavor of peanuts, and it may be one of the reasons why the U.S. leads the world in direct consumption of peanuts. Peanuts in the shell are often salted by soaking in a brine before roasting (3).

Roasted shelled peanuts. Shelled peanuts may be roasted in dry heat, or by frying in oil (11). Nut processors are often called "salters" and produce a variety of salted and unsalted whole, split kernel, and chopped nut products. These are used as snacks, garnishes in cooking, toppings for baked goods, and in confectionery products. Partially defatted peanuts, made by the Southern Regional Research Laboratories process, are being sold by several processors. In this process the kernel is pressed hydraulically to remove 50-60% of the oil. It is then reconstituted by soaking in brine, and is deep-fat fried. The resulting product is lighter in weight, and has a third less calories than regular roasted peanuts (12-15). A sophisticated science has evolved in processing peanuts as nuts, and preserving them through use of antioxidants, protective packaging, and vacuum and nitrogen packing (3,16).

Peanut candies. The potential variations for using peanuts in confections is unlimited. Over 50 types of peanut candies have been described (3). More than 60% of the nuts used in candies in the United States are peanuts. No other flavor ingredient, except chocolate, is used as broadly in confections.

TABLE III

Average Annual U.S. Production, Trading, and Uses of Peanuts for Period 1971-1975. (10)

Form	Weight (metric tons)
Farmer's Stock (in shell):	
Harvested	1,568,628
Processed	1,359,417
Shelled peanuts produced and traded:	
Edible grades	700,432
Oil Stock	278,546
Total U.S. production	978,978
Imported	227
Exported	197,877
Shelled peanuts processed:	
Crushed	299,263
Used in primary products:	
Peanut butter	280,882
Peanut butter sandwiches	10,571
Salted (nut uses)	123,486
Candy	110,223
Other uses	7,645
Total primary product uses	7,645
	532,818

Peanut butter. An unidentified St. Louis physician is believed to have invented peanut butter in the 1870s. The first patent for its preparation was awarded to J.H. Kellogg of Battlecreek, Michigan. Peanut butter is by far the most important use for peanuts grown in the United States. This product has long been enjoyed for its desirable flavor as a sandwich spread, as a versatile snack and cooking ingredient, and as a low cost source of protein. During the depression of the 1930s, "nickel" (5-cent) peanut butter sandwiches were frequently sold in restaurants. Peanut butter has also been included in armed forces rations, school lunches, and in programs to feed low-income groups in the United States and overseas (2,3).

The basic steps of manufacturing peanut butter include cleaning of shelled peanuts, roasting, blanching, blending of ingredients, grinding, cooling, and packaging. Numerous variations exist in the order of these steps. The typical formula includes at least 90% peanuts, and about 2% salt. Peanut butter is semiperishable. It is not normally subject to bacterial spoilage and doesn't require refrigeration but will mold under humid conditions. Hydrogenated oils or stabilizers are often added to prevent oiling-off during storage. There are three types of peanut butter: old fashioned, which does not contain stabilizers to prevent separation of oil; smooth, which is a finely ground stabilized product; and chunky, which is smooth butter with added pieces of peanuts to enhance mouthfeel. Peanut butter is available in household size containers sold through grocery stores, and in bulk containers for food manufacturing (3,11). It is used extensively as an ingredient in the production of peanut butter cracker sandwiches, and in peanut-flavored cookies, bakery goods, candies, breakfast cereals, and ice cream. Numerous peanut spread-type products, incorporating other ingredients, including sugar, honey, lecithin, yeast, malt, dried fruits, and natural and synthetic flavors, have been sold.

Peanut flakes. A process to make precooked full-fat peanut flakes has been patented, and a product is being introduced to the market place. The process consists of removing the hearts and skins from unroasted peanuts, drying to 2-4% moisture content, fine grinding, heating with water, and drum drying the product (18,19).

Extracted Peanut Ingredients

Considerable opportunities exist for development and innovative uses of extracted portions of the peanut. The most famous early peanut utilization scientist was Dr. George Washington Carver, who is credited with having developed over 300 uses for the peanut, including food, feed, and industrial products (3,20).

In recent years major efforts have been placed on developing high protein peanut ingredients including flours, meals, grits, concentrates and isolates.

Full and partial-fat peanut flours. Consumer demands for food ingredients with the unique flavor of peanuts have created markets for full-fat and partially defatted peanut flours. In partially defatted flours, ca. 55% of the original oil is removed by hydraulic pressing (21). A patent has also been issued for a process to make a saline-washed full-fat peanut flour. It is claimed that this product is free of peanut odor and objectionable natural compounds including tannins (22).

Defatted peanut grits, meals and flours. Grits, meals, and flours are made by essentially the same processes, and differ in degree of fineness of grind. Typically, a two-step defatting operation is used. Crushed peanuts are cooked by wet heat, mechanically expelled to 9 to 12% oil; and are then solvent extracted, usually with hexane (23,24). Production of a low-fat peanut flour by direct extraction of peanut slices has also been reported (25,26). Solubility of the flour can be modified by heating, and monitored by the Nitrogen Solubility Index (NSI) test.

Uses of peanut flours in compounded foods include breads and bakery goods, breakfast cereal flakes, meat patties, snack foods, beverages, ice creams, soups, spreads and frostings, textured vegetable protein ingredients, school lunches and mass feeding in India (27-32).

Peanut protein concentrates. Peanut flavor, bitter compounds and flatulence sugars are reduced in peanut products by conversion of flour to protein concentrates containing at least 60-70% protein on dry weight basis. Processes include using alcohol and acid

TABLE IV

Composition of Peanut Products and Ingredients

Item	Boiled peanuts (86)	Roasted peanuts (Salted, without skins) (86)	Peanut butter (Fat, salt, sugar added) (86)	Partially defatted peanut flour (Toasted) (21)	Defatted peanut flour (23)	Aqueous processed Concentrate (87)	Aqueous processed Isolate (87)
Water, %	36.4	1.6	1.7	1.2	7.0	4.3	5.6
Calories, (100 g)	376	585	589	---	---	---	---
Protein, %	15.5	26.0	25.2	42.1	57.0	67.1	93.8
Fat, %	31.5	49.8	50.6	34.1	0.6	2.4	0.2
Carbohydrate, %	14.5	18.8	18.8	20.2	30.0	17.6	5.2
Fiber, %	1.8	2.4	1.8	2.5	4.6	4.2	0.2
Ash, %	2.1	3.8	3.7	3.4	4.6	2.4	4.1
Calcium, mg/100g	43	74	59	55	140	4	3.4
Phosphorous, mg/100g	181.0	401.0	380.0	540.0	760.0	0.8	0.6
Iron, mg/100g	1.3	2.1	1.9	3.6	2.1	1.9	1.8
Sodium, mg/100g	4	418	605	11	180	146	464
Potassium, mg/100g	462	674	627	1075	1290	642	248

TABLE V

Amino Acid Composition of Peanut Protein Concentrate and Isolate. (59)

Amino acid	Grams amino acids/16 g nitrogen		
	Peanut[a]	Peanut protein concentrates	Peanut protein isolates
Lysine[b]	3.0	3.0	3.0
Histidine[b]	2.3	2.4	2.4
Arginine[b]	11.3	12.6	12.8
Aspartic acid	14.1	12.5	12.3
Threonine[b]	2.5	2.5	2.5
Serine	4.9	5.2	5.1
Glutamic acid	19.9	20.7	21.4
Proline	4.4	4.6	4.8
Glycine	5.6	4.2	4.1
Alanine	4.2	4.0	3.9
Cystine	1.3	1.4	1.4
Valine[b]	4.5	4.5	4.4
Methionine[b]	0.9	1.0	1.0
Isoleucine[b]	4.1	4.3	3.6
Leucine[b]	6.7	6.7	6.6
Tyrosine	4.1	4.4	4.3
Phenylalanine[b]	5.2	5.6	5.6
Tryptophan[b]	1.0	1.1	1.0

[a]Peanut meal defatted with hexane at room temperature.
[b]Essential amino acids.

washes followed by partial drying, neutralization and flash-drying (33). A patent has been issued for the production of a 60% protein concentrate using an isoelectric wash (34). Procedures for producing a 67% protein concentrate directly from whole peanuts using the aqueous extraction process have also been described (35,36). An advantage of preparing concentrates and isolates by aqueous extraction is the opportunity to destroy aflatoxin by use of oxidizing agents such as hydrogen peroxide or sodium hypochlorite (37). Good results have been obtained using aqueous-processed peanut protein concentrates in bread at levels up to 10% of flour (38).

Peanut protein isolates. These contain 90% or more protein on a dry basis. Typically, isolate production processes include the steps of solubilizing protein with alkali and reprecipitation with acid. Production of spray-dried (39) and wet isolates (40) from defatted peanut flour, and dried isolates from whole peanuts by aqueous processing (35), have been described in the literature.

Isolates are used where bland and highly concentrated forms of peanut protein are desired; for example, in bread and bakery goods. Experiences in India, using peanut protein isolates in the preparation of Miltone, an extended milk, (40) a curd-type derivative (41), and a cheese-like product (42), demonstrate their applicability in dairy-type products.

Modified Peanut Protein Ingredients. Current research activity on modification of peanut protein ingredients is high. Recent publications describe preparation of succinylated peanut flour (43), fungal fermented flours (44,45) and enzymatically modified flours (46-48). Reports indicate improvement of protein functionality through modification, and may anticipate development and marketing of new types of improved peanut protein products in the future. Peanut curd products resembling "tofu" are used in Japan (49); and preparation of peanut flour miso- and koji-like products in India using defatted peanut flour has also been reported (50).

NUTRITION

Amino acid contents of peanuts and aqueous process concentrates and isolates are shown in Table V. Commonly reported PER values for peanuts are about 1.5 to 1.8 (51). Biological value estimates usually fall in the range of 50 to 75% of reference proteins. These estimates were made, however, when the primary emphasis of nutrition thought was on relative comparisons with optimally blanced proteins. Although methionine, lysine and threonine are often reported to be limiting amino acids in peanut products at low protein dietary level, it has been shown that growth of rats fed 16.7 and 20% peanut protein is essentially equivalent to that of animals fed 12 to 24% casein protein (52). There may be many conditions in the world where higher levels of lower biological value proteins would result in as good a growth as can be obtained with practical diets of supplemented or mixed proteins.

Numerous early explorers of the New World noted in their journals that eating raw peanuts caused headaches, stomach distress, and full-headedness, but that roasting solved these problems (2). As in many oilseeds, antinutritional factors including trypsin inhibitors, goitrogenic factors, phytohemagglutinins, phytic acid, and oxalic acid, have been found in peanuts (53-56). The trypsin inhibitor level of raw peanuts is ca. 20% of that found in raw soybeans, but is enough to cause significant pancreatic hypertrophy in rats receiving 15% of protein intake from peanuts (57). Autoclaving and dry heating substantially reduce trypsin inhibitor activity.

Total monosaccharide content of peanuts is about 5.0% and consists of 2.9% D-glucose, and 2.1% D-fructose. Total oligosaccharide content is about 3.3% and consists of 0.9% sucrose, 1.0% raffinose, 0.8% stachyose, and 0.3% vebascose (58). However, values of raffinose and stachyose flatulence sugars have generally been reported for peanuts, than for soybeans.

BIOCHEMISTRY AND FUNCTIONALTY

Peanuts contain about 26 to 29% protein (N x 5.46). Approximately 10% of the proteins are water soluble and are considered to be albumins. The remaining 90% are anionic globulins consisting of two major fractions, arachin and conarachin, occurring in approximate ratios of 2:1 to 4:1 depending upon the fractionation technique. These fractions occur in nature as complex polymers, and numerous isolation procedures and molecular weight estimates have been reported in surveys of varietal, cultural and physiological age effects (59-64). Recent studies report molecular weights of 44,000 and 23,000 daltons for two

TABLE VI

Comparative Functional Properties of Four Defatted Oilseed Flour Suspensions. (88)

Ranking	Functional property			
	Protein solubility	Viscosity	Emulsion capacity	Foam capacity
(Highest to lowest)	Peanut	Soybean	Soybean	Peanut
	Soybean	Pecan	Pecan	Field pea
	Field pea	Field pea	Field pea	Soybean
	Pecan	Peanut	Peanut	Pecan

subunits of arachin and 67,000 daltons for conarachin under the influence of sodium dodecyl sulfate and 2-mercaptoethanol (62). It is believed that arachin is localized in the protein bodies (aleurone grains) of the seed, and that conarachin is cytoplasmic (65,66). A study of eight varieties of peanuts grown in different locations concluded that arachin has a chemical score of 31 to 38% (1965 FAO Reference Pattern), arising from limitations in the sulphur-containing amino acids, cystine and methionine; and conarachin has a chemical score of 68-82% because of limitations in threonine (61).

The isoelectric point of peanut protein is about pH 4.5, resulting in minimum nitrogen solubility of flour, concentrates, and isolates at that pH (33,66,67). Viscosity increases as pH of aqueous peanut protein solutions is raised. Foam viscosity in whipping tests is about five times greater at pH 6.6 than at 4.0 (61). In evaluating functionality of peanuts, the most desirable emulsions and foams are produced by adjusting pH of peanut meal-water suspensions in 2 steps: first from pH 6.7 to 4.0, and then to 8.2 (68,69).

Mild dry heating of peanuts increases available lysine and PER values (70); but continued high temperature dry roasting decreases protein solubility (71) and protein quality (72).

Solubility of protein in peanuts treated with moist heat is affected by prior growing and storage conditions (73). Prolonged atmospheric moist heating decreases protein solubility and increases emulsion and foaming capacity (74,75).

Beneficial functional properties of peanut protein ingredients in the marketplace include: white color, bland flavor, high solubility, low viscosity, heat stability, aerating ability and compatibility with other ingredients (76). Functional properties of four defatted oilseed flour suspensions are summarized in Table VI.

Success in utilization of peanut protein ingredients is dependent upon appropriate selection of the food system in which they are used. Ingredients can often be modified to optimize their performance in specific applications. For example, current peanut protein isolates would probably perform well in beverage products where bland flavor, high solubility, and low viscosity are desired (30), but flours would find strong competition from soy as meat binders where high emulsification and viscosity properties are desired and less bland ingredients can be used.

PROBLEMS AND RESEARCH NEEDS

Surveillance for aflatoxins produced by the mold *Aspergillus flavus* is more intense in peanuts than in any other oilseed crop. Toxicity of these compounds was brought to world attention in 1961 as the result of large losses of turkey poults in England which were fed peanut meal imported from Brazil (3). In succeeding years the ability of aflatoxins to cause liver cancer in test animals has been established. Permitted aflatoxin tolerance level in U.S. peanut products is 20 ppb., and there are deliberations to reduce the level to 15 ppb. It is estimated that, as a result of these regulation changes, the average level of aflatoxins actually found in peanut products will drop from the current 2 ppb. to 1.5 (77). Peanuts with excessive aflatoxin content are pressed for oil, and the meal cannot be used in foods. Ressearch has shown that treatment of peanut meal with gaseous ammonia is 99% effective in reducing aflatoxin content in feed uses (78). Excellent results in destroying aflatoxins with strong oxidizing agents (benzoyl peroxide, hydrogen peroxide, and sodium hypochlorite) during production of peanut food protein concentrates and isolates by aqueous processing methods have been reported (37). Sodium hypochlorite is the oxidant of choice, and causes only minor changes in color, solubility, and viscosity; although loss of tyrosine and tryptophan are noticeable (79). None of these methods are currently approved for production of food or feed products from condemned peanuts.

Not all species of *Aspergillus flavus* produce aflatoxins, and effects of infection by other molds, including *Aspergillus parasiticus, Aspergillus oryzae,* and *Rhizopus oligosporous* on peanut quality have been studied (80-82). While retention of strong peanut flavor is sought in some food applications, complete blandness is desired in others, especially where peanut concentrates and isolates are used. Both extreme objectives have proven elusive. Twenty-seven carbonyl compounds were reported in raw peanuts, and 33 in roasted peanuts. Hexanal and octanal occur in concentrations exceeding flavor threshold in raw peanuts, and are thought to be responsible for "green" or "beany" flavor and aroma. Compounds exceeding flavor threshold values in roasted peanuts, and thought to contribute fatty or deep-fried notes to flavor and aroma, are 2-methylepropanol, 3-methylbutanol, 2-methylbutanal, hexanal, 2-octenal, 2-monenal, 2-decanal, and 2,4-decadienal (83). Roasting has been shown to decrease the measurable free amino acid content by 77.8% (dry), 64.6% (microwave), and 52.0% (oil) (84). Studies of white skinned Spanish variety peanuts as potential peanut protein raw materials have been reported (66). They are more bland than red-skinned varieties and contain no detectable reducing and flatulence sugars.

Loaf volume of breads baked with 15 and 20% of flour replaced by peanut protein concentrate are significantly lower than for breads baked with the same concentrations of defatted peanut flour and full-fat soy flours (38). Use of sodium stearoyl-2-lactylate, ethoxylated monoglycerides, or sucrose monopalmitate counteracts adverse effects on wheat flour, and enables production of acceptable breads which retain softness during storage when up to 15% defatted peanut flour or 20% peanut meal are used (85).

Additional research needs in peanut utilization technology which have been identified by a select U.S. industry task force include improvement of flavor and stability of peanut products; increased fundamental information on nutrient and antinutritional factor compositions; biochemistry of flavor, effects of cultural, storage, and processing practices on quality, and development of additional new peanut food products and by-product uses (53).

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