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PEANUT COMPOSITION

Relation to Processing and Utilization

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The chemical composition of peanut kernels, hearts, and skins is reviewed in relation to the processing and edible use of peanuts. The changes that may occur as a result of roasting include volatilization, degradation, and chemical interactions, some of which contribute to the improvement of the flavor and aroma of peanut products.

PEANUTS ARE AN EXCELLENT SOURCE of food, oil, and protein. The roasting process employed in preparing them for use as salted and roasted nuts, in candies and bakery products, and in the manufacture of peanut butter imparts a desirable aroma and flavor which contribute to consumer acceptance. A thorough knowledge of the composition and characteristics of the constituents of the peanut kernel is basic to improving the quality of peanut products for edible uses.

The kernel consists of two cotyledons and the heart (germ) enveloped in a thin skin (testa). These portions of the kernel differ markedly in chemical composition.

Composition of Kernels

The literature reports a large number of analyses of kernels. The ranges and average values of the constituents tabulated in Table I are the results of the work of a number of investigators (*15, 23, 39, 41, 42, 44, 57, 65, 67*). The average of the results of analysis of the kernels of Spanish, Runner, and Virginia peanuts from the 1942 domestic crop (*67*) are given in Table II. These data indicate that on a dry basis peanut kernels contain approximately 50% oil and nearly 30% protein.

Like most edible vegetable oils, the oil of peanuts consists of the glycerides of long-chain fatty acids. As shown in Table III (*24, 25, 30, 66*), the fatty acids present include oleic, linoleic, palmitic, stearic, arachidic, behenic, and lignoceric.

The phosphatides, lecithin, and cephalin (*19, 23*), occur in the sludge which settles out of the crude oil. Though the peanut oil phosphatides have not been thoroughly investigated, Rewald (*55*)

Table I. Composition of Peanut Kernels

Constituent	Range, %	Average, %
Moisture	3.9–13.2	5.0
Protein	21.0–36.4	28.5
Lipides	35.8–54.2	47.5
Crude fiber	1.2– 4.3	2.8
Nitrogen-free extract	6.0–24.9	13.3
Ash	1.8– 3.1	2.9
Reducing sugars	0.1– 0.3	0.2
Disaccharide sugar	1.9– 5.2	4.5
Starch	1.0– 5.3	4.0
Pentosans	2.2– 2.7	2.5

has found that they consist of almost twice as much cephalin as lecithin.

Antioxygenic constituents, consisting of tocopherols and related compounds, are also present in the oil to the extent of from 0.03 to 0.05%. Fisher (*12*) reported 0.018 to 0.030% α-tocopherol and 0.018 to 0.022% γ-tocopherol in crude peanut oil. δ-Tocopherol has also been identified (*64*) but β-tocopherol has not been found in peanut oil. These constituents contribute to the excellent stability of peanut oil and other peanut products containing the oil.

Klostermann and Opitz (*34*) reported 247.9 mg. of phytosterol, a portion of which is esterified, per 100 grams of oil. This makes up the greater portion of the unsaponifiable fraction. Minor constituents in this fraction include higher hydrocarbons (*40*), methyl nonyl ketone, methyl nonyl carbinol, terpenes (*31*), and squalene (*13*). These constituents no doubt contribute to the characteristic odor of raw peanuts.

A number of workers have investigated the protein of the peanut kernel. In 1916 Johns and Jones (*32*) isolated and described two globulins which they named arachin and conarachin. About one fourth of the protein is conarachin, which is more soluble than arachin. Additional work indicates that neither arachin nor conarachin is a pure protein. Electrophoretic analysis (*29*) shows the presence of two major and two minor components in peanut protein. Arachin consists of only the two major components, while conarachin consists of one of the major and both of the minor components. The protein remaining after removal of arachin and conarachin consists largely of the minor components. This residual protein contains 2.9% sulfur, a particularly high sulfur content for a vegetable protein.

One of the important criteria of the nutritional value of a protein is its content of amino acids. The amino acids found in arachin, conarachin, and total peanut protein are shown in Table IV

Table II. Average Composition of Peanut Kernels from 1942 Crop

(Moisture-free basis)

	Spanish	Runner	Virginia
No. of samples	172	123	84
Oil, %	50.8	50.3	48.4
Nitrogen, %	4.93	4.84	4.77
Nitrogen (oil-free basis), %	10.01	9.74	9.27
Protein (N × 5.46), %	26.92	26.41	26.05
Iodine No. of oil	95.7	91.6	93.6
Free fatty acid of oil, %	0.4	0.65	0.3

Table III. Composition of Peanut Oil[a]

Glycerides	Variety Unknown, %	Spanish, %	Virginia, %	Senegalese, %	West Africa, %
Oleic	55.7	52.9	60.0	65.7	71.5
Linoleic	25.9	24.7	21.6	19.2	13.0
Palmitic	8.3	8.2	6.3	7.2	6.0
Stearic	3.1	6.2	4.9	2.6	3.0
Arachidic	2.4	4.0	3.3	2.6	3.5
Behenic	3.1	..	..	..	..
Lignoceric	1.1	3.1	2.6	2.6	3.0
Unsaponifiable material	0.4	0.2	0.3	..	..
Total	100.0	99.0	99.6	99.9	100.0

[a] Calculated as simple triglycerides.

(*22*). Peanut kernels contain appreciable amounts of the 10 nutritionally essential amino acids. Feeding experiments (*33*) indicate that arachin is deficient in tryptopan and methionine and also in a third factor, possibly isoleucine. Conarachin, on the other hand, according to Baernstein (*2*) is an excellent protein for growth when fed as the only source of protein. Baernstein also reported that whole defatted peanut kernel, total peanut protein, or total peanut globulin is approximately equivalent to casein in promoting growth. These findings were confirmed by other investigators (*54*). It is therefore apparent that the peanut is a fair source of the essential amino acids. The digestibility coefficient of peanut protein from unroasted peanuts has been found to be 93, using human subjects (*45*).

The peanut kernel contains about 4% of starch (*60*), about 2% of cellulose (*27*), and about 4% of pectic material which is a complex of araban with pectic acid (*27*). The only sugar present in appreciable quantities is sucrose, which makes up 2 to 5% of the peanut kernel (*36*).

Peanuts contain practically no vitamin A or D (*47*), but the kernels are an excellent source of the B vitamins [see Table V (*3, 7, 8, 20, 58*)]. They also contain appreciable tocopherol (vitamin E) (*12*). Vitamin K is probably also present (*47*), as well as small amounts of ascorbic acid (*17*).

The ash content of peanut kernels is not high, most reported values being between 2 and 3%. The inorganic constituents found in the peanut are listed in Table VI (*1, 5, 15, 35*).

The enzyme systems in the peanut have not been thoroughly investigated, but the presence of several enzymes has been established. Both soluble and insoluble catalases were found by Loew (*38*). An active lipolytic enzyme (*9, 11*) and an enzyme which hydrolyzes glucosides (*37*) were also detected. The presence of a trypsin inhibitor in peanut kernels has been reported (*4*). Phytase (*14*), glycerophosphatase, pyrophosphatase (*18*), and a proteolytic enzyme (*28*) are also present.

A number of other minor constituents have been reported in peanut kernels, including phospholipides (*23*), choline (*10*), organic acids (*22*), and free amino acids (*53*).

Heart (Germ) The heart is frequently separated from the rest of the kernel prior to processing for edible uses. This fraction represents about 2% of the whole kernel (*28*). As shown in Table VII the heart contains considerable oil and nitrogenous material and its ash constituents are similar to those in the whole kernel (*21, 50*). A bitter principle is also present in the hearts, but so far it has not been identified.

Skin (Testa) The skin of the peanut, which makes up about 3% of the kernel (*59*), is frequently removed by blanching in the preparation

Table IV. Amino Acids in Peanut Proteins

	Total Protein, Wt. %	Arachin, Wt. %	Conarachin, Wt. %
Alanine	4.2	4.11	...
Arginine[a]	10.6	13.51	14.60
Aspartic acid	5.8	5.25	...
Cystine	1.9	1.51	3.00
Glutamic acid	19.2	16.69	...
Glycine	5.6	1.80	...
Histidine[a]	2.1	1.88	1.83
Hydroxy-lysine	..	0.01	...
Isoleucine[a]	4.3	...	...
Leucine[a]	7.0	3.88	...
Lysine[a]	3.4	4.98	6.04
Methionine[a]	1.2	0.67	2.12
Phenyl-alanine[a]	5.4	2.60	...
Proline	..	1.37	...
Serine	..	5.20	4.99
Threonine[a]	2.9	2.56	2.02
Tryptophan[a]	2.0	0.88	2.13
Tyrosine	4.4	5.50	2.86
Valine[a]	8.0	1.13	...
Ammonia	..	2.03	1.90

[a] Nutritionally essential.

Table V. Vitamins in Peanut Kernels

Vitamin	Amount Present, γ/G.
B vitamins	
Riboflavin	1.05– 1.57
Thiamine	8.5– 14.0
Nicotinic acid	88.0–200.0
Pantothenic acid	25.0
Pyridoxin	3.0
Biotin	0.34
Inositol	1800.0
Folic acid	2.8
	Mg./100 G.
Vitamin C (ascorbic acid)	5.8
Vitamin E (tocopherol)	11.9
Carotene (provitamin A)	Present
Vitamin K	Present

of edible products. The average composition of the red skin of the peanut is tabulated in Table VIII (*21*, *35*, *47*). These values indicate that it is high in fiber and ash and contains appreciable nitrogenous material. Fuchs (*16*) found 17% protein and 18% fat, but probably pieces of kernel were included in the samples he examined. Pickett (*47*) found the red skins contained about 7% tannins. The skins from the white varieties of peanuts, not commercially available, were practically free of tannin. Stansbury *et al.* (*59*) report that the native pigment is predominantly a catechol-tannin which gives a dark red phlobaphene on treatment with acid. These tannin materials contribute to the bitter flavor of peanut products from which the skins have not been removed. Other pigments which are present in red skins in smaller amounts include leuco-anthocyanin (*56*) and a flavanone (*43*, *62*). Booher (*3*) reported the red skins contained 7.9 mg. of thiamine per 100 grams. Pickett also found that the thiamine content is very high (*47*). As thiamine is heat-labile, the content of this vitamin is reduced considerably in roasting.

Table VI. Inorganic Constituents in Peanut Kernels

	In Kernel, Mg./100 G.
Potassium	680 –890
Sodium	Trace
Calcium	20 – 80
Magnesium	90 –340
Phosphorus	250 –660
Sulfur	190 –240
Chlorine	Trace
SiO_2	80
Zinc	1.7 – 80
Manganese	0.8 – 50
Iron	1.8 –100
Cobalt	0.03
Copper	0.7 – 30
Boron	2.6 – 50
Fluorine	0.14
Iodine	0.02
Strontium	0.8 – 5
Barium	8 – 30
Vanadium	10 – 50
Chromium	1 – 30
Aluminum	100
Nickel	3 – 8
Titanium	30 – 80
Molybdenum	0.8 – 3
Tin	0 – 5
Lead	0 – 50

Compositional Changes Due to Roasting

Any consideration of roasting must recognize the effects due to interaction between the various constituents as well as those involved in thermal decomposition and loss of volatile products. Because peanuts are roasted during processing for most edible purposes, the changes brought about in the process are of considerable interest. In general, as the internal temperature of any foodstuff increases, changes occur more rapidly and become more complex. The internal temperature of relatively dry materials, such as peanuts and coffee, rises rapidly in processing and the effect of heat is pronounced. Peanuts, with an initial moisture content of 4 to 6%, are roasted at an internal temperature of 265° to 300° F. and the moisture in the finished product is generally lowered to about 1%. Extensive studies have been reported on the roasting of coffee, but very few investigations have been undertaken to establish the influence of processing on peanuts. Pickett and other workers at the Georgia Experiment Station (*48*, *49*, *51–53*) have demonstrated that a large portion of the thiamine is destroyed, while nicotinic acid, choline, and riboflavin are reduced but little by roasting. Although proteins are denatured as shown by the change in solubility in water and salt solutions, their original amino acid content (*26*) and nutritive value are apparently unchanged by moderate heat treatment (*6*). There is no appreciable change in the free fatty acids in the oil as a result of roasting (*52*). The apparent total sugars decrease when peanuts are subjected to a heavy roast, but the starch content is not significantly altered (*53*).

A number of constituents have been identified by Pickett and Holley (*53*) in the volatile materials which are expelled during roasting. These include relatively large amounts of carbon dioxide and small amounts of furfural derivatives, vanillin, ammonia, hydrogen sulfide, and diacetyl. Most of these constituents have also been identified in the volatile substances expelled in the roasting of coffee (*63*). It therefore seems likely that some similar changes in constituents are involved in roasting both peanuts and coffee. Consideration of the properties of the various constituents and their behavior under the influence of heat suggests that the following changes take place. The sugar probably undergoes caramelization to some extent and at the same time reacts with the free amino groups of the protein and with the free amino acids to produce nonenzymatic browning. The browning reaction is extremely complex and its mechanism is not thoroughly understood. It is known, however, that the reaction of sugars with amino acids produces characteristic flavors and aromas. The products evolved in this reaction include carbon dioxide and furfural derivatives, both of which have been identified among the products volatilized when peanuts are roasted (*53*). When extensive browning occurs there is usually a loss of nutritive value of the protein (*46*).

Table VII. Average Chemical Composition of Peanut Hearts

(Dry basis)

Constituent	Spanish Germ, %	Runner Germ, %
Oil	42.41	41.23
Nitrogen	4.53	4.08
Ash	3.07	2.94
Calcium	0.07	0.06
Magnesium	0.22	0.23
Chlorine	0.01	0.02
Sulfur	0.18	0.15
Potassium	0.75	0.80
Phosphorus	0.54	0.65
Phytin	...	0.50
Iron	0.0034	
Crude fiber	1.8	
Reducing sugar	7.9	
Total sugar	12.0	

The polysaccharides present, such as the arabans, are degraded and possibly decomposed by heat. There is also probably some thermal decomposition of the protein, since sulfur compounds (*53*) have been identified in the volatile matter. The characteristics of the oil undergo very little, if any, change, but the lower viscosity of the heated oil allows it to penetrate and wet all parts of the kernel. Other changes which also take place include inactivation of the enzymes, destruction of heat-labile vitamins such as thiamine, and changes in the over-all acidity.

Summary

Peanut kernels contain approximately 50% oil and 30% protein. The oil consists of the glycerides of long-chain fatty acids and contains tocopherols which serve as antioxidants, contributing to its excellent stability. The protein has a high digestibility coefficient and contains appreciable amounts of the 10 nutritionally essential amino acids. Carbohydrates present in the kernel include

Table VIII. Average Composition of Red Skin of Peanut

Constituent	%
Moisture	9.0
Protein	12.2
Fat	1.2
Fiber	19.3
Ash	2.1
Catechol-tannin and other pigments	7.0
Carbohydrates	49.2

starch, sucrose, pectic materials, and cellulose. Although peanuts contain practically no vitamins A or D, they are an excellent source of the B vitamins. They also contain small amounts of a number of inorganic constituents and several active enzyme systems.

Peanuts are roasted in preparing them for most edible uses in order to develop desirable aroma, flavor, and palatability. Consideration of the chemical constituents of the peanut suggests that during the roasting process moisture and other volatile constituents are driven off, proteins are denatured and react with sugars to produce nonenzymatic browning, sugars undergo caramelization, and some of the polysaccharides are degraded. The oil undergoes practically no chemical change but flows throughout the kernel, wetting the entire cellular structure. Enzyme systems are inactivated and some heat-labile vitamins are destroyed.

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