

GROUNDNUT UTILIZATION FOR FOOD AND FEED

by

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INTRODUCTION

The vegetable oil problem in Pakistan is rapidly approaching crisis proportions. Spurred by rising incomes and a declining real price for vegetable ghee (Vanaspati), per capita consumption of edible oil has registered an annual increase of about 7 percent per year during the past decade. With the population increase at 3 percent a year, the result has been an annual growth in edible oil consumption of 9 percent (1). Consumption has arisen from 300,000 tonnes in 1973 to an estimated 1,014,800 tonnes in 1985. The net result has been steadily increasing imports of edible oil and soaring expenditures of foreign exchange. As a result unless bold action is taken now, Pakistan will be faced with an edible oil import bill of \$565 million by the year 1990.

The origin of groundnut is unknown, though they were known as early as 950 BC. They are supposed to have been found first in Brazil or Peru and spread from there to the rest of the world. The groundnuts contain 35.8 to 54.2 percent oil and 21.0 to 36.4 percent protein. With proper planning, this crop can make the country self sufficient in edible oils to a great extent. The cultivation of groundnuts in Pakistan dates back to 1948. It is mostly grown under rainfed conditions in Rawalpindi Division and in some parts of Sind and NWFP. Groundnut contributes 70 percent of the total edible oil production in India whereas only 10 percent groundnut oil is used in Pakistan because it is mostly consumed as roasted nut (2). Pakistan's yield for groundnuts is well above the Asian average and the average for all developing countries but area only half of that produced by the United States. Furthermore, groundnuts are produced on a very small scale in Pakistan, using only 38,000 ha and accounting for well under 1 percent of world production. The yield, area harvested and production of groundnuts in some selected areas of the world (3) is shown in Table 1. This paper deals with nutritive value and utilization of groundnut for food and feed.

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TABLE 1
AN INTERNATIONAL COMPARISON OF YIELD, AREA HARVESTED
AND PRODUCTION OF GROUNDNUTS IN 1983

Region (Nation)	Yield (kg/ha)	Area Harvested ('000' ha)	Production ('000' tonnes)
Pakistan	1217	69	84
Burma	1109	623	491
China	1662	2429	4036
India	973	7500	7300
Indonesia	1600	475	760
Thailand	1204	130	157
All Asia	1159	11574	13410
U.S.A.	2668	557	1485
Brazil	1359	212	288
Developed Nations	2045	831	1700
Developing Nations	998	18134	18092

Source: FAO (1984)

COMPOSITION AND NUTRITIVE VALUE

Nutritive Value

The nutritive value of groundnut and some other oilseeds is presented in Table 2. Thus groundnut contains 28.5 percent protein and 47.5 percent fat. It provides 471 K Cals/100 g. It is low in fibre and contains 56 and 245 mg/100 g of Ca and P, respectively. It is however low in iron, calcium and phosphorus when compared to other oilseeds (4, 6).

The vitamin content of oilseeds is presented in Table 3. Thus groundnuts contain some vitamin A activity. It is poor in thiamine and riboflavin. It is however a good source of niacin and has the maximum ascorbic acid composition of some oilseeds and beef (4) presented in Table 4. The limiting amino acids and chemical scores of major oilseeds are shown in Table 5.

Both groundnut and sesame are lower in lysine as compared to the FAO pattern (1973). Groundnut and soybean are low in methionine and cystine as well. Groundnut is also deficient in threonine while soybean is deficient in value. Thus lysine, sulfur amino acids and threonine are the limiting amino acids of groundnuts.

TABLE 2

NUTRITIVE VALUE OF SOME OILSEEDS (EDIBLE PORTION)

Oilseed	Energy K Cal	Protein	Fat	Total Carbohydrate g/100 g	Fibre	mg/100 g		
						Ca	P	Fe
Groundnut	471	28.5	47.5	13.3	2.8	56	245	2.1
Soybean	400	35.1	17.7	32.0	4.2	226	547	8.5
Sesame	582	17.2	52.8	19.8	5.4	750	614	12.0
Sunflower	490	16.7	32.8	38.6	3.7	92	632	5.8

Source: FAO (1972). Freeman, et.al (1954).

TABLE 3

VITAMIN CONTENT OF SOME OILSEEDS

Oilseed	B-carotene Equivalent (ug/100g)	mg/100 g			
		Thiamine	Riboflavin	Niacin	Ascorbic Acid
Groundnut	20	0.97	0.18	9.7	11
Soybean	10	0.66	0.22	2.2	0
Sesame	15	0.72	0.17	5.1	0
Sunflower	0	0	0.07	2.4	0

Source: FAO (1972)

TABLE 4

ESSENTIAL AMINO ACID CONTENT OF SOME OILSEEDS (mg./g.N)

Essential Amino Acid	Groundnut	Soybean	Sesame	FAO Pattern
Lysine	210	391	196	340
Leucine	350	494	487	440
Isoleucine	201	290	293	250
Cystine	58	81	62	0
Methionine	58	84	204	220(met+cyst)
Phenylalanine	261	341	338	380(phe+Tyr)
Tyrosine	156	165	219	0
Threonine	188	247	295	250
Tryptophan	69	76	87	65
Valine	314	291	354	310

Source: FAO (1972)

TABLE 5
MAJOR OILSEEDS, LIMITING AMINO ACIDS, CHEMICAL SCORES

Oilseed	Limiting Amino Acid (Reference: Egg Protein)		Chemical Score
	Gross Deficiency	Marginal Deficiency	
Groundnut	Lys, Thr	Ileu, Val, Leu	43
Bambara Groundnut (West Africa)	Cyst, Met	Ileu	51
Soybean	Cyst, Met	Thr, Val	47
Sesame	Lys	Thr, Ileu	42
Sunflower	Lys	Leu, Cyst, Met	56

Source: Silano, et.al (1981)

Oil Content

The groundnut is an important source of edible oil. It contains about 36 percent oil. The oil content of various oilseeds and the rate of recovering of this oil by the use of the expeller and the solvent extraction processes is presented in Table 6.

Thus 86 percent of the oil present in groundnut can be recovered by the use of the expeller process. The recovery rate with solvent extraction process is much higher (97 percent) resulting in almost complete recovery of the oil (2).

Groundnut oil is a good source of polyunsaturated fatty acids including the two essential fatty acids, i.e., linoleic acid and linolenic acid. The fatty acid composition of groundnut oil and some other vegetable oils and animal fats (4) is presented in Table 7.

Thus milk fat contains only traces of the essential fatty acids while beef fat contains no linolenic acid and only 0.9 percent linoleic acid. The vegetable oils are rich in polyunsaturated fatty acids including the essential fatty acids. Thus groundnut oil contains 32.3 percent linoleic acid, the sesame oil contains 31.5 percent linoleic acid while soybean oil and cottonseed oil contain 51.0 percent and 40.4 percent of linoleic acid, respectively. Thus all the vegetable oils are very rich in essential fatty acids. It may be interesting to note that for human adults, a dietary intake of at least 3 percent of energy as essential fatty acids (EFA) is recommended. For infants an intake of 6 percent of energy as EFAS is recommended. EFA requirements are also higher in pregnancy and lactation and the recommended minimum intake is raised to 4.5 percent

and 4.7 percent of energy, respectively (5). Thus animal fats like beef fat and milk fat are unable to meet these requirements for EFAS and the diet must contain reasonable amounts of vegetable oils, e.g., groundnut oil to satisfy the human needs for EFAS.

TABLE 6

OIL CONTENT AND RECOVERY OF DIFFERENT OILSEEDS

Crop	Content Oil %	Extractable Oil %	Recovery of Oil	
			Expeller	Solvent Extraction
Rape & Mustard	40	35	88	97
Sunflower	40	33	83	97
Soybean	20	19	0	95
Groundnut	36	31	86	97
Sesame	50	44	88	98

Source: Mohammad and Khan (1981)

TABLE 7

FATTY ACID COMPOSITION OF SOME VEGETABLE OILS (g/100 g)
(compared with Beef)

Product	Saturated Fatty Acids			Unsaturated Fatty Acids				
	Total	Palmitic	Stearic	Total	Oleic	L'leic	L'lenic	Others
Beef Fat	8.1	4.8	2.2	13.1	11.1	0.9	0	1.1
Milk Fat(cow)	1.8	0.9	0.4	1.4	1.1	Trace	Trace	0.3
Groundnut Oil	21.9	12.5	4.6	72.0	38.4	32.3	1.3	0
Sesame Oil	22.2	12.8	4.5	71.6	38.4	31.5	1.7	0
Soybean Oil	12.8	8.5	3.7	81.7	28.9	51.0	1.9	0
Cotton Oil	32.7	25.9	4.2	62.0	21.6	40.4	0	0

Source: FAO (1972)

Groundnut Cakes/Meals

The chemical composition of some oilseed cakes/meals are presented in Table 8. Thus all these cakes/meals are high in protein (37.2 to 45.4 percent). Sunflower and sesame cakes are also high in crude fibre. The N-free extractives range from 20.3 to 32.1 percent. The protein digestibility of groundnut meal varies from 88.9 to 92.0 percent compared to 90.2 percent for soybean meal. The protein digestibility of groundnut cake varies from 89.2 to 91.8 percent compared to 90.0 percent for soybean cake and 76.8 to 85.8 percent for cottonseed cake. The net protein utilization values (NPU) of some oilseed, their protein isolates and flour are compared with the NPU value of some other common foods in Table 9. Thus the NPU value of these oilseeds, isolates and flour range from 30 to 70 and more or less are in the same range as those for cereals (7, 8). The protein of groundnut meal has suboptimal levels of cystine and methionine although lysine is the limiting amino acid. The oilseed cakes/meals are mainly used in animal feed but they are also used to some extent for human consumption as well, especially after conversion into flour. The palatability of the meal is high but it should not form more than 25 percent of the diet for lactating cows as it tends to produce a soft body fat and may have troublesome laxative action. Otherwise it forms an excellent and acceptable protein source for lactating cows.

Groundnut is fed to all types of animals. For poultry feed, it should be supplemented with protein rich ingredients which are high in lysine and methionine. The cake should be free from aflatoxins which are toxic to poultry, calves and ducklings. Sheep are apparently resistant to aflatoxins.

Use for Direct Human Consumption

The extent to which groundnuts are used for edible purposes in countries of origin appears to vary very widely. Thus about 7 percent of India's domestic utilization of groundnuts is for edible purposes compared to 73 percent of U.S.A. The form in which groundnuts are consumed also varies considerably from area to area. In contrast to soya, large quantities are eaten raw, or after the simplest form of processing, namely roasting, and in these forms are also used as an ingredient in a number of traditional dishes in many countries. More elaborate forms of home processing include hand expression of groundnuts to produce oil and a crude form of flour, which is used in dishes such as soups and stews. Hand expression is widely practised in the groundnut growing areas of Nigeria, and it also takes place in Ghana, but in other parts of Africa, such as Uganda and also India, the practice appears to be unknown.

TABLE 8

REPRESENTATIVE ANALYTICAL DATA ON FIVE OILSEEDS CAKES/MEALS

Cakes/Meals	% Dry Matter	% Crude Protein	% Crude Fat	% Crude Fibre	% N-Free Extractives
Groundnut Cake (decorticated)	90.0	45.4	6.0	6.5	26.4
Soybean Meal	89.0	44.8	1.5	5.1	32.1
Sesame Cake	91.0	44.7	11.9	4.5	21.0
Cottonseed Cake (decorticated)	90.0	44.1	8.0	7.8	26.4
Sunflower Cake (decorticated)	90.0	37.2	13.7	12.1	20.3

Source: Orr, E. and Adair, D. (1967)

TABLE 9

REPRESENTATIVE NET PROTEIN UTILIZATION VALUES

Source of Protein	Net Protein Utilization (%)
Hen's Egg	87
Cow's Milk	81
Beef, Medium Fat	76
Fish, Whole	75
Soya Flour	36 - 70
Coconut Protein Isolates	40 - 70
Cottonseed Flour	41
Groundnut Flour	45 - 57
Sunflower	55
Sesame	50
Rice, Milled	67
Millet, Ragi	56
Maize, Whole	54
Wheat	50

Sources: Orr, E. and Adair, D. (1967) and Pellet, P.L. and Young, V.R. (1980)

GROUNDNUT PRODUCTS

Roasted groundnuts have been ground into a paste and mixed with honey and cocoa in South America for centuries. A considerable amount of raw groundnut paste is made in South Africa near Cape Town. For eating, this is simply spread on bread. Those unaccustomed to eating it consider it sticky and sickening. Composition of some products is shown in Table 10.

Butter

Commercial manufacture and consumption of groundnut butter is largely an American art. About half of the edible peanuts go into groundnut butter after being split blanched. Substantial quantities of groundnut butter (about 50 million pounds) are purchased for use in USDA programs. Groundnut butter is mainly used as a spread for bread or biscuits. It is also used in cookies, in sandwiches, by itself or combined with meat, in candies and in frostings or icings. It is a favourite item in school lunches supported by USDA because, (1) it is an excellent source of protein supplement and very high in total energy value; (2) it is a fair source of calcium, iron, thiamin, riboflavin and an excellent source of niacin; (3) its flavour is liked by children; (4) it is easy to prepare since no additional cooking is required; (5) a minimum amount of time and equipment is required in preparing items containing peanut butter; (6) it can be held in unopened containers for many months without deterioration. Groundnut butter is also used in nutty bars, cream patties, chocolate bars, wafers, butter toffees, etc. Groundnut butter is also available in powder form, the product is very smooth with milk flavour and assumes the characteristics of groundnut butter when a small amount of water is added. Second to groundnut butter, the largest amount of edible groundnuts are salted. Among the groundnut eating people of the world, salting is the most preferred way of eating. While usually eaten directly, they may be used in candies, salads, desserts, and other ways.

Cheese

Groundnut cheese is a novelty item that may compete in price and quality with animal cheese. Cheese like products have been made from groundnut like groundnut protein isolate just as cheese is made from cow's milk. It has good quality protein, is easily prepared and low in cost. It is being used for "Mix" feeding of undernourished groups notably in India. A processed cheese spread has been prepared from peanut protein based tone milk in India. It has a smooth consistency and milky flavour. It compares favourably with standard cheese spread in composition and organoleptic qualities. The chemical composition of some of these products is shown in Table 8.

TABLE 10
COMPOSITION OF EDIBLE GROUNDNUT PRODUCTS

	Roasted Peanuts			Groundnut Fat Salt	Butter Added Fat, Salt Sugar	Groundnut	
	with Skins	without Skins	Boiled			Spread	Flour
Moisture (%)	1.8	1.6	36.4	1.8	1.7	2.2	7.3
Calories	582.0	585.0	376.0	581.0	589.0	601.0	371.0
Protein (%)	26.2	26.2	15.5	27.8	25.2	20.3	47.9
Fat (%)	48.7	49.8	31.5	49.4	50.6	52.1	9.2
Carbohydrate (%)	20.6	18.8	14.5	17.2	18.8	22.0	31.5
Fibre (%)	2.7	2.4	1.8	1.9	1.8	1.5	2.7
Ash (%)	2.7	3.8	2.1	3.8	3.7	3.4	4.1
CA (mg %)	72.0	74.0	43.0	63.0	59.0	50.0	104.0
P (mg %)	407.0	401.0	181.0	407.0	380.0	322.0	720.0
Fe (mg %)	2.2	2.1	1.3	2.0	1.9	1.5	3.5
Vit. A (I.U.)	-	-	-	300.0	300.0	-	-
Thiamin (mg %)	0.32	0.32	0.48	0.13	0.12	0.10	0.75
Riboflavin (mg %)	0.13	0.13	0.08	0.13	0.12	0.10	0.22
Niacin (mg %)	17.1	17.2	10.0	15.7	14.7	12.4	27.8
Ascorbic Acid (mg %)	-	-	-	13.0	13.0	-	-

Source: Watt and Merrill (1963)

Oil

Groundnut oil is used primarily as a cooking and salad oil, small quantities are used in the manufacture of shortening and margarine. Groundnut oil is an excellent fat for pan frying or deep fat frying. Pastries shortening, oleomargarine, mayonnaise, salad dressing and other food products can be easily made with this bland vegetable oil. For use in mayonnaise, it should retain its natural yellow color; for oleomargarine, it should be colorless; for shortening or other plastic fats, it is hydrogenated and often blended with other vegetable fats; and for all purposes, it should contain an antioxidant. Groundnut oil is also marketed as crude oil for soaps and detergents. It forms the base of many face creams, shaving creams, hair lotions and other cosmetics because it is believed to energize the skin. It is used extensively for massaging polio patients. It is also used as a carrier of adrenalin in the treatment of asthma and other ailments.

Peanut Flour

More than 4000 tonnes of highly refined groundnut flour are used in India for the culture of molds and production of antibiotics. Approximately, 400 tonnes are used in the preparation of high protein instant drinks. Its use in low calorie diet foods is increasing. Flour of high quality (60 percent protein, 0.75 percent crude fibre, 4.5 percent ash, 22.5 percent carbohydrates) was found suitable in soups, cold drinks, hot drinks, hot cakes, breads, cakes, instant puddings, congealed salads, ice cream and confections. It was found to be especially beneficial for treating hemophiliacs. Bleeding is controlled by incorporating 6.8 ounces in the daily diet. It causes shrinking of the capillary blood vessels preventing bleeding. This activity lasts for two days.

It is an excellent protein supplement for wheat flour compensating some of its deficiencies particularly protein.

Groundnut flour is used in many parts of the world to prepare beverages and baby foods (10). The components and chemical composition of these products is presented in Tables 11 and 12, respectively.

TABLE 11

COMPONENTS OF PROTEIN RICH FOODS BASED ON GROUNDNUT

Country	Product	Ingredients %			
		Groundnut	Wheat	DSM	Chickpea
India	Nutro Biscuits	24	40	-	-
Nigeria	Arlac	75	-	25	-
India	Protamin	75	-	-	25
India	MPF (CFTRI)	75	-	-	25
India	MPF (Chandra)	75	-	-	25
India	MPF (Aggarwal)	75	-	-	25
Senegal	Ladylac	15	45	20	-
India	Bal-Ahar	25	65 (Millet)	10	10

Source: Orr (1972)

TABLE 12

COMPOSITION OF GROUNDNUT BASED PROTEIN RICH FOODS

Country	Product	Protein %	Fat %	Carbohydrate %	Calories /100 g
Mozambique	Super Maeu	23.4	4.9	69.7	380
Senegal	Ladylac	18-20	-	-	-
South Africa	Pronutro	22.0	11.5	56.2	413
India	Multipurpose Food (chandra)	42.0	8.5	35.8	388
India	Protamin	45.0	3.0	50.0	407
India	Bal-Ahar	21.0	-	-	-
India	Nutro Biscuit	16-17	-	-	-

Source: Orr (1972)

GROUNDNUTS IN ANIMAL FEED

Groundnut Hay

In addition to groundnut cakes and meals, the following groundnut products are also used as animal feed and for making other products.

When peanuts are harvested and cured by hand, most of the leaves are retained and the hay is valued for livestock feed. With windrowing the plants and mechanical harvesting the nuts, the vines are not cured for hay but are scattered over the land for soil improvement (11, 24). There are three varieties of peanut hay. Their chemical composition is shown in Table 13.

Pelleted Groundnut Vines

Tests have shown that dehydrated and pelleted groundnut vines are a valuable by product. Pelleted vines are far superior to Bermuda grass in digestible nutrients and possibly superior as a source of carotene.

Groundnut Shells

These are low in oil, protein, ash and feeding value. Their chief use is for fuel. Other uses are as a filler for fertilizer mulch for growing plants, roughage for cattle feed when mixed with molasses and mineral supplements, litter for poultry houses, abrasive for polishing steel and aluminium, insulation for farm buildings, as a base for making crowns for beverage bottles, filler for plastic wood veneer boards and as high grade activated charcoal.

TABLE 13

COMPOSITION OF PEANUT HAY

Hay	Protein %	Fat %	Crude Fibre %	Carbohydrate %	Ash %	Digestible Protein %
Peanut Mowed	11.1	5.1	21.9	42.1	9.7	7.1
Peanut without nuts	9.5	3.1	24.3	45.3	8.2	6.2
Peanut with nuts	13.2	13.1	23.7	34.9	6.7	10.0
Alfalfa	14.7	1.9	28.4	37.3	8.4	11.0
Millet, Hay	6.9	1.4	40.7	41.3	9.8	0

Source: Woodroof, J.G. (1973), Sen, et.al (1978)

Groundnut Butter Bird Feed

Tests at the Georgia Experiment Station have shown groundnut butter to be a favourite feed for birds. Feed containing groundnut butter is attractive to seed eating birds as well as those that eat insects. It is estimated that the use of wild bird feed mixtures containing seed and grains amounts to more than 300,000 tonnes annually in the U.S.A., of this amount 10,000,000 pounds might be groundnut butter. It services a double purpose, that of adding flavour and nourishment as well as acting as a binder.

Toxic Factors

The groundnut contains goitrogens in the testa. There have been reports of the presence of a trypsin inhibitor and a haemagglutinin in the kernel. The heat treatment of the kernel does not produce an improvement in its nutritive value. Greater concern is occasioned by the possibility of exogenous toxicity in groundnut products. It has been shown that some strains of Aspergillus flavus growing on groundnuts elaborate compounds which are extremely toxic to some species of monogastric animals including poultry. The general name aflatoxin has been given to these compounds. This matter began to receive attention in 1960, when 100,000 turkey poults on British farms died from a disease of unknown etiology. Investigation revealed that all the stricken birds had received feeds containing groundnut meal and that other animals including pigs and calves could also be similarly affected by such rations. In practice aflatoxin B₁, is encountered most frequently, the others being absent or present in negligible amounts, but exceptional B₁, accompanied by significant amounts of either G₁ or B₂ may be found. They are extremely potent hepato toxic agents and carcinogens as demonstrated

in various animal experiments. The amounts of aflatoxin involved are extremely small, contaminations of the order of a few parts per million being significant. Thus the meal implicated in the turkey debacle contained about 7 parts per million of aflatoxin. This is a very high figure, and it is probable that for many purposes contamination levels exceeding 0.05 parts per million would be unacceptable. When first lifted, the groundnut contains over 30 percent moisture and so offers an ideal growth medium, while the causative mold, *A. flavus* is a very common one whose spores are abundant both in the soil and in the air. However the intact shell provides a considerable degree of protection against mold attack, but unfortunately, shell damage is frequent (12).

In humans, low levels of aflatoxin may cause various nutritional interactions resulting in suboptimal growth. There are indications that aflatoxins may interact with nutrients at the biochemical level (13). Any doubts that remained about the hazardous nature of aflatoxins to human health have been cleared by the unfortunate aflatoxin related episode in India. In 1974, people of a corn eating ethnic group in India who reportedly consumed 0.25 to 15.6 ppm (2 to 6 mg) aflatoxin along with contaminated corn developed acute toxicosis with 106 deaths.

Antinutritional and Other Factors in Peanuts

Trypsin inhibitor activity in peanuts have been reported to be about one half to one fifth of the activity found in soybeans (14). This activity in peanuts is significant enough to cause pancreatic hypertrophy in rats receiving 15 percent of protein intake from peanuts. Earlier studies indicated that this activity was heat resistant but later studies showed that the inhibitory activity could be destroyed by heat, although, the results with respect to degree of inactivation were not consistent enough between various laboratories.

Lectins or phytohemagglutinins have been found in peanuts (15) and roasting of peanuts does not destroy them (16). Enterokinase has been shown to be inhibited by protein fractions isolated from various plant sources with peanut seeds showing the highest enterokinase inhibitor activity (17). A number of other pharmacologically and toxicologically important compounds have been reported to be present in peanuts. These include hemostatic agents and goitrogenic glycoside arachidic acid in peanuts. Oilseed proteins constitute the most highly allergenic food groups. Peanuts have also been shown to be highly allergenic. Thus, May (18) observed that in 11 children in whom food allergy symptoms could be evoked with food challenges, peanuts were responsible for eight hypersensitivity reactions. Many people claim untoward effects of peanut consumption, especially new headaches to total unconsciousness and may be related to hypersensitivity reactions and idiosyncrasies. Phytic acid and oxalates

are also commonly found in peanuts. Hymowitz, et.al (19) reported varietal differences in peanuts in their ability to cause flatulence.

Peanut Oil and Atherosclerosis

The atherogenicity of groundnut oil is well established as is the fact that the structure of the component triglycerides of groundnut influences its atherogenicity. It is more atherogenic than the other unsaturated fats in the rat. It is also atherogenic in the rabbit and rhesus monkeys. This property is not related to the degree of unsaturation of its component fatty acids. Some studies suggest that the atherogenic potency may be due to the triacylglycerol structure of the peanut oil (20). Randomised or racemic synthetic peanut oils in which the position of fatty acids on glycerol are changed were shown to possess marginal atherogenic activity when tested in animals (21,22). If the atherogenic property is indeed due to the triacylglycerol structure, there seems to exist some genetic potential among cultivars for development of non-atherogenic lines of peanuts (23).

CONCLUSIONS

Groundnuts are rich in both calories and protein. However, a negative correlation between percentages of oil and protein has been reported. The oil is largely used for human nutrition, the residue remaining after oil extraction being used mostly as animal feed; only a very small portion of meal is used directly for human nutrition. Breeding of groundnut should be focused on improving the quantity and quality of oil and meal and improving the triglyceride structure of the oil so as to minimize its atherogenic potential. The plant breeding programmes should also focus on developing those varieties of groundnuts which possess the minimum content of allergenic proteins and antinutritional factors.

REFERENCES

1. Amann, V.F. 1983. Pakistan's oilseeds industry. Office of International Co-operation and Development. USDA, Washington, D.C.
2. Mohammad, A. and A.R. Khan. 1981. Perspective of edible oil research and production in Pakistan. Pakistan Agricultural Research Council publication. p.13.
3. FAO. 1984. Production Yearbook. Vol. 37, p.141.
4. Leung, W.T.W., R.R. Butrum. and F.H.Chang. 1972. Food composition tables for use in East Asia. Food and Agriculture Organization. Rome. p. 298
5. Mead, J.F. 1980. Dietary fats and oils in human nutrition, report of an expert consultation. Food and Agriculture Organization. Rome. p. 24.
6. Freeman, A.F., N.J. Morris, R.K. Willich. 1954. Peanut butter. U.S. Dept. Agri. AIC-370.
7. Orr, E. and D. Adair. 1967. The production of protein foods and concentrates from oilseeds. Tropical Products Institute. Report No. G. 31, p. 6 and 112.
8. Pellet, P.L. and V.R. Young. 1980. Nutritional evaluation of protein foods. The United Nations University. Tokyo. p.31.
9. Silano, V., H.C. Bansul, A. Bozzini. 1981. Improvements of nutritional quality of food crops - a state of art report - FAO/WHO. p. 6.
10. Orr, E. 1972. The use of protein rich foods for the relief of malnutrition in developing countries - an analysis of experience. Tropical Products Institute. Report No. G. 73, London, U.K. p. 13.
11. Woodroof, J.G. 1973. Peanuts: production, processing, products. 2nd edition. Alvi Publishing Products Co. West Port, Connecticut. p. 292.
12. Rao, D.R. 1982. Peanuts in human nutrition. Univeristy of Georgia, College of Agriculture Experiment Stations. Special publication No. 16. p. 154.

13. Voight, M.N., R.D. Wyatt, J.C. Ayers, and P.E. Kohler. 1980. Abnormal concentrations of B vitamins and amino acids in plasma, bile and liver of chicks with aflatoxicosis. *Appl. Environ. Microbiol.* 40,870.
14. Lusas, E.W. 1979. Food uses for peanuts. *J. Am. Oil Chemists Soc.* 56, 425.
15. Leiner, I. 1979. Significance for humans of biologically active factors in soybeans and other legumes. *J. Am. Oil Chemists. Soc.* 56, 124.
16. Lau, A., H. Ako, and W. Washburne. 1980. Survey of plants for enterokinase inhibitors. *Biochem. Biophys. Res. Comm.* 92, 1243.
17. Nachbar, M.S. and J.D. Openheim. 1980. Lectins in the United States diet: A survey of lectins in commonly consumed foods and a review of the literature. *Am. J. Clin. Nutr.* 33, 2338.
18. May, C.D. 1976. Objective clinical and laboratory studies of immediate hypersensitivity reactions to foods in asthmatic children. *J. Allergy Clin. Immunol.* 58, 500.
19. Hymowitz, T., F.I. Collins, J. Panczner, and W.M. Walker. 1972. Variations in the intestinal gas forming sugars in peanut cultivars. *Crop Sci.* 12, 710.
20. Kritchevsky, D.S., S.A. Tepper, D. Vesselinovitch, and R.W. Wissler. 1973. Cholesterol vehicle in experimental atherosclerosis. Part 13 (randomized peanut oil) *Atherosclerosis*, 17, 225.
21. Kritchevsky, D.S., S.A. Tepper, D. Vesselinovitch, and R.W. Wissler. 1973. Cholesterol vehicle in experimental atherosclerosis. Part II (peanut oil) *Atherosclerosis*, 14, 53.
22. Kritchevsky, D.S., S.A. Tepper, D.M. Klurfeld, D Vesselinovitch, D. and R.W. Wissler. 1974. Experimental Atherosclerosis in rabbits fed cholesterol free diets. *Atherosclerosis*, 50 (3), 253.
23. Hokes, J.C. and R.E. Worthington. 1979. Structure of peanut oil triacylglycerols from cultivars of diverse genetic background. *J. Am. Oil Chemists Soc.* 56, 953.
24. Sen, K.C., S.N. Ray, and S.K. Ranjhan. 1978. Nutritive value of Indian cattle feeding of animals. ICAR, New Delhi.