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INDUSTRIAL PROCESSING OF GROUND-NUTS

BY

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NOTE: The terms "ground-nuts" and "peanuts" are used interchangeably in this study.

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1 - THE PEANUT AS RAW MATERIAL

The peanut belongs to the leguminosae family, and its cultivated variety is the Archis hypogaea Linne. The origin of the peanut has long been uncertain, and is now considered as being the Gran Chaco area which includes the Paraguay and Parana valleys. At the beginning of the XVI century, its culture appears to have been introduced into the west coast area of Africa by the Portugese and into the Philippines by the Spanish. From the Philippines this culture presumably spread towards China, Japan, South east Asia, India and the East coast of Australia. It then appears to have spread from Sri Lanka or Malasia to reach Madagascar and the East coast of Africa. This species may therefore be said to have been propagated along two main axis, with the intersecting point situated in Africa. Subsequently, the peanut was carried to the United States with the slave trade from the West coast of Africa (Hammons, 1973 (60)).

1.1. The plant (Gregory and al, 1973 (56) ; Hammons, 1973 (60)).

1.1.1. General morphology

The main stem of the peanut is always erect, and the secondary branches either rise in the air in the erect "Spanish" varieties or run along the ground in the runner varieties. The main stem and the secondary branchlets may reach lengths or between 0.20 and 0.70. They are pale green, dark green or of a purplish colour. Bunting, 1955 (25) and 1958 (25) has classified cultivated peanuts into two types according to the way they branch and to the relative position of the vegetative and reproductive branches :

- the sequential branching type which includes the Spanish and Valencia types : The plants have a central axis with between four and six branches which, in turn, bear few secondary branchlets. The branches of this type of plant are always erect.

- the alternate branching or Virginia type : the central axis bears four to six branches, sometimes more. These branches bear successively two vegetative branches and two reproductive branches. Growth is either erect or running.

The radical system is a tap root system. A dense network of lateral roots form the primary root. Adventive roots may grow on the hypocotyl and also on the above-ground branches which come in contact with the ground. Nodes, which are the result of the symbiotical association of the plant and of nitrogen-fixing bacteria occur about two weeks after sowing, as deep as 15 cm. They are between 800 and 4.000 in number, and between 1 to 4 cm. in size.

The leaves are pinnated with two pairs of leaflets,(folioles) they are supported by a 4 to 9 cm long petiole, and develop at each node. The folioles bear stomas on both sides and have a spongy mesophyllum which can store water.

The inflorescence consists of a spike of 2 to 5 flowers growing out of the vegetative branches at the axil of the leaves. After fertilization the base of the ovary becomes elongated to form a type of stem called the gynophore. This gynophore curves down and forces the fruit underground where it takes up a horizontal position at a depth of between 2 and 7 cm. The fruit consists of a pod which has more or less marked constrictions between the seeds present (between two and four). The size of pods varies from 1 x 0,5 cm. to 8 x 2 cm. The shell or pericarp, which is about 2 mm thick, consists of an exocarp, a sclerenchymatic mesocarp and a parenchymatic endocarp. The exocarp is worn away during growth, and reveals the mesocarp.

The endocarp practically disappears at the time of maturity, and the remaining part becomes dark brown or black due to the insoluble tanin contained in the mesocarp. The seed is covered with a fine shrivelled seed coat, either white,pink, violet or black, and weights between 0,2 and 2 g. The shape of the seed may be spherical and elliptical, more or less elongated, with at times a flat part where it touches the seed next to it.

1.1.2. Vegetative cycle

Seeds of peanut stored at a nomal temperature keep their germinative faculty only if the humidity is lower than 8 %, (Gillier and Silvestre, 1969 (54)). Under these conditions, at a temperature equal to or lower than 15°C, the duration of the seeds germinative capacity is five years. Some of the seed varieties are able to germinate only after a period of rest called "dormancy". This is the case for the Virginia-type seed which remains "dormant" during ont to four months after maturity unlike those of the Spanish Runner and Valencia types. Numerous process have been suggested to reduce the "dormancy" period. The most practiced is the heat treatment advised by the International Seed Testing Association (Gillier and Silvestre, 1969 (54)) : during which seeds are maintained at 40°C temperature during 14 days.

Peanut seeds are fairly large in size and require large quantities of water to germinate (a 35 to 45 % imbibition rate).

The growth may be broken down into the following stages, (Prévot, 1949 (109)) :

The sowing to flowering period : The duration of this period is a varietal characteristic within given ecological conditions, but is also subject to climatic elements : 15 to 20 days in tropical areas, and 40 to 50 days in temperate areas. The number of flowers produced by the plant varies according to type : for a Spanish type peanut the maximum is between 600 to 700 flowers while it may reach 1000 for a Virginia type peanut.

Fertilization : The peanut is almost totally self pollinating. This is due to nocturnal fertilization and most particularly to the fact that the flower does not open before fertilization (cleistogamie). Nevertheless a minute percentage of cross pollination does not exist and is higher for the Spanish-Valencia varieties than for Virginia varieties. (Gillier and Silvestre, 1969 (54)). The time required for the development of fruit varies. Generally flowers produced during the first two or three weeks of the flowering period produce the best fruit yield. In the case of extensive culture, an average of five to ten flowers are needed to produce one pod. According to Boldhuis, 1958 (17,18) and 1959 (19,20), fertilization and development of fruit on the plant may slow down the flowering rythm and even bring it to a complete halt.

The duration of the vegetative cycle depends on climate and particularly on temperature,(Bolhuis and De Groot, 1959 (21)). In Madagascar for instance, total cycle duration (vegetative cycle and ripening) vary between 100 and 140 days according to the variety of peanut, (see table 1.)

Varieties	Duration of the cycle
1. Early varieties	
1.1. Oil-industry varieties	
Hybrid 33	120 days
Spanish 224	120 days
Buitenzorg 214	120 days
1.2. Edible varieties	
Valencia	100 - 110 days
2. Late varieties (with dormancy)	
2.1. Oil-industry varieties	
Mitwunde	135 days
2.2. Edible varieties	
Bunch 210	135 - 145 days
Bunch madirovalo	135 - 140 days
Bunch 145	135 - 140 days
Kiraromena	135 - 140 days

TABLE 1. Average duration of the vegetation-maturation cycle for various varieties of peanut in Madagascar. (Silvestre, 1963 (129)).

1.2. Interdependance climate-soil-plant

For peanuts as for all other plants, the physical characteristics of soil have an effect on the type and form of the root and consequently on hydromineral nutrition. In the case of peanuts, they have an additional effect on the ripening, on the quality of pods and the yield harvested.

1.2.1. Soil

It is very important that the texture and structure of the soil should provide good drainage and aeration. Montenez, 1957 (93), has shown that optimal germination conditions are achieved when the soil is maintained at a moisture content lower than its maximum water holding capacity. Aeration of the soil is very important during the development of the embryo as the air requirements of the growing pods are very high. Peanuts grow in soils of very varied texture and structure. For instance, the peanut soils of West Africa are generally soils with a coarse texture, but the culture is also possible in fine soils if they are well structured with a stable composition to make them light textured and porous. Peanuts seem to accept widely varying pH contents as they are cultivated in soil with a pH 4 content in certain parts of the U.S.A. and pH 9 in Israel and the Sudan (Gillier and Silvestre, 1969 (54) ; Reid and Cox, 1973 (113)).

1.2.2. Climate

Growth and expansion of the species are dependant on climatic factors.

1.2.2.1. Temperature

Germination is rapid taking between 4 to 5 days at a temperature around 32 - 34°C (Catherinet, 1956 (27) and Montenez, 1957 (93)). Germinative power decreases with temperatures below 15°C and above 45°C.

Regarding the preflowering period, optimal temperatures are between 30°C to 33°C. Growth becomes considerably delayed with scanty flowering at about 18°C. Excessive difference between night an day temperature is also unfavorable to growth and to early flowering. Bolhuis and De Groot, 1959 (21), Fortanier, 1957 (46) and Niclaes and Demol, 1958 (97) have paid particular attention to the effect of temperature on flowering and have observed that the optimal temperature is between 24°C and 33°C. According to Fortanier, 1957 (46), the utilization factor of the flowers, which is the inverse ratio to that of flowering intensity reaches a maximum of 21 %, for night and day temperatures of 23°C and 29°C respectively.

Development is much hampered when night temperatures drop below 10°C.

1.2.2.2. Lighting

During germination, light slows down seed impregnation as well as root development (Montenez, 1957 (93)) ; it also slows down the elongation of the hypocotyl (Fortanier, 1957 (46)). During the development of the fruit, exposure of the gynophores to the light delays their growth and the fruit only grow in the dark (Shibuya, 1975 (128)). Apparently the florale initiation is not photosensitive because, as stated by Prévot, 1949 (109), the sexuality of the plant is visible from the first stage of the shoot's development. However, the development of reproductive buds and the blossoming of the flowers appear to be photosensitive.

1.2.2.3. Water requirement

The peanut is fairly drought resistant. Taking into account loss by evaporation, water requirements range between 450 to 700 mm, varying during the vegetative cycle and according to the variety (Table 2)

TABLE 2. Evolution of average daily water consumption during the growth of the peanut : comparison between Valencia and Virginia varieties from 2 locations : Congo and Israel (Gillier and Silvestre, 1969 (54)).

Location	Israel		Congo	
Varieties	Virginia		Valencia	
Growth cycle duration	135 days		110 days	
	Phase of the cycle	daily consumption	Phase of the cycle	daily consumption
	0 - 15 days	1,4	0 - 30 days	3,9
	15 - 45 "	3,3	30 - 60 "	4,8
	45 - 75 "	6,1	60 - 90 "	6,0
	75 -105 "	6,9	90 -110 "	2,5
	105 -135 "	4,8		
Total water consumption in mm		665		490

Drought has a depressive effect on vegetation throughout the cycle. However, this effect is more serious when it occurs during the height of the flowering period.

1.3. General farming practices

Numerous works have been written on the peanut culture. We note the joint work, published in 1973 by the American Peanut Research and Education Association : Peanuts, culture and uses (185) and the earlier work, published in 1969, by Gillier and Silvestre (54).

In most cases the culture is done according to traditional practices. The improvment of farming techniques combined with varietal selection, results in an increase in yield, as shown in table 3. The main factors contributing to this increase are : crop rotation and association , preparation of the soil, treatment of the seed, the time, density and method of sowing, the maintenance of farmland, the use of fertilizers and pesticides, and the use of irrigation (Sturkie and Buchanan, 1973 (133)).

TABLE 3. Average yield of peanuts per continent. The increase in yield between 1948 - 1952 and 1965 shows the influence of improved farming methods (Gillier and Silvestre, 1969 (54)).

Area	Average yield Kg / ha	
	1948 / 1952	1965
Europa	1.470	1.830
North America	920	1.860
Latin America	940	1.240
Near East	910	950
Far East	740	630
Africa	740	960
Worl average	650	860

TABLE 4. Response of peanuts to plant nutrients throughout the world (according to G. Martin quoted by Reid and Cox, 1973 (113)).

Location		N	P	K	Ca	Mg
Asia	India	-	+	±	0	0
	Indonesia & Philippines	-	0	0	+	0
	Burma	±	0	0	0	0
	Thailand	0	0	0	+	0
	China	+	+	0	0	0
Australia		+	+	0	0	0
Africa	Congo	+	0	0	+	0
	Central Africa	+	+	0	0	0
	Upper Volta	0	+	0	0	0
	Dahomey	+	+	±	0	0
	Senegal	+	+	+	0	0
	Tanganyka	0	+	0	0	0
	Gambia	±	+	0	0	0
	Sierra Leone	0	0	+	+	+
	Nigeria	0	+	0	0	0
	Ghana	+	+	0	0	0
North America	Georgia	-	±	+	+	0
	Florida	-	±	+	+	0
	North Carolina	-	±	±	+	0
	South Carolina	-	+	+	0	0
South America	Brazil	0	+	+	0	0
	Venezuela	+	+	0	+	0
Europe	Bulgaria	+	+	+	0	0
	Hungary	+	+	0	0	0
	Spain	+	+	0	0	0
Middle East	Turkey	+	+	±	0	0
	Israel	+	+	+	0	0

* Response obtained +

No response obtained -

Response doubtful ±

No information 0

The favorable effect of fertilization is not always evident. The response to a supply of fertilizers and plant nutrient requirement vary according to local conditions as shown in table 4. It must be remembered that the peanut rhizobium can assimilate a certain amount of atmospheric nitrogen only when the specific bacteria is present in the soil. If this is not the case, the seeds must be inoculated before sowing.

1.4. Various varieties of peanut - Selection - quality

As noted by Woodroof, 1973 (153), it must be noted first and foremost that any listing of peanut varieties is very confused. For reasons of yield and quality improvment, and to promote the development of peanut uses, seldom does a year pass in the U.S.A. without the creation of a new variety and, at the same time an existing variety is discontinued. The same goes for Africa and Asia, where considerable efforts of selection have characterized recent production campaigns (Norden, 1973 (98)).

Whatever the use of peanut, selection is always based on adaptation to local conditions (climate and soil), disease resistance and yield (in-shell or after shelling). The oil content and the fatty acid composition of the oil are important quality factors for oil industry peanuts. In the case of edible peanuts, for a long time low oil content varieties were selected. Today, the evolution in processing technology has lessened the importance of this constraint and research is concentrated on form, color and favourable organoleptic characteristics (Rodrigo and al, 1970 (118)).

According to the intended end product, priority is given by countries to specific objectives :

- Overall yield

- In U.S.A., Israel and Madagascar, the organoleptic properties and resistance to cercosporosis for the use as edible peanut.

- Generally in Africa and specially in Senegal and Nigeria as well as in Latin America and in India, rusticity (sometimes with a lower consideration for yield), a high oil content, adaptation to various climates and disease resistance (Rosette, cercosporiosis).

1.4.1. Main peanut types and varieties and their predominent culture area.

The various cultivated types of Arachis hypogaea can be divided into three main varietal groups : Virginia, Spanish and Valencia. A fourth one, the Runner group, genetically linked to the Virginia type, is mainly ruled by commercial considerations.

Virginia

This type is characterized by large pods containing one or two elongated kernels. The constriction of the shell is well marked. The kernels are well separated and without any flattened area.

This is the most usual type. The U.S.A. produce large quantities in the States of Virginia, North Carolina, Tennessee and Georgia. It is used as a selection basis for several African countries such as the Senegal, Nigeria and Zambia, and it also represents the largest part of the production from China.

The numerous varieties are grouped into two categories according to their type of growth : erect or running. Virginia Bunch Large - Virginia Bunch Small - Virginia Bunch 46-2 - Virginia Bunch 67 - Virginia Bunch G2 - Virginia Runner G26 - NC 4X - NC 5 - Georgia Hybrid 119.20 - Holland Jumbo - Florigiant are only a few of the varieties listed in the American catalogue.

Runner

This is a Virginia type variante. The kernels are smaller less elongated, often with a flattened part.

Southern Runner 56-15, Dixie Runner, Early Runner, Bradford Runner and Florunner are varieties developped in different States of the U.S.A.. Egyptian Giant and Rhodesian Spanish Bunch are varieties cultivated in South Africa while the Shulamit variety is cultivated in Israel.

Spanish

This type is characterized by small pods generally containing two round well separated kernels. Prior to 1940, this type formed 90% of all cultivated varieties in the American State of Georgia, and it remains the predominente culture in the States of California, Texas and Oklahoma, with the Dixie Spanish, Improved Spanish 2B, GFA Spanish, Argentine, Spantex, Spanette... Natal Common Spanish is the most usual variety grown in South Africa.

Valencia

The pod of this variety is smooth without any constriction - The shell contains three seeds which very often have flat extremities. Fourth fifths of U.S. Production of this variety are located in the State of New Mexico.

1.4.2. Choice of types according to farming conditions

The three main types given above are not only characterized by the morphological characters of their pods and kernels, but also by the duration of their vegetative cycle.

The cycle of the Virginia type (between 130 to 140 days) is longer than that of the Spanish type, while the Valencia type with 120 days is considered as an early type (see table 1).

Although they have a higher production potential (see § 1.4.3.), the varieties of Virginia type have a stricter ecological requirements than Spanish or Valencia type particularly in the case of bigger kernel varieties. This explains why the Virginia type is predominent in areas having favorable cultural conditions and is the basis of local adaptation and selection tests in many producing countries. The Spanish and Valencia short cycle types remain the best adapted to the equatorial zone and to altitude farming while certain varieties of the Spanish group are suitable for the driest area of the sudano-sahelian zone.

1.4.3. Yield and quality of the various types and varieties

1.4.3.1. In-shell yield

In-shell yield depends not only on type and variety but also on local conditions of climate and soil and on farm management (Sturkie and Buchanan, 1973 (33)).

The influence of variety is shown in table 5 which gives the yield of various varieties in the comparatively homogeneous conditions of the Georgia State.

TABLE 5. Average yield of different varieties of peanuts in Georgia State (according to Woodroof, 1973 (153)).

Varieties	Yield in lb / acre
1. Spanish type	
- Dixie Spanish	1.700
- Improved Spanish 2 B	1.700
- G.F.A. Spanish	2.200
2. Runner type	
- Southeastern Runner 56 - 15	2.300
3. Virginia type	
- Virginia Bunch 67	2.400
- Georgia Hybrid 119 - 20	2.400
- Virginia Runner G	2.270
- Georgia Hybrid 119 - 18	2.500

It may be seen that the Virginia variety and the Runner variety give slightly better results than the Spanish variety.

Sturkie and Buchanan, 1973 (133) reviewing the results of numerous culture tests conducted in the U.S.A., clearly demonstrate the influence of farming practices on the yield of the different varieties. For instance table 6 shows the effect of cercosporiosis prevention on the yield in the Cameroun where the climate is particularly favourable to the development of this disease. The increases in yield compared with reference samples are 74 and 80 % respectively.

TABLE 6. Influence of farming practices on yield : treatment against cercosporiosis. (Fraquin and Tardieu, 1976 (106)).

Varieties	65 - 7		65 - 13	
	Reference sample	Treated	Reference sample	Treated
Average yield (6 years) 1969 - 1974 (KG / ha)	2.655	4.780	2.470	4.295

1.4.3.2. Shelling yield

As shown in table 7, considerable difference in yield exists after shelling, both for edible peanut varieties and for the oil-industry varieties.

TABLE 7. Shelling yield with regard to various peanuts varieties (Woodroof, 1973 (155) and Silvestre, 1963 (129)).

Varieties	Yield after shelling
1. Edible peanut	
Spanish type	
Dixie Spanish	76 to 79 %
Runner type	
Southeastern Runner 56 - 15	75 %
Virginia type	
Virginia Runner G26	75 %
Virginia Bunch Large	65 to 68 %
Virginia Bunch 67	72 to 74 %
Virginia Bunch Small	61 to 72 %
Valencia type	70 %
2. Oil-industry peanut	
Hybride 33	75 %
Spanish 224	75 %
Buitenzorg 214	75 %
Mwitunde	78 %

As may be seen, the results of Virginia type given above in terms of in-shells yield are counterbalanced by poor performances after shelling.

For oil-industry varieties, the difference is less marked.

1.4.3.3. Oil content

The oil-content is obviously a quality for the oil-industry production. In the past it was considered as a defect for edible peanuts which, should not contain more than 42 % to 45 % of oil. Today, this constraint is of less importance due to a certain processing methods.

In fact there is little difference between edible peanuts and oil-production peanuts, as shown in table 7 for varieties cultivated in Africa.

TABLE 8. Oil content comparison between edible peanuts varieties and groundnuts for the oil-industry (Silvestre, 1963 (129)).

Edible peanuts		Oil-industry peanuts	
Variety	Oil content	Variety	Oil content
Valencia 247	48 %	Hybride 33	49 %
Bunch 210	46 %	Spanish 224	45 %
Bunch Madirovale	46 %	Buitenzorg 214	47 %
Kiroeromena	42 %	Mwitunde	49 %

1.4.4. Peanut kernel composition

Table 9 gives the composition of the whole peanut kernel (range and average figures)

TABLE 9. Composition of peanut kernels
(Freiman and al. cited by Woodroof, 1973 (153)).

Constituent	Range %	Average %
Moisture	3.9 - 13.2	5.0
Protein	21.0 - 36.4	28.5
Lipids	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
Disaccharides	1.9 - 5.2	4.5
Starch	1.0 - 5.3	4.0
Pentosans	2.2 - 2.7	2.5

Naturally the composition of peanuts varies according to variety, location and year of production (Holaday and Pearson, 1974 (62)). The two most important elements are fatty acids and amino acids.

TABLE N° IO. Fatty acid composition and stability values of oil from 5 peanut varieties grown at Tifton, Georgia (Worthington and Hammons, I97I (I55)).

Varieties	Year	Oil stability (days) (1)	Fatty acids (%)							
			Palmitic I6:0	Stearic I8:0	Oleic IL	linoleic I8:2	Arachidic 20:0	Eicosenoic 20:1	Behenic 22:0	Lignocer 24:0
1) <u>Spanish Type</u>										
Dixie Spanish	1965	15	13,7	3,1	42,9	34,2	1,3	0,9	3,0	1,0
	I967	15	12,6	3,4	42,8	34,0	1,7	1,1	3,4	1,1
	I968	9	12,3	3,1	43,7	35,2	1,5	1,1	2,4	0,6
Natal Common	I965	15	12,3	3,5	45,1	32,4	1,4	1,3	3,1	1,1
	I967	16	11,4	3,6	43,4	34,5	1,8	0,9	3,5	1,0
	I968	10	11,6	3,7	44,0	35,7	1,4	0,9	2,0	0,6
Argentine	I965	13	12,1	4,0	43,8	32,8	1,8	0,8	3,5	1,3
	I967	14	12,2	3,3	43,6	35,0	1,6	0,9	2,9	0,6
	I968	10	11,8	3,3	43,3	35,5	1,5	0,9	2,8	0,8
2) <u>Virginia Type</u>										
Virginia Bunch 67	I965	17	9,2	3,1	57,2	23,4	1,4	1,4	2,6	1,8
	I967	17	9,0	2,7	56,0	25,4	1,5	1,4	2,7	1,3
	I968	13	9,0	2,4	57,6	25,8	1,2	1,3	1,9	0,8
Georgia	I965	13	10,5	3,1	52,1	29,1	1,1	1,0	2,0	1,1
hybrid IO80	I967	16	10,2	2,6	49,3	33,0	1,4	1,2	1,8	0,6
	I968	11	10,5	2,9	48,8	31,1	1,4	1,3	3,1	0,9

(1) Length of oil autoxidation induction period.

1.4.4.1. Composition in fatty acids

Numerous works have been carried out in the U.S.A. (Holaday and Pearson, 1974 (62)), and particularly in Georgia by the Worthington team (Worthington and Hammons, 1971 (155) and 1977 (156) ; Worthington and al., 1972)) and in India by Sekhon and his assistants (Sekhon and al., 1972 (124) and 1973 (123)). Their research has shown the variation in fatty acid content according to variety, environment and season.

Table 10 clearly shows the effect of variety and harvesting year on the fatty acid composition and on the oil stability and therefore on the quality of oil.

The incidence of harvesting appears more important than that of variety. In general, oil obtained from the Spanish type has a higher linoleic acid content than oil obtained from the Virginia type, and is therefore more subject to rancidity through oxidation.

TABLE 11. Comparison between Spanish and Virginia types according to their linoleic acid content.

Types/Varieties	linoleic acid (in % fatty acid)
Spanish type	
Dixie Spanish	35,2
Natal Common	35,7
Argentine	35,5
Virginia type	
Virginia Bunch	25,8
Georgie hybrid	31,1

It should be noted however, that Martin, quoted by Norden, 1973 (96), has shown that the oil content is largely dependant on factors of heritability.

1.4.4.2. Protein and amino acid composition

The work of Young and his assistants (Young and Hammons, 1973 (160) and Young and al., 1974 (161) (163) (164)) has shown the influence of farming procedure and variety on the amino-acid composition and the protein content of peanuts. Amaya and his assistants, 1977 (5) have shown a correlation between the tryptophan and the protein content of peanuts.

Table 12 gives the average amino-acid composition of the peanut kernel ; this data, from Adrian and Jacquot, 1968 (4) summarise the results of various authors.

TABLE 12. Amino-acid composition of peanut protein.
(Adrian and Jacquot, 1968 (4)).

Amino acids	Busson and coll.		Results obtained by			
	Average	Range	Hirsch	Taira	Chai	Average
Arginine	11,6	10,7 - 12,4	10,6	11,35	11,5	11,2
Cystine	1,45	1,3 - 1,6		0,85		1,15
Histidine	2,2	1,9 - 2,4	2,8	2,55	2,1	2,4
Isoleucine	3,6	3,4 - 3,8	4,5	3,65	2,7	3,6
Leucine	6,65	6,3 - 6,9	5,0	6,65	5,5	5,9
Lysine	3,45	3,3 - 3,6	3,9	3,1	4,7	3,8
Methionine	1,4	1,3 - 1,5	0,9	0,75	1,3	1,1
Phenylalanine	5,05	4,8 - 5,3	5,6	5,1	3,25	4,75
Threorine	2,7	2,4 - 3,0	2,9	3,0	2,2	2,7
Tryptophan	1,05	0,9 - 1,2	1,1	0,9	0,6	0,9
Valine	4,4	4,2 - 4,7	5,5	5,05	4,05	4,75

1.4.4.3. Others components

Among the qualities related to vegetal material, the cellulose content , and volatile components (Pattee and Singleton, 1972 (102)) which influence the organoleptic qualities of edible peanut should also be mentioned. However, in the case of the fatty acid composition , these are debateable and have little effect on the main selection criteria.

1.5. Storage and drying techniques

The quality of the raw material does not depend solely on its original vegetal condition. It depends also, perhaps even most on the condition in which it is offered to the buyers. That is why, in the case of peanuts, drying and storage operations following harvesting, are of greater importance. According to the climatic conditions during harvesting , the kernel moisture content may vary from 35 to 55 %. As the gethering period is fairly long, the kernel maturity is very often heterogeneous. Moreover, storage atmospheric conditions are those of the culture areas which are not usually the most favourable. Drying is absolutely necessary soon after harvesting to avoid temperature increase in the stock and development of toxin productive moulds (Cobb and al., 1969 (32)).

1.5.1. Drying

Because certain kernel characteristics depends on it, drying must be perfectly controlled. Too great a temperature causes the development of unpleasant flavors and increases the risk of cotyledon splitting and of skin slipping during shelling. Moreover, and for similar reasons, it is preferable for moisture not to drop below 7 %. However, if humidity is much over this figure, it favors the liberation of fatty acids and the evolution of fungi, which result in a drop in refining yield.

Drying is carried out either naturally by spreading the nuts out in the field to dry in the sun, or in industrial driers, and sometimes by associating the two methods (Dickens and Pattee, 1973 (42)). Windrow drying gives good results if initial humidity is not too high.

In the U.S.A. the pods are dried in windrows on the field up to a moisture of 20 % (Samples, 1969 (120)) before combining and completing the drying under cover. On this last point, the most generally accepted method consists in forcing constant heated air vertically through peanuts layers until about 10 % moisture is reached. A suitable balance between the temperature and the relative moisture of the drying air through the layer must be maintained to avoid rapid and concentrated loss of water in the lower portion of the bins and to insure proper drying in the upper portion of the bins.

To achieve this it has been recommended that the temperature should not exceed 35° C and the relative humidity should not be lower than 55 % (Woodward and Hutchison, 1972 (154)). Hutchison and Woodward (Hutchison, 1967 (63) ; Woodward and Hutchison (154) have developped a process in which hot air is introduced simultaneously into both extremities of the bins, and peanuts are dried on belt conveyors to reduce heating time and allow a more uniform drying.

1.5.2. Storing

Suitable storing conditions should preserve the initial qualities of the product. The three following points should receive particular attention :

- The possible development of fungi
- Insects infestation
- Free-fatty acid content

In some countries, kernels are stored in the open air, in these storage areas such as the "seccos" of the Senegal, insects destruction is done by spraying with insecticide. Fumigation under tarpaulin covers, or the construction of fumigatable store -houses allow better insect control in peanuts stocks (179). Storage in a store-house with a circulated atmosphere is largely used. This of course, concerns in-shell nuts.

Unshelled peanuts in bags may be stored under the same conditions.

These storage methods are widely used particularly in Africa on the production areas. In the U.S.A. unshelled peanuts are also stored in refrigerated storehouses. (Woodroof, 1973 (153)).

Storage under metal or concrete has also been developed : air-ventilated or inert atmospher silos (Bagot, 1967 (9) ; Reimbert, 1967 (114)). Wilson and Jay, 1976 (150) have shown the effect of the atmosphere composition of the storage enclosure on the increase of free fatty acids and on the aflatoxin rate in 16,7 % humidity content unshelled kernels. This increase appears to be enhanced by a high oxygen percentage. Jenkins, 1968 (66) has pointed out the correlation between the temperature and the free fatty acid increase. Much research has been made on storage in an artificial atmosphere particularly in a CO^2 atmosphere (Sankara Rao and Achaya, (121) Jay and al., 1970 (65)).

The choice of storage method should take into consideration the acceptable cost of this operation and the final quality of the peanut. The risk of unpleasant flavors developing during the storage is very important for the edible peanut (Pattee and al., 1971 (103)).

1.6. Contamination and preventive methods

1.6.1. Damage by insects and other parasites

Storage silos are a favourable environment for insects who feed on the seed, thereby reducing the stock and undermining its quality. Quality is lowered by a reduction of germinative possibilities and by a change in storage conditions, the production of hydrophyl fragments and dirt capable of causing fermentation and acidification of oleaginous substances.

The main parasites are : the Pyrales (Corcyra cephalonica and Ephestia cautella), the weevil (Caryedon fuscus Goeze or Pachymoerus cassiae Gylh.), bugs (Aphanus sordidus and apicalis and Dieuches armipes and patruelis), Trogoderma granarium, Tribolium confuseum and castaneum and at last Orizaephilus mercator.

Widespread damage is caused in peanut pods all over Africa by the weevil larvae. The cotyledons are eaten completely, making the kernels unusable for industry or as seed (Delbosc, 1966 (41)).

In-shell storage seems to be a good protection against most of insects. Only weevils and bugs succeed in destroying peanut shell.

Many insecticides, given in table 13, are used for the treatment of stocks as well as for their enclosures. One of the most widely used fumigants is methyl bromide (Leeschand&al. 1974 (80)). In some countries, the use of parathion and malathion is forbidden by Law.

TABLE 13. Chemical prevention during storage - Delbosc, 1966 (4)).

Product	Treatment	Quantity in g. of active substance
Zeidane/DTT	Treatment of bags and walls	1 g/m2
	Treatment of kernels	5 g/100 kg of pods
HCH	Treatment of unedible kernels	7,5 g/ql
Lindane	Treatment of premises	0,1 g/m2
	Treatment of kernels	0,5 g/ql
	Fumigation of premises	4 g/100 m3
Parathion	Treatment of unedible kernels	0,2 g/ql
Malathion	Treatment of premises	0,5 - 0,7 g/m2
Carbon sulfur	Fumigation	150 - 300 g/m3
Methyl Bromure	Fumigation	15 - 30 g/m3/48 h
Ethylen oxyde	Fumigation	40 - 50 g/m3/24 h
Pyrethrins	Treatment of bags and walls	0,1 g/m2
	Treatment of kernels	1 g/ql
	Fumigation	10 g/100 m3

Weight loss in peanut stocks may be also caused by the infestations of Acaroid mites (Zdarkova and Reska, 1976 (168)).

1.6.2. Pesticide contamination

The use of fumigation in controlling insects in stored peanuts may result in kernel contamination. Thus, peanuts treated with methyl bromide have residual contents of 34,8 and 55,1 ppm 4 hours after treatment and of 29,1 to 41,8 ppm 72 hours after treatment respectively, according to methods of treatment. These rates of 29,1 and 41,8 ppm are given as being permanent (Leesch and al., 1974 (80)). Nevertheless, the contamination of products and by-products for the oil-industry is practically non existant as shown by Florence and al., 1974 (45) and Listopadova and Horak, 1972 (82).

Table 14 show the HCH pesticide content regarding various products.

TABLE 14 - Pesticide content of the various peanut oil-industry products (Florence, 1974 (45)).

Type of product	H C H ppm	DDT, DDE, DDD ppm	Others ppm
Ex-works peanut cake (30 samples)	0	0,01	nill
Peanut cake after storing and transport (10 samples)	0,05 - 0,3	0,07	Dieldrine 0 - 0,15 %
Crude oil	0,05 - 0,2	0,01	nill
Final product oil	unnoticeable	unnoticeable	nill

It may be seen that the HCH pesticide content is very low in defatted cakes, i.e., after hexane extraction of oil from the full fat cakes. The liposolubility of pesticides results in the contamination of the crude oil, however, crude oil deodorisation eliminates nearly all the pesticides content , and refined oil has no measurable quantities.

It should also be noted that considerable quantities of cake may be recontaminated during storage or transportation, by external factors.

1.6.3. Fungi infestation

Undoubtly, fungi infestation is by far the most serious, the most important of which is the production of a series of highly toxic substance generally called aflatoxin, by the fungi Aspergillus Flavus, Link & Fris and by the Aspergillus parasiticus, Speare. A certain number of others moulds also produce toxins which, although less well known, are also very harmful (Juillet, 1971 (68)).

TABLE 15. Main moulds other than Aspergillus flavus and mycotoxins, other than aflatoxins in the peanuts (Juillet, 1971 (68)).

Moulds	Toxins
Aspergillus	
A. Chevalieri	Gliotoxin
A. restrictus	Unidentified
A. versicolor	Averain, nidulotoxin, sterigmato stin, etc...
Penicillium	
P. ctrinum	Citrinin
Rhizopus	
R. Nigricans	Unidentified
R. oryzae	Unidentified

Considering the frequency of the presence of Aspergillus in peanuts, the toxicity of aflatoxin and the fact that absence of aflatoxin is considered by a growing number of countries as a prevailing condition to the importation of edible peanuts, we will give particular attention to this problem here.

1.6.3.1. Formation and growth conditions of aflatoxin

The growth of Aspergillus Flavus requires conditions of humidity and high temperature (Tango and al. 1966 (135) ; Sledd and al., 1976 (130)). The fungi cannot develop on pods or kernels with a water content below 9 % and 16 % respectively. Moreover, no more aflatoxin is produced if the fungi continues to develop above 41°C. The danger zone of temperatures is between 13°C and 41°C (Diener and Davis, 1970 (43)).

1.6.3.2. Toxins produced and their effect

Four aflatoxins must be mentioned (Labarthe, 1975 (75)), classified into two groups according to their carbon atoms and to the presence or absence of lactone on the last core (nucleus) :

- Aflatoxin B1 and B2 : 5 carbon atoms
- Aflatoxin G1 and G2 : 6 carbon atoms + 1 Lactone

They act on the cells reducing mitoses and slowing down protein synthesis by inhibiting the metabolic process.

In the human system , injury to the liver is the most obvious. Amongst the animal species, birds are the most sensitive to this toxin, and monogastric mammals the least. Adult polygastric mammals do not appear to be very subject to this type of intoxication but they become vectors of aflatoxin by their contaminated milk. (Lafont, 1974 (76)).

1.6.3.3. Methods of prevention

It is to be noted that some varieties of peanuts are more susceptible than others to attack by fungi (Zambettakis, 1975 (166) ; Mixon and Rogers, 1973 (92) ; Gillier, 1970 (53)). These varietal differences depend on the structure of the pod and of the seed coat (Amaya and al., 1977 (6) ; Zambettakis and Bockelee-Morvan, 1976 (167)).

However, with prevailing conditions as they are, it is necessary to take precautionary measures during harvesting and storing if contamination is to be kept to a minimum (Bockelee-Morvan and Gillier, 1974 (15) and 1976 (16)). In practice, the most favourable conditions for the development of <u>Aspergillus flavus</u> are those present during digging, moisture content in the nuts being between 30 and 40 %. During the drying period, when the moisture content of the nuts is about 15 %, there is still a strong risk of contamination.

Anything which causes dammage to shells during the period of digging or drying, increases the risk of toxic contamination ; frequent and careless handling, prolific insects and other parasites (Troeger and al., 1970 (141)).

Digging at the moment of peak maturity is a wise precaution, as the longer the nuts remain in the ground so the probability of contamination by mould increases. After harvesting, it is still possible to control contamination, either by rapid drying at a low temperature, or by the use of antifungal products (Zambettakis, 1974 (165)), or by storing in an atmosphere of carbon dioxide (Adrian, 1969 (21)). Modification of storage atmosphere is also of interest. The work of landers and al., 1967 (77), and that of Wilson and Fay, 1976 (150), have shown that rarefaction of the oxygen considerably reduces the development of aflatoxin without having much effect on lipasic activity, characteristic of the biochemical activity of mould. This was in fact, found to be totally arrested by an increased carbondioxide concentration, even with oxygen presence.

In present conditions rapid drying and storing away from moisture present the best means of preventing mould.

1.6.3.4. Eradication methods

Before industrial conversion, it is possible to extract the nuts attacked by mould from contaminated batches, by sorting after shelling. This sorting is based on the difference in density between mouldy and sound nuts (Prévot, 1974 (107) and 1976 (108)). The zig-zag sorter, with a 12 tons per hour capacity provides an adequate output for an oil-mill but eliminates a large percentage of the nuts. Sorting according to colour, with individual inspection of the nuts by a photo-electric cell (Sortex process) is valid in the edible peanut industry, but its output is too low for use in oil-mills.

Roasting tends to reduce the aflatoxin rate in peanuts by between 20 and 50 % (Lee and al., 1968 (79) ; Waltking, 1971 (147)).

During extraction of protein isolates or concentrates, hyperchlorite, hydrogen peroxyde, benzoyl peroxide and ammonia treatments destroy aflatoxin effectively (Rhee and al., 1977 (117)).

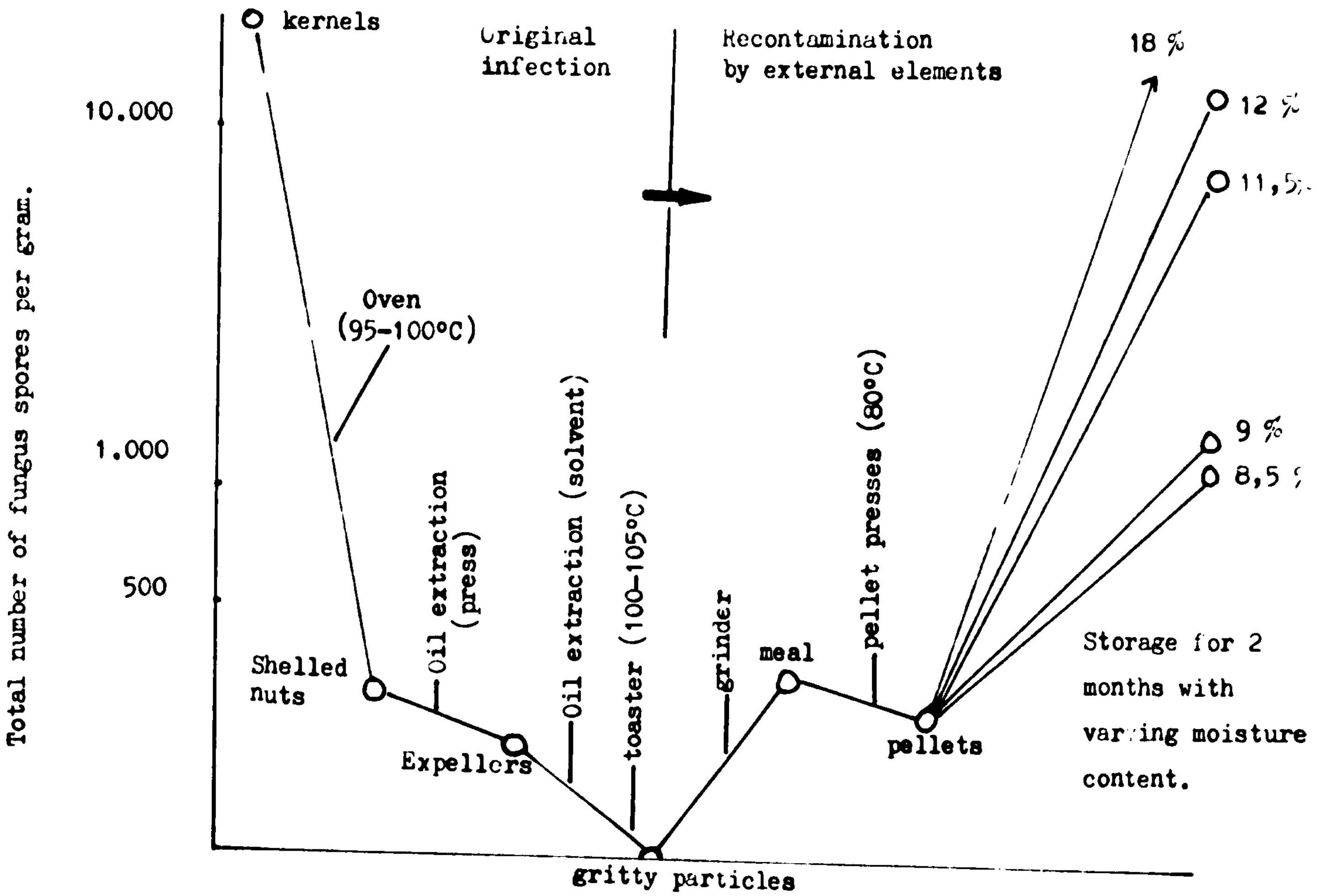
During conversion, the virgin oil obtained by pressing contaminated batches, contains aflatoxin, so also does oil extracted by the solvent hexane which carries some aflatoxin with it. Adrian, 1969 (2), quoting results obtained by various authors, studies the evolution of the aflatoxin rate during extraction and refining - the oil produced finally is free from aflatoxin.

Neutralisation eliminates most of the aflatoxin present, and the action of bleaching soil eliminates the rest.

In 1974, Prévot (107) made an assessment of work done on peanut cake : the extraction of oil and aflatoxin using a ternary solvent mixture, e.g. acetone-hexane-water, does not give satisfactory results as neither the aflatoxin nor the oil are removed completely. Much research carried out in the United States, in the laboratories of the USDA in New Orleans (Mann and al., 1970 (83) ; Gardner and al., 1971 (50) ; Codifer and al., 1976 (33)), showed the most economical method to be that using amonia gas. Recently, formaldehyde and calcium hydroxide have been tested and given good results. Peanut cake with a 12 to 15 % moisture content is shaken up in a reactor for 15 minutes under a 2 or 3 bar pressure of amonia. Removal of aflatoxin is considerable, but the protein content is weakened. The l sine content is only very slightly affected, but cystine is partially destroyed. Apart from these considerations, it is therefore possible to obtain meal almost completely free from mould and aflatoxin. Use of amonia however, is pointless is subsequent recontamination during storage and transport, is not avoided. Subsequent moulding is a cause of regeneration of toxins. Meal put on the live-stock feed market must therefore be guaranteed not only as having been treated for the removal of aflatoxin, but also as being free from any contamination subsequent to the treatment.

Variations in the extent of contamination by mould and re-contamination risks in peanuts and by-products are given in Fig. 1

Figure 1. Evolution of the number of fungi spores in peanuts and cake during oil-mill processes (Moreau, 1976 (94)).



1.7. Quality grading

In the United States, Israel, South Africa etc... control of commercialisation regulations concerning edible peanuts calls for a wide range of small standardized apparatus (Gillier, 1969 (52)).

The following are the main items of equipment :

- a pneumatic sampling machine which selects samples from trailer and truck loads carrying the nuts to the processing plant,
- a set of size screens which separate the nuts into three size grades and remove foreign material or accidentally shelled nuts,
- a shelling machine with different compartments for each nut size,
- a weighing machine
- a hygrometer to measure the moisture content of the nuts
- a series of screens to separate the kernels into different size grades, and remove split kernels,
- a small cruscher to crush the kernels and remove the cotyledons so as to be able to examine the interior of the nut.

Each batch is thus classified according to the various standards.

In-shell peanuts

The characteristics taken into consideration are : size, colour, texture and condition of the nuts.

. The size should be regular, and the shape of the shell should have a marked constriction. The external appearance is most important. For this reason nuts are often subjected to a light treating process such as washing or immersion in a kaolin bath. Quality standards may be decided either according to size (U.S.A.), ot to weight (France). The largest and heaviest nuts fetch the best prices.

. The colour of the shells is also important, expecially in Europe, preference being given to the lightest in colour.

. The texture of the shells, which is shown by their resistance during processing is another point to be considered as well as the condition of the kernels. The shells should contain no immature, mouldy or dammaged kernels.

Shelled nuts

Buyers consider peanuts as falling into three main categories : Virginia Large Variety, Virginia Small (Runner) and Spanish varieties.

Each quality is tested for the various standards such as size and homogeneity of the nuts, colour and shape, taste and odour and finally skinning aptitude.

The nuts are graded according to shape and size, established per 100 kernels or the number of kernels per ounce. Batches with 60 to 80 nuts to an ounce are considered as small, with 40 to 60 as medium, with 30 to 40 as large and with 20 to 30 as very large. Other points taken into consideration are : colour, condition, cleanliness, split resistance, moisture and oil content, although the latter characteristic is now of less importance, as mentioned above. Tatste and odour are particularly important where the nuts are to be made into peanut butter and roasted peanuts. There are no standards, but tests may be carried out by specialised "tasters" who usually take the flavour of the South African Natal as check sample.

The maturity of the seeds may be checked with a process developed by Kramer and his team, and based on spectrophotometry (Kramer and al., 1963 (72)). Other methods of analysis have also been established to measure the maturity of edible peanuts (Young, 1973 (159)); oil content (Heinis and Saunders, 1974 (61) ; oil quality (Young and Waller, 1972 (162)).

In table 16, we give, as an example of classification, the specifications corresponding to top quality edible peanuts in the United States.

TABLE 16. Specifications of Raw Shelled Peanuts of Nº 1 U.S. grade (according to Tiemstra, 1973 (158)).

Accepted defects (%)	Varieties		
	Runners	Spanish	Virginia
Others varieties	1,0	1,0	1,0
Splits	3,0	2,0	3,0
Damaged kernels	1,5	1,5	1,25
Damaged + minor defects	2,0	2,0	2,0
Foreign material	0,1	0,1	0,1
Pass through screen	3,0	2,0	3,0
Screen slot width (in inches)	16/64	15/64	15/64

The main problem concerning the quality of edible peanuts is that of their aflatoxin content (Wilson, 1975 (151).

American authorities have suggested methods of analysis after shelling which have given rise to much controversy with, for instance, European importers. It is particularly difficult to take a representative sample from a load of nuts in which contaminated nuts may be few but nevertheless mean that the entire load is doubtful (Whitaker and Wiser, 1969 (149)). After shelling, only the loads containing less than 1,25 % of infected kernels may be used for edible peanuts. Nuts to be used for the production of oil and peanut cake raise no problems of this type because, as we have seen, the aflatoxin may be eliminated during processing. In the case of these nuts, it is mainly the foreign materials and moisture content which are considered.

The W.H.O. recommend a threshold of 30 microgrammes per kilo (p.p.b.) which is 50 times less than that usually eccpeted as having no ill effect. Every importing country has established their own standards regarding aflatoxin. The strictest regulations are to be found in Holland, Italy and Japan, who have set this threshold at 5 p.p.b.. In the U.S.A. the Food and Drug Administration tolerate rates of 25 p.p.b. and 20 p.p.b. respectively in raw peanuts and in peanut products.

Aflatoxin is present in greater or smaller quantities depending on the country of origin of the peanuts. Peanuts from China have no aflatoxin content, South African Natal varieties and U.S.A. Runners only a very small quantity. Nuts from Argentina, Egypt and the Senegal are farily reliable, whereas those from India, Malawi, Nigeria and Brazil are considered as doubtful.

Many countries do not have standards regulating peanuts for use in oil-mills, but the European Community sets a shelled peanut reference price for a standard product with the following characteristics :

- Oil content 49 %
- Free fatty acid content expressed as oleic acid 3 %
- Free from foreign matter

2 - EDIBLE PEANUTS

The term "edible peanuts" covers a wide range of products : in-shell peanuts, shelled nuts, roasted nuts, salted nuts, peanut butter, candies and peanut bakery sweets (Fevre, 1971 (44) ; Tressler and Woodroof, 1976 (140)).

These different types of product all require specific equipment, but certain industrial operations are common to all.

2.1. Shelling

2.1.1. Cleaning in-shell peanuts

Before shelling, certain precautionary measures must be taken in preparing the nuts. The shells should be clean, and conform to quality standards regarding colour : cleaning is usually necessary. In Africa the nuts are washed in revolving cages, the lower parts of which are immersed in water. After drying in the sun or hot air, the nuts are again sorted to eliminate those which are dammaged and which would enable mould to reach the kernels. However, washing is inclined to weaken the shell surface making the nuts unfit for roasting (178).

In the United States a somewhat more expensive technique is used : the nuts are cleaned in a stream of wet coarse sand. The sand is screened out and reused, the nuts are dried and "powdered" with talc or very fine kaolin. The excess powder is removed by brushing. This process gives the shells a light colour and sheen. (Woodroof, 1973 (153)).

2.1.2. Actual shelling

Peanuts are shelled by friction caused between the nuts themselves and the walls of the shelling machines, which are usually cylinders with walls made of metal bars, or perforated metal sheets. A cross-bar beater or drum revolves in side the cylinder. The broken shells drop through the grates in the drum wall. The type of material which causes the least dammage to the kernels is that which consists of a metal bar cylinder with a smooth inner drum ; this type of material is recommended for treating edible peanuts (178).

If the loads of nuts to be treated are mixed, they should first be sorted into size grades in cages with adjustable bars. The beater-shelling machine spacing is then adapted to the size-grade of each load.

Simple manually operated machines have been adapted to permit shelling by the farmer ((180° ; Coward and al., 1977 (37)).

2.1.3. Sorting and storing after shelling.

A preliminary sorting over "jitter bugs" or shaker screens removes the shells and foreign material from the kernels. This preliminary sorting has therefore an essential rôle in removing most of the dammaged kernels in which aflatoxin is generally concentrated.

A second sorting operation removes defective kernels or those without skins. This operation is carried out either by use of electronic machines (SORTEX-type machines) or by hand. In the first case, the kernels pass trough photoelectric-cell beams set at the correct kernel colour.

A jet of air separates discoloured or darker kernels (indication of mould) from the rest. In the second case the kernels pass over picking tables lit by fluorescent lights to render the colour of the kernels more apparent. The kernels which do not have the standard colour are rejected by hand. This process is to be recommended in certain conditions, in Africa for instance, not only due to the cost of labour which is lower than in the United States but also because of the delicacy of SORTEX-type machines in african climatic conditions.

After shelling and sorting, storing must maintain the quality of the kernels. Peanuts are particularly subject to attack by mould and insects. Their colour is easily altered by the action of very small doses of amonia, they are apt to loose their flavour by absorbing surrounding odours, and they become rancid through oxydation (Woodroof, 1973 (153) ; Pattee and al., 1971 (103)). To avoid these risks, the storage temperature should be low. At 21°C shelled peanuts retain their qualities for four months but are subject to insect infestation and to an unfavourable change in colour. At 7°C peanuts may be held for six months, and insects are "arrested". Storage time may be increased still more by lowering the temperature : 2 years at 0°C to 2°C ; 5 years at -4°C and 10 years at -12°C.

2.2. Blanching

For the preparation of roasted or salted peanuts, the kernels must be skinned, and in the case of peanut butter it is also necessary to remove the heart which gives a bitter flavour to the butter (Woodroof, 1973 (153)).

There are four methods of blanching :

2.2.1. Dry blanching

This is the least complicated method. The shelled peanuts are heated at 140°C for 25 minutes, these figures may vary slightly depending on the type and humidity content of the nuts. The skins crack, and the peanuts are then cooled and afterwards passed between brushes or ribbed rubber rollers which remove the skins.

2.2.2. Hot water blanching

In this process, the kernels are rolled over fine stationary steel blades which cut the skin longitudinally on opposite sides. The kernels are sprayed with hot water to loosen the skins which are then removed by passing the kernels between a rubber pad and an oscillating cloth-covered pad. Finally the kernels are dried under a current of hot air (45° C), over a period of six hours. Hot water blanching has the advantage of not heating the kernels and means they keep longer and better than nuts blanched by other methods. This is due to the fact that the natural antioxydants present in the nuts are not destroyed. Moreover the hot water spray dissolves some of the kernels' surface protein, and a hard glaze is formed, thus protecting the kernel against oxydation and mechanical injury. However, drying the nuts is delicate, and its technique is more costly than dry blanching.

A variation of the water blanching method consists of heating the kernels at 100°C to 130°C after slitting the skins, and of then passing them between rubber belts which roll and rub the skins off. Spin blanching gives results similar to those obtained by dry blanching.

2.2.3. Sodium hydroxide blanching

The shelled nuts are immersed for eight seconds in a 1 per cent solution of sodium hydroxide and then rapidly dipped into a 1 per cent solution of hydrochloric acid to avoid the appearance of any red stains on the kernel. The skins are rinsed off with water, and finally the kernels are dried.

2.2.4. Hydrogen peroxide blanching

This new technique was introduced in Japan in 1970. The peanuts are immersed in the peroxide for 30 to 60 seconds. The catalase contained in the nut decomposes the peroxide into water and oxygen which causes the skin to swell away from the kernel, providing easy removal. The whole operation takes between 10 and 15 minutes.

2.2.5. Comparison of different blanching methods

As for the results obtained by these various methods, it is generally admitted that water blanched peanuts have a better appearance and keep better, but the quality of the kernels is largely dependant on drying conditions. Nuts dried too rapidly become tough, and subsequent cooking in oil is inclined to provoke warping. Because of its cost, sodium hydroxide blanching is good for treating small quantities of nuts.

In African conditions, cost and easy handling are the deciding factors in opting for the dry blanching method.

Whichever method may be used, a final inspection is necessary to remove discoloured, unblanched or partially blanched kernels. This operation is carried out, as seen in para. 2.1.3. above, by electronic sorting machines, of which there are several makes (e.g. Sortex, Schmitz-modern electronic etc..) which can treat from 100 kg. to 400 kg. per hour. Good results are also obtained by manual sorting, where the nuts pass along moving belts. In cases where the low cost of labour makes this solution possible, it may be selected in all confidence.

2.3. Roasting and Salting

Roasting develops the flavour of the nuts, (Mason and al., 1969 (85) ; Walradt and al., 1971 (46)), and one of two methods are used, depending on whether the nuts are to be used to make peanut butter or for other purposes.

For the manufacture of peanut butter roasting may be carried out either continuously or in batches. Batch roasting enables separate treatment of nuts having different characteristics, especially as regards moisture content, this being the most important characteristic during roasting. The batch method is therefore more adaptable. The peanuts are heated to 160°C for 50 to 60 minutes in a countercurrent air roaster heated to 425°C. The nuts gradually become browner, but a control device automatically checks this cloiour change and actuates the discharge of the roaster at the right moment whilst controling the cooler at the same time. About 200 Kg. of nuts are roasted in each batch. Roasting has the effect of causing rapid drying. Moisture content drops from 5 to 0.5% ; which is accompanied by the appearance of oil on the surface of the cotyledons. Continuous roasters have been on the increase since 1955 so as to reduce labour costs and decrease spillage. However with the use of continuous roasting, special attention must be given to the temperature, so as to avoid the formation of charred particles, scratching the surface of the nuts, precipitation of the oil and producing a burnt flavour in the nuts.

Cooling should be carried out very rapidly, so as to obtain a uniform product. The cooler consists of a perforated metal cylinder into which a stron stream of air is blown through the mass. (Kurz, 1976 (74)).

Salted peanuts may be roasted using the method described above, but the traditional method consists of roasting the nuts in oil after skinning (Gaupp, 1970 (51)). The oil is often gas-heated to a temperature of 135°C to 145°C, and for an immersion time graduated from 3 to 10 minutes according to the varieties treated and the quality required. The peanuts are then cooled by passing on a conveyor under a stream of cold air.

The cooking oil most often used is coco-nut oil and sometimes cottonseed oil or peanut oil. The oil must be continuously filtered and adjusted to volume and the free fatty acids should be maintained at a maximum range of 0.2 to 0.3 %.

Charred particles which may sink to the bottom of the roasting tank should be removed. This, as well as a close check kept on the temperature and time of roasting, makes it more difficult to control batch roasting than continuous roasting.

The actual salting process develops the flavour of roasted peanuts. The main difficulty encountered during this process is that of ensuring that the salt adheres to the surface of the nuts and avoiding does not fall to the bottom of the bags in which they are sold. For this reason coconut oil or solid shortening are prefered to liquid oils for roasting, and salting is carried out during the process of cooling the nuts. Sometimes an improved result is sought by spraying the nuts with coconut oil. The quality of the salt used is of the utmost importance : preference is given to salt flakes rather than very fine granulated salt. Copper and iron contents should be practically inexistent (less than 1,5 ppm) as the presence of these metal accelerates rancidity of oil. Calcium and magnesium contents must also be small to avoid the product having a harsh flavour. Nuts are salted at a level of about 2%, and the addition of antioxidants is recommended, either in the roasting oil, or at the time of salting.

To obtain de-oiled peanuts, the kernels are pressed after skinning(Pomanski and al., 1975 (104)).

2.4. Packaging

Packaging should fill two types of functions : firstly a commercial function , the packing materials should be attractive to the consumer; secondly a technical function , they should ensure a given shelflive for the packed product maintaining the initial qualities of the product, which means protection against oxydation, loss of flavour, moisture and attack by insects and rodents.

For the transportation of in-shell nuts, 30 to 35 Kg. jute sisal or polypropylene bags may be used.

Transportation of shelled peanuts is done in 50 kg. Bags. Unfortunately these types of packaging do not protect the product against mechanical injury and the bags should be handled with care.

Skinned nuts are usually packed in 30 kilo drums or baxes.

The shelf life of salted peanuts is directly affected by exposure to light and air. Vacuum packaging, in hermetically sealed opaque packages gives the best results. At present either cellophane or , preferably, metal packaging materials are used. Addition of antioxidants such as BHA (butylated hydroxyanisole) and BHT (butylated hydroxytoluene) improve storing conditions of the nuts.

Peanuts sold in the shell after roasting only. In France, Italy and in most mediteranean countries this procedure does not raise any particular problems.

3 - PEANUTS AS A SOURCE OF PROTEIN IN THE HUMAN DIET

Before looking into the various processes for manufacturing protein for human consumption, it should be remembered that in Africa, peanut flour, partially de-oiled by hand, is used in a large number of dishes, and that in China peanut milk and curd are common products.

3.1. Methods used to obtain peanut protein

The processes usually used to obtain protein from oilseeds are also used in the case of peanuts.

The traditional methods used to prepare peanut protein (De and Cornélius, 1970 (38)) may be divided into two types depending on whether meal or whole nuts are to be processed to obtain the protein isolate.

3.1.1. Oil-mill method (fig. 2)

The oil is extracted either by continuous expelling or by means of solvents, as in oil-mills, but the preliminary preparations are carried out much more carefully so as to ensure that the raw material is of the highest quality. The nuts must be sound and free from mould and insects. They must therefore be absolutely clean. After shelling, the shells and dammaged kernels are screened out. Electronic or manual sorting is carried out to remove mouldy or undersized kernels from each batch treated.

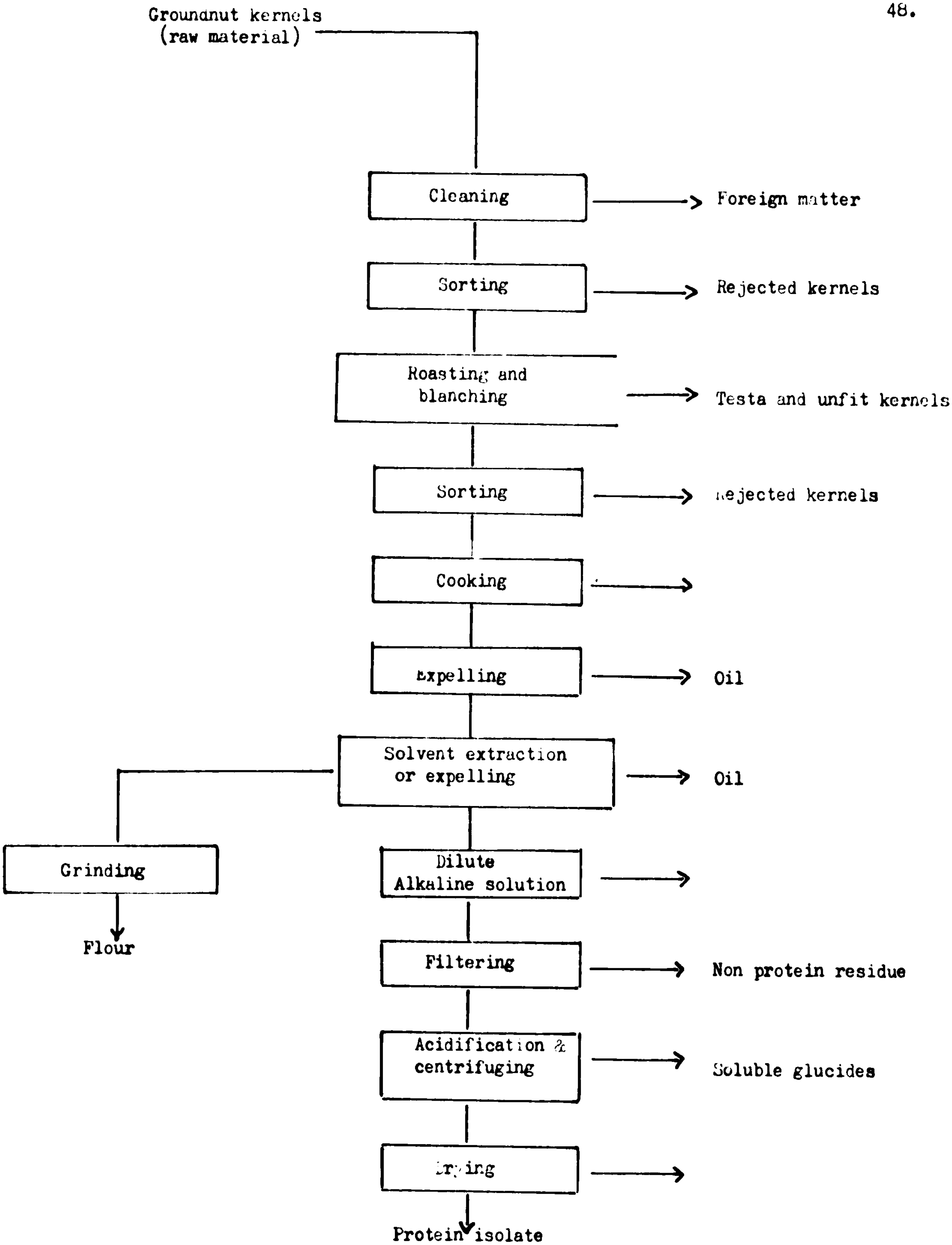


FIG. 2. Production of flour and peanut protein isolate by traditional methods. (Je et Cornélius, 1970 (38)).

The skins are then removed and also the hearts, as mentioned in chapter 2 above. A final inspection is made. The nuts are crushed to provide an even distribution of moisture and good heat exchange in the subsequent heating operation, during which the temperature must not be raised above 120°C to avoid dammage to the protein content. After pressing, peanut flour is obtained.

Initial water and free fatty acid contents of the kernels must be less than 12% and 0,5% respectively. Moreover, it is essential for the heart to be removed as it contains goiterogeneous properties. The final product should be free of Escherichia Coli, Salmonella and any other pathogenic elements. The total number of bacteria should be less than 20,000 per gram. The aflatoxin content should be low ; there is no set rate, but a product containing 5 μg/kg. is considered unfit for human consumption (Chandrasekhara and Ramanna, 1968 (28)).

Various traditional methods are also recommended to determine assimilable lysine and soluble protein rates.

Below are the standards given by Adrian and Jacquot, 1968 (4) for edible peanut flour :

- the kernels should have a good appearance and be neither rancid nor mouldy,
- all shells and at least 40% of the skins and hearts should have been removed,
- the protein content of the kernel should be 27% (± 10%);
- if heat is used in the skinning method, this should not exceed 150°C for a lenght of time of not over 10 minutes ;
- the oil may be extracted either by the expelling or solvent methods, but in the latter case the solvents must be conform to standards regarding the quality of the meal ;

- roasting in the roasting machines, and expelling of the oil should be regulated so that no blocking or deterioration of amino-acids occur ; the temperature should therefore not exceed 120° in the pressure expeller nor be maintained for more than 30 mn.;

- the flour obtained from meal must be sieved to ensure that 9/10 pass through an 80 mesh screen and that the total quantity passes through a 40 mesh screen ;

- the flour must be sound, and come up to the bacteriological food standards and be free of any insect or parasite infestation ;

- addition of chemical products either for preservation or other purposes is not allowed ;

- the flour should contain at least 50% protein (N x 6,25), 3 to 5% ash at the most, less than 6% moisture, less than 6% fat and less than 4% crude fibre ;

- the lysine content in the protein should be at least 3% (± 10%) ;

- digestibility tested on rats should be at least 95% and the biological value of the proteins should be at least 55% .

3.1.2. <u>Recovery of protein isolates</u>

Recovery is based on the solubility of protein in a soda aqueous solution. From a nutritional point of view, it is preferable to use skinned peanuts ; but in treating expelled or solvent extracted meal , it is also possible to recover oil (see fig. 2). In the two processes described below, kernels are used, and oil and protein concentrates are recovered simultaneously.

The Chayen or Lypro process : after skinning and removal of hearts, the kernels are immersed in an aqueous solution of becarbonate of soda. The nuts are crushed so as to burst the cells and promote the disolving of the protein. Then, by means of centrifuging three elements are separated : a fibrous element, an oily element and an aqueous element which contains the protein, the glucides and about a third of the dispersed oil. The protein is precipitated either by the use of heat or acid. Part of the oil being taken by precipitation, a final product, after drying with 65% protein and 32% oil is obtained.

The CFTRI (Central Food Technological Research Institute, Mysore) process. This process is an improved variation of the process described above. The skinned and flaked kernels are immersed in an aqueous soda solution. After filtering and centrifuging, the protein is precipitated by acidification at 4.5 to 5 pH, end the oil is removed by use of a solvent (see fig. 3). The final product contains 92 % protein (Bathia and al., 1965 (12)).

In India, an industrial plant operates with this process, but as the maximum oil extraction figure was not reached, it is at present using solvent extracted meal .

Recently improvements on these processes have been studied in the United States (Rhee and al., 1972 (115)). The extraction of oil and protein is operated simultaneously (fig. 4). A better recovery of oil is obtained by centrifuging at a pH close to the isoelectric point (Mieth and al., 1975 (89 and 90)). Processing with hydrogen peroxyde, or sodium hypochlorite allows the removal of aflatoxin (Rhee and al., 1973 (116)).

3.2. Technical-economical comparisons

The cost of flour, concentrates and even of isolates related to a kilo of protein, is noticeably lower than that of animal protein, except in the case of skimmed milk which is similar (Orr and Adair, 1967 (100)).

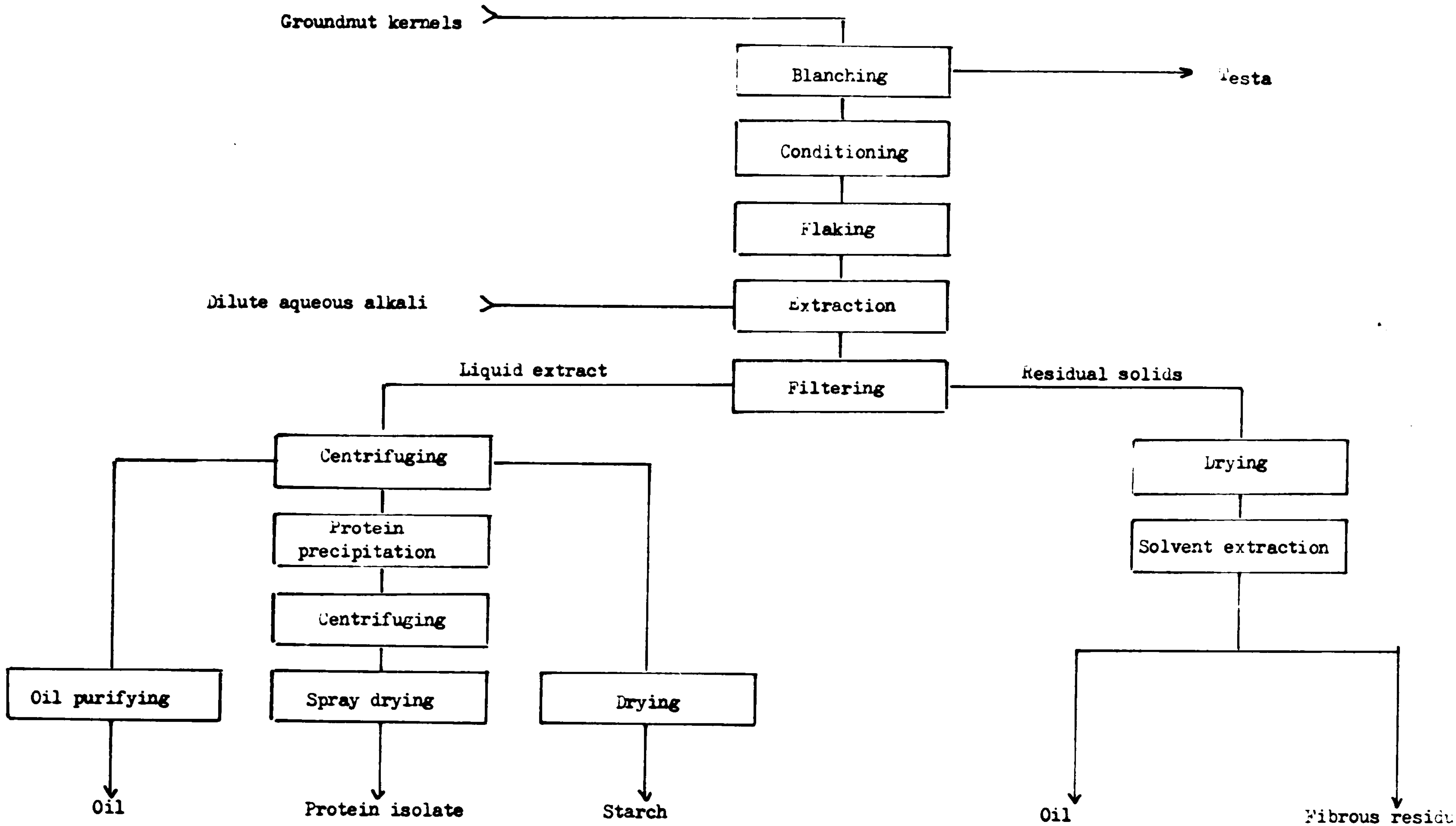
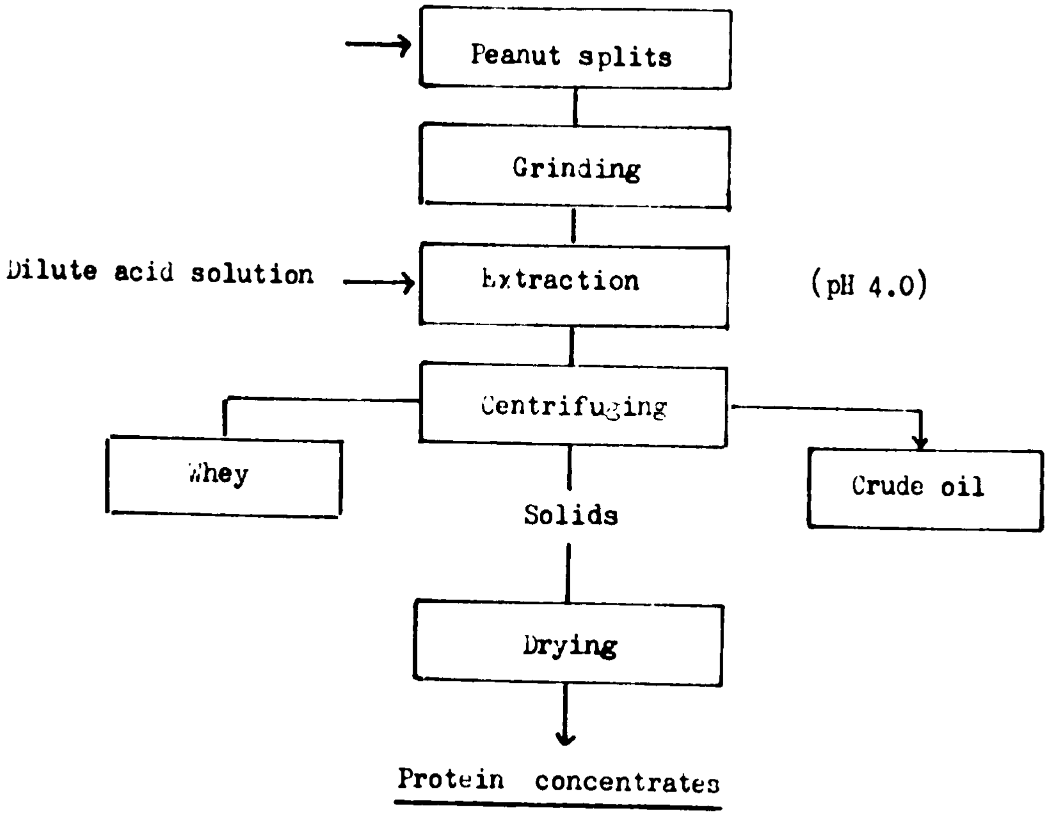
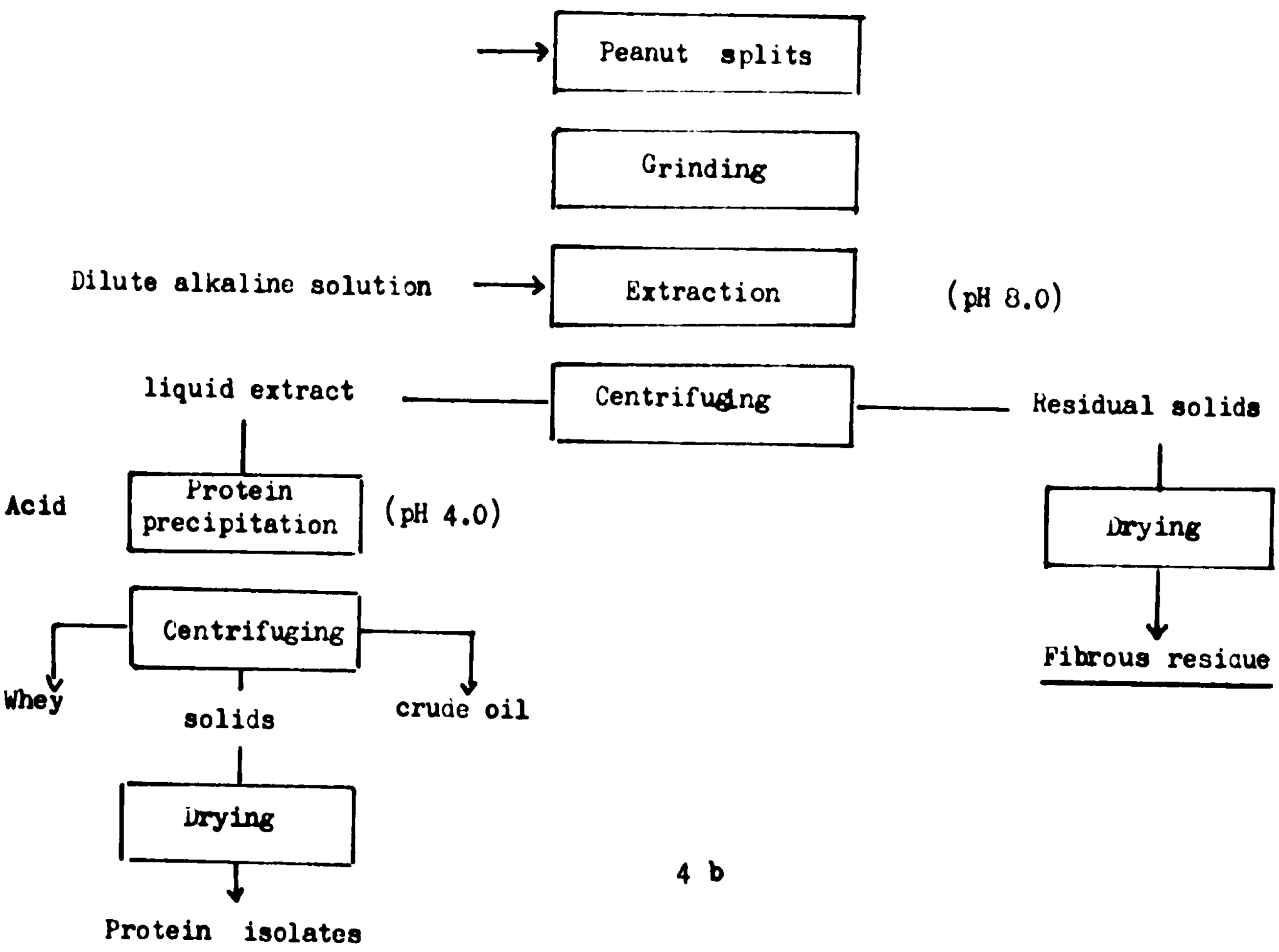


FIG. 3. C.F.T.R.I Protein isolate process
(De et Cornélius, 1971 (38)).



4 a



4 b

FIG.4. Simultaneous extraction of protein and peanut oil for the production of concentrates (4 a) and isolates (4 b).

(Rhee et al., 1972 (115)).

However, no large industrial installation exists producing protein concentrates or isolates of peanuts, which makes it difficult to establish a truly representative comparison of cost. In theory the production of concentrates should not lead to prices much higher than those of oil meal, as only a small amount of extra equipment is necessary for its production, but it requires a much larger labour force. Moreover, production capacity, in the absence of a clearly defined market, should be limited, and the close relationship between the capacities treated and a drop in cost price is well known in the field of oil mills. In the case of isolates, production processes call for specific equipment which produce lower quantities of oil than those produced by traditional oil mills. Oil has a heavy influence on the cost of the product. The mills must also maintain high hygiene conditions. There are many reasons to explain why private industry has taken little interest in such production.

3.3. The different uses in food

The various products, flour or isolates, are used in their original form and sometimes to supplement or mix in with other products (Adrian and Jacquot, 1968 (4)). Such preparations are used in many countries, but it is mainly in India that the largest number of uses are to be found (Chandrasekhara and Ramanna, 1968 (28)), where formulae for flour, biscuits and milk have been elaborated. Among the foodstuffs obtained from peanut flour, the "Indian multipurpose food" should be noted, this consists of a mixture of 75 % peanut flour and 25 % chick pea flour, cooked and with extra vitamins and mineral salts added. Also to be noted is the Bal Ahar, mainly intented for children, which has 70 % wheat flour, 25 % peanut flour, 5 % skimmed milk powder and vitamins, the final product has a 22 % protein content. To reduce malnutrition after weaning, a product has also been developped based on peanut flour enriched in sulphurated amino acid by the addition of sesame seeds and in lysine by the addition of chick peas. The "Nutro biscuit" has a high protein content : the addition of 22 % peanut flour raises the protein content from 7 to 17 %.

The protein isolates produced by the CFTRI process were intented as a substitute for imported skimmed milk powder which made any mixture based on cow-buffalo milk very expensive. After the addition of glucose and vitamins, a mixture based on nationally produced products is obtained, having acceptable organoleptic qualities and which is known as "lactone".

In Africa, especially in Nigeria and the Senegal, an effort has also been made to prepare foodstuffs with peanut flour produced on the spot. The flour is mixed with skimmed milk powder to produce "Arlac" or millet flour to produce "Ladylac".

Research continues in the United States in the Universities of Texas (A and M) and Georgia and in the U.S. Department of Agriculture, as well as in India, on the use of peanut flour in the production of bread and biscuits (Khan and al., 1975 (70) ; Khan and Rooney, 1977 (71) ; Beuchat, 1977 (14) ; Matthews, 1972 (86) ; Sahni and al., 1975 (119)).

Attempts to improve the food value and particularly the protein value by fungal fermentation of peanut flour have been made (Quinn and al., 1975 (11)). Results do not appear to be of any great interest.

3.4. <u>Storing and Conditionning</u>

As peanut flour and proteins are products destined for human consumption appropriate storage and packing facilities are necessary to ensure quality maintenance.

Care must be taken to avoid dammage from mould and from insects and rodents, and also chemical deterioration through oxydation and lipolysis.

To avoid moulding, the relative moisture of the storage area should be kept at 60 %. The moisture rate of the flour should be maintained between 7 and 11 %, the lower limit being that at which oxydation of lipids occurs, and the upper figure being that of lipolysis. With a set relative moisture figure for the air, the moisture of the flour depends largely on its oil content ; it is therefore necessary to find a solution to ensure these two standards.

The choice of packing techniques depends also on future handling and transportation conditions. Three types of packaging are possible, depending on technical requirements, and considering cost and marketing requirements : paper or jute bags with an inner packaging og plastic for bulk selling ; tin cans with an inner plastic packing holding 3 to 10 kilos of flour for semi-bulk selling ; tins or cardboard boxes also with a plastic inner for sale to the consumer (100 g. to 1 kilo). For this type of packaging it should be possible to reclose the bag hermetically if the flour is not to be used all at one time.

Whichever solution is chosen, the packaging material should be tested before any final choice is made, and should guarantee the maintenance of product quality for 6 months for small quantity packages and for one year in the case of large sacks.

Some countries, such as India, have set quality standards for these products (Achaya, 1976 (1)).

4 - TABLE OIL

In countries where liquid cooking fats are traditionally used, peanut oil is often preferred to other types of oil, but it is expensive.

In table 17 the average characteristics of peanut oil depending on origin are given according to Wolf, 1968 (152).

4.1. Main characteristics

4.1.1. Fatty acids composition

The composition of peanut oil in fatty acids depends on the genetic characteristics of the seed as well as climatics conditions affecting growth (see chap.1 and Worthington and al., 1972 (157) ; Young and al., 1974 (164)). It is nevertheless possible to give the average composition of the various types as seen in table 17. The arachidic acid content is comparatively high. The high linoleic acid content of American produced oil should be noted, and also the high oleic acid content in African oil.

Usually, peanut oil contains 77 to 82 % unsaturated fatty acids, mostly oleic and linoelic. These figures are similar to those of cottonseed oil, which is about 70 %, and soya bean oil, about 75 % (Grieco and Piepoli, 1967 (57)). In fact the fatty acid composition of peanut oil is in general very similar to that of other common vegetable oils as shown on table 18.

TABLE 17. Main characteristics of peanut oil (Wolff, 1968 (152)).

D_4^{20} : density at 4 and 20°C.

S.N. : Saponification number
I.N. : Iodine number

Characteristics		Composition of unsaponifiable matter in mg per 100g. of oil	
D_4^{20}	0.914 - 0.916	Carbohydrates	30 - 40
		Squalene	40 - 70
		Tocopherol	25 - 55
		α-tocopherol	32 %
n_d^{20}	1.470 - 1.472	γ-tocopherol	68 %
		Terpenic spirits	30 - 45
		Sterol	200 - 300
S.N.	189 - 196	cholesterol	2 %
I.N.	85 - 98	campesterol	11 %
Strength	27 - 32	Stigmasterol	10 %
Unsaponifiable	0,6 - 1,0 %	β-sitosterol	77%

Composition of fatty acids as % of acids

	Range	Average		Range	Average
C_{16}	8,2 - 11,7	9,5	C_{20}	1,0 - 2,3	1,5
C'_{16}	0,0 - 0,3	0,1	C'_{20}	0,9 - 2,1	1,3
C_{18}	1,2 - 3,7	1,7	C_{22}	1,5 - 2,7	2,3
C'_{18}	57,0 - 70,8	63,7	C_{24}	1,0 - 1,8	1,4
C''_{18}	15,3 - 23,5	18,5			

TABLE 17. (...continuation)

b) American and South African peanuts

Characteristics	Composition in fatty acids as % of acids	
		Range
D_4^{20} .... 0,917 - 0,920	C_{16}	9,1 - 12,5
n_d^{20} .... 1,472 - 1,474	C'_{16}	0,2 - 0,3
	C_{18}	2,9 - 4,9
S.N. .... 188 - 194	C'_{18}	39,7 - 46,0
I.N. .... 98 - 108	C''_{18}	29,3 - 37,4
	C_{20}	1,4 - 2,5
Strength .... 24 - 28		
Unsaponifiable ..... 0,6 - 1,0 %	C'_{20}	0,9 - 1,5
	C_{22}	3,2 - 4,8
	C_{24}	1,2 - 2,5

C_{16} : palmitic acid

C'_{16} : palmitoleic acid

C_{18} : stearic acid

C'_{18} : oleic acid

C''_{18} : linoleic acid

C_{20} : arachidic acid

C'_{20} : gadoleic acid

C_{22} : behenic acid

C_{24} : lignoceric acid

TABLE 18. Main fatty acid contents of common vegetable oils (Adrian and Jacquot, 1968 (4)).

OIL	ACIDS			
	Palmitic	Stearic	Oleic	Linoleic
Peanut	6,3 - 12,9	2,8 - 6,3	39,2 - 65,7	16,8 - 38,2
Soya	6,8 - 11,5	2,5 - 5,5	22,0 - 34,0	49,8 - 60,0
Cotton	17,1 - 23,4	0,9 - 2,7	18,0 - 44,2	33,9 - 55,0
Olive	7,0 - 20,0	0,3 - 3,3	53,1 - 85,8	4,0 - 22,5

4.1.2. Lipid composition

Peanut oil has a high triglyceride percentage. Sempore, 1975 (125) and Sempore and Bézard, 1977 (126), analysed the triglycerides of oil from the Upper Volta ; their results (table 19) show that triolein is to be found in largest quantities and that together with dioleolinolein and palmitodiolein it forms aver half of the triglycerides.

Peanut oil has a comparatively low phospholipid content, containing only between 0,65 and 1,35 % as opposed to 3,2 % for soya bean oil (Adrian and Jacquot, 1968 (4)).

4.1.3. Unsaponifiable matter (table 17)

Peanut oil contains between 0,2 and 1,8 % unsaponifiable matter which may be split into four elements, one of these, the sterolic element has been analysed (Itch and al., 1973 (64)). The presence of sterol has the effect, according to Mullor, 1971 (96), of lowering the cholesterol rate in the blood stream.

This oil has a high tocopherol content, about 40 to 50 mg per litre of oil. This content is less than that of soya-bean oil (100 to 175 mg), or cotton-seed oil (110 mg).

Squalene, at a rate of 40 to 70 mg per 100 g. oil may also be detected (Wolf, 1968 (152)).

TABLE 19. Main types of triglycerides in peanut oil (over 1%) (Sempore and Bézard, 1977 (126)).

Types of triglycerides		% in mols
triolein	18 : 1 ; 18 : 1 ; 18 : 1	24,6
dioleolinolein	18 : 1 ; 18 : 1 ; 18 : 2	17,2
palmitodiolein	16 : 0 ; 18 : 1 ; 18 : 1	11,7
palmitooleolinolein	16 : 0 ; 18 : 1 ; 18 : 2	7,1
oleadilinolein	18 : 1 ; 18 : 2 ; 18 : 2	5,5
stearodiolein	18 : 0 ; 18 : 1 ; 18 : 1	4,8
behenodiolein	22 : 0 ; 18 : 1 ; 18 : 1	2,6
stearooleolinolein	18 : 0 ; 18 : 1 ; 18 : 2	2,6
arachidodiolein	20 : 0 ; 18 : 1 ; 18 : 1	2,5
behenooleolinolein	22 : 0 ; 18 : 1 ; 18 : 2	1,7
palmitodilinolein	16 : 0 ; 18 : 2 ; 18 : 2	1,7
gadoleodiolein	20 : 1 ; 18 : 1 ; 18 : 1	1,5
lignocerodiolein	24 : 0 ; 18 : 1 ; 18 : 1	1,5
di palmitoolein	16 : 0 ; 16 : 0 ; 18 : 1	1,4
arachidooleolinolein	20 : 0 ; 18 : 1 ; 18 : 2	1,4
palmitobehenoolein	16 : 0 ; 22 : 0 ; 18 : 1	1,2
lignocerooleolinolein	24 : 0 ; 18 : 1 ; 18 : 2	1,0
oleogadolinolein	20 : 1 ; 18 : 1 ; 18 : 2	1,0

4.1.4. Chemical characteristics
(table 17)

Table 17 shows some of the characteristics of peanut oil.

Peanut oil solidifies into amorphous crystals at about 8° - 10°C, and it must be heated at about 14°C over a short period of time for it to become liquid. It has high anti-oxidation stability both when hot and cold, due to the absence of linoleic acid, and to the presence of natural antioxidants (topherol).

4.1.5. Nutritional characteristics

During nutritional tests, peanut oil proves to have no adverse effects either toxic or metabolic (Landes and Miller, 1975 (78) ; Sergiel and al., 1975 (127)). On the contrary it is often used as a check sample in tests on animals. Peanut oil has a very favourable reputation among nutritional experts because of its linoleic acid content (Vigne, 1974 (145)). Moreover, its particularly high resistance to heat, especially in cooking, causes it to be recommended for this use (Prandini, 1974 (105)).

4.2. Various qualities

Peanut oil is consumed either as crude oil or virgin oil in many producing countries. In table 20, an abstract of the FAO standard (184) is given, which shows the charecteristics of peanut oil intended for human consumption. Oil produced by methods used in the home, or non industrial means does not usually come up to these standards.

TABLE 20. Main elements of composition and quality for peanut oil intented for human consumption (F.A.O., 1970 (184)).

2.1.	Distinctive characteristics	
	2.1.1. Relative density (20°C/water at 20°C)	0,914 - 0,917
	2.1.2. Refractive index ($n_d^{40°C}$)	1,460 - 1,465
	2.1.3. Saponification number (mg KOH/g oil)	187 - 196
	2.1.4. Iodine number (Wijs)	80 - 106
	2.1.5. Unsaponifiable matter	maximum 10 g/kg
2.2.	Arachidic acid and high quality fatty acid content	minimum 48 g/kg
2.3.	Quality characteristics	
	2.3.1. Colour : characteristic of product stated	
	2.3.2. Smell and flavour : characteristics of product stated and free from any foreign flavour or smell and from any rancid flavour.	
	2.3.3. Acid number	
	virgin oil	maximum 4 mg KHO/g oil
	non-virgin oil	maximum 0,6 mg KOH/g oil
	2.3.4. Peroxide number	maximum 10 milliequivalents of peroxyde oxygen per kilo of oil

4.3 Interchangeability with other oils

The characteristics of peanut oil make it apt for use both hot and cold. For utilization when cold, it comes into competition with other cheaper oils, such as soya-bean oil or colza which are comparable to it when not reused or oxydised. But peanut oil is out classed as regards dietetic quality for sunflower seed and corn oil which have a higher linoleic content. For use when heated, its outstanding stability and comparatively slight odour during cooking, make it preferable to soya or colza oil, and on some markets, to concentrated oils and shortenings used for cooking (Lesieur, 1976 (81)).

The main drawback for the housewife is its high cost. The same may be said for the food industry, manufacture of margarine and of shortening, in which soya, colza and sometimes even sunflower seed oils are preferred.

In general, apart from the aspect of individual taste of the consumer, the deciding factors in substitution are economic, the avaibility of other oils on the market, and the cost of these oils. It should be noted that interchangeability of products leads to cost interdependance. The above is true in European countries and Japan, where the market is dependent on peanut producing countries. In other countries, consumption also depends on local production and foreign markets. Thus, on the American market, preference is given to cottonseed, or soya bean oil and margarine. In South-East Asia preference is given more particularly to palm or coconut oil, and in Scandinavia, Australia and New Zealand animal fats are preferred. Obviously national produce is at an advantage, due to buyers' habits, protection of home markets and saving on transport costs.

5 - OIL PRODUCTION

Of all oilseeds, peanuts are among those easiest to triturate, and peanut oil is one of the easiest to refine ; however, the peanut presents certain specific characteristics.

The peanut kernel is fragile and may be broken during the various handling operations, sometimes into very small particles which are easily subject to moulding, which, in a short time leads to hydrolysis of the oil, increasing the fatty acid content by several percentage points. Handling operations should therefore be adapted (Garcia, 1976 (49)). Especially in the case of pneumatic landling methods, circulation speed rates should be kept to a minimum, and sharp angles should be eliminated.

Peanuts more than any other seed, are inclined to form clusters in handling machines ; ovens and solvent removing machines. The surface in which moisture is collected, rapidly becomes soiled. The installations should be cleaned frequently.

Apart from the points mentioned above which are of general nature, the various operations carried out in the oil mill (fig. 5) present very few difficulties.

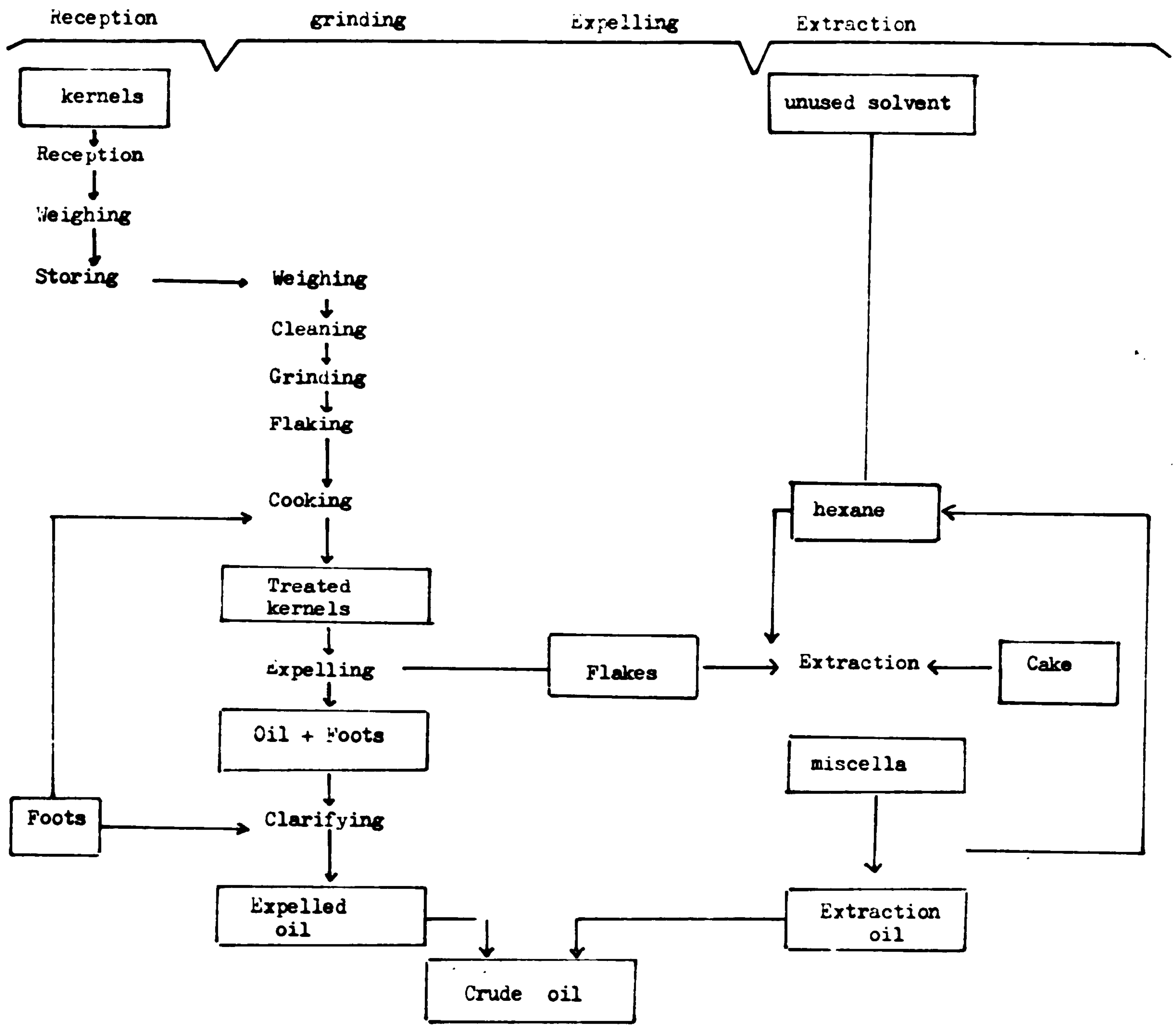


FIG. 5. <u>Crude oil productio~ diagramme</u> (Colin, 1976 (34)).

5.1. Sequence of operations

The points discussed here are those specially concerning peanuts ; for information concerning oil-mills in general see the UNIDO edition "Guidelines for the establishment and operation of vegetable oil factories", 1977 (183)).

5.1.1. Cleaning the shells (see fig.6)

The apparatus for cleaning the shells should be equipped with gratings adjusted to the main foreign materials present, i.e. sand and sticks, and should remove any stones present among the nuts (Garcia, 1976 (49)).

5.1.2. Shelling

During shelling, care should be taken to leave the least amount of broken kernels possible in with the shells, the oil content of which should not be more than 1 %. The main points to be watched during this stage are : size consistency of the loads and moisture content of the kernels, a low quantity of foreign bodies and regular feeding of the shelling device.

Shelling is still done by hand in some parts of the world, but recently "bush" shelling machines have appeared (1967, 180) ; Coward and al., 1974 (57)). of non industrial manufacture, which have the advantage of producing cleaned nuts, and reducing transport costs to the factory. Their disadvantage is the quantity of product to be treated required to justify such an outlay, and the fact that production is lower thant that of industrial-type shellers. Another drawback is the fact that the shells are almost found to be unrecoverable. Industrial shelling apparatus are of the same type as those used for edible peanuts, that is to say friction operated, but in the case of nuts intented for oil the breaking of kernels is of no importance.

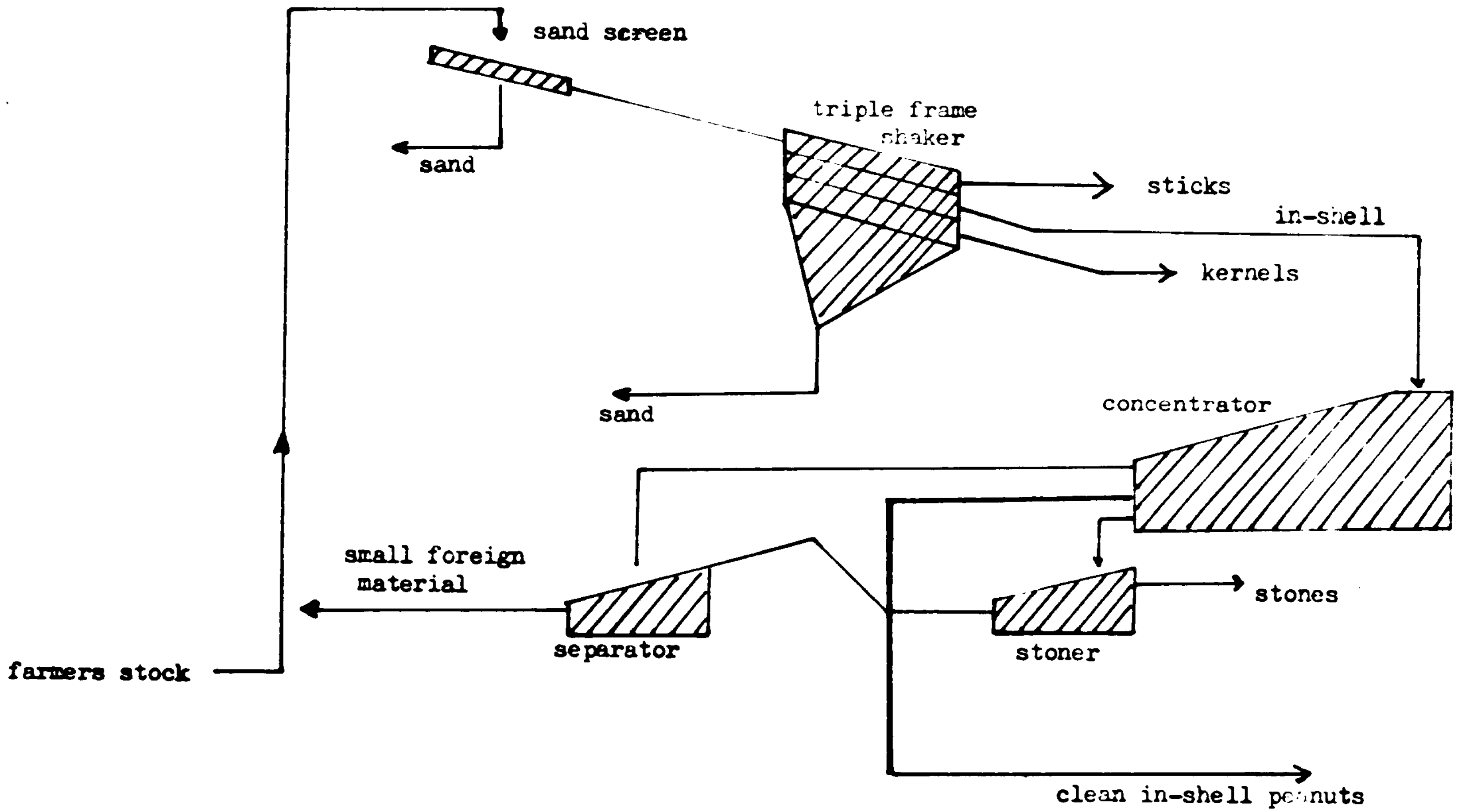


FIG. 6. Cleaning station diagramme
(Garcia, 1976 (49)).

Experimental pneumatic shelling has also given encouraging results in the case of peanuts, as this process avoids breaking the nuts, but the efficiency of this method depends on having good quality nuts at the outset of the operation (Michalon and al., 1972 (88) ; Colin, 1976 (34)).

Storing of shelled peanuts can be done either in bulk or bagged, preferably in storage areas adapted to this purpose. The precautions to be taken are those applied to nearly all agricultural products ; constant checking of temperature, moisture of the nuts and of the air as well as of attack by mould or rodents (Gustafson, 1976 (59)).

5.1.3. Crushing

Nuts intented for oil used to be skinned, as in the case of edible peanuts, as the meal thus obtained after crushing was much lighter and sold better. Nowadays, this method has practically disappeared as it demands a high initial outlay, and causes the skins, which contain some oily substance to be discarded.

Crushing of nuts is very simple and is carried out in a hammer crusher. This step is not always necessary (Ward, 1976 (148)), especially where African nuts are concerned, as these are easily broken, and are sufficiently crushed during handling operations.

5.1.4. Roasting

Roasting the crushed nuts prior to pressing should be regulated to avoid loss of protein and darkening the colour of meal.

Roasting at 90°C for about 20 minutes, and with 8 or 10 % moisture is frequently employed ; this is followed by drying at 105°C for 30 minutes which reduces the moisture to 5 or 6 %.

However sometimes more vigorous cooking conditions are employed to obtain a higher production rate than that of the presses, or simply to obtain more oil. Such advantages as these are however offset by a drop in quality, both of the meal and the oil.

5.1.5. Pressing

Peanut pressing does not present any specific characteristics either in the production of expeller meal or rich meal. The layout of the presses is the same as for any oily raw material (Ward, 1976 (148) ; Bredeson, 1977 (23)).

The crude oil coming from the presses, in particular that obtained from poor quality nuts have a high "foots" content. Foots are the solid matter contained in the oil ; kernel particles, nut dust and mucilage, which are in fact a mixture of protein, phospholipids and sterol. Certain crude oils have up to a 20 % food content. Compared with other oil-seeds, such a percentage is high and calls for equipment with many filters and centrifuge aparatus. The foots may be recycled before pressing or even during extraction if they are gritty enough and if extraction is not being run at maximum output.

5.1.6. Extraction

On leaving the presses, the "flakes" still contain about 10 % oil (Stein and Glaser, 1976 (132)) which has to be removed by the use of a counterflow method. The solvents most frequently used are B spirit, hexane and trichlorethylen, but others have proved successful in pilot operations : hydrated acetone and alcohol for instance (181 ; 182).

Peanuts can break into very small particles, which can lead to difficulties during extraction. An immersion extractor may therefore prove preferable particularly for direct extraction (Milligan, 1976 (91)), which is now available (Bernardini, 1975 (13)), but it is early as yet to be able to assess the efficacity of this technique.

After extraction the meal must have the solvent removed.

It appears that the food value of the meal is affected by the solvent employed (Adrian and Jacquot, 1968 (4)).

5.1.7. Refining

Refining crude oil is not usually a difficult operation (Cowan, 1976 (36) and Carr, 1976 (26)). Steam or brine mucilage removal is seldomnecessary, simple treating by phosphoric acid proving sufficient. Other acids, in particular, oxalic acid, have been tested as mucilage removal agents (Ohlson and Svensson, 1976 (99)), to attempt to reduce pollution. Neutralization to eliminate free fatty acids by caustic soda or carbonate of soda (Solomon, 1972 (131)) raises difficulties only in the case of very poor quality oils, whose treatment necessitate the use of concentrated soda.

After this operation, standard quality peanut oil, is already very light in colour. However, the addition of small quantities of bleaching soil (Goebel, 1976 (55)), followed by filtering (Muller, 1967 (95)) enables the elimination of traces of soap and impurities.

Frequently only 0,1 to 2 % bleaching soils is used, but exceptionally, very dark oil, or oil with a burnt flavour, or oil presenting the cast of mineral oil, much larger quantities of bleaching soils may be used or activated charcoal. Deodourising is also simple by vaccum steam distilling (Zehnder, 1976 (169)).

Neutralising distilling was applied in some countries to peanut oil. It seems to produce lower quality products for poor quality raw oils, it is much more expensive per capacity unit ton, but for some countries this method does away with the problem of water pollution. Its use is justifiable only in certain specific cases.

5.1.8. Storage, package and handling of oil

The problems raised in these fields by peanut oil are no different from those concerning other oils (Johansson, 1976 (67) ; Wright, 1976 (158)). The oil should be protected against oxydation risks, increase of free fats and contamination by materials with which the oil is in contact.

Refined oil is more subject to oxydation than crude oil ; the same may be said of "moist" oil, thus, peanut oil with an 0,08 % water content undergoes an increase in fatty acid content from 0,3 to 0,9 % in 10 days (Iabst, 1957 (101)). The oil may be stored in stainless steel, lined steel or polyester tanks, and even under vacuum or in nitrogen.

5.2. Equipment in peanut oil mills

Because the treatment of peanuts is simple, the equipment used in peanut oil mills is that currently used ; and if necessary may be easily adapted to treat other seeds. However, cleaning, shelling and handling equipment is specially adapted to the treatment of peanuts (Garcia, 1976 (49) ; Colin, 1976 (34)).

A wide range of continuous presses are offered by the manufacturers, with capacities ranging from 5 to 460 tons per day. (Tindale and Hill-Haas, 1976 (139)). Many extracting agents are also available, both for percolation and immersion methods of extraction. Immersion machines are easier to operate than percolation machines (Milligan, 1976 (91)). There is also a wide and varied choice of filtering and refining material. Progress of the material in general may be characterised by an increase in treating capacity, development of means of control and by automatication (Colin, 1976 (34)).

Table 21 gives a list of the main manufacturers of material with the type of material proposed.

TABLE 21. MANUFACTURERS AND TYPES OF MATERIAL AVAILABLE

(This list is not exhaustive)

Manufacturers / Type of material	Cleaning Shelling	Cooking	Expellers	Extraction	Filtering Refining
Anderson C° Cleveland, USA			x		
Bauer Brothers C° Springfiels, USA	x				
Cambrian Engineering Croup Ltd Mississanga, Canada					x
Chemetron Corp. Louisville, USA					x
Crown Iron Works C° Minneapolis, USA				x	
Dammon Croes ALFA LAVAL Tumba, Sweden					x

TABLE 21. (Continuation...1.)

Manufacturers \ Type of material	Cleaning Shelling	Cooking	Expellers	Extraction	Filtering Refining
Dravo, Blawkurt Pittsburgh				x	
EMI Corp. Des Plaines, USA				x	x
Extraktionstechnik Hamburg, West Germany				x	x
French Oil Mill Piqua, USA			x	x	
Granazza, Italy Costruzioni Meccaniche Bernardini SpA - Rome				x	
Heinz Schumacher VDI				x	
HLS Ltd Israel				x	x
Krupp Mashinen Hamburg, West Germany			x	x	x
Lurgi Warmetechnik GmbH Frankfurt, West Germany				x	x

TABLE 21. (Continuation...2.)

Manufacturers / Type of material	Cleaning Shelling	Cooking	Expellers	Extraction	Filtering Refining
N.V. Extraction De Smet Edegein-Antwerpen, Belgium				x x	
Parkson Corp. Fort Lauderdale, USA					x
Simon Rosedowns Ltd Hull, UK			x	x	x
Speichim Paris, France			x	x	
Stork Amsterdam Amsterdam, Netherlands		x	x		
Wurster and Sauger Chicago, USA					x

5.3. Conditions required for the installation of a peanut oil mill

A distinction must be made between the conditions required for oil-mills in general which are given in publications issued by UNIDO (Schneider, 1974 (122) ; 1977 (183)), those concerning the peanut in particular and those which are related to the shelling procedure.

5.3.1. Positioning of the shelling installation

It is necessary to choose between rural shelling, which may be manual or non-industrial, industrial shelling as part of a plant, and shelling for an oil-mill. The points to be taken into consideration are : the amount of the initial outlay, the shelling output, the recovery of the shells, transport cost, use of storage capacity already existing and the drop in quality between in-shell peanuts and shelled peanuts.

5.3.2. General problems on the installation of an oil-mill

The destination of the oil to be produced is of primary importance. Depending on whether the oil is intented for consumption on the home market, or abroad, the layout of the plant must be designed very differently. As regards a choice of capacity, of technique between simple pressing and pressing and extraction combined, continuous or batch methods etc... These are not specific to the peanut and are covered by many written works.

Here it suffices to recall that continuous presses exist with capacities ranging from 5 tons per day to 460 tons per day, that solvent extractors are expensive and that their operation calls for specialised care by a trained operator. This type of apparatus does not appear worthwhile for an output of less than 100 tons per day, but as the output increases so the unitary processing cost price drops, this becomes very marked between 200 and 500 tons per day, above the figure the phenomena is less noticeable.

Continuous refining can only be considered for a daily production of more than 30 tons. In this case also the processing unit cost price drops noticeably when out put increases up to 150 tons per day ; and then diminishes up to 300 tons per day.

To make it possible to reach the tonnages given above, it should be remembered that trituration and refining can very well be polyvalent, that is to say that other seeds apart from peanuts may be treated. Complementary tonnage of this kind may improve the value of transport and storage, especially if the harvest of the other basic products is at a different time from that of peanuts.

5.4. Pollution and water problems in oil-mills

These problems are not specific to peanut oil-mills.

5.4.1. The problem of water in peanut oil-mills

In peanut oil-mills, water requirements for the production of one ton of oil are given in table 22.

The quantity of oil used, and therefore the quantity of water to be treated for pollution, may vary greatly depending on the refining installations and the quality of the oil treated.

TABLE 22. Consumption of water required for the various operations in peanut oil-mills (François, 1972 (48)).

Operations	water required for 1 ton of oil
1) Water for the treating systems	
- crushing	411 kg steam
- extraction	3.000 kg steam
- refining	210 kg steam
2) Water for condensers in extraction and refining	
- extraction	163 m^3
- refining	38 m^3
3) Refining effluent	1,35 m^3

5.4.2. Water pollution in oil-mills

Table 23 gives a summary of the various sources of pollution in oil-mills/refinery and solutions for treating the effluents.

TABLE 23. Summary of pollution problems in a traditional oil-mill/ refinery (Colin, 1976 (35)).

	Type of pollution	Solution for treating of water
Water of exchangers and surface condensers	Thermic	Closed circuit operation with cooling tower
Water of mixing condensers	Thermic and carry over of treated product	Closed circuit operation with cooling tower. The circuit includes a device to recover the picked-up product
Water used to wash floors, cooling of joints, gas washers, etc...	Thermic and carry-over	Filtering plant before evacuation
Acidified water decompositin of soapstocks	Thermic + carry over of fats + Free acidity + Dissolved organic matter (especially glycerol) + Various salts	Filtering plant Removal of fats Neutralisation Concentration or destruction of hydro-soluble organic matter.

The main sources of pollution are caused during refining of the product : desodorisation effluents (water from mixing condensers), in large quantities, and effluents from the decomposition of soapstocks with a high fat content.

Thus a 150 tons per day deodoriser with a steam washer consumes 250 to 300 m^3 water per hour, waste water contains 12 to 15 ppm fat, i.e. 12 to 15 g per m^3, i.e. an effluent of 108 kg per day. Where there is no steam washer, pollution by fat is 5 times more and evacuation may reach 500 to 600 kilos of fat a day (Choffel, 1974 (29)).

The soapstocks decomposition effluent is less. If we take the example of a refinery installation with a capacity of 150 tons per day, the soapstocks decomposition uses 4 m^3 per hour of water. The approximate composition of the effluents is given in Table 24 (Colin, 1976 (35)).

TABLE 24. Composition of the soapstocks decomposition effluents (Colin, 1976 (35)).

Fats with lecithine in various stages of emulsification	0,5 to 4 g.p.litre
Sulphuric acid	10 to 60 g.p.litre
Sulphate of soda	10 to 40 g.p.litre
Sodium chlorate	0 to 15 g.p.litre
Glycerol	3 to 10 g.p.litre
Sodium phosphate acid	0 to 10 g.p.litre
Presence of sugar and gum	

The temperature of these effluents is from 70°C to 95°C, the DCO (1) is between 7.000 to 30.000 mg per litre, and the DBO (2) between 5.000 to 20.000 mg per litre.

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(1) DCO : Demande chimique en oxygène (Chemical oxygen demand)

(2) DBO : Demande biologique en oxygène (Biological oxygen demand)

The recovery of oil-mill by-products (see chapter 7) makes it possible to reduce the pollution of evacuated water. The purification of used water is necessary all the same, especially as local regulations have become stricter concerning waste water.

Purification of used water should take the following into consideration :

- the fat content of the water
- surrounding acidity
- characteristics of water used (Choffel, 1974 (29)).

This operation is always based on gravity separation of the oily matter contained in the water. The acidity of the water sometimes makes neutralisation necessary to obtain a pH of about 7. In this case lime wash is usually used (Colin, 1976 (35)). The main purification processes are (Choffel, 1976 (30)) :

- lagunage
- aeroflotation (KURLINE SANDERSON process)
- electroflotation
- P.P.I. (Parallel Plate Interceptor) and TPI (Tilted Plate Interceptor) systems
- The VORTEX BERTIN system
- activated mud purification
- complete purification with filtering.

Attempts at biological purification have been made on acid water from the soapstock treatment (Colin, 1976 (35)).

All purification processes are expensive ; any definition of a solution for water pollution problems, must take local conditions into consideration.

5.4.3. Air pollution

Air pollution is caused by two main sources : dust and exhaust gases.

Dust comes mainly from the treatment of the nuts and mealcake.

Exhaust gas comes mainly from pressing, especially from extraction.

The elimination of dust may be carried out by using dust filters. Combined dust and greasy vapour may bubble in gas washers, the effluent of which is treated with the other waste water (Colin, 1976 (35)).

Catalytic combustion of exhaust gases has also been attempted (Christner, 1971 (31)).

Special attention should be given to the recuperation of solvents, for which a certain number of apparatus are available.(Milligan, 1976 (91)).

Dust and solvent steam should be controlled all the more carefully, as their presence presents a risk of explosion or fire.

6 - PEANUT CAKE

6.1. Characteristics of peanut cake

6.1.1. Composition

The average composition of peanut cake is given in table 25.

The total composition of the cakes obviously varies according to the type of raw material nuts, but also according to the process used to obtain the cake, as may be seen in tables 25 and 26.

TABLE 25. Main analytic characteristics of certain cakes (in %) (Vachel, 1970 (144)).

Category of cake	Name	raw nitrogeneous matter (protein)	fatty matter	Crude cellulose	Phophorus	Calcium
	Peanut (with oil)	46 / 50	4/8	5 / 10	0,6/0,8	0,12/0,15
	Peanut (deoiled)	50 / 54	0,5 - 1	5 / 12	0,6/0,8	0,12/0,15
	Cotton (deoiled)	38 / 44	0,5 - 1	9 / 15	1,1/1,2	0,25
ich in raw rotein	"44" Soya	40 / 47	0,5	6 / 9	0,6	0,25-0,20
	"50" Soya (skinned)	48 / 51	0,5	2,5 / 4,5	0,6	0,25-0,30
	Sesame (deoiled)	45 / 47	2 - 2,5	7 / 8	1,1/1,2	20
	Sunflower (Shelled, deoiled)	28 / 45	0,5 - 1	8 / 16	1,1/1,2	0,2 / 0,2
	Colza (deoiled)	33 / 37	0,5 - 2	10 / 15	0,7/0,8	0,2 / 0,2
ntermedia- content n raw rotein	Linseed (with oil)	23 / 24	3/8	7 / 12	0,8	0,4
	Linseed (deoiled)	20 / 25	0,5 - 1	7 / 12	0,8	0,4
	Sunflower (partly shelled deoiled)	25 / 28	0,5 - 1	16 / 20	1,2/1,4	0,2 / 0,3
	Coconut (deoiled)	20 / 22	0,5 - 2	10 / 12	0,6/0,7	0,2 / 0,3
oor in raw rotein	Corn	14 / 17	2/4	5 / 7		
	Palm (deoiled)	20 / 21	0,5 - 2	8 / 12	0,5/0,6	0,4

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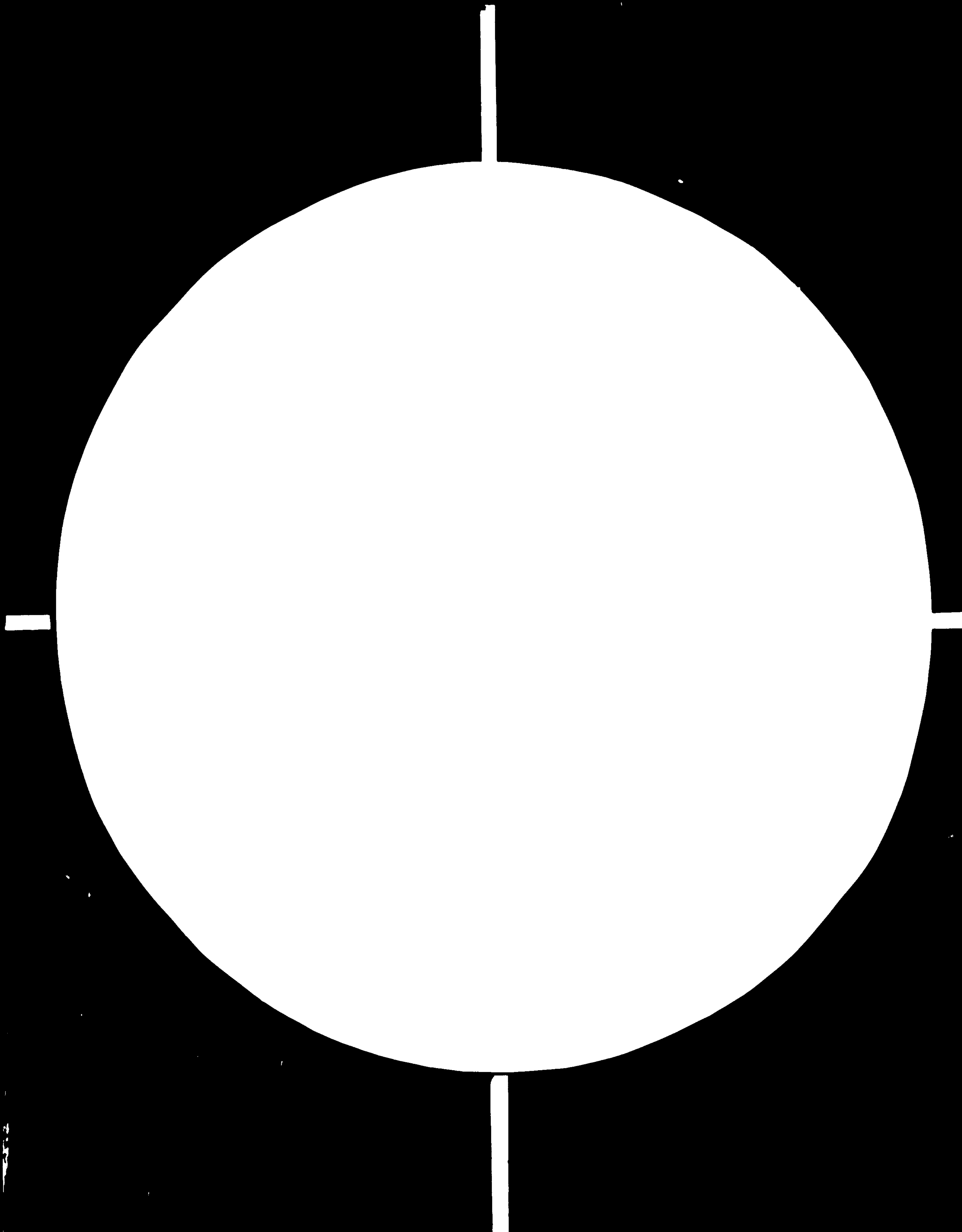

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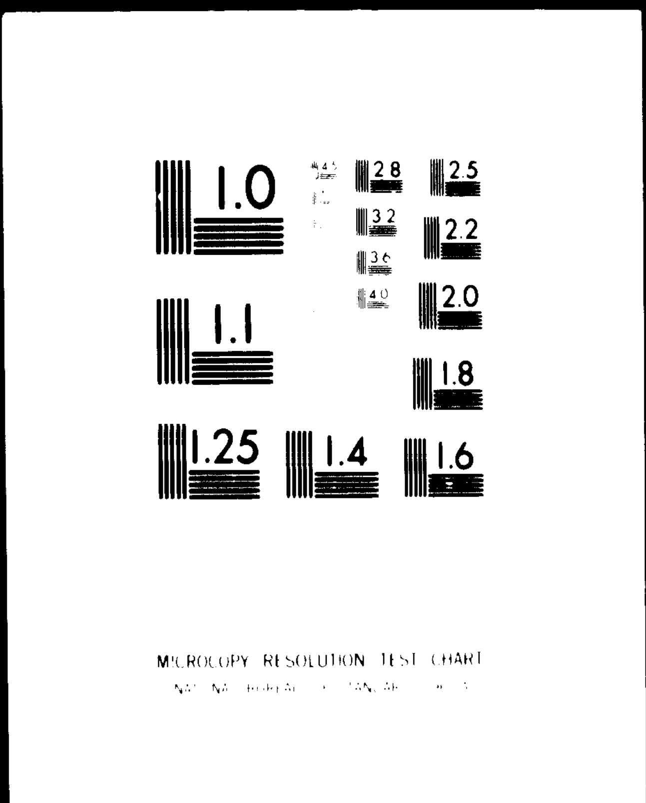

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TABLE 26. Composition characteristics of cakes according to type of preparation (Adrian and Jacquot, 1968 (4)).

TYPE	Method of preparation	Composition in fresh matter				
		Moisture	Protein	Lipids	Cellulose	Ash
Fibrous cake	Contains 65 % shell	10,5	20,5	4,5	30,0	4,1
Pressure cake	Slightly shelled	10	30,0	11,0	19,5	7,1
	Shelled	10	47,5	8,0	4,5	4,1
Meal (fine fleur flower)	Pressure cake sifted	4,5	59,0	9,5	2,5	3,8
Extraction cake	Slightly shelled	7,5	32,0	2,0	25,5	4,3
	Shelled	8,0	52,5	0,8	7,0	4,2

Cleaning and shelling, depending on whether they are effectively operated or not, can cause considerable variations in the cellulose content of the cake (see table 26).

Cooking conditions (temperature and moisture content) before extraction of the oil can affect the solubility and distribution of the proteins, in particular the lysin, although this action is only slightly noticeable in the case of peanuts (Vachel, 1970 (114) ; Adrian and Carroget, 1976 (3)). The acidity of the residual oil in the cake increases with the cooking temperature (Defromont, 1964 (39)).

There is no very great difference between expeller and extractor cake, the oil content of the former is higher : 3 to 8 % as against 0,5 to 1 % for extractor cake. However, the type of solvent used for extraction can alter the total composition and that of the protein contained in the cake (Defromont and Delahaye, 1961 (40)).

Table 25 shows clearly that peanut cake is the richest in protein of all oil-seed cakes. However the nutritive qualities of the cake depend not only on the protein content, but also on the aminated acid composition of these proteins.

Table 27 gives a comparison between the amino acid content of peanut cake and that of the other principal oil-seed cakes.

TABLE 27. Amino Acid content of various cakes (in g. for 16 gN) - (186)

Amino acids	Peanut	Soya	Sunflower	Colza	Lin	Coconut
aspartic Ac.	11,8	11,7	8,9	7.15	9,9	7.7
Thréonin	2.75	4.05	3.65	4.65	3,9	3.0
Sérin	5,1	5,1	4,35	4.45	5.1	4,25
glutamic Ac.	19,6	18,6	21.05	18 7	20,9	19,2
Prolin	4,6	5,35	4,20	6,35	3,85	3.4
Glycin	5,7	4,4	5,7	[illegible]	6.15	4,2
Alanin	4,1	4,55	4,3	4,95	4.75	4.1
Valin	4,8	5,5	5,7	5,6	5.5	5.45
Isoleucin	3,8	5,1	4.65	4,2	4.6	3.5
Leucin	6,5	7,9	6,25	6.95	6.1	6.2
Tyrosin	4,4	4,0	2,8	3,2	2.65	2.45
Phénylalanin	5,5	5,4	4,8	4.0	5 05	4.25
Méthionin	1,1	1,3	2,2	2.15	1,9	1,3
Cystin	1.4	1,6	1,95	2,85	2.1	1,65
Lysin	3.4	6.6	3,6	5,2	3,9	2,8
Histidin	2,35	2,75	2,5	2,55	2.1	1,85
Arginin	11,4	7,6	8,5	5,9	9,6	11,8

6.1.2. Contamination - Aflatoxin.
(see chap. 1 also)

The main contamination risk, as for the nuts themselves, is that produced by aflatoxin. This is due to the initial contamination of the kernels, but even more to subsequent recontamination during the various processes (Moreau, 1977 (94)). It is therefore sometimes necessary to decontaminate the cake.

6.2. Treatment of peanut cake

The various processes applied to peanut cake before use in animal feed as given below.

6.2.1. Agglomeration to form pellets

The cakes are heated to 80 - 90°C before being formed into pellets in channelled presses producing granules which are cooled before storage. The floury residue of this agglomeration operation is recycled. The production of pellets is energy consuming and requires relatively expensive material. However, it presents a certain number of advantages which explain its development over the last few years. These advantages are :

- an improved quality of the product, in particular a regular moisture distribution.

- an improvment in subsequent storage and handling operation ; improved disposal, reduction of dust ; and hence reduced explosion risk ; a 10 to 20 % reduction in volume.

- the possibility and facility of incorporating the granules into a certain number of oil industry by-products : mucilage and soapstock.

- reduction of fungi pollution (Moreau, 1977 (94)).

6.2.2. Detoxification of peanut cake

Fungi contamination of the cake may be high enough to necessitate decontamination. Two methods are used (Prévot, 1974 (107) and 1976 (108)) :

- solvent extraction of the aflatoxin : industrial results are disappointing, but the nutritive quality of the cake seems to be only very slightly affected,

- blocking of the functional aflatoxin group with strong alcali (soda, sodium carbonate, methylamin or ammonia) or by other compositions such as oxydising agents (ozone, peroxide, biological oxydation) or aldehydes.

Oxydation treatment has given only mediocre results on peanut cake (Guilbot and Jemmali, 1975 (58)).

Treatment by ammonia gas appears to have the brightest future, and to be the best at present (Moreau, 1977 (94)), whether it is used during the production of pellets or during storage (Thiesen, 1977 (136)). However, a modification in the amino acid composition of the cake is apparent : the lysin content remains unchanged, but the cystin is, for a large part, destroyed. Nutritional tests do not, however, show any change in the protein efficiency of peanut cake (Prévot, 1976 (108) ; Adrian, 1976 (3)).

6.2.3. Storing peanut cake

During storing, the cakes may undergo certain changes : oxydation (rancidity) of the residual oil, hydrolysis of the various ingredients, fermentation of glucides, and insect infestation.

For the best preservation during storage, the conditions required are (Lefromont and Delahaye, 1961 (40)) : storage in bags at a temperature of 20°C with an atmosphere moisture content of 60 to 70 %, which corresponds to a moisture content in the cakes of less than 12 %.

The presence of dust and possibly that of residual solvent causes explosion and combustion risks (Uzzan, 1969 (143)) which are increased if the bulk of cake becomes heated due to the alteration action.

Storehouses must be kept quite clean and disinfected.

6.3. Use of cake

6.3.1. Use in live-stock feed

It is mainly in cattle feed and human consumption that peanut cake finds an outlet and its maximum value (its use for human consumption is covered in chapter 5). Its main quality is its high protein content.

For livestock feed peanut cake has several drawbacks. For one thing the quality of the protein is less than that of soya, sunflower seed or colza cake for instance, or than that of fish flour.

Compared with eggs, its lysin content, which is of importance in the case of growing animals, is lower by about 40 %, and its methionin and cystin by about 25 % . For another thing, its cellulose content (5 to 10 %) is relatively high, especially compared with shelled soya (see table 25). Moreover, the mineral and vitamin contents of peanut cake are low.

The presence of aflatoxin is the main limitation. Legislation has been made to limit the quantities of aflatoxin in live-stock feed. As an example, table 28 gives the maximum aflatoxin content permitted in animal food in the E.E.C.

TABLE 28. Maximum aflatoxin content in animal food in E.E.C. Countries
(Law of 19th July, 1976, appearing in the "Journal officiel" of the French Republic on 20th August 1976, which officially stipulates the Community instructions concerning maximum aflatoxin content, in particular B1)

Foodstuffs	Maximum content in mg/kg of foodstuffs (ppm) related to a moisture content of 12 %
Complete feed for livestock (apart for milch cattle, calves, and lambs)	0,05
Complete feed for pork and fowls (except for young animals)	0,02
Other complete feed	0,01
Supplementary feed for milch cattle	0,02

According to the various types of livestock, peanut cake can be used either as a supplement ot to increase the quality of cake supplied (Adrian and Jacquot, 1968 (4)). For fowls, peanut cake may be used to supply half the protein requirement ; the complement being supplied by cereals or protein of animal origin (Rathoré and Chaturvedi, 1971 (112), the limiting factor here being the lack in lysin and methionin, and to a lesser degree, the slightly lower energy value than that of soya cake.

For pork, also, peanut cake may also be used to supply part of the protein requirements.

In the case of ruminants, the lack of lysin and methionin do not appear to present any major drawbacks. The presence of aflatoxin does not appear to be a problem, except in the case of milch cows, as their milk may be contaminated.

6.3.2. Other uses of peanut cake

Peanut cake is used, but in only limited quantities, for various utilisations (Archambaud, 1964 (8)).

Using protein extracted from the cake, glue is produced for board, or nutritive "milieu" for the reproduction of antibiotics.

In many countries peanut cake is used as an organic amendment or for fertilizer.

7 - PEANUT BY-PRODUCTS APART FROM PEANUT CAKE

7.1. Peanut shells

7.1.1. Characteristics of peanut shells

The composition of peanut shells is fairly variable. All contain a high content of woody matter and carbohydrates (table 29).

Recovery of this by-product should not be neglected as alone it forms 20 to 30 % of the initial product.

7.1.2. Direct uses

7.1.2.1. Fuel

In spite of a calorific value 40 % less than that of fuel oil, shells are used mainly as industrial fuel in oil-mills processing in-shell nuts. The calorific output of the boilers is considerably less (about 10 %) than those using fuel oil : moreover, it is necessary to have boilers adapted to this type of fuel to avoid deposits of ash and silica on the heating surfaces, and with an effective system of ash evacuation.

In non-coal producing countries, the shells may be compressed into cylindrical blocks with a density of about 0,7/0,8 , which can be sold as household fuel. Through another process, the shells are burnt to obtain charcoal which can be compressed and sold in blocks.

By means of gaseification of the shells, it is possible to obtain a gas of low calorific value : 1.360 to 1.400 cal.

TABLE 29. Biochemical composition of peanut shells
(Adrian and Jacouot, 1968 (4)).

	TYPES OF PEANUT			
	Spanish	Virginia	Others	
in g. per cent				
Moisture	9,3	4,4	9,0-12,0	
Protein	4,8	5,6	5,0- 9,5	6,7
Lipids	1,3	2,8	1,2- 4,0	1,2
Non-nitrogenous extract			11,0-24,0	19,7
Hydrolysable sugars	13,2	9,4		
Cellulose	67,4	74,3	58,0-79,0	60,3
Ashes	2,2	1,9	2,8- 6,8	4,5
in mg. per cent				
Calcium	129	127	320	
Phosphorous	52	39	70	
Ca/P	2,5	3,25	4,55	
Iron	8,3	2,8	4,0	
Potassium			950	
Sulphur			60	
Copper			4,5	

7.1.2.2. Drilling mud

Another secondary use is the mixing of shells with various products to produce drilling mud.

7.1.2.3. Feed for livestock

After grinding, the shells may be mixed into feed for ruminants ; the energy giving value is, however, low, and the shells are used mainly to provide roughage (Utley and al., 1973 (142) ; Boza and al., 1969 (22)).

7.1.2.4. Fertilizer

The shells, either natural or in compost form may be incorporated in the soil to provide a considerable increase in the organic matter content. They also serve to improve the structure and increase the moisture retention of the soil.

7.1.2.5. Agglomerate boards

Mention should also be made of the manufacture of agglomerate board. After grinding, drying and the addition of gum, a product inferior in quality to that made with wood may be obtained.

7.1.3. Indirect uses (François, 1964 (47)).

7.1.3.1. Manufacture of furfural

The pertosan contained in the shells make it possible, after hydrolytic cleavage, to obtain furfural. This is produced on a large scale in the U.S.A., using oat straw, with an excellent output, peanut shells therefore do not appear to be competitive in this field.

7.1.3.2. Cellulose extraction

It is also possible to extract cellulose with soda or sulphite.

All these uses except for those concerning manure or live-stock feed, require extensive industrial equipment, the cost of which is rarely justifiable. For this reason, the only use which has been widely developed, is that of fuel.

7.2. Peanut skins

The skins of peanuts may also be used in cattle feed in place of wheat bran. Cattle feed with peanut skins is inclined to be more indigestible. This effect is less noticeable in the case of ruminants, for whom this by-product may be used in feed (Adrian and Jacquot, 1968 (4)). Chemical processing, in particular, the action of hypochlorite, improves digestibility (Barton and al., 1974 (11)).

7.3. Soapstock

This is the residue coming from the neutralisation of oil (see chap. 5). The average composition of soapstock is given by Thurman (137) :

- neutralised oil		18,7 %
- soda soap		26 %
- water		45,6 %
- non-glyceridic matter		8,95 %
- total fats	more than	40 %

7.3.1. Recuperation of neutralised oil

Recovery of neutralised oil, seeing the quantity contained in the soapstock, is worthwhile, even though difficult. It is carried out only on soapstock produced by batch processes. The main problem is the fact that the mixture forms an oil-type emulsion in water, stabilised by viscous matter. Two methods of separation exist.

1) - Decanting : the mixture, after addition of brine, is brought up to boiling point. It is left to decant and the oil is collected on the surface. The output is not very high, and the oil obtained is coloured.

2) - Centrifuging : after disolving in salt water (at 10° be), the mixture is heated to about 60°C, homogenised and centrifuged. The centrifuging force being stronger than the force used for decanting makes it possible to recover 60 % of the soapstock oil.

7.3.2. Recovery of soaps

Use of soapstock in its original form produces poor quality soap. Usually, the remaining oil is saponified and then washed in salt water and clear water after salting out.

Soap obtained from peanuts is soft (due to its content of unsaturated fatty acid). It is therefore necessary to make it harder by adding tallow, coconut or palm oil.

7.3.3. Recovery of fatty acids

The most frequent valorization of soapstock is the recovery of fatty acids.

After total autoclave saponification, the soapstock is hydrolysed with sulphuric acid (Colin, 1976 (35)). Foreign matter is removed by coagulation, and the fatty acids are recovered. At present it is possible to recover up to 96 % of the fatty acids (Svenson, 1976 (134)). The firms Sharps and Alfa-Laval have developed a process to carry out both operations continuously. The hydrolysis of the soapstock in an autoclave can also be carried out under a pressure of about 30 kg. By this method even the phospholipids are destroyed. The result of these various operations is a product containing a major part of acids, known as crude fatty acids, foreign matter and glycerides. The crude fatty acids can be sold as they are. But it is sometimes necessary to distill the fatty acids. The residual matter is again subjected to autoclave treatment.

All these transformations of the soapstock call for a fairly high initial outlay, which means that the cost price is also relatively high.

The choice of the type of recovery to be applied to the soapstock depends firstly, on the existence of a soap-works, and on the quality of soap produced. Local regulations concerning evecuated water must also be taken into consideration. To obtain the best value for distilled fatty acids they should be sold at the price of good quality tallow ; the price of tallow should therefore also be considered.

It should be noted that in some countries, it is possible to reincorporate soapstock in peanut cake.

7.4. Use of bleaching soil

The oil content of used bleaching soil varies. It depends on the soil selected and on the recovery method used. The cakes usually retain from 20 to 60 % of their weight of oil.

There is a considerable risk of spontaneous combustion in the soil, and a change, particularly oxydation, may occur in the oil. The recovery of the oil should therefore be carried out rapidly. It may be recovered during filtering with hot water or solvent extraction. When the soil is treated in a separate workshop, solvent extraction may be used or autoclave extraction in the presence of a tensio-active agent (Svensson, 1976 (134)).

As very small quantities of bleaching soil are used in treating peanut oil, autoclave recovery methods are usually selected. The recovered oil is then used in soap-works, either for cattle feed or for producing fatty acids.

7.5. Other oil-mill by-products

7.5.1. Mucilage

Mucilage may be recovered, but it has a dark colour and contains much degraded and oxydised matter. It is therefore not competitive with soya mucilage.

7.5.2. Deodorisation by-products

The neutralised oil carried over, if of good quality may be recycled as crude oil. If it is degraded it is used in cattle feed (Svensson, 1976 (134)).

The distillate from deodorisation represents between 0,1 to 0,3 % of the oil produced. It contains free fatty acids, oxydised acids, aldehyde and a large proportion of unsaponifiable matter including sterol which may be recovered.

The best use is in the addition of the distillate to fuel oil for use as fuel. Another possibility is its use in cattle feed (Svensson, 1976 (134) ; Kehse, 1976 (69)).

This type of recovery is not specific to peanut oil however.

7.6. Use of the peanut plant

The leaves (Kumar and Sampath, 1974 (73)), and the whole plant (Prine, 1973 (110)) of the peanut can be used most successfully as fodder.

8.1. World production

As result of an annual harvesting mainly in areas of the world which have a very irregular rainfall , the peanut production is therefore subject to fluctuations which vary from year to year. These fluctuations can reach 100 %.

Moreover, as the peanut culture usually forms an important part of the national income for the producing country, both culture and trade are subject to political and economical interventions which, in many cases accentuate these fluctuations.

The production of the main peanut producing countries for the period 1970 to 1976 is shown in table 30.

TABLE 30. Production of the main peanut producing countries over the period 1970 - 1976

Country	1970	1971	1972	1973	1974	1975	1976
India	6.111	6.181	4.092	5.932	5.111	6.991	5.700
China	2.772	2.678	2.494	2.698	2.794	2.891	2.889
U.S.A.	1.351	1.363	1.485	1.576	1.664	1.750	1.701
Sudan	337	394	568	635	930	931	980
Senegal	583	988	587	675	1.006	1.476	1.192
Indonesia	468	473	470	505	512	550	550
Brazil	928	945	956	590	439	441	514
Burma	529	502	391	412	467	517	520
Argentina	235	388	252	440	290	375	338
World total	18.428	19.275	15.948	17.085	17.378	19.598	18.495

Unit : 1.000 t. in-shell peanuts   Source : Food and Agricultural Organisation (175, 170).

8.2. Position of the peanut compared with other oil-seeds

As regards quantity production of oi-seeds, the peanut comes third in line after the soya bean and cotton seed, and ahead of the sunflower seed, colza and the other oil-producing fruits and seeds (Table 31).

TABLE 31. Comparison of world-wide production of various oil-seeds over the period 1970 to 1976

Oil seed	1970	1971	1972	1973	1974	1975	1976
Soya bean	46,5	48,5	52,3	62,3	56,9	68,9	62,1
Cotton seed	22,1	23,5	24,7	24,9	25,9	22,9	23,6
Peanut	18,4	19,2	15,9	17,0	17,3	19,6	18,5
Sunflower seed	9,9	9,7	9,5	12,0	10,9	9,4	10,0
Colza	6,7	8,1	6,8	7,1	7,2	8,4	7,5
Coconut	3,6	3,9	4,4	3,7	3,6	4,5	4,9
Linseed	4,1	2,8	2,5	2,4	2,3	2,5	2,5
Sesame	2,2	2,0	1,9	1,9	1,9	1,9	2,0

Unit : millions of tons

Source : Food and Agricultural Organisation (175 ; 170)

Peanut production has decreased regularly over the last few years partly because of poor crops, but mainly due to considerable development of the soya bean. In 1970, peanut production represented 16 % of world oil-seed and fruit production, whereas in 1975 it had dropped to 10,9 %.

The value of oil seeds depends almost entirely on their oil content and the protein count of the cake after trituration. Each oil has its particular characteristics both regarding composition and employment, as has been described in the preceding chapters. Table 32 gives a comparison of the protein and oil content of the main oil seeds, showing that the peanut contains a high oil content and also a considerable protein content.

TABLE 32. Comparison between the peanut and the other main oil seeds as regards oil and protein content (Gattil, 1974 (87)).

Oil seed	Oil %	Protein %
Soya bean	20	42
Cotton seed	19	21
Shelled peanuts	46	19
Sunflower	39,6	13,6
Colza	51	20
Sesame	50	25
Coconut	69	7,4

8.3. Foreign Trade

International trade covers only a fraction of the total tonnage produced (5 %), firstly because of a large home consumption in some producing countries such as India and China, and secondly because an increasingly large proportion of the production is converted directly into oil at the place of production.

Trade in nuts for trituration nearly always concerns shelled nuts, as is the case for edible peanuts exported by certain countries such as the U.S.A., India and China.

The main import and export flow for the period 1971 to 1976 is shown in table 33 hereafter.

TABLE 33. World Trade of the peanut during the period 1970 - 1976

	1970	1971	1972	1973	1974	1975	1976
Total Exports	993.189	867.216	907.978	949.880	847.340	872.529	995.039
- Cameroun	13.373	6.964	4.793	16.508	23.279	18.115	6.680
- Gambia	38.123	31.069	43.415	27.383	42.859	52.765	51.640
- Malawi	22.511	29.190	35.704	27.380	20,653	25.814	26.050
- Niger	131.877	93.333	92.720	41.657	7.305	2.451	5.000
- Nigeria	291.177	136.534	106.155	198.658	30.350	2.000	1.600
- Senegal	51.447	32.540	13.935	3.379	9.917	9.484	126.540
South Africa	70.303	72.104	45.611	52.692	40.000	60.000	30.000
- Sudan	63.923	117.006	109.350	136.242	128.398	202.940	250.000
- U.S.A.	48.756	108.062	187.605	186.140	254.848	240.796	129.754
- Brazil	53.473	35.666	55.923	54.285	50.610	53.417	20.814
- China	16.605	21.338	40.152	34.410	28.122	22.700	29.600
- India	25.830	28.482	25.320	30.604	88.213	69.964	170.000
- Indonesia	26.631	20.881	12.981	21.030	11.055	7.075	2.271
Total Imports	1.051.415	866.706	850.323	962.441	861.121	858.084	1.019.256
- Canada	49.047	51.373	52.559	59.952	59.338	60.379	61.587
- Japan	58.848	52.382	62.320	76.324	52.652	51.247	71.096
- Czechoslovakia	19.084	18.443	20.283	16.987	17.139	14.410	13.946
- France	314.408	224.479	145.454	242.871	236.930	199.260	256.612
- West Germany	89.163	66.440	54.149	69.924	57.062	53.486	52.950
- Italy	116.885	104.680	105.693	94.315	79.385	76.038	99.327
- Netherlands	42.464	40.200	48.397	47.758	46.619	55.274	63.279
- Portugal	48.014	42.810	71.790	51.911	43.517	61.487	73.410
- Spain	26.726	27.603	27.611	24.761	16.442	19.712	21.753
- Switzerland	80.888	57.165	55.899	65.718	45.042	50.049	50.809
- Great Britain	61.567	50.231	63.276	74.020	64.931	71.688	82.765

Unit : tons

Source : Food and Agricultural Organisation (171, 177).

Of the importing countries only France, Italy and Portugal play a large part in the importing of peanuts for trituration. France is the world's largest importer due to the marked preference of the french consumer for peanut oil.

8.4. Prices on the world market

Usually, the market price of peanuts is higher than that of other oilseeds coming from tropical or temperate countries, as it is a raw material much appreciated for the reasons already given above, and which are : high oil content 45 to 50 %, easy to triturate ; the oil is easy to refine and treat ; it contains a number qualities which are not to be found united in rival oils : stability, flavour, resistance to high temperature, etc.. (see chap.4).

The influence of traditional and privileged trade between African producers and European consumers also plays an important role. Large companies own trituration installations at the place of production and with the producers concerned they devote much attention to the promotion of peanuts products.

The price of trituration peanuts is therefore dependant on the market supply, and the market price rate which in turn depends on the rates of oilseeds and competitive oils, in particular those of the soya bean which influences all the oil seed price rates. The number of organisations involved on this market are few.

For the producers, commercialization is either controlled by a Board-type State monopoly in African countries, or by very strict regulations in countries such as the U.S.A. or Argentina (Ames, 1975 (7)).

Buyers of peanuts for trituration are also very few and consist of large firms suc as Lesieur, Unilever, Astra-Calvé, and Unipol who own factories at the place of production.

Hence large transactions are carried out which often reach several thousands of tons and the quotations of which, given in U.S. $ per ton CI.F. European port, provide the basis for the world market rate.

Because of the few operators, fairly long delays, several weeks may occur between transactions, and therefore between quotations.

The annual average rates of product imported into Europe are given in Table 34. The prices given are C.I.F. Rotterdam, U.S.$ per ton of shelled peanuts.

TABLE 34. Average peanut rate (1970 - 1976)

Year	1970	1971	1972	1973	1974	1975	1976
From Nigeria	229	256	263	372	603	459	417
From the Sudan	215	252	320	349	558		495
From Cameroun Dahomey	222	257		386	588	455	437

Unit : US $ per ton

Source : Food and Agricultural Organisation (170)

8.5. Transport Costs

Transport costs greatly influence the final price of peanuts, as they can amount to 10 % or even 20 % of the C.I.F. price. Because of the quantities concerned, transport is carried out by sea, either in the traditional manner in bulk in the hold or in containers.

The main exporting countries are the Sudan, India, the U.S.A. and South Africa, and the prices of these different countries reflect the influence of the distance on freight costs.

Table 35 groups the items for calculating the cost of a shipment by sea from these different countries to a destination in Northern Europe : Hamburg, Rotterdam, Antwerp, le Havre. These are the "Conférence" (1) prices at present in force and given in US $ per ton of shelled peanuts. It should be noted that by a collective grouping of the product to be exported, so as to load a ship of over 10.000 tons, it is possible to obtain a reduced freight rate of about 20 $ per ton.

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(1) "Conférence" is the name given to the group of Merchant Navy Companies following the same regular sea transport lines. For instance, there exists two "Conférences" between the East Coast of the U.S.A. and the ports of North Europe; sea traffic is thus shared between a certain number of "Conférences". The members of which agree to practice the same freight price rates.

TABLE 35. Cost of shipment by sea to WestEuropean Ports

Country	Port of loading	Packaging	Basic freight charges US$/t.	Various adjustments(1)	Total cost US $ (2) / ton
Sudan	Sudanese port	bulk	42,20	32,5 %	59,69
India	Bombay	containers	52,65	41,14 %	77,08
	Outside Bombay	containers	52,65	33,64 %	71,70
U.S.A (East)	Savannah	containers	67,42	13,00 %	79,69
U.S.A (West)	Los Angeles	containers	134,65	7,00 %	152,00
South Africa	Cape Town	containers	56,07	5,37 $/ton	61,44
Senegal	Dakar	bulk	19,00		27,00

Sources : - Compagnie Générale Maritime, Tour Winterthur, Paris La Défense

- United States Lines, 2, rue de Penthièvre, 75008 Paris
- Barry Rogliano Salles, Courtier maritime, 37, rue Caumartin, 75009 Paris.

(1) These cover currency adjustments, and possible additional harbour tax charges

(2) Including loading and unloading costs.

8.6. Means of transport

Means of transport differ according to the quantities of product transported and to the methods usually employed by the producer.

For small quantities consisting of a few dozen tons, containers 6 or 12 metres in length may be used, which represent useable volume of 27 or 54 m^3, i.e. 9 to 18 tons of product. The nuts are packed in sacks and loaded, at the place of production, into the containers which are not opened until they reach their destination. All transport handling operations, during land transportation up to the port of embarkation, loading on board, unloading and delivery by rail or road, are thus limited to simple handling of the containers.

The rates given in table 34 do not include these preliminary transport operations.

For quantities of several hundred tons, the nuts packed into bags can be placed directly into the holds of the ships.

Finally, for quantities of over several thousand or several tens thousand tons, sa small ship is usually freighted or several holds of a large ship. This type of loading is that generally used, in particular from African Countries : The Sudan, the Senegal, the Ivory Coast and South Africa. The nuts are shipped in bulk in specially fitted out holds. Loading on board and unloading are carried out by hoist conveyors specially designed for this type of product (nuts, peanut cake, etc...). These machines have the advantage of cutting out labour requirements and of providing rapid transport (Barolet, 1975(10)).

8.7. Exporting peanuts and local trituration

Usually, an economic survey shows the advantage of placing transformation industries as near as possible to the area producing the raw material, so that transport costs may be applied to products which have already obtained a certain additional value. Large companies practiced this policy for many years, placing their factories in the producing countries. The advantages of this policy are obvious. In emergent countries, the cost of labour was low and the fact that the oil mills held a practical monopoly meant that buying could be done in the best conditions.

Today, however, the factories no longer control buying prices. Since their independance, many African States have decided to dispose of this raw material which often forms a large part of their ressources. For this reason they have created commercial administration which manage all movements of the nuts. Local factories are not necessarily supplied at preferential prices. When large interests are at stake, the Government can take a share in transformation and commercialisation, as is the case in the Senegal where the oil mills are merely transformers operating on behalf of SONACOS, a semi-public organisation which is in charge of the sale of all transformed peanut products. In this case, the national interest calls for the greatest saturation possible of all transformation equipment available. Under such conditions, trituration at the place of consumption becomes more valid for European firms, who can work their machines regularly throughout the year due to the wide time span of supply.

8.8. Commercialisation on the home market

Commercialisation of the peanut is influenced by certain characteristics specific to this product.

Apart from the United States, where the peanut is cultivated on a wide scale, peanut production is usually based on wide spread family farming. In the Senegal, for instance, the size of plots of land is between 1 and 4 ha. with an output of between 0,5 to 2 tons of nuts per ha.

The farmer does not usually have his own storage or transport facilities, and therefore has to call on an outside collecting organisation. In-shell peanuts are very space concuming, operations call for a fairly extensive organising environment. Before the creation of commercialisation auhtorities, this was provided by the oil-mills. At present, the administration organises co-ordination at all levels : management of the producer, collection of product, storage and sale to oil_mills or export. All these operations are controlled by regulations which in particular fix the payment of middlemen.

Each year the buying price of "bord de champ" peanut is fixed by the State, taking into consideration the various factors of local agricultural economy : salaries given to the farmers by rival cultures, encouragement or disencouragement of the culture of peanuts etc.. These decisions are usually taken at the top level, ministerial or even presidential.
In the United States, the USDA, has direct influence on fixing the production price (Ames, 1975 (7)).

8.9. Commercialisation abroad

Export of peanut kernels is either carried out directly by the State and its commercialisation authority, or left to private enterprise, in the latter it is subject to very strict laws. In India and China for instance, the export of nuts is prohibited except for edible peanuts. World trade is thus closely controlled. Few organisations are involved : exporting companies, the large trituration companies, wholesale merchants and brokers.

Wholesale merchants act as financiers adopting the position of buyers or sellers according to their financial interests, they are few. Brokers are even fewer, as there are only three important broker at the international level. They have the role of advisors to buyers and sellers, and act as wholesale merchants in transactions.

The various State controlled organisations use different commercial supports in the sale of their product. Some go through the international merchants, others, considering that the small number of clients enables a reduction in the number of middlemen carry out transactions direct through brokers.

Trituration peanuts are sold in large quantities of several thousand tons, and the commercialisation authorities usually prefer to make the final decisions.

9 - THE PEANUT OIL MARKET

9.1. World production and international Trade

Peanut oil is produced, for a large part, in the countries producing the nuts themselves and to satisfy the demands of the home market. Production is often non-industrial, and the oil sold as crude oil, whose flavour is appreciated by local consumers. This oil is not exported in spite of the additional price offered on the international market, as the collection of this product is difficult, the local population is accustomed to its consumption, and importing substitute oils is expensive. Thus India, the largest worl producer, consumes its entire production, about 2,3 litres each year per inhabitant.

The production of the main countries is given in table 36 for the period of 1972 - 1976.

World trade concerns less than 20 % of the total production and only a small number of countries export their oil : the first ten exporting countries provide 85 % of the international oil trade, and the Senegal dominates the market, supplying 30 to 40 % of the quantities concerned. An examination of the production and trade tables will show the extent of annual fluctuations, following variations in quantities harvested : Nigeria, for instance, who held second place among the exporting countries, barely satisfied the demands of the home market in 1976, and the tonnage exported by the Senegal produces sometimes three times as much one year as another.

Amongst all the importing countries, France holds first place, with an annual demand of between 150.000 and 200.000 tons, which represents about 40 % of the total demand. France imports mainly from the Senegal, where many large companies have oil-mills. The European Community buys about 75 % of the tonnage available on the world market.

In table 37 the development of the oil trade during the period 1970 - 1976 is given.

TABLE 36. World production 1972 - 1976 of peanut oil

	1972	1973	1974	1975	1976
World production	2.958	2.501	2.508	2.565	3.111
- U.S.A.	120	126	88	107	221
- Argentina	62	90	67	50	52
- Brazil	131	79	44	46	81
- Niger	24	34	21	27	13
- Nigeria	92	140	61	29	43
- Senegal	214	167	148	192	258
- South Africa	61	56	41	72	50
- Sudan	44	53	45	44	88
- China	398	377	407	421	424
- India	1.354	949	1.131	1.116	1.409
- France	68	84	114	102	90
- Italy	43	33	29	37	37
- Switzerland	24	24	22	17	18

Unit : 1.000 tons

Source : Oil World Information Service for Statistical Analysis of the World Market of Oil Seeds, Oil Meals, Vegetable, Animal, and Marine Oils and Fats. Ista-Mielke and C°, 2100 Hambourg 90 - POB 900803 - R.F.A.

TABLE 37. World trade of peanut oil (1970 - 1976)

	1970	1971	1972	1973	1974	1975	1976
Total Exports	429.568	359.817	524.611	500.737	371.873	396.657	537.563
- Gambia	15.997	14.257	14.093	16.892	17.582	13.274	18.252
- Niger	7.871	10.436	21.550	21.302	5.353	6.219	1.200
- Nigeria	90.292	43.012	39.665	110.796	23.496	274	-
- Senegal	146.065	71.914	229.965	77.264	104.751	196.653	233.800
- South Africa	13.919	16.821	10.260	9.306	11.800	14.600	7.000
- U.S.A.	14.528	38.572	27.532	47.028	20.949	12.249	47.960
- Argentina	42.567	44.391	35.838	78.738	68.852	-	44.771
- Brazil	31.902	57.624	77.294	44.425	31.605	37.582	94.127
- China	7.000	11.000	14.000	11.000	14.000	11.000	15.000
- France	20.364	13.860	12.428	17.698	14.816	43.914	16.020
Total Imports	430.836	386.671	520.271	534.077	390.812	420.016	513.529
- Hong Kong	12.262	14.755	15.512	16.221	12.474	15.722	20.850
- Belgium	21.404	28.502	32.926	32.020	22.579	20.899	30.850
- France	142.648	123.956	205.923	167.303	142.594	180.382	217.755
- West Germany	52.277	54.651	71.535	66.272	51.235	38.129	36.632
- Italy	8.235	8.182	15.087	26.138	35.070	23.528	21.979
- Netherlands	9.350	10.538	9.485	20.036	15.526	9.217	8.366
- United Kingdom	95.778	67.766	60.787	74.836	36.293	28.834	19.951

Source : Food and Agricultural Organisation (171, 177).

9.2. Prices on the world market

The price of peanut oil is placed on a considerably higher level than that of other tropical oil (coconut oil, palm oil, cotton seed oil), or temperate oils (colza, sunflower seed). This may be explained by the qualities of the product. In fact, the main african producing countries : Gambia, Mali, Nigeria, Senegal and the Sudan who have grouped themselves in the African Peanut Council, use the quality characteristics to promote peanut oil.

However, the price of peanut oil is directly influenced by the price of soya bean oil. Although the latter does not have comparable qualities, it dominates world price rates due to the large quantities of soya oil on the market, which represent 40 % of the total edible oils. Moreover, the 'reduction' of sunflower seed oil in relation to peanut oil is an important factor, as it has a direct influence on the housewifes' buying tendencies. The threshold at which a consumer transfer operates is reached when the 'reduction' of sunflower seed oil reaches about 400 $ a ton C.I.F. Rotterdam. This happened in 1974 and again at the beginning of 1978. At present, the rate of peanut oil reaches about 960 $ a ton, whereas sunflower seed oil is situated at about 560 $ a ton, and specialists in the oil trade fear a drop in sales.

Trends in the annual average rates in crude peanut oil of all origins, in US $ per metric ton C.I.F. Rotterdam, may be found in table 38 for the period 1960 to 1977.

TABLE 38. Annual average rates of crude peanut oil in Rotterdam (1960 - 1977)

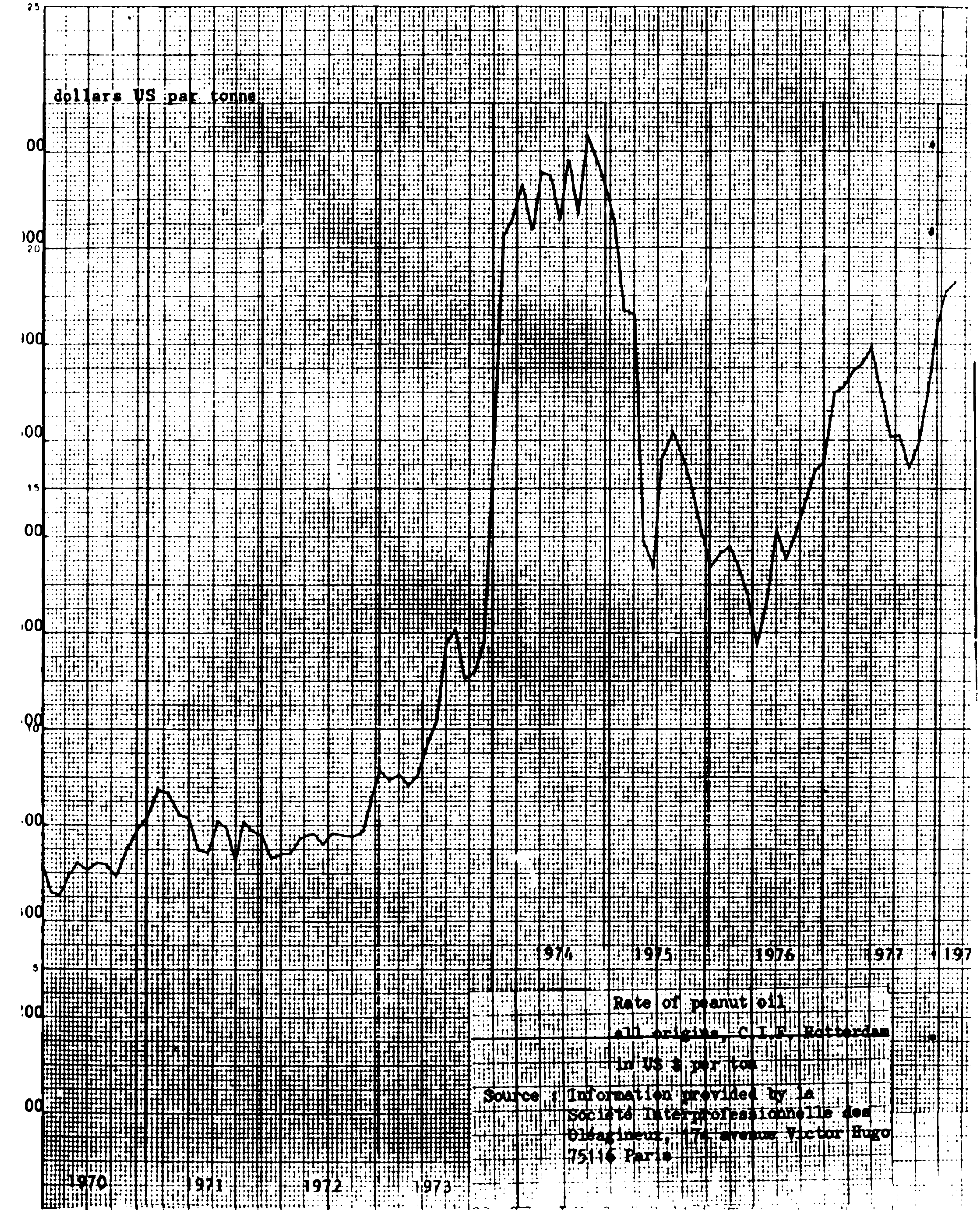
Year	Price US $ / ton	Year	Price US $ / ton
1960	326	1969	332
1961	331	1970	379
1962	275	1971	441
1963	268	1972	426
1964	315	1973	545
1965	324	1974	1.077
1966	296	1975	857
1967	283	1976	744
1968	271	1977	845

Source : Food and Agricultural Organisation (170, 172, 173, 1974 ; 176)

Information supplied by "la Société Interprofessionnelle des Oléagineux, 174, Avenue Victor Hugo - 75116 Paris.

The average monthly rates of crude oil are given in graph. nº 1, where it may been seen that the monthly fluctuations are considerable. For instance, there is a strong upward trend at present with the expectation of a very poor harvest in the Senegal, about 400.000 tons of nuts.

These rates are those of crude oil, which are the basis for most large transactions. Refined oil, which can be produced either in the exporting country or at the place of consumption in Europe, is negotiated at a rate which takes refining costs in either place into consideration.



Graph. 1 - Monthly fluctuation [illegible]

9.3. Transport costs

The transport of peanut oil, from the place of production to the area of consumption, is carried out by sea, usually on board ships specially equipped as tankers. The value of oil being considerably higher than that of nuts, the influence of freight charges on the final price is less, but this still remains an important element. This cost, which depends on the distance covered, varies according to the country of origin.

In table 39 the elements for calculating sea freight costs in 1978 are given, with loading in the various exporting countries and a destination in Northern Europe. The costs given are "Conference" costs (1), except as regards West Africa. Due to the quantity of product exported from the Senegal, producers usually freight whole ships, thus obtaining lower costs.

TABLE 39. Cost of transport for peanut oil from various countries to West Europe.

Country	loading port	Packaging	basic freight rate US $ / ton	various adjustments (1)	Total cost (2) US $ /ton
Brazil	Recife	bulk	36,54	11,90 %	50,88
Senegal	Dakar	whole tanker	21,00		27,00
U.S.A. (East)	Savannah	containers	180,51	7, %	196,9

Source : Compagnie Générale Maritime - United States Lines
Barry Rogliano (see par. [illegible])

(1) Mainly currency adjustments and including additional harbour tax charges

(2) Including loading and unloading costs.

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(1) see note p.

9.4. Commercialisation of peanut oil

In the preceding chapter it was stated that the trituration of peanuts for the production of oil is carried out either in the producing countries or by the consumers.

9.4.1. In the case of producing countries

In general the plant owners buy the nuts from the organisation responsible for their commercialisation, and proceed with shelling and trituration operations and then sell the oil and peanut cake produced themselves. As it is question of basic food products, exports are strictly controlled in almost all cases, including in the U.S.A.

The oil is sold, either as crude oil which goes to european refiners, or as refined oil. In the latter case the plant owner processes the quantity of oil intended for the local market.

The present organisation of the Senegalese peanut oil trade is unusual, it consists of a single semi-public company formed by the State and private trituration companies installed in the country : Lesieur, Sodec, Petersen etc... This organisation, the S.O.N.A.C.O.S., is in charge of the commercialisation of all products coming from the transformation of peanuts : crude oil, refined oil, peanut cake etc...

9.4.2. In the case of importing countries

The oil trade mobilises a large number of participants than the nut trade. The producers are more or less the same, but the buyers ; wholesale merchants, refiners and processers, are spread throughout the various European consumer countries.

When it is question of crude oil, the transactions concern large tonnages of over 500 to 1.000 tons. This oil is refined by large European groups, and treated for retail selling.

Refined oil may also be bought, the only operation to be carried out by the buyer then being the final processing.

9.5. Situation of refining activities

As the trade concerns both crude oil and refined oil, the latter requires more handling, transport and preserving precautions. For this reason, oil mills have often preferred to have a refining system at the place of consumption, which has the additional advantage of enabling recovery of large quantities of by-products, for instance in soap works.

9.6. Quality control

The contracts which regulate edible oil transactions, are international documents, well known to the profession. The fame of the signing parties ensure the respect of these contracts. They set the conditions of transportation of the product, delivery time spaces, quality and price. Usually a sample of the oil is sent by the seller to the buyer who has the sample analysed. The subsequent transaction is based on the quality of the sample. In the case where the actual delivery does not conform, the parties concerned apply to a recognised international arbiter to settle the dispute in the best conditions. This arbiter is usually selected among the specialised firms, the best known of which are installed in London.

10.- THE PEANUT CAKE MARKET

10.1. The world situation

Peanut cake represents between 50 and 55 % in total weight of products derived from shelled nuts, or 35 to 37 % from in-shell nuts. Peanut cake is highly regarded in the feeding of livestock. The protein content varies according to the process used to extract the oil . "Expellers" cakes, that are, cakes obtained from continuous pressing, contain 56 % protein, whereas meal with oil extracted by solvents contains only 50 %.

World production in 1972 to 1976 of oil-less cakes is given in table 40. It will be noticed that the main nut producing countries which carry out trituration on the spot, are also the main producers of peanut cake.

TABLE 40. World production of oil-less peanut cake (1972 - 1977)

Country	1972	1973	1974	1975	1976
U.S.A	154	165	118	137	285
Argentina	109	151	111	78	81
Brazil	201	120	68	70	120
Niger	28	41	25	33	16
Nigeria	111	167	73	35	52
Senegal	250	204	185	236	322
South Africa	60	69	49	88	62
Sudan	71	84	112	81	143
China	577	547	591	611	614
India	1.964	1.376	1.640	1.619	2.043
France	73	91	124	110	97
Italy	50	39	35	44	45
Switzerland	30	30	27	21	22
World total	4.107	3.472	3.536	3.557	4.325

Unit : 1.000 tons

Source : Oil World Information Service for Statistical Analysis of the World Market of oil seeds, oil meal, vegetable, animal, and marine oils and fats. Ista-Mielke and C° - 21000 Hambours 90 POB 900803 R.F.A.

On a world-wide level, the production of peanut cake comes third, after soya and cotton seed cake.

International trade concerns very high quantities, which reach about 40 % of the total production. The use of these cakes for animals is mainly developed in countries where the raising of livestock is dominant, which is not the case in countries producing peanuts, apart from the U.S.A. and Argentina.

In 1976 trade covered 1.900.000 tons coming 28 % from Africa and 64 % from Asia, and, as regards the latter, almost entirely from India which is by far the world's largest producer and exporter.

Table 41 gives the main trade fluctuations between 1970 and 1976.

TABLE 41. World trade of the peanut cake (1970 - 1976)

	1970	1971	1972	1973	1974	1975	1976
Total exports	1.523.091	1.349.190	1.546.619	1.500.415	1.168.097	1.168.554	1.872.577
- Gambia	16.489	13.005	14.509	20.481	21.675	29.966	26.2[illegible]5
- Niger	11.096	9.462	26.823	25.065	7.286	7.036	10.700
- Nigeria	162.114	99.231	99.292	139.140	32.877	7.700	31.071
- Senegal	199.726	126.204	313.170	166.474	184.333	312.025	318.000
- South Africa	24.876	23.219	50.331	56.633	66.000	100.000	100.000
- Sudan	36.514	24.888	50.315	31.622	21.501	31.778	32.000
- Argentina	64.613	88.396	33.187	99.033	44.140	33.100	35.000
- Brazil	201.174	201.122	169.963	80.380	74.827	35.573	87.964
- India	655.060	633.413	665.391	748.624	678.738	536.442	1.200.000
Total imports	1.759.678	1.702.329	1.725.278	1.660.672	1.168.097	1.168.554	1.872.577
- Japan	141.902	122.000	143.076	182.406	119.042	25.871	114.727
- Belgium	52.515	66.262	54.787	60.200	22.542	31.905	54.903
- Czechoslovakia	190.000	211.240	100.000	100.000	82.000	41.000	90.000
- France	243.265	214.661	342.039	322.688	198.351	254.019	427.172
- East Germany	92.000	110.000	58.000	49.000	61.000	72.000	110.000
- West Germany	114.706	120.674	146.646	136.693	64.944	82.409	103.853
- Hungary	64.429	100.071	90.156	36.634	62.164	44.347	26.620
- Netherlands	12.326	11.978	34.082	27.683	47.507	9.104	25.075
- Poland	200.000	189.000	170.000	152.700	175.500	210.000	290.000
- Great Britain	374.020	292.491	297.589	317.628	160.076	211.259	364.648

Source : Food and Agricultural Organisation (171, 177)

Unit : Ton

France and Great Britain are the largest consumers, partly due to trade traditions between these countries and their ex-colonies.

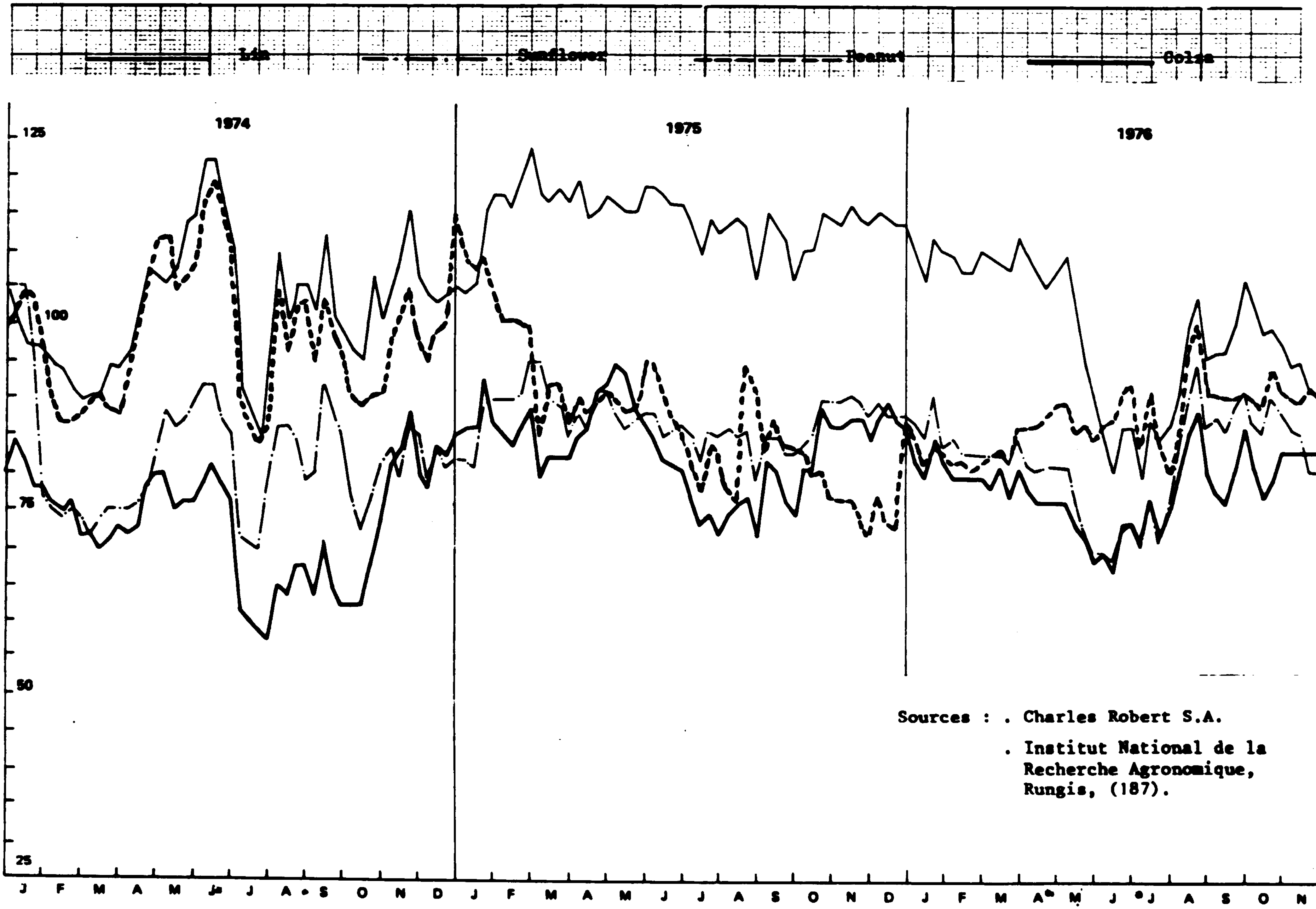
In spite of the fact that it holds second place, from the point of view of the cake trade, well behind soya cake (11.300.000 tons in 1976), the relative importance of peanut cake is decreasing steadily. Trade of the peanut cake represented in 1966, 22,6 % of the world cake trade, and in 1975 only 9 %, although the quantities concerned have changed but slightly. This drop is due to the spectacular development of soya cake over the last decade and to the consequence of regulations concerning aflatoxin.

10.2. Prices on the world market

The price of peanut cake is directly influenced by the availibility of nuts in producing countries and by the evolution of quantities and price rates of soya cake in Chicago. Thus in, 1973, there was an upheaval on the market, caused by the U.S. embargo on soya exports, moreover this coincided with a very poor peanut harvest in India the preceding year. In july 1973, peanut cake reached record price rates, over 500 US $ a ton C.I.F. Rotterdam, when average rates were between 200 and 250 US $. Usually peanut cake prices have a ratio of 0,80 to 1 with that of soya cakes, as indicated in the comparative graph on the next page (Graph n° 2).

The average annual rates of peanut cake for the period from 1970 to 1976, are given in table 42. This price is the C.I.F. Rotterdam price in US $ per ton of meal with a 50 % protein content of all origins, and of expeller cake from Nigeria with a 50 % protein content.

Graph. 2. - Prices evolution of various cakes compared with soya prices



Sources : . Charles Robert S.A.

. Institut National de la Recherche Agronomique, Rungis, (187).

TABLE 42. Average annual rates of peanut cake (1970 - 1976)

Type of cake	1970	1971	1972	1973	1974	1975	1976	1977
50 % all origins	102	98	122	265	174	140	176	218
50 % Nigerian expellers	123	115	144	305	226	167	213	-

Unit : US $ per ton

Source : Société Interprofessionnelle des Oléagineux
174, Avenue Victor Hugo, 75116 Paris.

10.3. Economic importance of peanut cake and oil

These two products form part of two completely different markets : one, that of livestock feed and the other, that of human consumption. However the reactions of both are identical as regards substitution for other products whenever there is a marked upward trend of the price rates.

On an average, the import price of oil has been, over the last few years, from two to six times higher than that of cake as shown in table 43. However, if the exceptional years 1973 to 1975 are aside, this difference is brought down to about 3,5 to 4.

TABLE 43. Comparison of average prices of peanut cake and oil (1970-1977)

Product	1970	1971	1972	1973	1974	1975	1976	1977
Cake	102	98	112	265	174	140	176	218
Oil	379	441	426	545	1.077	857	744	845
Oil/cake	371	450	349	205		612	422	387

Thus it may be seen that the economic importance of oil still dominates that of cake. In 1976, peanut oil production represented 2,6 billion dollars and those of peanut cake 0,9 billion dollars.

10.4. Case of emergent nations

Peanut cake is mainly used in livestock feed formulae or distributed as they are. In most emergent countries, the livestock feed industry is almost inexistant due to the lack of any outlet towards intensive stock raising. Demand on the home market is therefore very limited and the cake not exported is either distributed as it is to the livestock or simply destroyed.

The development of the home market in these regions thus remains dependant on livestock raising, which in turn depends on the standard of living and meat eating customs of the local inhabitants. In general livestock raising is practiced over wide areas, and in spite of extensive efforts made by certain states, the industrial threshold which would mark the rapid development of demand for cake, is still a long way off.

10.5. Commercialisation

As for the nuts and for oil, the cake trade is strictly controlled by the governments of producing countries. It may be controlled either directly by a State monopoly, or be left to the initiative of the producing industrialists, but within the framework of government decisions setting the quotas. Thus, India, at present the world's top exporting country, is to close its frontiers by 1980.

The cake trade follows the same pattern as that of preceding products : international wholesale merchants, specialised brokers, companies employing the product, in particular the manufacturers of livestock feed, are all to be found.

Tonnages concerned are high, often reaching several thousands of tons at each transaction. Disputes on quality are settled by international experts.

10.6. Means and cost of transport

As transport concerns several thousands of tons, it must be carried out by sea. There is no question here of containers or of any other type of packaging. The cake is transported in bulk in the special holds used also for nuts.

Loading and unloading operations is carried out by means of special high capacity handling machines, almost doing away with labour requirements.

In spite of this mechanisation and of collective transport with other agricultural products, such as cereals, to obtain the freighting of entire ships, freight charges remain an important element in the final cost of cake. This reaches 20 US $ per metric ton, to which must be added 6 to 8 $ for various harbour costs. In the collective conditions mentioned above, this freight cost varies somewhat, whatever the origin of the product : the Senegal, South Africa, India, U.S.A. etc..

Transport is carried out in the same sanitary conditions as for oil seeds, cereals and other food stuffs transported in bulk.

11 - THE EDIBLE PEANUT MARKET

11.1. Situation of world demand

Edible peanuts are part of a sector of the economy very different from that of trituration peanuts, both by their destination and by their presentation. Not only are the raw nuts classified under this heading, but also salted and roasted peanuts, and other products such as peanut butter, snacks and the various types of presentation intented for the baking trade. The varieties of nuts are different and concern larger, longer and less oily nuts than those used to produce oil.

Edible peanuts are produced in the same countries as trituration nuts. India, China and the U.S.A. are among the main producing countries and to a lesser degree, South Africa, Malawi, Nigeria, the Sudan and the Senegal. In general, a large part of the production of the producing countries goes to human consumption in the countries themselves ; the United States is an example (Ames, 1975 (7)).

No exact statistics are available on a world wide level concerning edible peanuts, as they are usually grouped together with peanuts for trituration.

There is a steady upward trend in international trade : from 285.000 t of equivalent nuts in 1965, world exports rose to 450.000 tons in 1973 (Wilson, 1975 (151)). Since 1975 the trend has been maintained. Edible peanuts are exported both shelled and in-shell.

Shelled edible peanuts

This is the most common form, and covers about 75 % to 80 % of trade : in 1973, world exports concerned 350.000 shelled nuts and 100.000 tons of in-shell nuts (Wilson, 1975 (151)). The market is dominated by the United States ; China and India come second, but with very variable availibility, as their exported product is secondary to their high demand on the home market. Malawi, South Africa and the Sudan export smaller quantities.

In the absence of exact statistics, an estimation of average quantities exported may be given as follows for 1972 (Wilson, 1975 (151)).

World exports		400.000 to 500.000 t.
- U.S.A.	115.000 t	
- China	40.000 t	
- India	40.000 t	
- Malawi	25.000 t	
- South Africa	35.000 t	
- Sudan	25.000 t	
- Nigeria	15.000 t	
- Indonesia	10.000 t	

In-shell nuts

In-shell nuts are usually exported to be consumed as they are. The quantities concerned are small. Brazil, the U.S.A. and China dominate the market, but there are extensive fluctuations.

Israel, Egypt, Turkey and Thailand are among other countries exporting in-shell nuts. The Sudan, a large producer until 1972, now only exports intermittently.

Trends in exports, according to the F.A.O. is as follows, in table 44.

TABLE 44. Calculated volume of in-shell peanut exports of the main producing countries (1970 - 1975)

	1970	1972	1974	1975
World exports	93.574	134.509	115.976	101.742
- Egypt	12.143	9.598	6.600	6.744
- Sudan	16.618	18.189	5.487	-
- U.S.A.	1.124	15.407	24.059	11.907
- Brazil	26.000	25.000	8.000	20.000
- Israel	7.188	12.640	6.912	10.376
- Turkey	3.882	4.308	3.343	4.000
- Thailand	6.445	1.524	4.631	5.015

Unit : ton

Source : Food and Agricultural Organisation (177)

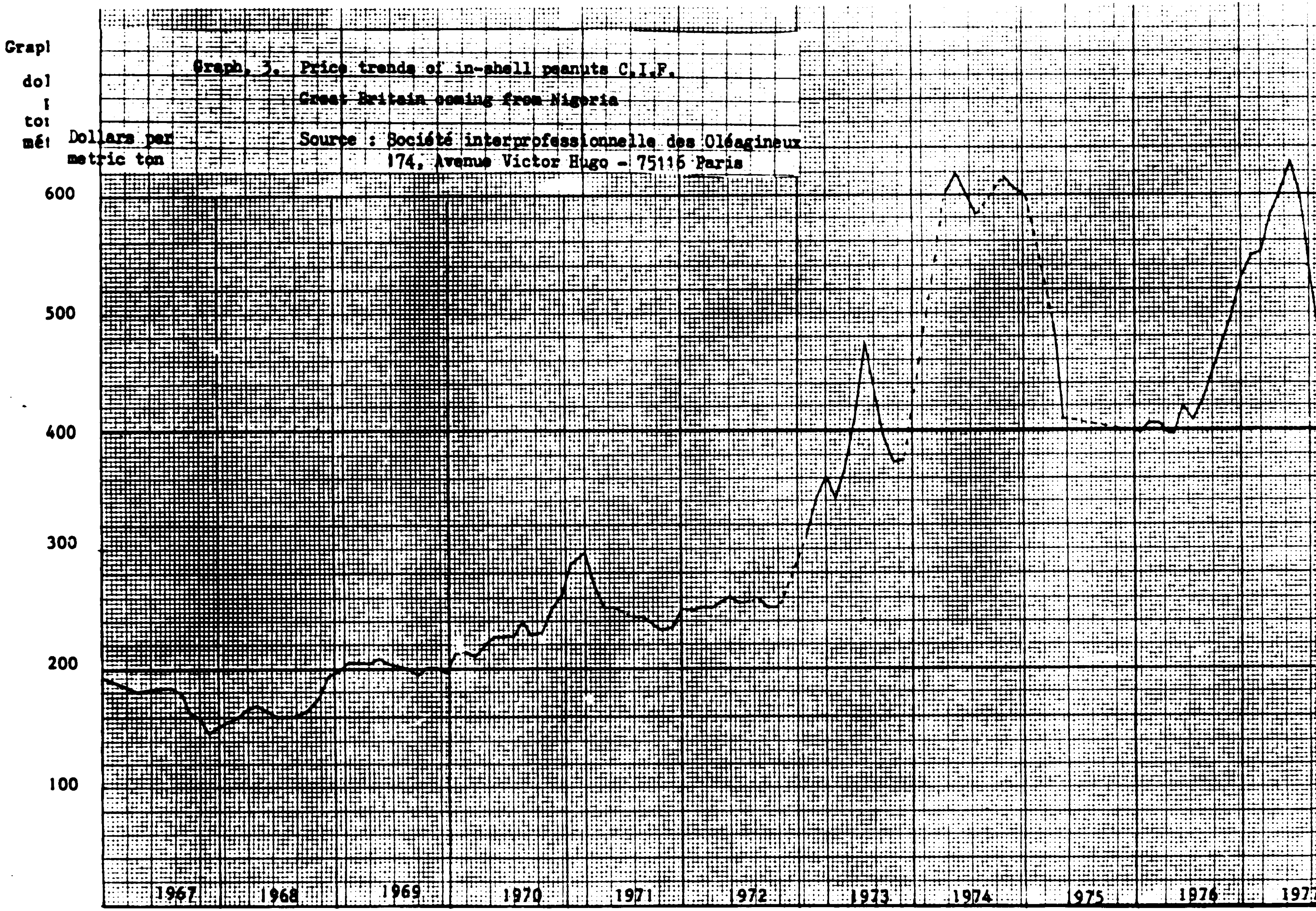
TABLE 45. Comparison of prices in pounds per ton of various dry fruits (Wilson, 1975 (151)).

Year	Cashew nuts	Sweet almonds	Hazel nuts	Peanuts
	India whole nuts	Spain not sorted	kerassundes	Natal 60/70's
1960	312	262	343	107
1965	324	383	229	147
1972	639	821	565	165
1973 (6 months)	790	1.193	588	238

11.2. Prices

The price of edible peanuts is mainly dependant on world trends in trituration nuts, which in turn depends on harvests and on the rates of other oil seeds, and also on the variety and size of the nuts. Thus the large Virginia nuts obtain higher prices than the Valencia and Runner varieties.

In-shell nuts follow the same pattern. Graph n° 3 shows the trend of prices since 1967 for nuts coming from Nigeria and imported into Great Britain.


Graph. 3. Price trends of in-shell peanuts C.I.F.
Great Britain coming from Nigeria
Source : Société interprofessionnelle des Oléagineux
174, Avenue Victor Hugo - 75116 Paris
Dollars per metric ton
600
500
400
300
200
100
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977

The price of peanuts is considerably lower than that of other dry fruits, such as almonds, cashew nuts, Brazil nuts etc... (see table 45). This price factor has a very marked effect on demand.

11.3. Consumer countries

It should not be forgotten that all producing countries are also consumer countries, and that world trade in fact only represents a fraction of the quantities of peanuts produced for human consumption. Thus India and the United States are the largest producers and consumers in the world.

As regards the distribution of world demand, Japan, Great Britain and Canada come first, followed by the Federal Republic of Germany, Holland and the U.S.S.R.

Unfortunately no exact figures exist for the import of edible peanuts for the reasons given above.

We give below estimations for 1972, used by Wilson, 1975 (151) except for Spain and Portugal, for which countries figures were provided by Lasies (1).

Import of peanuts

- Japan	60.000 to 70.000 t
- Great Britain	60.000 to 70.000 t
- Canada	60.000 t
- West Germany	50.000 t
- Netherlands	40.000 t
- U.S.S.R.	25.000 t
- Italy	20.000 t
- Portugal	15.000 t
- Spain	15.000 t to 20.000 t

(1) Lasies, Oilseed brokers - 8, rue de l'Isly, 75008 Paris - France

Shelled peanuts are consumed either salted or roasted. The producers pack these nuts in aluminium cans or in vacuum packs, either on their own or mixed with other dry fruits such as almonds, hazel nuts etc... In this case the main use is as cocktail accessories.

Shelled peanuts may also be made into peanut butter or paste. In the U.S.A. and Holland, consumption of peanut butter is extensive. The variety preferred in this case is the Spanish variety. It should be noted that consumer habits vary from one country to another. In the U.S.A., Canada and Holland, consumption concerns mainly peanut butter. In Great Britain, New Zealand, West Germany and Norway it concerns roasted salted peanuts, whereas in Spain, Portugal, Italy and France the in-shell nut is preferred.

11.4. Commercialisation

The same State-run centralised organisation exists in the producing countries regarding this product as has been described in the preceding chapters concerning trituration peanuts, oil and cake. A state monopoly exists in China, the Sudan, Malawi, the Senegal, Gambia etc... However, in the U.S.A., India, Nigeria, Brazil, Argentina, South Africa etc.. export of nuts remains in the hands of private companies, but within the frame of strict annual quotas, fixed by the government (Ames, 1975 (7)).

Transactions may be carried out directly between the seller and the processing client where large quantities or regular supplies are concerned. But more frequently transactions are made through specialised wholesalers who split the available supplies between processing units which are far more numerous than in the case of trituration nuts

Brokers also play an important role in these transactions as advisers and negociators between the various parties concerned.

Sales are usually made on bulk loads of shelled or in-shell nuts, but not roasted nuts. Processing concerns the appropriate conditioning and packaging. In mediterranean countries, this kind of activity is carried out by a large number of independant workers who supply the local market. However, in Holland, in West Germany or in Great Britain much larger firms with divers activities fill this rôle.

11.5. Transport

The nuts are packed in bags of 50 kg. and grouped either in containers of 18 to 20 tons, or on barges of 350 ton capacity. Freight charges are the same as those applied to trituration nuts when the latter use the same means of transport.

Below the "Conférence" (1) rates in force at the beginning of 1978 from various origins are given.

Country	Loading port	Means of transport	Basic freight charges US $ per ton	various additional costs	Total cost US $ per ton
West U.S.A.	Los Anegeles	Containers	134,65	4,5 %	152
East U.S.A.	Savannah	"	67,42	7 %	75,9
South Africa	Cap Town	"	56,07	5,37 $	61,44
Sudan	Port Sudan	"	45,20	32,5 %	59,89
India	Bombay	"	52,65	41,14 %	77,08
	Outside Bombay	"	52,65	33,64 %	71,70

Source : - Compagnies Générale Maritime, Tour Winterhur, Paris La Défense

- United States Lines, 2, rue de Penthièvre, 75008 Paris

(1) see note p. 106

BIBLIOGRAPHY

(1) ACHAYA (K.).- Standards for protein based foods in developing countries. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 316-320.

(2) ADRIAN (J.).- Les aflatoxines. 3. Les moyens de prévention et de détoxification. Oléagineux, 24, n° 3, 1969, pp. 155-161.

(3) ADRIAN (J.), CARROGET (C.).- Evolution de la lysine, méthionine et cystine dans le tourteau d'arachide traité à l'ammoniac. Revue Française des Corps gras, 23, n° 4, 1976, pp. 209-212.

(4) ADRIAN (J.), JACQUOT (R.).- Valeur alimentaire de l'arachide et de ses dérivés. Paris, Maisonneuve et Larose, 1968, 274 p.
(Techniques agricoles et productions tropicales 26).

(5) AMAYA (J.), YOUNG (C.), HAMMONS (R.).- The tryptophan content of the U.S. commercial and some South American wild genotypes of the genus Arachis. A survey. Oléagineux, 32, n° 5, 1977, pp. 225-229.

(6) AMAYA (F.), YOUNG (C.), MIXON (A.), NORDEN (A.).- Soluble amino and carbohydrate compounds in the testae of six experimental peanut lines with various degrees of Aspergillus flavus resistance. Journal of Agricultural and Food Chemistry, 25, n° 3, 1977, pp. 661-663.

(7) AMES (G.).- Peanuts : Domestic, world production and trade. Athens, University of Georgia, 1975, 40 p.
(University of Georgia, Department of agricultural economics, Research report 215).

(8) ARCHAMBAUD (J.).- Emploi non alimentaire des tourteaux. In : Journées d'information sur les produits dérivés de l'huilerie. 1964. Paris. Paris, Institut des Corps gras, 1964, pp. 110-122.
(N° spécial. Revue Française des Corps Gras).

(9) BAGOT (Y.).- Altération et conservation des oléagineux tropicaux. In : Journées d'information sur l'huilerie. 1967. Paris. Paris. Institut des Corps Gras, 1967, pp. 19-28.
(N° spécial. Revue Française des Corps Gras).

(10) BAROLET (J.).- Transport des graines oléagineuses. Le déchargement mécanique des navires grainetiers. Oléagineux, 30, n° 7, 1975, pp. 325-329.

(11) BARTON (F.), AMOS (H.), ALBRECHT (W.), BURDICK (D.).- Treating peanut hulls to improve digestibility for ruminants. Journal of Animal Science, 38, n° 4, 1974, pp. 860-864.

(12) BATHIA (D.), KALBAG (S.), SUBRAMANIAN (N.), ANANTHARAMAN (K.), EAPEN (K.), SREENIVASAN (A.).- Technology of peanut protein isolate. In : International congress of food science and technology. 1. London, 1962. LEITCH (J.).- Proceedings. 4. Manufacture and distribution of foods. New York. Gordon and Breach, 1965, pp. 755-766.

(13) BERNARDINI (E.).- The "Direx-40" process for direct solvent extraction of seeds with a high oil content without pre-pressing, i.e. without using expellers. La Rivista Italiana delle Sostanze Grasse, 52, n° 8, 1975, pp. 271-275.

(14) BEUCHAT (L.).- Modification of cookie-baking properties of peanut flour by enzymatic and chemical hydrolysis. Cereal Chemistry, 54, n° 3, 1977, pp. 405-414.

(15) BOCKELEE-MORVAN (A.), GILLIER (P.).- Essai d'élimination de l'aflatoxine de l'arachide par des méthodes physiques. Oléagineux, 29, n° 11, 1974, pp. 513-516.

(16) BOCKELEE-MORVAN (A.), GILLIER (P.).- Réduction de l'aflatoxine de l'arachide au niveau de la production agricole. Cahiers de Nutrition et de Diététique, 11, n° 2, 1976, pp. 101-104.

(17) BOLHUIS (G.).- Observations on the flowering and fructification of the groundnut Arachis hypogaea. Netherlands Journal of Agricultural Science, 6, n° 1, 1958, p. 18.

(18) BOLHUIS (G.).- Observations on the flowering and fructification of the groundnut Arachis hypogaea. Netherlands Journal of Agricultural Science, 6, n° 4, 1958, pp. 245-248.

(19) BOLHUIS (G.).- Observations on the flowering and fructification of the groundnut Arachis hypogaea. Netherlands Journal of Agricultural Science, 7, n° 1, 1959, pp. 51-54.

(20) BOLHUIS (G.).- Observations on the flowering and fructification of the groundnut Arachis hypogaea. Netherlands Journal of Agricultural Science, 7, n° 2, 1959, pp. 138-140.

(21) BOLHUIS (G.), DE GROOT (W.).- Observations on the effect of varying temperature on the flowering and fruit set in three varieties of groundnut. Netherlands Journal of Agricultural Science, 7, n° 4, 1959, pp. 317-326.

(22) BOZA (J.), FONOLLA (J.), ESCRIVA (J.), VARELLA (G.).- Estudio de la cascara del cacahuete en la alimentacion de los ruminantes. Avances en Alimentacion y Mejora Animal, 10, n° 10, 1969, pp. 787-790.

(23) BREDESON (D.).- Mechanical pressing. Journal of the American Oil Chemists'Society, 54, n° 6, 1977, pp. 489A-490A.

(24) BUNTING (A.).- A classification of cultivated groundnuts. Emp. J. Exp. Agric., 23, n° 91-92, 1955, pp. 158-170.

(25) BUNTING (A.).- A further note on the classification of cultivated groundnuts. Emp. J. Exp. Agric., 26, n° 103, 1958, pp. 254-258.

(26) CARR (R.).- Degumming and refining practices in the U.S. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 347-352.

(27) CATHERINET (M.).- Quelques données sur la germination de l'arachide. Etude de la température optimum. Ann. C.R.A. Bambey, Bulletin Agronomique, n° 16, 1956, pp. 93-98.

(28) CHANDRASEKHARA (M.), RAMANNA (B.).- Isolates and concentrates from peanut in the feeding of children. In : Symposium international sur les sources nouvelles de protéines dans l'alimentation humaine. 9. Amsterdam. 1968. Den Haag, Stichting tot wetenschappelijke, voorlichting op voedingsgebied, s.d., pp. 107-121.

(29) CHOFFEL (G.).- Eaux résiduaires. B - Solutions industrielles d'épuration et de recyclage des eaux résiduaires. Revue Française des Corps Gras, 21, n° 5, 1974, pp. 301-307.

(30) CHOFFEL (G.).- Liquid waste treatment in the vegetable oil processing industry - European practices. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 446-448.

(31) CHRISTNER (H.).- Aufarbeitung von Abluft aus den Ol- und Fettbetrieben mittels Katalytischer Verbrennung zur Geruchsminderung. Fette, Seifen, Anstrichmittel, 73, n° 2, 1971, pp. 122-126.

(32) COBB (W.), GILLILAND (S.), WILLIAMS (E.).- Chemical and microbiological changes in stored uncured peanuts. Food Technology, 23, n° 12, 1969, pp. 1586-1589.

(33) CODIFER (L.), MANN (G.), DOLLEAR (F.).- Aflatoxin inactivation : treatment of peanut meal with formaldehyde and calcium hydroxide. Journal of the American Oil Chemists'Society, 53, n° 5, 1976, pp. 204-206.

(34) COLIN (J.).- Evolution des procédés, des techniques et des matériels dans l'industrie des corps gras. Industries Alimentaires et Agricoles, 93, n° 9-10, 1976, pp. 1131-1138.

(35) COLIN (J.).- Aspects de la pollution des eaux dans le domaine de l'huilerie. Industries Alimentaires et Agricoles, 93, n° 2, 1976, pp. 177-183.

(36) COWAN (J.).- Degumming, refining, bleaching and deodorization theory. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 344-346.

(37) COWARD (L.), BEAUMONT (J.), MANSER (P.).- The decortication of some tropical nuts. In : IUFOST. Proceedings of the international congress of food science and technology. 4. Madrid. 5. Madrid. Consejo superior de Investigaciones Cientificas. Instituto Nacional de Ciencia y Tecnologia de Alimentos. 1977, pp. 407-411.

(38) DE (S.), CORNELIUS (T.).- Technology of production of edible flours and protein products from groundnuts. Rome, FAO, 1970, 79 p.
(Agricultural Service Bulletin n° 10).

(39) DEFROMONT (C.).- Tourteaux d'oléagineux : constituants, modifications au cours des traitements d'obtention et de la conservation. In : Journées d'information sur les produits dérivés de l'huilerie. 1964. Paris. Paris, Institut des Corps Gras, 1964, pp. 68-89.
(N° spécial. Revue Française des Corps Gras).

(40) DEFROMONT (C.), DELAHAYE (E.).- Etude du comportement du tourteau au cours du stockage. Revue Française des Corps Gras, 8, n° 6, 1961, pp. 359-375.

(41) DELBOSC (G.).- Les parasites des stocks d'arachide. Oléagineux, 21, n° 5, 1966, pp. 233-236.

(42) DICKENS (J.), PATTEE (H.).- Peanut curing and post-harvest physiology. In : Peanuts : Culture and uses. A symposium. Stillwater. American Peanut Research and Education Association, Inc., 1973, pp. 509-522.

(43) DIENER (U.), DAVIS (N.).- Limiting temperature and relative humidity for aflatoxin production by Aspergillus flavus in stored peanuts. Journal of the American Oil Chemists'Society, 47, n° 9, 1970, pp. 347-351.

(44) FEVRE (P.).- L'arachide et ses emplois en pâtisserie industrielle et en biscuiterie. Biscuits, Biscottes, Panification Industrielle, Produits diététiques, Chocolaterie, Confiserie, 39, n° 11, 1971, pp. 32-33.

(45) FLORENCE (J.), MONTSEIGNY (A.), ZWOBADA (F.).- Teneur en pesticides organophosphorés des produits et sous-produits d'huilerie. Revue Française des Corps Gras, 21, n° 6, 1974, pp. 359-362.

(46) FORTANIER (E.).- De beinvloeding van de bloei big Arachis hypogeae L. Mededelingen Landbouwhogeschool, 57, n° 2, 1957, 116 p.

(47) FRANCOIS (R.).- Les coques d'oléagineux. Traitement et utilisation. In : Journées d'information sur les produits dérivés de l'huilerie. 1964. Paris. Paris. Institut des Corps Gras, 1964, pp. 60-67.

(48) FRANCOIS (R.).- Measures against water pollution in industries producing edible oils and fats. Pure and Applied Chemistry, 29, 1972, pp. 163-171.

(49) GARCIA (E.).- Processing peanuts and cottonseed. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 259-260.

(50) GARDNER (H.), KOLTUN (S.), DOLLEAR (F.), RAYNER (E.).- Inactivation of aflatoxins in peanut and cottonseed meals by ammoniation. Journal of the American Oil Chemists'Society, 48, n° 2, 1971, pp. 70-73.

(51) GAUPP (E.).- Snacks und Knabberartikel : automatisch geste erte Erdnuss-Verarbeitungs-Anlage. Ernährungswirtschaft, 17, n° 9, 1970, pp. 675-678.

(52) GILLIER (P.).- La commercialisation de l'arachide aux Etats-Unis. Oléagineux, 24, n° 3, 1969, p. 139.

(53) GILLIER (P.).- Recherches de l'I.R.H.O. sur l'aflatoxine dans l'arachide de bouche. Oléagineux, 25, n° 8-9, 1970, p. 467.

(54) GILLIER (P.), SILVESTRE (P.).- L'arachide. Paris, Maisonneuve et Larose, 1969, 292 p.
(Techniques agricoles et productions tropicales 15).

(55) GOEBEL (E.).- Bleaching practices in the U.S. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 342-343.

(56) GREGORY (W.), GREGORY (M.), KROPOVICKAS (A.), SMITH (B.), YARBROUGH (J.). Structure and genetic resources of peanuts. In : Peanut. - Culture and uses. A symposium.- Stillwater, 1973, American Peanut Research and Education Association Inc., 1973, pp. 47-133.

(57) GRIECO (D.), PIEPOLI (G.).- Composition en acides gras des huiles végétales alimentaires. Oléagineux, 22, n° 10, 1967, pp. 611-612.

(58) GUILBOT (A.), JEMMALI (M.).- Recherche de procédé de détoxification de tourteaux d'arachides contaminés par l'aflatoxine. Paris. DGRST. 1975, n.p.
(Action concertée : Technologie alimentaire et agricole. Contrat n° 72.7.0275).

(59) GUSTAFSON (E.).- Loading, unloading, storage, drying, and cleaning of vegetable oil-bearing materials. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 248-250.

(60) HAMMONS (R.).- Early history and genetic resource of peanuts. In : Peanuts - Culture and uses. A symposium.- Stillwater, 1973, American Peanut Research and Education Association Inc., 1973, pp. 17-45.

(61) HEINIS (J.), SAUNDERS (M.).- Evaluation of the Foos-Let instrument for determining oil content in peanuts. Oléagineux, 29, n° 2, 1974, pp. 91-93.

(62) HOLADAY (C.), PEARSON (J.).- Effects of genotype and production area on the fatty acid composition, total oil and total protein in peanuts. Journal of Food Science, 39, n° 6, 1974, pp. 1206-1209.

(63) HUTCHISON (R.).- Recherches sur le séchage des arachides stockées par les cultivateurs. Oléagineux, 22, n° 12, 1967, pp. 737-740.

(64) ITOH (T.), TAMURA (T.), MATSUMOTO (T.).- Sterol composition of 19 vegetable oils. Journal of the American Oil Chemists'Society, 50, n° 4, 1973, pp. 122-125.

(65) JAY (E.), REDDLINGER (L.), LAUDANI (H.).- The application and distribution of carbon dioxide in a peanut groundnut-silo for insect control. Journal of Stored Products Research, 6, n° 3, 1970, pp. 247-254.

(66) JENKINS (G.).- Nut meats - their selection and storage. The Manufacturing Confectioner, 48, n° 7, 1968, pp. 29-30.

(67) JOHANSSON (G.).- Finished oil handling and storage in Europe. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 410-413.

(68) JUILLET (M.).- Les mycotoxines - sauf aflatoxine - dans les graines oléagineuses. Revue Française des Corps Gras, 18, n° 5, 1971, pp. 301-307.

(69) KEHSE (W.).- Lavage des éluats et récupération des distillats en désodorisation. Revue Française des Corps Gras, 23, n° 9, 1976, pp. 493-496.

(70) KHAN (M.), RHEE (K.), ROONEY (L.), CATER (C.).- Bread baking properties of aqueous processed peanut protein concentrates. Journal of Food Science, 40, n° 3, 1975, pp. 580-583.

(71) KHAN (M.), ROONEY (L.).- Baking properties of oilseed flours. Evaluation with a short-time dough system. Bakers'Digest, 51, n° 3, 1977, pp. 43-44.

(72) KRAMER (H.), GATES (J.), DEMAREE (K.), SID (A.).- Spectrophotometric investigations on peanuts with particular reference to estimation of maturity. Food Technology, 17, 1963, pp. 1044-1046.

(73) KUMAR (M.), SAMPATH (S.).- The chemical composition and nutritive value of groundnut - Arachis hypogaea Linn. - Haulms. Indian Journal of Dairy Science, 27, n° 3, 1974, pp. 175-178.

(74) KURZ (M.).- Erdnussbutter. Bedeutung und Herstellung. Die Ernährungsindustrie, n° 5, 1976, pp. 34-36.

(75) LABARTHE (B.).- Etude d'une mycotoxine, polluant de denrées alimentaires : l'aflatoxine de l'arachide. L'Alimentation et la Vie, 63, n° 1, 1975, pp. 12-25.

(76) LAFONT (P.).- Contamination de produits oléagineux par les mycotoxines et mycotoxicoses liées à la consommation de ces produits. Revue Française des Corps Gras, 21, n° 2, 1974, pp. 77-84.

(77) LANDERS (M.), DAVIS (N.), DIENER (U.).- Influence of atmospheric gases on aflatoxins production by Aspergillus flavus in peanuts. Phytopathology, 57, 1967, pp. 1086-1090.

(78) LANDES (D.), MILLER (J.).- Effects of several vegetable oils on lipid classes and very long chain polyenoic fatty acid content of rat liver and heart. Journal of Agricultural and Food Chemistry, 23, n° 3, 1975, pp. 551-555.

(79) LEE (L.), CUCULLU (A.), GOLDBLATT (L.).- Appearance and aflatoxin content of raw and dry roasted peanut kernels. Food Technology, 22, n° 9, 1968, pp. 81-84.

(80) LEESCH (J.), GILLENWATER (H.), WOODWARD (J.).- Methyl bromide fumigation of shelled peanuts in bulk containers. Journal of Economic Entomology, 67, n° 6, 1974, pp. 769-771.

(81) LESIEUR (B.).- Salad and cooking oils. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 414-416.

(82) LISTOPADOVA (E.), HORAK (E.).- Rezidua metylbromidu v olejninach. Prumysl Potravin, 23, n° 2, 1972, pp. 40-43.

(83) MANN (G.), CODIFER (L.), GARDNER (H.), KOLTUN (S.), DOLLEAR (F.).- Chemical inactivation of aflatoxins in peanut and cottonseed meals. Journal of the American Oil Chemists'Society, 47, n° 5, 1970, pp. 173-176.

(84) MASELLI (J.).- Controlling aflatoxin in your plant. The Manufacturing Confectioner, 57, n° 2, 1977, pp. 35-41.

(85) MASON (M.), NEWELL (J.), JOHSON (B.), KOEHLER (P.), WALLER (G.).- Non volatile flavor components of peanuts. Journal of Agricultural and Food Chemistry, 17, n° 4, 1969, pp. 728-732.

(86) MATTHEWS (R.).- Some functional aspects of oilseed flours in bread. Bakers'Digest, 46, n° 2, 1972, pp. 46-78.

(87) MATTIL (K.).- Review and comparative analysis of oilseed raw materials and processes suitable for the production of protein products for human consumption. New York, Nations Unies, 1974, 36 p. (UNIDO ID/1-6).

(88) MICHALON (D.), FRECHURET (G.), VIAL (M.), DELORT-LAVAL (J.), MELCION (J.).- Nouveau procédé pneumatique pour morceler des corps solides poreux, notamment végétaux, et en particulier pour le décorticage des graines. Paris. DGRST. 1972, pp. 1-21. (Action concertée : Technologie agricole. Contrat n° 71 72 751).

(89) MIETH (G.), KROLL (J.), POHL (J.), BRUCKNER (J.).- Trends bei der Verarbeitung von Olsamen und frUchten. Die gleichzeitige Gewinnung von Olen und Proteinen. Die Nährung, 19, n° 8, 1975, pp. 687-696.

(90) MIETH (G.), KROLL (J.), POHL (J.), LINOW (F.), PRAHL (L.).- Untersuchungen zur gleichzeitigen Gewinnung von Proteinen und Fetten aus Olsamen. 1. Mitt. Verfahrensprinzip. Die Nährung, 19, n° 9-10, 1975, pp. 955-960.

(91) MILLIGAN (E.).- Survey of current solvent extraction equipment. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 286-290.

(92) MIXON (A.), ROGERS (K.).- Peanuts resistant to seed invasion by Aspergillus flavus. Oléagineux, 28, n° 2, 1973, pp. 85-86.

(93) MONTENEZ (J.).- Recherches expérimentales sur l'écologie de la germination chez l'arachide. Bruxelles, Direction Agricole Forêts Elevage, 1957, 130 p.

(94) MOREAU (C.).- Contamination fongique des arachides et de leurs tourteaux. Revue Française des Corps Gras, 24, n° 1, 1977, pp. 27-34.

(95) MULLER (H.).- Emploi des filtres funda dans l'industrie des corps gras. Oléagineux, 22, n° 2, 1967, pp. 109-112.

(96) MULLOR (J.).- Integracion biologica de los aceites alimenticios. Informaciones sobre Grasas y Aceites, 9, n° 3, 1971, pp. 48-70.

(97) NICLAES (J.), DEMOL (J.).- La floraison de l'arachide dans les conditions climatiques de Bambesa. Bulletin Agricole Congo-Belge, 49, n° 6, 1958, pp. 1501-1502.

(98) NORDEN (A.).- Breeding of the cultivated peanut. In : Peanuts - Culture and uses. A symposium.- Stillwater, 1973, American Peanut Research and Education Association Inc., 1973, pp. 175-208.

(99) OHLSON (R.), SVENSSON (C.).- Comparison of oxalic acid and phosphoric acid as degumming agents for vegetable oils. Journal of the American Oil Chemists'Society, 53, n° 1, 1976, pp. 8-11.

(100) ORR (E.), ADAIR (D.).- The production of protein foods and concentrates from oilseeds. London, Tropical Products Institute, 1967.
(Tropical Products Institute Report G 31).

(101) PABST (P.).- Stockage des huiles brutes et raffinées, différents moyens et traitements permettant d'en maintenir la qualité. Revue Française des Corps Gras, 14, 1967, pp. 167-172.

(102) PATTEE (H.), SINGLETON (J.).- Comparison of geographical and varietal effects on the peanut volatile profile by peak-ratio analysis. Journal of Agricultural and Food Chemistry, 20, n° 6, 1972, pp. 1119-1124.

(103) PATTEE (H.), SINGLETON (J.), JOHNS (E.).- Effects of storage time and conditions on peanut volatiles. Journal of Agricultural and Food Chemistry, 19, n° 1, 1971, pp. 134-137.

(104) POMINSKI (J.), PEARCE (H.), VIX (H.), SPADARO (J.).- Improvement of shelf life of partially defatted peanuts by intromission of nitrogen into the interstices of the peanuts. Journal of Food Science, 40, n° 1, 1975, pp. 192-194.

(105) PRANDINI (D.).- Les huiles alimentaires fluides et concrètes. Aspect pratique. Les Annales d'Hygiène de Langue Française. Médecine et Nutrition, 10, n° 1, 1974, pp. 71-79.

(106) PRAQUIN (J.), TARDIEU (M.).- L'arachide dans les zones d'altitudes de l'Ouest Cameroun. Agronomie Tropicale, 31, n° 1, 1976, pp. 83-89.

(107) PREVOT (A.).- Evolution et méthodes d'élimination des aflatoxines dans les produits oléagineux - huiles et tourteaux -. Revue Française des Corps Gras, 21, n° 2, 1974, pp. 91-103.

(108) PREVOT (A.).- Evolution et méthodes d'élimination des aflatoxines dans les produits oléagineux. Cahiers de Nutrition et de Diététique, 11, n° 2, 1976, pp. 105-116.

(109) PREVOT (P.).- Croissance, développement et nutrition minérale de l'arachide. Paris, SETCO, 1949, 108 p. (Oléagineux Coloniaux, Série scientifique n° 4).

(110) PRINE (G.).- Perennial peanuts for forage. In : Soil and Crop Science Society of Florida. Annual Meeting. 32. St. Petersburg. 1972. Proceedings. Gainesville. University of Florida, 1973, pp. 33-35.

(111) QUINN (M.), BEUCHAT (L.), MILLER (J.), YOUNG (C.), WORTHINGTON (R.).- Fungal fermentation of peanut flour : effects on chemical composition and nutritive value. Journal of Food Science, 40, n° 3, 1975, pp. 470-474.

(112) RATHORE (B.), CHATURVEDI (D.).- Studies on cereal-fre rations based on rice polishings and groundnut cake for growing chicks. 3. Effect of cheap protein supplements. Poultry Science, 50, n° 2, 1971, pp. 370-374.

(113) REID (P.), COX (F.).- Soil properties, mineral nutrition and fertilizer practices. In ; Peanuts - Culture and uses. A symposium.- Stillwater, 1973, American Peanut Research and Education Association Inc., 1973, pp. 271-297.

(114) REIMBERT (A.).- Génie civil des silos et magasins de stockage des graines oléagineuses. Revue Française des Corps Gras, 14, 1967, pp. 29-35.

(115) RHEE (K.), CATER (C.), MATTIL (K.).- Simultaneous recovery of protein and oil from raw peanuts in an aqueous system. Journal of Food Science, 37, n° 1, 1972, pp. 90-93.

(116) RHEE (K.), MATTIL (K.), CATER (C.).- Recovers protein from peanuts. Food Engineering, 45, n° 5, 1973, pp. 82-86.

(117) RHEE (K.), NATARAJAN (K.), CATER (C.), MATTIL (K.).- Processing edible peanut protein concentrates and isolates to inactive aflatoxins. Journal of the American Oil Chemists'Society, 54, n° 3, 1977, pp. 245A-249A.

(118) RODRIGO (M.), TEJEDOR (C.), DURAN (L.).- Caracteristicas industriales y bioquimicas de variedades de cacahuetes. Revista de Agroquimica y Tecnologia de Alimentos, 10, n° 4, 1970, pp. 560-570.

(119) SAHNI (S.), KRISHNAMURTHY (K.), GIRISH (G.).- Development of high protein bread. Part 1. Groundnut flour and groundnut protein isolate utilisation. Journal of Food Science, 12, n° 6, 1975, pp. 283-289.

(120) SAMPLES (L.).- Le séchage de l'arachide, facteur de qualité. Oléagineux, 24, n° 1, 1969, pp. 27-29.

(121) SANKARA RAO (D.), ACHAYA (K.).- Occurence and possible protective function of carbon dioxide in oilseeds. Journal of the Science of Food and Agriculture, 20, n° 9, 1969, pp. 531-534.

(122) SCHNEIDER (M.).- Pre-investment considerations and appropriate industrial planning in the vegetable oil. New York, United Nations, 1974, 32 p.
(UNIDO ID/122).

(123) SEKHON (K.), AHUJA (K.), JASWAL (S.), BHATIA (I.).- Variability in fatty acid composition in peanut. 2. Spreading group. Journal of the Science of Food and Agriculture, 24, n° 8, 1973, pp. 957-960.

(124) SEKHON (K.), AHUJA (K.), SANDHU (R.), BHATIA (I.).- Variability in fatty acid composition in peanut. Journal of the Science of Food and Agriculture, 23, n° 8, 1972, pp. 919-924.

(125) SEMPORE (G.).- Etude des triglycérides de l'huile d'arachide. Thèse Docteur Ingénieur. Biochimie appliquée option nutrition. Université Dijon, 1975, 132 p.

(126) SEMPORE (G.), BEZARD (J.).- Les triglycérides de l'huile d'arachide. Revue Française des Corps Gras, 24, n° 12, 1977, pp. 611-621.

(127) SERGIEL (J.), ROCQUELIN (G.), RECORBET (L.).- Digestibilité des huiles de colza, de canbra et d'arachide. Etude de leur lipolyse in vitro et in vivo. Annales de Biologie Animale, Biochimie, Biophysique, 15, n° 1, 1975, pp. 103-114.

(128) SHIBUYA (T.).- Morphological and physiological studies on the fructification of peanut (Arachis hypogea L.). Formose, Imperial University, 1935, 120 p.

(129) SILVESTRE (P.).- Production d'arachide à Madagascar. Agronomie Tropicale, 18, n° 5, 1963, pp. 511-526.

(130) SLEDD (C.), EADIE (T.), O'REAR (C.), LLEWELLYN (G.).- Evaluation des facteurs liés à l'environnement et présence des aflatoxines dans les arachides décortiquées de Virginie de 1964 à 1968. In : Sharpley (J.), Kaplan (A.).- Proceedings of the International biodegradation symposium : sessions 4, 14, 3. Kingston. London, Applied Science Publishers Ltd. 1976. pp. 625-634.

(131) SOLOMON (B.).- Les procédés ZENITH et de KAMINSKIJ et l'amélioration des coefficients de neutralisation des huiles végétales. Revue Française des Corps Gras, 19, n° 2, 1972, pp. 107-111.

(132) STEIN (W.), GLASER (F.).- Continuous solvent extraction of sunflower seed, groundnuts, palmkernels, rapeseed, and copra. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 283-285.

(133) STURKIE (D.), BUCHANAN (G.).- Cultural practices. In : Peanuts - Culture and uses. A symposium.- Stillwater, 1973, American Peanut Research and Education Association Inc., 1973, pp. 299-326.

(134) SVENSSON (C.).- Use or disposal of by-products and spent material from the vegetable oil processing industry in Europe. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 443-445.

(135) TANGO (J.), MENEZES (T.), DE TEIXEIRA (C.).- Levantamento da ocorrencia de aflatoxina em sementes de amendoim nas safras das aguas e da seca. Coletanea do Instituto de Tecnologia de Alimentos, 1, n° 1, 1966, pp. 1-11.

(136) THIESEN (J.).- Detoxification of aflatoxins in groundnut meal. Animal Feed Science and Technology, 2, n° 1, 1977, pp. 67-75.

(137) THURMAN (B.).- Losses in the refining of edible oils. Industrial and Engineering Chemistry, 15, 1923, pp. 395-396.

(138) TIEMSTRA (P.).- Determining the quality of raw peanuts and manufactured products. In : Peanuts - Culture and uses. A symposium. Stillwater. American Peanut Research and Education Association, Inc., 1973, pp. 603-656.

(139) TINDALE (L.), HILL-HAAS (S.).- Current equipment for mechanical oil extraction. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 265-270.

(140) TRESSLER (D.), WOODROOF (J.).- Peanut products. In : Tressler (D.), Woodroof (J.).- Food products formulary. Vol. 3. Fruit, vegetable and nut products.- Westport, AVi Publishing Co., 1976, pp. 233-240.

(141) TROEGER (J.), WILLIAMS (E.), HOLADAY (C.).- Aflatoxin incidence in peanuts as affected by harvesting and curing procedures. Oléagineux, 25, n° 4, 1970, pp. 213-216.

(142) UTLEY (P.), HELLWIG (R.), BUTLER (J.), MACCORMICK (W.).- Comparison of unground, ground and pelleted peanut hulls as roughage sources in steer finishing diets. Journal of Animal Science, 37, n° 2, 1973, pp. 608-611.

(143) UZZAN (A.).- L'inflammation des tourteaux : causes et prévention. Revue Française des Corps Gras, 16, n° 11, 1969, pp. 713-719.

(144) VACHEL (J.).- L'utilisation des tourteaux. Revue de l'élevage, Bétail et Basse-cour, n° 48, 1970, pp. 117-124.

(145) VIGNE (J.).- Effets éventuels de l'huile d'arachide sur l'athérosclérose humaine. Les Annales d'Hygiène de Langue Française. Médecine et Nutrition, 10, n° 4, 1974, pp. 351-359.

(146) WALRADT (J.), PITTET (A.), KINLIN (T.), MURALIDHARA (R.), SANDERSON (A.).- Volatile components of roasted peanuts. Journal of Agricultural and Food Chemistry, 19, n° 5, 1971, pp. 972-979.

(147) WALTKING (A.).- Fate of aflatoxin during roasting and storage of contaminated peanut products. Journal of the Association of Official Analytical Chemists, 54, n° 3, 1971, pp. 533-539.

(148) WARD (J.).- Processing high oil content seeds in continuous screw presses. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 261-264.

(149) WHITAKER (T.), WISER (E.).- Theoretical investigations into the accuracy of sampling shelled peanuts for aflatoxin. Journal of the American Oil Chemists'Society, 46, n° 7, 1969, pp. 377-379.

(150) WILSON (D.), JAY (E.).- Effect of controlled atmosphere storage on aflatoxin production in high moisture peanuts - groundnuts -. Journal of Stored Products Research, 12, n° 2, 1976, pp. 97-100.

(151) WILSON (R.).- The market for edible groundnuts. London. Tropical Products Institute, 1975, 119 p.
(Report G.96).

(152) WOLFF (J.).- Manuel d'analyse des corps gras. Paris. Azoulay. 1968. 552 p.

(153) WOODROOF (J.).- Peanuts : production, processing, products. Second edition. Westport, The Avi Publishing Co., 1973, 330 p.

(154) WOODWARD (J.), HUTCHISON (R.).- Drying farmers'stock peanuts with intermittent exposures to heated air. U.S. Department of Agriculture, Marketing Research Report n° 933, 1972, pp. 1-25.

(155) WORTHINGTON (R.), HAMMONS (R.).- Influence de la variation génotype sur la composition en acides gras et la stabilité de l'huile d'Arachis hypogaea L. Oléagineux, 26, n° 11, 1971, pp. 695-700.

(156) WORTHINGTON (R.), HAMMONS (R.).- Variability in fatty acid composition among Arachis genotypes : a potential source of product improvement. Journal of the American Oil Chemists'Society, 54, n° 2, 1977, pp. 105A-108A.

(157) WORTHINGTON (R.), HAMMONS (R.), ALLISON (J.).- Varietal differences and seasonal effects on fatty acid composition and stability of oil from 82 peanut genotypes. Journal of Agricultural and Food Chemistry, 20, n° 3, 1972, pp. 727-730.

(158) WRIGHT (L.).- Finished oil handling and storage in the U.S. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 408-409.

(159) YOUNG (C.).- Automated colorimetry measurement of free arginine in peanuts as a means to evaluate maturity and flavor. Journal of Agricultural and Food Chemistry, 21, n° 4, 1973, pp. 556-558.

(160) YOUNG (C.), HAMMONS (R.).- Variations in the protein levels of a wide range of peanut genotypes. Oléagineux, 28, n° 6, 1973, pp. 293-297.

(161) YOUNG (C.), MATLOCK (R.), MASON (M.), WALLER (G.).- Effect of harvest date and maturity upon free amino acid levels in three varieties of peanuts. Journal of the American Oil Chemists'Society, 51, n° 6, 1974, pp. 269-273.

(162) YOUNG (C.), WALLER (G.).- Rapid oleic/linoleic microanalytical procedure for peanuts. Journal of Agricultural and Food Chemistry, 20, n° 6, 1972, pp. 1116-1118.

(163) YOUNG (C.), WALLER (G.), MATLOCK (R.), MORRISON (R.), HAMMONS (R.).- Some environmental factors affecting free amino acid composition in six varieties of peanuts. Journal of the American Oil Chemists' Society, 51, n° 6, 1974, pp. 265-268.

(164) YOUNG (C.), WORTHINGTON (R.), HAMMONS (R.), MATLOCK (R.), WALLER (G.), MORRISON (R.).- Fatty acid composition of Spanish peanut oils as influenced by planting location, soil moisture conditions, variety, and season. Journal of the American Oil Chemists'Society, 51, n° 7, 1974, pp. 312-315.

(165) ZAMBETTAKIS (C.).- Recherches sur la désinfection des arachides et des tourteaux parasités par l'Aspergillus flavus, champignon parasite et cancérigène, et méthodes culturales. In : Congrès International des Industries Agricoles et Alimentaires. 12. 1974. Athènes. Quelques problèmes intéressant les industries agricoles et alimentaires en zone méditerranéenne. Paris. Commission Internationale des Industries Agricoles et Alimentaires, s.d., pp. 195-202.

(166) ZAMBETTAKIS (C.).- Etude de la contamination de quelques variétés d'arachide par Aspergillus flavus. Oléagineux, 30, n° 4, 1975, pp. 161-167.

(167) ZAMBETTAKIS (C.), BOCKELEE-MORVAN (A.).- Recherches sur la structure du tégument séminal de la graine d'arachide et son influence sur la pénétration de l'Aspergillus flavus. Oléagineux, 31, n° 5, 1976, pp. 219-228.

(168) ZDARKOVA (E.), RESKA (M.).- Weight losses of groundnuts - Arachis hypogaea L - from infestation by the mites Acarus siro L and Tyrophagus putrescentiae - Schrank -. Journal of Stored Products Research, 12, n° 2, 1976, pp. 101-104.

(169) ZEHNDER (C.).- Deodorization 1975. Journal of the American Oil Chemists'Society, 53, n° 6, 1976, pp. 364-369.

(170) Annuaire FAO de la production 1976. Vol. 30, [redacted]. Rome, FAO, 1977, 354 p.

(171) Annuaire FAO du commerce 1976. Vol. 30. Rome, FAO, 1977.

(172) Annuaire de la production 1964. Vol. 18. Rome, FAO, 1965, 547 p.

(173) Annuaire de la production 1968. Vol. 22. Rome, FAO, 1969, 814 p.

(174) Annuaire de la production 1972. Vol. 26. Rome, FAO, 1973, 496 p.

(175) Annuaire de la production 1974. Vol. 28. Rome, FAO, 1975, 325 p.

(176) Annuaire de la production 1975. Vol. 29. Rome, FAO, 1976, 555 p.
(Collection FAO Statistique n° 2).

(177) Annuaire du commerce 1975. Vol. 29. Rome, FAO, 1976, 531 p.
(Collection FAO Statistique n° 3).

(178) Arachides de bouche. In : Commission des Communautés Européennes. Direction du Développement et de la Coopération. Direction des Echanges commerciaux et du développement. Possibilités de création d'industries exportatrices dans les Etats africains et malgaches associés. Conserves et préparation de fruits tropicaux : dattes, bananes, agrumes et huiles essentielles ananas et conserves au sirop, anacardes et amandes cajou, arachides de bouche, fruits exotiques divers.
Bruxelles. CEE. 1974, pp. 379-462.

(179) La conservation et l'entreposage des arachides. Dakar, Institut de Technologie Alimentaire. Rome, FAO, 1974, 43 p.

(180) Les décortiqueuses d'arachide à main. Oléagineux, 22, n° 2, 1967, pp. 95-97.

(181) Gemeinschaftsarbeiten der DGF, 63. Mitteilung. Gewinnung von Fetten und Olen aus pflanzlichen Rohstoffen durch Extraktion. 1. Fette, Seifen, Anstrichmittel, 77, n° 10, 1975, pp. 373-382.

(182) Gemeinschaftsarbeiten der DGF, 65. Mitteilung. Gewinnung von Fetten und Olen aus pflanzlichen Rohstoffen durch Extraktion. 2. Aus dem Arbeitskreis "Technologien der industriellen Gewinnung und... Fette, Seifen, Anstrichmittel, 78, n° 6, 1976, pp. 217-223.

(183) Guidelines for the establishment and operation of vegetable oil factories. New York. United Nations, 1977, 116 p.
(UNIDO ID/196).

(184) Norme internationale recommandée pour l'huile comestible d'arachide. Rome, FAO, 1970, 19 p.
(Commission du Codex Alimentarius, CAC-RS 21).

(185) Peanuts - culture and uses. A symposium. Stillwater, American Peanut Research and Education Association Inc., 1973, 684 p.

(186) Les tourteaux. Bulletin Cetiom, n° 52, 1973, pp. 15-18.

(187) Tourteaux et autres matières riches en protéines 1975-1976. Rungis, INRA, Laboratoire d'Economie rurale des I.A.A. Paris, Charles Robert S.A. 1977. 50 p.

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