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INDUSTRIAL PROCESSING OF COTTON-SEED

BY

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CHAPTER ONE : COTTONSEED RAW MATERIAL

II - THE EXISTING TYPES AND VARIETIES OF COTTON

The cotton (tree) belongs to the Malvaceae type, Hibisceae tribe, Gossypium genus. Some botanists (EDLIN, 1935) prefer to place the Hibisceae tribe in the Bombacaceae type, which allows all species offering staples attached to a seed or a capsule to be put together.

Gossypium is by far the most important genus of the tribe Hibisceae.

Numerous cotton varieties can be found in the natural state, either perennial or annual, ligneous or herbaceous, from o,5o m to 5 m high.

All cultivated species are supposed to derive from an Old Continent common ancestor, which could be Gossypium Herbaceum.

Cotton growing can be traced back to quite a long time ago : cotton rags 5 000 years old were found in India (Mohenjo Daro) and other ones 4 400 years old, in Peru.

The cotton tree is normally a perennial plant ; so were the former cultivated varieties, but they have gradually been replaced by annual plants. Such an evolution allowed cotton growing to develop in northern countries, whose cold winters it could not have held out against otherwise.

Generally speaking, most of the cultivated varieties are ligneous, annual, arborescent shrubs, no higher than 1 m.

Gossypium classification is an entangled and long debated point. We won't give details upon taxonomy, which is not our subject. We will only indicate that 15 wild lintless species are grouped into 6 sections, and that cultivated cotton trees can be divided into 4 main species : arboreum, herbaceum, hirsutum, barbadense, each one covering many sub-species and varieties.

III - Gossypium arboreum and Gossypium herbaceum are cultivated on the Old Continent. G. arboreum can be divided into 6 types, and G. herbareum into 5, according to their geographical origin.

a) G. arboreum

a 1) Indicum type : two varieties, one of them perennial and cultivated in the Western part of India, in Madagascar, and in Tanzania, the other one annual being found in India.

a 2) Burmanicum type : predominately perennial, but annual ones exist. Can be found in Burma, Bengal, Assam, Indo-China, Malays and Insulinde.

a 3) Cernuum type : annual, is cultivated in Assam and Bengal.

a 4) Sinense type : an annual and early sub-species, which exists not only in continental China (including Manchuria) but also Korea, Japan and Formosa.

a 5) Bengalese type : an annual one, which is found in Northern India and Pakistan.

a 6) Sudanense type : a perennial form, cultivated in Sudan and in West Africa.

b) G. Herbaceum

b 1) Persicum type : annual. Iran, Afghanistan, West Pakistan, Russian Turkestan, Iraq, Syria, Turkey, Greece and the Mediterranean Islands.

b 2) Kuljianum type : annual, found in Central Asia (Russia, Sinkiang, West China) whose short summers and cold winters it is quite fitted to.

b 3) Whightianum type : a West India annual type.

b 4) Acerifolium type : perennial. Africa (Sudan, Abyssinia, Egyptian, and Libyan oasis) and Arabia.

b 5) Africanum type : a perennial type. South Africa.

The linter still exiating on G. arboreum and G. herbaceum after ginning is not very thick : compared to the total seed weight, it does not mean more than 2 %, which makes the seed look almost bare.

112) Gossypium hirsutum, originating from the New Continent, includes one wild Hawayan type, G. tomentosum and 7 cultivated types (Marie-Galante, punctatum, palmeri, yucatanense, morrillii, richmondi, latifolium) which have spread out onto the entire world from their center point (South Mexico and Guatemala). The 3 main types are G. Marie-Galante, G. punctatum and G. Latifolium :

a) The Marie-Galante type, a perennial shrub, was the basic species used for the Antilles cultivations. It was brought afterwards into North and East Brazil, Ecuador, the Guianas and West Africa (Ghana, Togo, Ivory Coast...)

b) The punctatum type, also perennial, covers the tropical and semi-tropical zones : Central America, Antilles, Florida, West Africa, Egypt, Erithrea, India, Philippines, Australia. Annual forms have been developped in West Africa.

c) The Latifolium type, annual, derivated into the "Upland" type in the south of the United-States (Carolinas, Georgia).

The G. hirsutum type is the species which has most benefited from the selecting research work, done mainly in the USA in order to improve the yield and quality of cotton lint, according to local conditions (climate, soil, etc...). Many varieties, deriving either from former types development or from hybridization were found. Such work began in the early XIX th century and is still going on.

When the United-States were a British territory, two cotton varieties could be found in the south : the "Sea-Island" or "Lowland-cotton", originated from Antilles, whose seed after ginning does not keep any linter ; its colour is black or brownish-red (1), which makes it call "black seed". The other one, on the contrary, originated from Mexico, still shows after ginning a thick grey or white linter, and is called "Upland cotton". The "Upland cotton", offering a higher yield, superseded the "Lowland cotton", and due to applied research, gave forth, especially since 1850, to a great many types. We can't here detail the whole classification, but the more commonly known are derived from the 16 following types : EXTRA-LONG-STAPLE UPLAND, MISCELLANEOUS UPLAND, DELTAPINE, FOX, STONEVILLE, COKER 100, ACALA, EMPIRE, ROWDEN, MEBANE TRIUMPH, WESTERN MEBANE, LANKART, PAYMASTER, MACHA, HIBRED, DELFOS. Among which the four underlined are most important. Nearly all 16 types : some of them can be divided into sub-types - cover several varieties.

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(1) Generally speaking, the seed coat is black, but shades can vary from brownish-red to jet-black.

Some G. hirsutum varieties are note cultivated in the United-States, but in other places where they have been acclimatized : Brazil, Russia, Africa (Chad, Nigeria, Uganda), China, India, etc...

113) Gossypium barbadense finds also its origin in America and is composed of two sub-species :

- G. brasiliense : North-East part of Brazil, Central America and Antilles, Africa and India.

- G. darwinii : found in the Galapagos Islands, and quite unknown else where, though it can be related to other cultivated varieties.

Those 2 sub-species which were first perennial, became gradually annual as they developped in Africa (along the Guinea Golf : Nigeria, Togo, Dahomey, and afterwards in Egypt) and in America (for example in South Carolina, where they foreran the above mentionned Sea Island type, and in Peru).

G. barbadense have medium, long or extra-long staples.

In Egypt, are grown G. barbadense varieties with medium staples (Ashmouni,Giza 66), long staples (Giza 47, Dendera, Giza 67) or extra-long staples (Menoufi, Giza 45 or 68). The Russian long lint cotton are G. barbadense, deriving from the Egyptian one.

12 - SURVEY UPON COTTON VARIETIES CULTIVATED IN THE MAIN PRODUCING COUNTRIE

The main facts have already been given above, but it will be useful to come over it again.

a) The United-States

Originating from the South-East States (Virginia, Carolinas, Georgia, Louisiana) , cotton growing developped in the end of the XVIII th century, and gradually expanded to the whole cotton belt. Between the 2 World Wars, and moreover after the second one, the irrigation technique improvements enabled it to progress to the West.

The varieties which are grown there all derive from Upland, that is Gossypium hirsutum (cf. supra).

The cotton cultivated area can be devided into four main parts :

- the South-East (North Carolina, South Carolina, Georgia, Alabama, Florida, Virginia), where moderate rainfalls entail the contribution of irrigation on a poor soil, cut into small fields.

- the Southern-Center, also called "the Delta", includes all the states bordering on the Mississipi and its affluents (Missouri, Arkansas, Tennesee, Louisiana, Mississipi, Illinois and Kentucky). In spite of a rainy climate,irrigation is used to improve yields. Soils are light, deep and rich.

- the South-West, which covers all the South mountainous shelves : Texas, Oklahoma. Scanty rains command to choose dryness-resistant and forward variety. Soils are fine, sandy, and moderately rich.

- the West (California, Arizona, New Mexico, Nevada), a dry land, with deep and rich soils which offer high yields with the help of irrigation.

b) S.S.R.

Cotton growing is mainly concentrated in Central Asia Republics (Ouzbekistan, Tadjikistan, Turkmenistan...), but can also be found in Transcaucasia (Azerbeïdjan, Armenia). The climate there is continental and dry, hence irrigation appears necessary. Soils, generally deep and rich, are sometimes too salty.

The first cultivated species was G. herbaceum, which still remains the major part of the production. Upland varieties were introduced in the 80's, and G. barbadense more recently.

c) China

5 productive zones can be distinguished :

- the Houan-Ho basin, the main one which represents more than 50 % of the cultivated area. Rains are scanty and badly distributed.

- the Yang-Tse basin, rich alluvial plains on which rainfall is moderate.

- the North-West area (Sin-Kiang) where irrigation is necessary.

- the North-East area (the Laokei basin).

- the Southern area, with high rainfall.

The traditionnal species are G.herbaceum and G. arboreum ; the latter has been imported from India more than a thousand years ago. As to the Uplands, they were introduced in the middle of the XIX th century, but did not develop until 1930.

d) India

Cotton has always been cultivated in India. The following table indicates the producing areas and the main species :

. Northen area	: G. hirsutum, G. arboreum
. North Center area	: G. arboreum
. South Center area	: G. arboreum, G. herbaceum, G. hirsutum
. Southern area	: G. hirsutum, G. arboreum
. Western area	: G. herbaceum
. Eastern area	: G. arboreum

Some G. barbadense can be found along the coasts (Sea Island Andrews).

The local varieties, named "desi",are mainly G. arboreum. For the time being, it appears that approximately 60 % of the cotton area is grown with G. arboreum and G. herbaceum, and 40 % with G. hersutum. G. barbadense is considered negligible.

e) Pakistan

The Pakistan varieties are similar to the Indian ones. The only difference lays in a greater proportion of G. hirsutum, deriving from Upland.

f) Brazil

The 2 producing areas are distinctly separated : the South (Sao-Paulo, Parana and Minas Gerais states) which yields approximately 70 % of the production, with Upland varieties, and the North-East where the main varieties are either perennial "Moco type" (1) or herbaceous annual plants (2).

g) Egypt

The Low Egypt provinces (the Nile delta) are grown with extra-long staple varieties. Long and medium sized staple varieties grow in Middle Egypt, while in High Egypt, only the latter ones appear.

All of them belong to the G. barbadense species, whose products are weel-known for their lenght and good quality.

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(1) They derive from a complicated breeding of G. hirsutum (Marie-Galante), G. hirsutum latifolium, and G. barbadense brasiliense.

(2) They are improvements of former varieties from Africa or from the U.S.A.

h) Turkey

The cotton areas are as follows, from the main to the smaller ones :

- Tchoukouroua (Adana) = North-East of Cyprus
- Egea (Izmir)
- Antalya : North-West of Cyprus.

G. herbaceum (also called "yerli") which has been cultivated in Turkey for more than a thousand years, is now almost completely replaced by Upland. Some G. barbadense may eventually be found.

i) Mexico

Due to the US Cotton belt proximity, nearly all Mexican varieties are Upland.

j) Sudan

Like in Egypt, the plants grown in Sudan are mostly G. barbadense. Nevertheless, some Upland varieties are grown without irrigation in the South.

k) Peru

The main variety is G. barbadense.

13 - SURVEY UPON THE COTTON PLANT MORPHOLOGIA AND PHYSIOLOGY

Five phases can be distinguished during the cotton plant life.

a) The emergence phase, from germination to the cotyledons unfolding. It lasts from 6 to 30 days, and requires both moisture and heat.:

- it is necessary that water reaches the embryo for the germination biochemical process to start,

- even when there is water, germination does not start under 14° C ; it is slow between 14 and 25 ° C, quick and normal at 30 ° C, and above 40° C there is hardly none.

The best conditions are then :

- soil temperature : 25 to 30° C
- soil moisture : 90 % of its water capacity.

b) The "seedling" phase, from the cotyledons unfolding to the 3 - 4 leaves stage. It lasts from 20 to 35 days. The seedling completely mingles with its environment, and the cells metabolism becomes more intense ; the exchanges at the root and first leaves (cotyledons included) level are accelerated. They will depend upon the soil and atmosphere moisture, the temperature, the light, the soil physico-chemical nature.

The best conditions are :

- soil temperature : higher than 20° C
- air temperature : 25 to 30° C
- soil moisture : unsaturated damp and aerated ground.

Such period is a most important one for the plant further development, and a lack in nitrogen supply at that stage will be badly felt.

c) The pre-flowering phase, from the 3 - 4 leaves stage to the beginning of the bloom. It lasts from 30 to 35 days. The seedling grows quickly, the plant is taking shape. The first flower-bud appears generally 35 to 45 days after the emergence. The development afterwards is so quick that a new bud is individualized every 3 days.

Moisture, air and heat are important as always. The fuller the bloom, the more fruit-bearing branches are to be got, and the longer they will be. The plant further height will be proportioned to the bloom abundance. At that stage, the most important point is the ground fertility.

d) The bloom phase, which lasts from 50 to 70 days. A flower opens between 20 to 25 days after its bud individualization. The bloom rhythm is accelerated by a warmer and drier climate.

At that stage beginning, the plant growth slows down.

The cotton flower pollinization takes generally place on the very day of its opening.

The ovary comprises 2 to 6 carpelles, and each carpelle 8 to 12 ovules.

e) The capsule maturation phase. It lasts from 50 to 80 days. After fecundation, the ovary enlarges ; the fruit is a capsule, either ovoïd, round or slender, mottly greenish, from 2 to 5 cm high. On the surface, appear many glands. Inside the capsules, the seeds are 6 to 9 in each cell, which means 18 to 45 seeds per capsule. The seeds are rather big, 7 to 12 mm long and 4 to 6 mm large. They are either ovoïd or pearshaped. According to the year and variety, 100 seeds weigh from 7 to 17 g - such weigh, known under the anglo-saxon calling "seed index" is used to measure the seed size . The cultivated cottonseeds are covered with long fibres or "lint". *G. hirsutum* seeds are moreover coated with a thick down of shorter fibres called "linter" or "fuzz", *G. arboreum* and *G. herbaceum* are less fuzzy. *G. barbadense* do not present such additionnal sheathing, and after ginning - that is separating lint from seed - appear completely naked. The linter can be either white, grey, green or brown. The seed hull is black or brownish, hence the "black seed" name given to the *G. barbadense* ginned seed, as we have already said it.

During capsule maturation, water and light are most important. For the 21 first days, the ground must be moistened enough to enable the nutritive substances to migrate, but not to the stage of saturation. After the first 3 weeks, sunshine is necessary to hasten maturation and bring about dehiscence - that is capsule bursting - all along the carpelles suture lines.

The temperature also plays its part : the warmer the temperature, the more lint is to be found in the capsules, the shorter and more resisting is the lint, the lighter the seed, the lower its oil rate and the higher its protein rate. The effect, though, does not always go in the above indicated direction.

When the capsules are ripe, they open. The lint fluffs outside, and slowly dries, as well as the seeds.

Flowers may still bloom, even when the first capsules have opened, and offer a second blooming cycle.

14 - SURVEY UPON COTTON CULTIVATION

The cotton growing process depends both upon the farming type (extensive or intensive culture, small plots or large farms, etc...) and upon the economical development stage of the growing countries. For example, mechanization rate is very high in the USA, while in Africa, hands are the only possible means. Elsewhere, mixed situations are found : the main works are done mechanichally, and the finer ones carried out by hands.

We shall now survey some cotton tree growing aspects :

141 - Cropping plan

The cotton tree needs a good quality soil. Its tap-root, generally 0,60 m long (but it can reach 3 m lenght), requires a deep and porous ground. As stagnant moisture entails cotton diseases, the ground must also be well drained. It has moreover to be fertile since the plant attains its full development in a few months time. Cotton plant is among the most soil exhausting.

If the soil is very rich and with manure supply making up for the used nutrients, crop rotating is nevertheless often used, not only to maintain or increase fertility, but also to fight diseases and casual plants. In tropical areas, it also affords a means to minimize the soil washing out and eroding, since the cotton plant does not cover the ground all the year round.

The cropping plan choice is a difficult problem, in which many points, technical as well as economical, are to be considered. A triennal plan is often retained, which involves, besides cotton, a year of leguminous plants and a year of cereals.

142 - Climate conditions

In the best conditions, the whole cotton tree cycle lasts 166 days ; in less favourable ones, it lasts 205 days. As it fears cold, temperature must not get too low during the 5 to 7 months of its cultivation, and especially never get below 5° C, which entails :

- the geographical limits to be drawn at tropical or subtropical zones,
- the early varieties selection in cold winter countries (ex. SSR).

143 - Fertilization

Nitrogen is the most important element for the cotton tree, the more so that quite often the ground badly needs it. The supply of fertilizers (1) per hectare varies from 40 to 200 kg.

Phosphorus comes second. Phosphatic dungs produce generally 20 to 80 kg of P2 05 per hectare.

When potassium appears necessary, 20 to 50 kg per hectare are added.

144 - Irrigation

It is not used whenever possible. Such cultivation is then called "rain growth".

When the climate is dry and hot, irrigation is necessary to complement or completely supply the necessary water.

Generally speaking, irrigated cultivation offers higher and more regular yields, and fibre better quality.

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(1) The denomination covers also urea and ammonia.

145 - Harvesting

The seed cotton gathering is done in 2,3 or even 4 successive operations, either manual or mechanical.

The hand-gathering - the only one in use in former times- is still found in the countries where manpower is plentiful and cheap, or on small family-cultivated farms.

The mechanical gathering, which is more and more used, has been developped for economical motives : lower cost quest or hand shortage. But the seeds thus harvested are mingled with impurities (capsules, leaves, small branches) which must be taken off afterwards, by the means of processes which reduce the fibre resistance. Moreover, unripe capsules may as well be picked, which entails economical losses. The equipment manufacturers have tried to suppress such drawbacks, but their effort has not always been successful. Anyway, before the machine operating, defolients are spread out to avoid the leaves'over - mixing with the seed cotton.

The mechanical harvesters belong to 2 different types :

- the strippers, fitted with rollers, brushes or rakes which literally comb the shrub and strip out the capsules, ripe or unripe - the result is a high waste rate.
- the pickers whose front is fitted with pins fixed unto vertical axled drums. The drums while reeling drive the pins, set themselves in a revolving motion. They get through the cottonplant, and catch on the opened apsule fibres. To help such hooking, they are constantly moistened. Inside the machine, the fibres are taken off from the spins by a carder. In some pickers, pins are replaced by an air-aspiring or an electrical device which draws the fibres upon electricity charged stripes or fingers.

If pickers' output is inferior by the half to the strippers', on the other hand, the seed cotton they harvest is far cleaner.

146 - The cotton enemies

There are many of them, of 2 categories :

- microorganisms (fungus, bacteries, virus) responsible for the many cotton plant diseases,
- the parasitic insects.

In the damp tropical areas, diseases result in a loss of approximately 15 to 25 % (1). The percentage of loss due to the insects is yet unknown, but it must certainly be a high one.

The means used against them comprise pesticids, entomophage or insect parasit induction, waste destroying and cotton plant burning after the harvest, seed disinfection, crop rotating with at least a year without cotton growing .

15 - THE WORLD CULTIVATED AREAS, PRODUCTIONS AND YIELDS

As the economical value of the staple, for its textile uses, represents 80 to 90 % of the whole cotton products value - the seed rating no more than 10 to 20 % -, it is not surprising that the international production statistics are based upon lint weights.

However, the hereafter table shows how can be divided a whole dehydrated plant weight :

TABLE I - Weight in grams and per cent of different parts of mature dehydrated cotton plants

Plant part	Weight (grams)	Per cent
Roots	14,55	8,80
Stems	38,26	23,15
Leaves	33,48	20,35
Burs	23,49	14,21
Seeds	38,07	23,03
Lints	17,45	10,56
	165,30	100,00

(1) Even in the USA, the loss was yet recently (around 1960) rated to 16 %.

A ratio of 31,4 % appears between the lint weight and the total seed + lint weight. So it will be easy to convert a lint yield into a total seed yield by multiplying the first figure by 3 ; in the same way, the seed yield only can be obtained by multiplying the first figure by 2. The results of course are but approximate, since the lint percentage in the whole seed is different according to varieties and other factors. The usual ratio ranges from 30 to 43 %, with the following forks :

- for G. arboreum and G. herbaceum : 30 to 33 %
- for G. hirsutum : 33 to 39 %, which can rise to 40 to 42 % for some varieties
- for G. barbadense : 30 to 34 %

Tables 2, 3 and 4 show the variations on the last several years of the cultivated acreages, the yields and the productions in the world. It appears that in 1976/77 (provisional figures), the main producing countries lint yields have been in kg/ha :

S.S.R.	897
U.S.A.	521
CHINA	479
INDIA	143,5
PAKISTAN	205
BRAZIL	232
EGYPT	739
TURKEY	776
MEXICO	872
SUDAN	349
PERU	633

Source : FAO Statistics.

Converted into tons of lint, the 1976/77 production (provisional figures) appears so :

S.S.R.	2.645.000
U.S.A.	2.298.000
CHINA	2.363.000
INDIA	1.084.000
PAKISTAN	390.000
BRAZIL	499.000
EGYPT	396.000
TURKEY	470.000
MEXICO	221.000
SUDAN	152.000
PERU	67.000
TOTAL OF THOSE 11 COUNTRIES.......	10.585.000
TOTAL IN THE WORLD..........	12.505.000

16 - COTTON SEED DESCRIPTION AND COMPOSITION

The whole cotton seed comprises, as we have already said it, the lint and the seed itself. From now on, by the word "seed" by itself, we shall mean the seed bare of lint.

TABLE 2 : Cotton acreage and yield per acre

ACREAGE/YIELD — SUPERFICIE/RENDEMENT — SUPERFICIE/RENDIMIENTO

Cotton acreage and yield per acre — Superficies cotonnieres et rendement a l'acre

COUNTRY	ACREAGE				YIELD				PAYS
	1973/74	1974/75	1975/76	1976/77 prel.	1973/74	1974/75	1975/76	1976/77 prel.	
	1,000 acres				Pounds per acre				
NORTH AMERICA									AMERIQUE DU NORD
EL SALVADOR	230	230	184	200	717	717	713	717	SALVADOR
GUATEMALA	256	275	200	235	1,037	843	1,099	1,078	GUATEMALA
HONDURAS	23	20	11	25	514	540	628	485	HONDURAS
MEXICO	1,040	1,402	581	627	689	760	749	778	MEXIQUE
NICARAGUA	451	443	356	400	699	605	678	615	NICARAGUA
UNITED STATES	11,970	12,567	8,796	10,899	520	441	453	465	ETATS-UNIS
OTHERS	24	22	19	23	-	-	-	-	AUTRES PAYS
TOTAL	13,994	14,959	10,147	12,409	551	487	495	501	TOTAL
SOUTH AMERICA									AMERIQUE DU SUD
ARGENTINA	1,171	1,248	1,022	1,200	239	303	288	319	ARGENTINE
BOLIVIA 1/	136	120	75	90	404	398	510	478	BOLIVIE 1/
BRAZIL	5,700	5,500	4,700	5,300	207	212	186	207	BRESIL
COLOMBIA	633	727	622	800	468	460	430	329	COLOMBIE
ECUADOR	57	105	81	65	219	248	265	219	EQUATEUR
PARAGUAY	230	250	262	540	229	229	274	221	PARAGUAY
PERU	352	350	239	284	556	458	550	565	PEROU
VENEZUELA	200	310	151	125	299	285	333	325	VENEZUELA
OTHERS	1	1	1	2	-	-	-	-	AUTRES PAYS
TOTAL	8,480	8,611	7,153	8,406	251	262	244	251	TOTAL
WESTERN EUROPE									EUROPE OCCIDENTALE
GREECE	362	371	333	373	659	752	861	654	GRECE
ITALY	8	12	12	10	246	172	199	239	ITALIE
SPAIN	228	249	183	126	439	518	523	474	ESPAGNE
YUGOSLAVIA	20	20	15	15	263	263	320	319	YOUGOSLAVIE
TOTAL	618	652	543	524	561	637	717	593	TOTAL
EASTERN EUROPE									EUROPE ORIENTALE
ALBANIA	55	55	55	55	261	261	261	261	ALBANIE
BULGARIA	90	90	90	85	319	292	266	281	BULGARIE
TOTAL	145	145	145	140	297	280	264	273	TOTAL
USSR 1/	6,775	7,116	7,218	7,290	783	823	772	800	URSS 1/

CONTINUED - A SUIVRE

TABLE 2 (continued)

(Continued) **ACREAGE/YIELD** — **SUPERFICIE/RENDEMENT** — **SUPERFICIE/RENDIMIENTO**

Cotton acreage and yield per acre — (Suite) **Superficies cotonnieres et rendement a l'acre**

COUNTRY	ACREAGE 1973/74	ACREAGE 1974/75	ACREAGE 1975/76	ACREAGE 1976/77 prel.	YIELD 1973/74	YIELD 1974/75	YIELD 1975/76	YIELD 1976/77 prel.	PAYS
	1,000 acres				Pounds per acre				
ASIA AND OCEANIA									ASIE ET OCEANIE
AFGHANISTAN 1/	185	275	300	320	388	348	351	373	AFGHANISTAN 1/
AUSTRALIA	76	83	73	79	880	875	762	967	AUSTRALIE
BURMA	400	300	400	500	78	56	60	72	BIRMANIE
CHINA, PEOP.REP.	12,000	12,000	12,000	12,100	466	458	438	427	CHINE,REP.POP.
INDIA	18,715	18,830	18,435	18,700	141	151	139	128	INDE
IRAN	855	912	717	730	514	574	427	458	IRAN
IRAQ	150	150	130	150	223	223	202	223	IRAK
ISRAEL	78	95	95	101	1,060	1,157	1,132	1,183	ISRAEL
KOREA, REP.	33	26	25	25	300	259	268	287	COREE, REP.
PAKISTAN	4,559	5,019	4,574	4,694	318	279	248	183	PAKISTAN
SYRIA	495	509	514	487	695	630	678	638	SYRIE
THAILAND	105	140	150	170	341	307	319	337	THAILANDE
TURKEY	1,674	2,070	1,656	1,500	676	637	640	692	TURQUIE
YEMEN, P.D.R.	30	30	30	30	255	335	239	319	YEMEN, R.D.P.
OTHERS	122	130	126	134	-	-	-	-	AUTRES PAYS
TOTAL	39,477	40,569	39,225	39,720	303	303	282	268	TOTAL
AFRICA									AFRIQUE
ANGOLA	243	240	150	150	276	349	191	191	ANGOLA
BENIN	131	120	100	110	293	227	215	239	BENIN
CAMEROON,U.R.	151	159	181	198	152	210	238	218	CAMEROUN,R.U.
CENTRAL AFR.EMP.	309	334	334	330	118	115	79	101	EMP. CENTRAFRICAINE
CHAD	665	672	831	780	144	174	172	150	TCHAD
EGYPT	1,661	1,507	1,397	1,326	650	640	603	659	EGYPTE
IVORY COAST	144	145	168	173	359	363	341	304	COTE D'IVOIRE
KENYA	130	170	170	200	92	68	68	72	KENYA
MADAGASCAR	33	40	40	45	775	724	651	690	MADAGASCAR
MALAWI	110	100	100	100	139	110	120	120	MALAWI
MALI	172	171	216	280	245	296	398	324	MALI
MOROCCO	40	35	43	30	331	332	202	239	MAROC
MOZAMBIQUE	700	700	600	600	120	123	100	100	MOZAMBIQUE
NIGER	22	38	41	45	127	165	224	159	NIGER
NIGERIA	1,200	1,235	1,300	1,400	56	93	97	102	NIGERIA
SENEGAL	71	98	97	100	371	346	262	359	SENEGAL
SOUTH AFRICA	250	250	220	250	354	411	272	382	AFRIQUE DU SUD
SUDAN	1,223	1,223	1,013	1,075	426	397	212	311	SOUDAN
TANZANIA	700	700	500	700	205	225	186	222	TANZANIE
UGANDA	1,764	1,245	1,475	1,000	62	56	37	48	OUGANDA
UPPER VOLTA	165	152	168	230	132	164	236	229	HAUTE VOLTA
ZAIRE	400	390	265	350	101	92	72	75	ZAIRE
OTHERS	550	565	554	553	-	-	-	-	AUTRES PAYS
TOTAL	10,834	10,289	9,963	10,025	253	265	219	243	TOTAL
WORLD TOTAL	80,323	82,341	74,394	78,514	376	375	350	351	TOTAL MONDIAL
SOCIALIST COUNTRIES	18,990	19,331	19,475	19,600	577	590	558	566	PAYS SOCIALISTES
ELSEWHERE	61,333	63,010	54,919	58,914	314	309	276	280	AUTRES PAYS

1/ REVISED SERIES — 1/ SERIES REVISEE

TABLE 3 : Production of cotton, by countries

(in 1000 bales)

PRODUCTION — PRODUCCION

Production of cotton, by countries — **Production de coton, par pays**

COUNTRY	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/ prel.	PAYS
	YEAR BEGINNING AUGUST 1st				ANNEE COMMENCANT LE 1er AOUT					
	1,000 bales									
NORTH AMERICA										**AMERIQUE DU NORD**
BR. W. INDIES	1	1	-	-	1	1	2	1	1	ANTILLES ANGLAISES
COSTA RICA	17	10	6	-	1	3	2	2	6	COSTA RICA
CUBA	5	5	5	5	5	5	5	5	5	CUBA
EL SALVADOR	203	210	252	315	323	345	345	275	300	SALVADOR
GUATEMALA	380	260	265	375	430	555	485	460	530	GUATEMALA
HONDURAS	35	15	9	11	20	25	23	14	25	HONDURAS
MEXICO	2,450	1,750	1,440	1,715	1,780	1,500	2,230	910	1,020	MEXIQUE
NICARAGUA	420	310	360	480	485	660	560	505	515	NICARAGUA
UNITED STATES 1/ 2/	11,030	9,950	10,269	10.270	13,890	13,300	11,525	8,500	10,600	ETATS-UNIS 1/ 2/
OTHERS	3	3	3	3	3	3	3	2	2	AUTRES PAYS
TOTAL	14,544	12,514	12,609	13,174	16,938	16,397	15,18[illegible]	10,674	13,004	TOTAL
SOUTH AMERICA										**AMERIQUE DU SUD**
ARGENTINA	520	670	390	400	[illegible]	585	790	615	800	ARGENTINE
BOLIVIA	20	17	45	70	115	115	100	80	90	BOLIVIE
BRAZIL 3/	3,325	2,675	2,740	3.135	3,000	2,465	2.440	1,825	2,300	BRESIL 3/
COLOMBIA	640	590	540	590	630	620	700	560	550	COLOMBIE
ECUADOR	25	25	[illegible]	18	25	26	55	45	30	EQUATEUR
PARAGUAY	60	60	30	60	105	110	120	150	250	PARAGUAY
PERU 2/	515	393	410	400	315	405	375	290	310	PEROU 2/
URUGUAY	1	1	1	1	-	1	1	1	1	URUGUAY
VENEZUELA	71	66	76	98	95	125	185	105	85	VENEZUELA
TOTAL	5,177	4,497	4,253	4,772	4,960	4,452	4,766	3,671	4,416	TOTAL
WESTERN EUROPE										**EUROPE OCCIDENTALE**
GREECE	338	515	508	537	640	500	583	600	510	GRECE
ITALY	8	9	5	6	4	4	4	5	5	ITALIE
SPAIN	355	270	250	200	260	210	270	200	125	ESPAGNE
YUGOSLAVIA	18	19	20	16	12	11	12	10	10	YOUGOSLAVIE
TOTAL	719	813	783	759	916	725	869	815	650	TOTAL
EASTERN EUROPE										**EUROPE ORIENTALE**
ALBANIA	20	25	30	30	30	30	30	30	30	ALBANIE
BULGARIA	80	60	70	60	75	60	55	50	50	BULGARIE
TOTAL	100	85	100	90	105	90	85	80	80	TOTAL
U.S.S.R.	9,200	8,850	10,800	11,000	11,100	11,100	12,250	11,650	12,200	**U.R.S.S.**
ASIA AND OCEANIA										**ASIE ET OCEANIE**
AFGHANISTAN	110	130	100	105	115	150	200	220	250	AFGHANISTAN
AUSTRALIA	154	128	89	201	145	140	152	117	160	AUSTRALIE
BURMA	50	50	65	65	65	65	35	50	75	BIRMANIE
CHINA, PEOP. REP.	8,300	8.100	9,200	10,200	9,800	11,700	11,500	11,000	10,900	CHINE, REP. POP.
INDIA	4,900	4,850	4,400	5,800	5,370	5,530	5,950	5,350	5,000	INDE
IRAN	770	760	710	680	965	920	1,095	640	700	IRAN
IRAQ	60	65	65	65	65	70	70	55	70	IRAK
ISRAEL	154	183	163	169	186	173	230	225	250	ISRAEL
KOREA, REP.	20	20	20	19	18	21	14	14	15	COREE, REP.
PAKISTAN	2,433	2,470	2,502	3,263	3.237	3,037	2,925	2,370	1,800	PAKISTAN
SYRIA	710	690	690	725	750	720	670	730	650	SYRIE
THAILAND	200	200	85	150	95	75	90	100	120	THAILANDE
TURKEY	2,005	1,845	1,845	2,420	2,505	2,365	2,760	2,215	2,[illegible]70	TURQUIE
YEMEN, REP	3	2	2	3	3	5	12	5	5	YEMEN, REP.
YEMEN, P.D.R.	30	23	26	20	21	16	21	15	20	YEMEN, REP. DEM. POP.
OTHERS	29	31	21	27	25	26	33	32	44	AUTRES PAYS
TOTAL	19,928	19,547	19,983	23,912	23,365	25,013	25,757	23,138	22,229	TOTAL

CONTINUED - A SUIVRE

TABLE 3 (continued)

(Continued) **PRODUCTION** — **Production of cotton, by countries**

PRODUCCION (Suite) **Production de coton, par pays**

COUNTRY	YEAR BEGINNING AUGUST 1st — ANNEE COMMENCANT LE 1er AOUT 1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77 Prel.	PAYS
	1,000 bales									
AFRICA										AFRIQUE
ALGERIA	6	8	5	1	2	3	2	5	5	ALGERIE
ANGOLA	75	108	142	145	83	140	175	60	60	ANGOLA
BENIN	40	42	65	85	88	80	57	45	55	BENIN
BURUNDI	10	10	10	10	10	10	10	10	10	BURUNDI
CAMEROON, U.R.	115	157	65	73	77	48	70	90	90	CAMEROUN, R.U.
CENTRAL AFR. EMP.	100	102	91	78	88	76	80	55	70	EMP. CENTRAFRICAINE
CHAD	260	200	160	190	180	200	245	300	245	TCHAD
EGYPT	2,013	2,497	2,346	2,351	2,369	2,258	2,018	1,762	1,827	EGYPTE
ETHIOPIA	55	65	65	75	80	100	110	110	110	ETHIOPIE
IVORY COAST	78	61	54	91	99	108	110	120	110	COTE D'IVOIRE
KENYA	19	23	25	25	25	25	25	25	30	KENYA
MADAGASCAR	20	29	37	43	43	54	60	55	65	MADAGASCAR
MALAWI	25	30	33	33	25	32	23	25	25	MALAWI
MALI	75	80	92	117	112	98	106	180	190	MALI
MOROCCO	30	31	28	40	40	27	24	18	15	MAROC
MOZAMBIQUE	205	215	162	218	225	175	180	130	130	MOZAMBIQUE
NIGER	11	17	16	14	9	6	13	19	15	NIGER
NIGERIA	260	425	180	175	220	140	240	265	300	NIGERIA
RHODESIA	200	200	200	200	160	150	220	180	150	RHODESIE
SENEGAL	16	18	19	36	39	55	71	53	75	SENEGAL
SOUTH AFRICA	125	90	85	92	82	185	215	125	200	AFRIQUE DU SUD
SUDAN	1,050	1,135	1,130	1,125	920	1,090	1,015	450	700	SOUDAN
TANZANIA	240	330	350	305	355	300	330	195	325	TANZANIE
TOGO	9	9	10	14	10	15	18	16	10	TOGO
UGANDA	355	390	345	345	360	230	145	115	100	OUGANDA
UPPER VOLTA	53	61	39	48	55	45	52	90	110	HAUTE VOLTA
ZAIRE	75	80	90	95	110	85	75	40	55	ZAIRE
ZAMBIA	10	10	18	20	13	8	5	4	5	ZAMBIE
OTHERS	1	1	1	1	-	5	5	13	20	AUTRES PAYS
TOTAL	5,532	6,424	5,863	6,045	5,879	5,738	5,699	4,555	5,102	TOTAL
WORLD TOTAL	55,200	52,730	54,391	59,752	63,163	63,515	64,606	54,583	57,681	TOTAL MONDIAL
SOCIALIST COUNTRIES	17,615	17,050	20,115	21,305	21,070	22,905	23.850	22,745	23,195	PAYS SOCIALISTES
ELSEWHERE	37,585	35,680	34,276	38,447	42,143	40,610	40,756	31,838	34,486	AUTRES PAYS

1/ RUNNING BALES ADJUSTED FOR GINNINGS WITHIN SEASON, CITY CROP, ETC. EXCEPT THAT BEGINNING WITH 1972/73, DATA ARE IN BALES OF 478 LBS. NET.
2/ BASED ON GINNINGS WITHIN SEASON.
3/ REVISED SERIES.

1/ CHIFFRES EXPRIMES EN BALLES COURANTES AJUSTES POUR INCLURE LES EGRENAGES AU COURS DE LA CAMPAGNE AINSI QUE LE COTON RASSEMBLE APRES UTILISATION AUX FINS D'ECHANTILLONAGE, EXCEPTE POUR LES CHIFFRES A PARTIR DE 1972/73, QUI SONT EXPRIMES EN BALLES DE 478 LIVRES NET.
2/ DONNEES ETABLIES D'APRES LES EGRENAGES AU COURS DE LA CAMPAGNE.
3/ SERIES REVISEES

TABLE 4 : Estimated production of long and extra-long staple cotton

(in 1000 bales)

PRODUCTION / PRODUCCION

Estimated Production of long staple cotton (1-1/8" - 1-3/8") / **Estimation de la production de coton a soies longues (1-1/8" - 1-3/8")**

COUNTRY	YEAR BEGINNING AUGUST 1ST 1967/68	1968/69	1969/70	ANNEE COMMENCANT LE 1ER AOUT 1970/71	1971/72	1972/73	1973/74	1974/75	1975/76 prel.	PAYS
				1,000 bales						
BRAZIL	130	145	135	70	150	135	150	150	160	BRESIL
EGYPT	1,246	1,241	1,586	1,349	1,423	1,496	1,443	1,280	1,107	EGYPTE
INDIA	162	114	130	120	200	500	615	1,365	(1,000)	INDE
MEXICO	105	143	88	107	86	53	49	8	2	MEXIQUE
PERU 1/	250	347	265	250	279	222	262	210	165	PEROU 1/
UGANDA	88	135	155	195	140	95	115	70	70	OUGANDA
UNITED STATES 2/	748	1,819	693	719	1,590	997	750	1,414	1,022	ETATS-UNIS 2/
OTHERS	363	456	485	560	582	725	1,119	1,768	1,118	AUTRES PAYS
SUB-TOTAL	3,092	4,400	3,537	3,370	4,450	4,223	4,503	6,265	4,644	TOTAL PARTIEL
U.S.S.R.	1,780	1,575	1,550	1,555	1,300	1,425	1,500	1,700	..	U.R.S.S.
WORLD TOTAL 3/	4,872	5,975	5,087	4,925	5,750	5,648	6,003	7,965	..	TOTAL MONDIAL 3/

1/ BASED ON GINNINGS WITHIN SEASON.
2/ UPLAND ONLY.
3/ EXCLUDING CHINA, PEOPLE'S REP.

1/ DONNEES ETABLIES D'APRES LES EGRENAGES DE LA CAMPAGNE.
2/ COTON UPLAND SEULEMENT.
3/ SAUF LA CHINE, REP.POP.

PRODUCTION / PRODUCCION

Estimated production of extra long staple cotton (1-3/8" and over) / **Estimation de la production de coton a soies extra longues (1-3/8" et plus)**

COUNTRY	YEAR BEGINNING AUGUST 1ST 1967/68	1968/69	1969/70	ANNEE COMMENCANT LE 1ER AOUT 1970/71	1971/72	1972/73	1973/74	1974/75	1975/76 prel.	PAYS
				1,000 bales						
EGYPT	768	772	911	997	928	873	815	738	655	EGYPTE
INDIA 1/	-	-	-	-	-	-	305	187	655	INDE 1/
ISRAEL	1	3	5	7	10	15	14	19	12	ISRAEL
MOROCCO	24	30	31	28	40	40	26	24	18	MAROC
PERU	141	160	125	162	118	95	145	155	116	PEROU
YEMEN, P.D.R.	8	30	23	26	25	25	25	21	15	YEMEN, R.D.P.
SUDAN	735	860	925	945	935	740	885	810	275	SOUDAN
UNITED STATES	69	78	77	57	96	94	78	91	55	ETATS-UNIS
OTHERS	6	3	2	1	1	1	1	6	2	AUTRES PAYS
SUB-TOTAL	1,752	1,936	2,099	2,223	2,153	1,883	2,294	2,051	1,803	TOTAL PARTIEL
U.S.S.R. 2/	640	630	635	855	900	955	865	935	925'	U.R.S.S. 2/
TOTAL 2/	2,392	2,566	2,734	3,078	3,053	2,838	3,159	2,986	2,728	TOTAL MONDIAL 2/

1/ MCU-5 AND VARALAXMI VARIETIES TOGETHER COMPRISE ABOUT 95% OF THE TOTAL.
2/ REVISED SERIES.

1/ LES VARIETES MCU-5 ET VARALAXMI FORMENT A ELLES DEUX 95% DU TOTAL.
2/ SERIES REVISEES.

The seed thus defined has 3 main components :

- the linter (also called "fuzz") made of all the short staples still attached to the seed after ginning,
- the hull or spermoderm,
- the kernel or embryo.

The proportions of the 3 components depend upon the varieties, the growing conditions, the climate, the seed moisture rate, the seed maturity, the storage conditions, the processes it has stood, and so on. We have already said that the linter rate was inexistent in G. barbadense, in between 3 to 5,5 % (sometimes even lower than 2 %) in G. arboreum and G. herbaceum, in between 8 and 12 % (sometimes reaching 15 %) in G. hirsutum.

The distribution of linters, hulls and kernels in the seed has been largely studied in a rich international technical litterature, since the end of the late century until now for the new varieties. Information is sometimes contradictory, but the usual values (1) appearing hereafter can be retained for seeds rating a 10 % moisture rate :

TABLE 5 : Cottonseed percentages in linter, hull and kernel

	% linter	% hull	% kernel	TOTAL
G. hirsutum	9 to 12 average 10,5	36 to 40 average 38	50 to 53 average 51,5	100
G. arboreum & G. herbaceum	4 to 5 average 4,5	43 to 46 average 44,5	50 to 52 average 51	100
G. barbadense	0	36 to 41 average 38,5	59 to 64 average 61,5	100

Source : Miscellaneous.

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(1) Some few varieties exceed these values.

We must bear in mind that some specialists refer the percentages to the dehydrated seed weight, which may slightly affect the results.

Let us now look at the three components :

a) the linter

Like the lint, the linter is nearly pure cellulose (α - cellulose) since its rate ranges from 95 to 97 %. A part of it, however, (some 10 to 20 %) is represented by oxycelluloses, which are easily found out for they solve in alkalis. 0,20 % to 1,50 % oils and ether or benzene - soluble waxes, and 0,50 to 2 % ashes complete it.

b) the hull

Three main components : cellulose, pentosans (1) and lignin. The proportions are also dependant of the above -indicated factors, but do no exceed :

- α - cellulose	: 35 to 47 %	- average 44 %
- pentosans	: 19 to 35 %	- average 30 %
- lignins	: 15 to 25 %	- average 21 %
- proteins	: 3,50 %	
- fats	: 0,85 %	
- ashes	: 1,80 %	

c) the kernel

For the kernel also, and with the same remarks as above, we have established its two main components - that is oil and proteins - limit rates. The protein is obtained by multiplying the nitrogen rate by Kjeldahl coefficient (6,25), or by other systems (NH_3 x 5,13).

(1) Pentosans result from one glucoronic acid molecule (under the polyuromid form) combining with 10 to 16 xylose molecules.

TABLE 6 : Cotton seed kernel oil and protein percentage

	oil % in the kernel	protein % in the kernel
G. hirsutum	30 to 40 average 35	31 to 41 average 36
G. arboreum	36 average	27 to 35 average 31
G. herbaceum	32 average	29 to 37 average 33
G. barbadense	36 to 42 average 39	31 to 38 average 34,5

Source : Miscellaneous

Percentages, of course, are not the only point to look at ; the seed weight also is important, which appears in the "seed index" (weight for 100 seeds, ranging from 7 to 17 grams), as well as the ratio kernel/seed weight (cf. supra). All these factors are variable, and affect the oil and protein yields per ha.

Besides oil and proteins, other components are to be found, but they have not been much studied. Such are carbohydrates (approximately 14 % of the dry weight), made of mono-, di-and trisaccharides, pectins, dextranes, hemicellulose and cellulose, but with little or no starch. The main carbohydrate is the trisaccharide raffinose, which represents 5 to 10 % of the dry weight. The kernel also comprises phosphoreous derivatives (mainly phytic acid salts and phospholipids), mineral substances, non-protein nitrogeneous components, antioxydents, fat- and water- soluble vitamins.

Many an author refer the oil and protein percentages to the seed weight, without precising whether they are considering the whole linter + hull + kernel, or only the kernel. The results anyway do not differ so much, since, as we have seen it, linters and hulls contain very small proportions of those components.

The following percentages can be thus indicated :

TABLE 7 : Cotton seed oil and protein components

	oil average % in the seed	protein average % in the seed
G. hirsutum	20	21
G. arboreum	18	16
G. herbaceum	16	17
G. barbadense	24	21

Source : miscellaneous.

One must bear in mind that the real figures are very often far higher or lower than those appearing above.

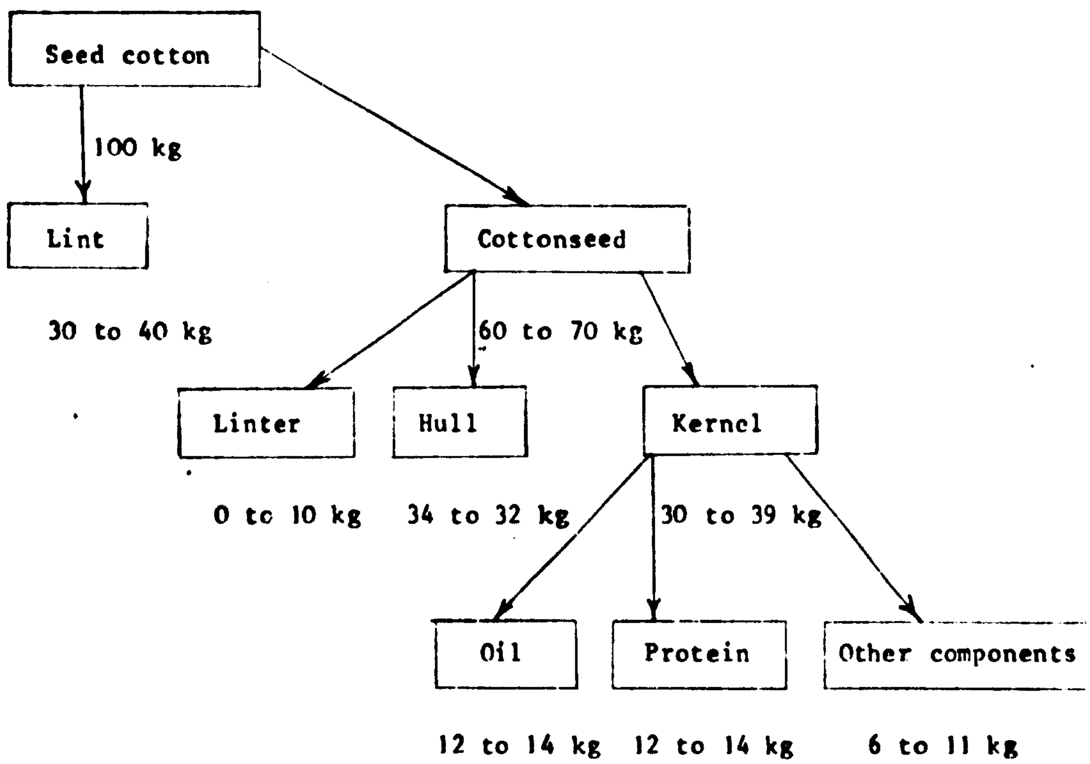
The general composition of the seed is listed below :

TALBE 8 : General composition of the seed

	% of the seed weight
Moisture	10
Oil	20
Proteins	20
Crude cellulose	23
Ashes	4
Other components (carbohydrates...)	23

Source : miscellaneous.

FIGURE 1 - Component average weights for100 kg of seed-cotton (Buffet, 1977 - 9)



The fig. 1 sums up the main data we have how given upon cottonseed. Since the variations in percentages of the different constituents are very large, we can only present approximative limits.

We can't here study each parameter influence affecting the seed composition. But one of them is most important : the seed maturity. From the fecundation day as a starting point, the fresh seed weight reaches its maximum in 5 weeks, but at that time only 15 % of the oil, less than 50 % of the protein and of the whole dry matter weights is attained, when compared to those reached at the ninth week. Harvest is thus to take place around the 60 th day, if oil and protein yields are the aim, for afterwards they get reduced.

17. GOSSYPOL

171. Gossypol in the cottonseed

Cottonseeds (as well as the plant other parts) are dotted with pigment glands, egg-shaped or round, whose larger axis is 100 to 400 µ long. These glands are unregularly distributed inside the kernel. They are envelopped in several layers of epithelial cells, inside which different pigments are held ; the main one is the gossypol, yellow-coloured, which represents 20 to 40 % of the gland weight and 95 % of the pigment weight.

Besides the gossypol, other components are to be found : purple-coloured gossypurpurin ; blue gossycaeruleum which is not a crude seed component but appears during heating ; orange gossyfulvine, very rare, which is mainly found in damp storaged seeds ; green gossyverdurine ; flavones ; violet anthocyanins ; carotenoïds ; chlorophyl ; resins etc...

It is thus understandable that the pigments give an orange/yellow colour to the cottonseed oil and flour.

Gossypol does not dissolve in water. However, when a ground kernel pigment glands are put into water, the layers are quickly broken, generally in a single point, and the pigments flow into water, in which they precipitate.

Gossypol dissolves in methanol, ethanol, isopropanol, n-butanol, ether, ethylacetate, aceton, chloroform, carbon tetrachlorure, cold diexane, diethylene glycol and pyridine ; it dissolves slightly in glycerol, cyclohexane and in high boiling point (100-110° C) petroleum fractional parts (it does not in low boiling point (30-60 °) parts). It dissolves also in cottonseed oil, in alkaline solutions and in some salts.

When solvents miscible with water (1) are used, the water breaks the gland layers, and gossypol gets dissolved, at variable speed and yield according to the products type and proportions.

Gossypol is a phenolic binaphtaldehyde.

(1) ex methanol, ethanol, etc...

172. Gossypol content of various cottonseed species

The cottonseed usual varieties all contain gossypol. This is the reason why they are called "glanded cottonseeds", to mark them off from the glandless cottonseeds", which we will see later on.

The gossypol content depends of many factors, but its weight stays in between 0,30 and 2 % of the seed weight.

Generally speaking, it is lower in G. herbaceum than in G. hirsutum, and highest in G. barbadense, but the test results are so contradictory that one must not rely too much on such a classification.

173. The gossypol drawbacks

a) Seed and its derivated products colour

Storage, especially when the seed is damp (more than 10 % moisture) and that its biochemical processes give out heat, entails free fatty acids developing and pigment glands breaking. Gossypol spreads all inside the seed, oxydes, combines with oil and proteins and darkens their colour.

The phenomenon called "pink white discoloration" (we shall study it in the chapter concerning cottonseed oil) derives from it : the eggs lain by hens fed with cottonseed cakes offer, after some storage, a strange colouring: the white turns pink or red, the yolk turns brown or olive green. This is due to the combined action of gossypol and of two free fatty acids, appearing in small quantities in cottonseed, the cyclopropene acids. The latter modify the egg vitellin membran, letting thus gossypol to get through to the yolk and change its colour.

b) The protein nutritive value lowering and toxicity

Many works have shown that the highest the nutritive value of cottonseed flour was, the less gossypol it contained.

In fact, during the cottonseed meat cooking, which is the first phase in oil extracting, a bound gossypol appears, as a result of its combination with the protein aminoacids, and especially with lysine (1). This gossypol-bound lysine can no longer be assimilated. Bound gossypol, moreover, reduces the protein digestibility by inactivating the proteolytic enzymes.

Once it has appeared in cottonseed flour, gossypol is very difficult to get rid of.

On the other hand, free gossypol has a slight toxic effect (weight reducing, etc...) upon non-ruminants and human kind. It can be lowered or suppressed by addition of ferrous salts, or of potassium. Ruminants, on the contrary, do not show any ill effects.

Cottonseeds have been eaten for a long time by some African tribes, generally during famines or in between 2 supply crops. Serious oedemas have been observed, but most ethnical consumer groups know how to inactivate gossypol, even partly, through cooking ways such as potassium addition under the form of ash water.

174. Separation of pigment glands from cottonseed

a) One method, the "Gland Flotation process", was developed at the Southern Regional Center (SRRC) by Boatner's group in 1946. They noted that the density of the pigment glands (1,26 to 1,38 g/cc) was lower than that of extraglandular kernel tissue (1,40 to 1,45 g/cc) and of the hulls (< 1,45 g/cc). They capitalized on these differences by violently disintegrating cottonseed flakes in a slurry of hexane and various other heavy solvents mixed in a proportion so as to give a resulting specific gravity of 1,378 g/cc. The glands which float to the surface can be mechanically separated from the oils and the precipitated gland-free tissues. Comminution was one of the major problems : too little resulted in high gossypol contents in the meals, too much resulted in essentially the same density for meal and glands with no separation possible. The necessity of using heavy solvents which were high-boiling and toxic was another factor against commercialization.

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(1) The principal binding site is thought to be the free epsilon- amino group of lysine.

b) The disadvantages of the Gland Flotation process led Vix & al. to develop a "Differential settling process". This process depends upon the fact that fine cottonseed meal particles (2-40 μ) settle more slowly in a hexane suspension than either hulls or pigment glands or meal particles larger than 40 μ. Although the meal produced by the "Differential settling process" has as low a gossypol content (0,006 per cent) as that produced by the flotation process, it was not economically attractive to industry.

c) Air classification is a process studied by Meinke and Reiser. Cottonseed kernels with controlled moisture content are ground, then oil is hexane-extracted, and the solvent free meal is disintegrated in an attrition mill. The meal is finally airclassified. From the original meal containing 1,08 % free gossypol and 50,6 % protein, air-classified cottonseed flour containing 0,88 % free gossypol and 62,4 % protein has been obtained.

d) The "Liquid Cyclone Process (LCP)", originally developed by Gastrock & al. (26) and refined to its present status by Vix and Gardner (Gardner & al. 1976 (25)), is the first economical and workable process capable of removing pigment glands from cottonseed to consistently produce a gland-free, high-protein, edible flour. It applies to dehulled seeds which have been ground in hexane into small particules. The pigment glands do not break off if the meal has less than 4 % moisture (1). Afterwards, the suspension is supplied under pressure through a tangential feed opening. This establishes within the cyclone a swiftly rotating body or vortex of fluid. Centrifugal forces in this vortex cause the heavy particles, among which the pigment glands, to move to the walls of the cyclone, while the light particules and most of the liquid are forced towards its axis. The heavy particles that have been thrown to the wall move down to the bottom where they are discharged. The bulk of the liquid, which contains the fine particles and particles lighter than the liquid, moves vertically along the axis of the cyclone and is discharged from the overflow opening.

The process is applied in a mill which has been built in 1973-74 in Lubbock, Texas, by PLAINS COOPERATIVE OIL MILL. Using cottonseed meats as raw material, it works as follows:

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(1) Some recent research works show that the glands do not break if water, even exceeding a 4 % rate, contains some mineral salts such as sodium (or aluminium, ammonium, cadmium, copper) sulfate, or calcium (or ferreous or magnesium) chlorides. Sodium sulfate especially is interesting, for it does not reduce the protein solubility. LCP process can thus be employed with different aqueous solutions.

The cottonseed meats, which contain around one-third oil and two-thirds solids, are first dried to less than 3 % moisture to avoid rupturing of the gossypol glands later in the process. Drying takes place at about 80° C, because too much heat degrades the protein.

From the dryer, a pneumatic system delivers kernels into a pair of pin-mills (1), which grind the particles to 0,2 to 0,3 mm thickness. Finer grinding (as with flaking mills) ruptures pigment glands.

Milled kernels are now fed into a mixer, where hexane is introduced. Then the slurry is diluted 45 % with additional solvent to facilitate subsequent cyclone separation.

The slurry (20 to 22 % solids) (2) is agitated as it is fed to liquid cyclones. There are two sets of dual-operationg cyclones (primary and secondary). This arrangement increases throughput and gains better separation of the overflow from the underflow.

The liquid cyclones classify the slurry into a gland-free overflow slurry, containing 13 to 15 % high protein solids, and a gland-rich coarse meal underflow slurry, containing 43 to 45 % solids. After adjustment of classification, the overs-unders fractions are directed to their respective recovery operations.

High-protein, solvent-damp cottonseed cake is recovered from the overflow slurry on a rotary vacuum drum-type filter. During the filtration step, the lipids level in the solvent free cake is reduced to approximately 0,60%. The filter cake is desolventized in a rotary twin shell "V"- type blender. The cake is heated to 82° C, whereupon nitrogen gas is injected into the blender to strip solvent from the flour to a level below 50 ppm. During stripping, the flour temperature is allowed to rise to 93° C to obtain maximum bacteria kill. Because of the absence of moisture in the flour, this increase in temperature has little to no effect on protein quality or flour color.

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(1) Alpine American Contraplex pin-mills.

(2) This solids level represents a balance between good fluidity in the cyclone, solvent costs, and yield.

The flour is then cooled to 43° C and collected in drums with double polyethylene bag liners under aseptic conditions. The composition of this flour, intended for human consumption, appears below :

TABLE 9 : Composition of cottonseed intended for human consumption

Components	%
Moisture	3,66
Lipids	0,62
Free gossypol	0,03
Total gossypol	0,12
Nitrogen	10,54
Protein (N^x 6,25)	68,40
Available lysine, g/16 g/N	3,94
Fibre	2,4
Ash	7,54
Residual hexane, ppm	35 ppm
Carbohydrates and other components	17,23

Source : PLAIN COOPERATIVE OIL MILL Documentation

The underflow from the cyclones contains 3 to 5 % gossypol, protein, solvent with oil, and water. The protein diverted to this high-gossypol content product does not exceed 35 % of the total. The underflow is pumped into a tank for hexane dilution. From here it is pumped into the second set of two cyclones for further separation of heavy overflow cuts. Secondary cyclones' underflows are pumped into a surge vat feeding a rotary, vacuum, pan-type filter. Hexane is used to wash the cake free of cottonseed oil. Underflow filter's cake is conveyed to a desolventizer equipped for solvent recovery. Solids are pneumatically conveyed to the oil mill for processing into cattle feed.

The process drawback is that the low gossypol content product does not amount to the kernel whole weight, as appears in Table 10 :

TABLE 10 : Composition of cottonseed different parts in hexane extracting

100 kg cottonseed give...............	- 10 kg linter - 38 kg hull - 18 kg oil - 18 kg low gossypol content flour - 13 kg high gossypol content flour

Source .: PLAINS COOPERATIVE OIL-MILL documentation

From a practical standpoint, an LCP plant for food-grade cottonseed flour must be located as an adjunct to a cottonseed meal (for animal feed) mill, for :

- it requires a preferred-quality feed of whole and cracked cottonseed meats with a minimum of hulls,
- the recovery and separation steps for hexane and oil are more economically done as part of the larger mill's facilities,
- the gossypol-containing by-product can be combined with the mill's regular animal-feed products.

The PLAINS COOPERATIVE OIL-MILLS' lubbock mill has a 25 t of low gossypol content flour capacity per day. Such capacity can be doubled if necessary.

175. Removal of gossypol from cottonseed oil

Degossypolization of cottonseed oil can be accomplished by several chemical reagents. It is well known that treatment of raw cottonseed oil with alkali or alkaline salts removes not only free fatty acids as soapstock, but also gossypol simultaneously. Thus it is reported that soapstock obtained from cottonseed oils in India contain as much as 20 % of gossypol. Among other chemicals used for degossypolization of cottonseed oil, mention may be made of sodium hypochlorite, p-aminobenzoic acid, anthranilic acid, diethylenetriamine, hydrogen peroxide, borax, p-aminosalicylic acid, sodium silicate.

176. Removal of gossypol from cottonseed meal or inactivation

Gossypol can be removed from the cakes, or inactivated by the means of different substances.

The addition of 2 % of stearylamine to meats during high-moisture cooking yields cakes with level of free gossypol below 0,01 % ; these have good nutritive values and do not show the usual ill-effects on the eggs of laying hens.

It can also be extracted with ether supplemented with acetic acid or other solvents (acetone, azeatropic mixings such as hexane-acetone-water or butane-acetone-hexane-water, and additives. A solution of ethanolamine in ethanol is also possible).

Gossypol inactivation is achieved by some ferreous salts, by calcium hydroxyde and by potassium.

177. Development of glandless cottonseeds

Cottonseed flour degossypolization has not yet developed, since it entails complicated devices and high cost for a non completely satisfying result.

A new way is opening : the breeding of glandless cottonseed, which appeared in 1959, due to the USA genetician Mc Michael's work.

Immediatly, an enormous cotton breeding effort to develop glandless varieties was initiated in the United States, and extensive research projects have attempted to determine their characteristics and advantages. The work done at the USDA Southern Regional Research Laboratory in New Orleans, and in the Food Protein Research and Development Center at Texas A & M University, is particularly noteworthy on this regard.

The two genes that are now used by breeders to develop glandless varieties were reported by Mc Michael and are designated gl_2 et gl_3. The first approach taken by most cotton breeders was the use of the backcross method. By using this method it was thought that the glandless genes gl2 and gl3 could be incorporated into existing varieties and within a matter of a very few years, the USA acreage would be converted to the glandless varieties.

This of course meant some more research work which still goes on. At the first Gregg 25 V and Watson ([illegible]) glandless varieties, other ones have been substituted whose fibre yields are practically the same as the glanded varieties grown in the USA :

TABLE II : Fibre yields of glandless breeds and glanded checks in some improvement programs (USA 1975)

	Improvement program						
	1	2	3	4	5	6	7
Best glandless breed (pd/acre)	671	994	842	960	647	804	735
Glanded check (pd/acre)	682	929	828	978	599	723	729
Glandless breed yield compared to glanded check yield, %	98	107	102	98	108	111	101

Source : BUFFET IRCT 1972 - la graine du cotonnier

What is more worrying is the marked infestation of glandless varieties by some insects (and not all sorts of them), which entails yields lowering.

For example, in California, the Acala 68160 glandless variety yields some 99 % of the SJ 1 and SJ 2 Acala average, unless it gets contaminated by the Lygus hemipter ; in which case, the yield gets reduced to 83 %.

Besides the USA, the Egyptian research work allowed to breed a glandless variety deriving from G. barbadense ; it is called Bahtin 110 and has been obtained by a radioactive phosphorus process upon Giza 45. Compared to Giza 45, bahtin 110 offers a less abundant crop, a ginning yield 3 % higher, and a lesser staple lenght and strenght.

The Indian Badnawar Glandless (Bgl) and Indore Glandless (Igl) varieties also are more infested than the check glanded Badnawar I variety ; but with using insecticids, and for at least some glandless subvarieties (Bgl 6, Igl 68-1, Igl 68-2, Igl 68-3), the yields rise higher than the check one.

Other breedings are also tried in Syria, Brazil, Mexico, in Africa and so on.

Generally speaking, glandless varieties require more pesticids and a more careful watch in order to interfere as soon as possible against the insects, and rats, mice, rabbits etc as well.

Moreover, care must be taken that glandless seeds do not get mixed up with glanded seeds, which implies a strict organization at all the producing and processing steps.

Now, we must bear in mind that for the producer, the seed is but a minor by-product of the staple ; for example, in the USA the per acre values of cotton lint and seed were in september 1976 :

	$ per acre	%
Seed	48,00	13,30
Lint	312,00	86,70
	360,00	100,00

The seed increased value, due to the oil lower refining cost and to the seed protein possible use in human and monogastric animal feeding, does not appear to be incentive enough for the farmer to strive to adapt.

Anyway, one can reasonably hope that some breedings at last will be obtained that offer the same strenght as the glanded varieties, and therefore will be largely grown. And also, in the developing countries which grow cottonplant and present a protein lack, steps could be taken in order to encourage the glandless varieties.

Glandless seed components have been thoroughly studied. Besides the fact that gossypol is practically non-existent (its rate ranges from 0,002 to 0,01 %), there is hardly any significant difference with the glanded seed. Perhaps only the oil yield is slightly higher in the former than in the latter.

178. Standards for gossypol in cottonseed products

The FAO/WHO/UNICEF Advisory Group (PAG) has laid a gossypol maximum content for cottonseed protein concentrates (that is delipidated flours) for human consumption :

Total Gossypol....... 1,2 % maximum of the flour weight
Free Gossypol........ 0,06% - - - - -

This rate is used as a basis for other countries regulations. In India, for example, the limit amounts to 1,1 % for total gossypol and 0,065 % for free gossypol. The USDA reduces to 0,045 % the free gossypol limit rate.

CHAPTER TWO : STORAGE, TRANSPORT AND GINNING OF SEED COTTON (1)

21. DEGRADING RISKS DURING STORAGE

Biochemical changes, either internal or extraneous may affect the seed quality, at different stages :

- when it is still linked to the plant, in the field
- during transport and storage before ginning
- during storage after ginning.

Among the extraneous changes - mainly mould contamination - one of the most embarrassing is the developing of toxins, which might still be met with in the cakes, meals and flours.

211. Internal biochemical changes

They are traced by heat and a free fatty acid increasing rate, both converging to darken the oil and meal colour.

The heat also lowers the grade of lint.

The main factor responsible for the heat increase is by far moisture. It appears only if the seed contains more than 10 % water. Let us note that the hull is generally damper than the kernel.

When a damp seed is stored, it can reach a 55° C temperature in some ten days.

The heat release comes from the kernel carbohydrats and the hull pentosanes ; the proteins are not metabolized, and instead get partially hydrolized and denaturated. The oil lipolyse entails, as we have said it, that the free fatty acid content rises.

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(1)"Seed cotton" is the seed which still possesses lint, as opposed to "cottonseed" which applies to the lintless seed, after ginning.

212. Contamination by micro-organisms

It only takes place when the seed moisture exceeds 15 %.

The micro-organisms liable to affect the seed belong either to the bactery family (ex. xanthomonas) when the moisture rate is high, either - and oftener - to the fungus one, the 2 main categories here concerned are Penicillium and Aspergillus (flavus, glaucus, niger...).

These micro-organisms, especially the fungus, are responsible for the fatty acid rate increase.

Aspergillus flavus is particularly to be feared, for it secretes aflatoxins, a most dangerous carcinogenic substance, which all the successive processes can't remove, and which is still to be found in the flours and oils.

Aspergillus flavus infestation appears on the plant itself, due to the insects, or to high rainfall, or else at harvest time, or also during storage. The problem has been thoroughly studied since several years. The main ways to fight against it are four :

- prevention of Aspergillus flavus mould growth in the commodity,
- developing means to physically separate contaminated products from uncontaminated ones,
- chemical treatment to inactivate the aflatoxins,
- solvent extraction to remove the aflatoxins.

In order to avoid all fungus growth, the first remedy consists in harvesting the cottonseed when it is dry, or in drying it. When the moisture rate stays below 10 %, it is considered that there is no risk. During storage also, the temperature must not stay in between 28° C and 37° C, which is the most favorable zone for Aspergillus flavus contamination. Chemical treatments against moulds (maleic hydrazide, or propylene glycol dipropionate mixed with 1,3 dimethyl 4,6 bis benzene) are not advisable, for they can as well be carcinogenic.

Autoclaving of wet toxic cottonseed meal can reduce the aflatoxin content, but the nutritive value of the end-product seems questionable. Ammonia may also be used.

Flour ozone oxydation destroys 90 % aflatoxins in two hours' time.

An infallible way is aflatoxin extracting by polar solvents, such as the azeotrope of acetone-hexane-water and of 2 - propanol water, aqueous acetone and aqueous ethanol.

Such treatments imply of course additional costs which are to take into account in the end-product price.

22. HANDLING AND STORAGE OF SEED COTTON

It was usual, after harvest, to dry the seed cotton in the sun - in so far as the weather conditions allowed it - in spreading it upon canvas or wattles. It was gathered before dark and stored in well-aired sheds for a whole week, during which it was regularly turned upside down.

In the USA, this farm classical drying has been less and less used for some forty years, since :

- mechanical harvesting development shortens the harvest period, thus the seeds get bulkily to the farm,
- anyway, as the cultivated acreage average has increased, it is difficult to fix large enough sheds,
- handwork - when there is some - becomes too expensive,
- farmers wish to be quickly paid for their crops, and try to get rid of them as soon as possible,
- transport means also have developed and allow a speedy conveying of the seed from the farm to the gin.

For so doing, trailers are used. When getting to the harvest peak, and if the gin has not storage sheds enough, the trailers must stay in the farm or in the mill, which affects badly the seed grade, in no more than 1 or 2 days.

Pallet trailers conveying allows to reduce the trailers number, but doesn't make up for the ginning tardy time.

Still worse, seed cotton during storage absorbs the moisture coming from the green vegetable scraps which have been harvested together with it. This green substance water rate ranges from 4 % to 60 % before the leaves complete drying and before frost.

The conventional seed cotton unloading system at the gin consists of an unloading or elevator fan, an unloading separator and an automatic feed control unit. The elevator fan supplies air of sufficient quantity to a telescoping pipe to remove seed cotton from the trailer by suction, and the unloading separator separates seed cotton from the conveying air. The automatic feed control unit consists of a hopper, two vacuum wheels, and a metering device system ; it allows to convey the cotton-seed to drying, cleaning and ginning units at desired rates.

An another method eliminates the pneumatic handling systems. This can be done by dumping the trailer load of seed cotton into a large hopper and mechanically conveying it to the automatic feed control.

The USA gins which get supplied in cotton seed by large bulks, as we have seen it, are more and more apt to dry it artificially, not only to avoid the fibre and the seed degrading risks, but also to help fibre removal.

A supplementary reason is that storing seed cotton for ginning later in the season may be a better economic alternative than building additional gin facilities which would be used for only a short time each year.

USA searchers have studied the connections appearing between the atmosphere, the lint and the seed moisture, as well as the artificial drying influence, at different temperatures, upon the lint and seed grades.

Artificial drying takes place only when the seed cotton is damp and must be stored for some time before ginning.

It can be achieved by air at normal temperature, or by hot air. In the latter case, the heat (70° C to 105° C) hardly contrieves to reduce moisture (1), but inactivates the enzyms responsible for the free fatty acid developing. Towards 105° C, the risk of protein degrading appears. Moreover, temperatures exceeding 90°C are apt to "cook" the lint, that is lower its strenght and characteristics. The best way then consists in a double drying at 65° C rather than a single one at 90° C.

The best ginning conditions imply a lint moisture rate of approximately 7 % at the time when the lint is removed from the seed. This is the reason why a satisfactory ginning can't be done without drying a damp seed. Such drying can take place at several stages : in the drying unit before the seed comes into the ginning device, or after a first cleaning (cf. below) or else in the ginner feed-cleaning device.

23. GINNING

231. Preliminary cleaning

After the first drying operation, the cotton seed is generally pre-cleaned, so as to take off the impurities (leave fragments, stem and bark scraps, sand, dust, and so on). The pre-cleaning is achieved by drums - from 4 to 15 of them - fitted with pins or teeth and reeling on top of riddles, in a successive line. They not only clean the seed cotton, but also make it fluffy, which helps for the following steps.

When the seed cotton contains too much sand, dust and unopened burrs, a special device called "airline-cleaner" is to be operated. It opens most of the closed burrs, and removes a good proportion of the other impurities Cottonseed is conveyed into it by air, which has sometimes been heated.

(1) It reduces the feed moisture rate by some 0,7 % only.

The next step is extracting, and consists in completing the above preliminary cleanings, in taking off the large impurities and the burr scraps. Such step is based upon the carding principle : a large diameter drum fitted with saw teeth and reeling at a slow speed takes on the cotton seed ; the stems, straw, empty burrs and other extraneous craps are then removed by smaller drums placed at the periphery. This "big burr-machine" or "master-extractor" appears necessary especially when the seed is harvested mechanically or by careless handwork.

Cotton-seed now can be conveyed either to the dispenser which distributes it through a crew into the ginners feeders (1), either into a second drying and cleaning device.

Anyway, when coming into the ginners, it is cleaned once more, as the ginners are fitted with cleaner-feeder or extractor-cleaner-feeder units, whose three duties are : ginner input regulation either by hand or mechanically, cottonseed cleaning by the means of small saw-teethed drums, and eventually cottonseed hot air drying. These unit efficiency allows a single cleaning step for the cotton-seed which has been carefully hand-picked.

232. Ginning itself

Two main categories of gins can be distinguished :

- the roller-gins, which are the older ones. They comprise : a roller, a fixed blade and a working one whose movement separates the seed from the lint wedged up between the roller and the fixed blade. Single-roller gins can be found, with two fixed blades, as well as two roller gins. The capacity of the double-roller gin is about one-and-a-half times that of the single-roller gin.
- The saw-gins, whose capacity is much higher, and therefore they are used in modern mills, especially in the USA.

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(1) One dispenser may feed from 2 to 5 ginners.

We shall now see how the saw-gins work.

The cotton-seed coming from the feeder gets into a chamber the floor of which is made of bars. Inside it a battery of saws is reeling along an horizontal axis ; it takes the form of teethed discs regularly placed along the axis and solid with it. Every gin comprises some 80 to 120 saws, and the rotating speed ranges from 500 to 800 turns/mn. The saws pass through the bar intervals. They bite onto the seed bulk, take on the lint and get it through the bars which retain the seeds, recovered elsewhere.

Lint is removed from saws either by a brush drum, which turns at high speed in the opposite way, either by air carried tangentially to the saws and downwards ("air-blast system"). The air-blast system simplifies the gin building and maintenance, but on the other hand, lint is less easily removed when it is damp.

The saw-gins also allow to take off impurities left over after the preceding cleanings. Such a step is called "moting" (superior and inferior moting).

233. Comparing roll-gins and saw-gins

For a fair comparing, different variables must be taken into account :

- Lint quality : with roll-gins, the lint is packed or wadded, and makes heaps,while saw-gins offer a fluffy lint, of a regular quality. On the other hand, the latter sometimes cut the staples, and thus can't be used for extra-long staples.

- Lint purity : roll-gins break many seeds, which get mixed with the lint, while saw-gins give out a very clean lint.

- Seed quality : saw-ginned seeds are whole and clean, but keep more fuzz on.

- Capacity : a saw-gin capacity is some 27 times higher than a double-roll gin, 40 times higher than a single-roll gin.

- Material yield : losses are more important with a saw-gin. For example, a roll-gin will give out 33 % to 34 % of lint against 32 % for a saw-gin, from the same seed-cotton.

- Investment : a saw-gin is far more extensive than a roll-gin. It is thus necessary to make it work longer, 4 to 5 months every year if possible, which implies seed storage.

- Hands : for 1 kg of lint, the hand cost is far lower with a saw-gin, though the hands are to be more qualified.

- Energy : in itself, a saw-gin uses more energy than a roll-gin, but the reverse becomes true when the cost is calculated on a 1 kg produced lint basis.

- Maintenance : a saw-gin maintenance is more difficult and implies expensive spares to be bought.

234. After ginning lint process

The mechanically harvested cottonseed can't be perfectly clean after ginning. Therefore units called "lint-cleaners" are used, some based upon air principle, other upon a teethed drum combing system. Sometimes both devices are used, but mainly for low grade lint.

When it comes out from the lint-cleaners, the lint is air-conveyed into condensators which shape it into sheets, and then gets pressed into bales.

CHAPTER THREE : THE COTTONSEED IN HUMAN NUTRITION

31. PREAMBLE

Malnutrition from a lack of proteins, mainly among children, is frequently found in many countries where the cottonplant is growing. Therefore in the last forty years, and especially since 1960, human feeding from cottonseed meal has been tried ; but the experiences, few as yet, concern only a small percentage of the world total weight available. Nevertheless, the pioneers' efforts have shown that, provided some technical conditions are fulfilled which we well deal with later on, such development is both advisable and possible with glanded and evenmore with glandless cottonseeds.

70 % of the cottonseed world crop tonnage have been processed in 1975 to obtain oil and cakes ; the remaining 30 % either go directly (1) to animal feed, or are used as fertilizers, or as combustibles.

Unfortunately, part of the cakes is unfit for non-ruminant animal feeds, due to their free gossypol content, the inconveniences of which are indicated above. They can't either be used, of course, for human consumption. We shall see thereunder what steps are to be taken to increase quality and get an edible flour, but we must be aware that oil is considered as the main output of the mills, and that cakes (or meals) being looked upon as byproducts, the millers are not apt to improve their quality ; they can anyway get interested in it only in so far as it does not bear prejudice to the oil yield and quality.

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(1) That is under the whole seed form.

32. THE UNDESIRABLE CONSTITUENTS IN COTTONSEED FLOUR

321. Gossypol, and its effect on the lysine rate

The most undesirable component of meals designed for human consumption - simply called thereafter "flours" - is gossypol :

- as free gossypol, it is toxic
- when linked to the protein amino-acids, it reduces their nutritional value, especially in lowering the available lysin rate (1).

The free gossypol rate goes down all the more the meats are cooked before oil extraction. However an exaggerated cooking reduces the protein value, not only because gossypol binds with lysin and other amino-acids, but also because heat encourages other reactions, such as the so-called "de Maillard", which binds some glucids to the amino-acids : such is the case with the meat raffinose which links with lysin. Consequently, during the cooking prior to the oil extracting, a compromise must be found that allows to reduce at the utmost the free gossypol value without degrading too much the protein quality.

We have mentioned in the first chapter (176) that different process were used to extract or inactivate chemically the cake gossypol ; some of them can be applied to the flours, but it is not always necessary, since other steps allow to obtain flours in which free gossypol and total gossypol values are quite satisfactory.

The best technical way, with a great future, is the use of glandless seeds. We shall only underline that care must as yet be taken to avoid all overcooking that might lead to Maillard reactions.

It is interesting to compare the available lysin rate in the cottonseed proteins according to the oil extracting procedure. Measured in % proteins by the Kjeldahl method (Nitrogen quantity x 6,25), it amounts to :

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(1) Other amino-acids, such as glutamic and aspartic acids also become partly unavailable.

- approximately 4,50 % in the meat itself (1) , before any extracting (according to the authors, it ranges from 3,20 to 6 % ; the average value of 4,5 % seems the most likely). With such rate in mind, the further process results can be estimated.

- 2,5 to 3 % in the cakes or meals whose oil has been extracted by continuous screw press.

- 3,10 to 3,60 % in the cakes or meals whose oil has been extracted by a pre-press solvent processing (hexane).

- about 3,40 % in the cakes or meals whose oil has been obtained through direct hexane solvent extraction.

- from 3,70 to 4,40 % in the cakes or meals whose oil has been obtained through azeotrope-acetone-hexane-water extraction.

Such percentages shows that one can hardly hope to reach more than 3,60 % when oil is extracted by continuous screw press, while it rises up to 4,40 % with the only use of some solvent, provided that proper precautions are taken during the prior processing steps.

The available lysin proportion, which depends upon its association with gossypol and incidentally with the flour glucids, is a fair index of the cottonseed protein nutritional value. Such value can be measured through different procedures, the most usual being to compare the weight increase of young rats fed on one side upon caseine, on the other side upon the considered proteins ; a Protein Efficiency Ratio (PER) is thus obtained, once admitted that caseine PER is 2,50. Cottonseed protein PER rates from 1,5 to 2,2 and is correlative to the available lysin content, which is proved by an increased PER when lysin is added. So lysin appears as the first limiting factor.

The other limiting amino-acids in cottonseed are isolencine, methionine and threonine, as we will see later on.

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(1) In that respect, there is no significant difference between the cottonplant species.

322. Other undesirable constituents

They are numerous, and among them :

- pesticids,
- solvents,
- machine lubricating oils,
- toxic vegetable particles, gathered in the same time as the cottonseed,
- aflatoxins (see chapter two, 212)
- bacteria,
- insect scraps, rodent hair, etc...

We must add that the two cyclopropenic acids (the malvalic and sterculic acids), responsible with gossypol of the egg yellow-colouring (see chapter first - 173 a) may be found in the flour, if it contains oil in a non-negligeable quantity. It is not sure whether they are noxious for human feed, but they are generally removed.

33. STEPS TO BE [illegible] TAIN GOOD QUALITY FLOURS

331. The choice of the cotton-seed

The raw material must of course be first choice. The document established in 1965 by the Protein Advisory Group (PAG) of WHO/FAO/UNICEF, revised in 1970, suggests the following requirements : "Human feed flour must be processed from high quality cleaned cotton seeds, with less than 1 % of extraneous matters (other species seeds included), less than 10 % moisture, less than 1,8 % of free fatty acids appearing in the oil analysis. The bleached meat rate must not exceed 5 %.

Though gossypol has not to appear here (we shall find it later, in chapter 4, about the finished products), except to underline that the seeds generally preferred do not have high gossypol contents.

As concerns aflatoxin, the PAG sets cotton on the same line as the other proteaginous plants : there must be none apparent, which implies a limit of 30 ppm (30mg/kg).

While chapter 4 will show in detail the successive processes applied to cottonseed after it has been separated from staple, we shall now quickly review them in so much as they are related to the meals.

332. Storage

It must be carefully looked upon so that moisture stays under 10 %, which might imply artificial drying.

333. Cleaning, delinting

These operations must be carried out more thoroughly than usual. It is therefore advisable to set additional cleaning machines.

334. Dehulling and hull separation

Classical machinery is used, and set up in order to get the hulls apart as much as possible. The result however is economically disadventageous, since with the hulls is also removed a fair proportion of the oil.

The remaining hull proportion affects the product final protein rate. The USA cottonseed cakes devised for non-ruminant feed generally contain 41 % proteins, but a proportion of 43 % and even more can be found. As for flours from which practically all parts of hull have been removed, the protein minimum rate is about 50 % (see hereafter).

335. Rolling and cooking

The cotton-seed meals (abrev. in "meals" where no ambiguity is possible) have to be eventually moisturized so as to reach a rate of 10 to 12 % moisture.

The flakes should not preferably be more than 0,10 inch thick (0,254 mm).

As we have already said it, the best conditions for cooking meal are but a compromise between a will to get rid of the free gossypol and a will to obtain a high protein value. A good way out is to moisturized the flakes to a 12-14 % rate, then to heat them to 93° C (200°F). The cooking time depends upon the process applied for oil extracting : 75 to 85 mn if it is followed by press-extracting, 30 to 40 mn only if a solvent-extracting with pre-press proceeding is to take place. At the end of the cooking, temperature must not exceed 110° C.

All this applies to classical cottonseeds. With glandless seeds where there is no free gossypol to eliminate, such heat is unnecessary and a lower temperature can be chosen, which degrades and bleaches less the proteins.

336. Oil extracting

Hydraulic presses - very seldom used howadays - and screw presses inactivate the free gossypol main part, but also reduce fairly the protein nutritional value, because of the over-temperature and pressure. The effect clearly appears in the available lysin low value (see above). A correct flour can be get only if there is a sufficient water proportion left in the meals ; in such a case, the flour has a high oil content (ex. 6,5 %), which is not economically advisable, since milling's first aim is to produce oil.

It has been thought for a long time that solvent direct extraction did not withold free gossypol enough, and consequently could be only applied to glandless seeds. In the same time, it was acknowledged that the protein value was perfectly kept. Since 1960, much research work has been done on the subject. A procedure set up by the Southern Regional Research Laboratories (SRRL) in New Orleans (USA) uses the aceton-hexane-water mixing. The VACCARINO prodedure, applied in Sicily (Italy) only uses aceton. The 2 proceedings remove nearly all the free gossypol, without lowering the protein value. The available protein rate is practically the same than the rate appearing before hand in the meat. The remaining oil proportion in the flour is very low. Nevertheless, the SRRL method has been said to give a bad taste to the flour.

Moreover, it implies some plant adapting, since the oil solvent extracting mills use hexane, and it is not obvious that the higher sale price obtained through the oil and flour improved quality will pay back the additional investments. Neither SRRL, neither VACCARINO proceedings thus are as yet a big success anyway (apart from Italy for the latter).

As concerns the Liquid Cyclone Process (LCP), it is surveyed in chapter 174, d).

337. Aging, grinding and sieving of cottonseed flour

Flour ages for a few days before grinding.

Grinding, together with sieving which comes afterwards, allows to adapt the desired proportion of hull fragments (1).

Grinding is done with classical machines, set up at normal, or a little quicker than normal pace. (2).

Thin sieving is uneasy to achieve when the flour contains more than 3 % oil.

Some grinding machines used in the USA are based upon air flotation principle, for separation. The results are more satisfying that those of sieving, provided there is no linter fragments that might be taken up with the flour (though a last sieving could help get rid of them).

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(1) It completes the hulling effect, which can't reduce the hull scrap rate in the meal under 10 % without lowering the yield rate as well (some oil and meal parts are eliminated together with the hulls).

(2) Hammer mills appear to be more adequate - they spend less energy than attrition mills. But it all depends upon the remaining hull proportion.

34. CHARACTERISTICS OF THE FLOUR

341. The PAG Norms (1965) (74)

This text, reviewed in 1970, which we have already quoted for the part concerning the raw material, specifies that the processing mills must answer to the usual sanitary regulations relative to human food manufacturing.

The oil extracting proce ses must be adapted to the production of flour ; the temperature especially must be carefully checked so as to destroy or inactivate gossypol while degrading as little as possible the protein quality ; during the process, it should not exceed 121° C (250° F).

The solvents shall be without chlore, and appear among thos listed as fit to food industry. Lubricants also should be free from chlorate products.

Sodium proponiate can be us d as fungal inhibitor only under the rate of 0,3 %.

The norms of the flour compositi n are as follows :

- water...................... maximum 10 % of the flour weight
- oil... .... - 6 % - - - -
- free fatty acids........... - 1,8% of the oil weight
- proteins (N x 6,25)......... minimum 50 % of the flour weight
- soluble p oteins (1)........ - 65 % of the protein weight
- total gossypol.............. maximum 1,2 %
- free gossypol.............. - 0,06 %
- disposable lysine....... ... minimum 3,6 % of the protein weight

(1) The soluble protein rate is an indicator for the heat treatment intensity and the relevant loss of nutritional value ; the higher the solubility th lesser the heat and the loss of nutriti e value.

Other advisable characteristics :

- no mould or solvent odour,
- under 20 000 bacteria per gram, and among them no pathogeno s variety (E. Coli, salmonellas, etc),
- no insect or fragment of insect, no rodent hair or excrement, etc,
- 0,1 % maximum of extraneous minerals (sand, ? , etc),
- under 0,03 ppm (30 mg per kg of aflatoxin),
- the flour should be packed up in protective wrappings (brown paper coated with polyethylene).

342. Available flours

Only few cottonseed flours are yet availabe, but many tests, either experimental or commercial, have been made that show industry can process flours answering to above-quoted norms, provide that the mentionned precautionary steps re taken.

Solvent extraction, with or without pre-press, allows it more eas ly hat screw-press extraction, but event the latter process can be used.

Let's analyse the different elements of the norm :

- no difficulty to maintain the moisture rate under 10 %, the average being 7 to 9 %,
- the 6 % maximum oil proportion is necessary to avoid rancidity. Screw-pressing gives out some 4 % oil-containing flour, and the solvent process reduces the rate to 1 %,
- the protein content varies according to the seed species and the hull scrap residual percentage. It often exceeds 50 % and may rise to 65 %,
- the total gossypol content limit seems fair enough, but once linter, hull and oil are removed, the kernel usually retains 0,7 to 1,5 % of it, so that all processes are not adequate. And Glandless seeds are obviously the best raw material,
- the limit of 0,06 % for free gossypol is essential, since it means protection against toxicity,
- the considered lysine rate implies oil solvent extracting.

The best cottonseed flours, processed from classical or glandless seeds are light in colour, have hardly any odour, and meet the PAG requirements. They moreover contain 2 to 4 % of crude fibre, 6 to 10 % ashes - among which the main cations are phosphorus and potassium - and a certain amount of group B vitamins. The other components (glucides, etc...) have not yet been studied.

35. NUTRITIONAL VALUE OF A HIGH QUALITY FLOUR

We shall now compare the composition in amino-acids of a high quality cottonseed flour (glandless seed and/or solvent oil extracting only) to that of soya flour (1) and to two animal proteins used as references : egg-white and casein.

TABLE 12 - Protein components of cottonseed flour compared to soya flour, egg-white and casein

AMINO ACIDS	Cottonseed flour	Soya flour	Egg-white	Casein (cow milk)
Arginine	11,2	7,0	6,3	4,1
Cystine	2,0	1,2	2,5	0,4
Histidine	2,7	2,8	2,7	3,1
Isoleucine	3,9	4,7	7,2	5,8
Leucine	6,1	7,9	8,5	9,2
Lysine	4,2	6,3	7,0	7,6
Methionine	1,5	1,3	4,1	2,8
Phénylalanine	5,2	5,3	6,1	5,4
Threonine	3,4	3,9	5,2	4,5
Thryptophane	1,4	1,3	2,0	1,3
Tyrosine	3,2	3,8	4,6	5,7
Valine	4,9	5,0	8,8	7,1

(Weight in 100 g of proteins - N x 6,25)
Miscellaneous sources - average values

(1) Also of a high quality

The column relative to cottonseed flour has been taken from BAILEY'S "Cottonseed Products".

Cottonseed proteins thus show a lack in lysine when compared not only to the two animal proteins, but also to soya flour. It however contains more of it that cereal proteins, for which the lysine average value is as follows :

TABLE 13 - Protein content of different cereals

Corn	Barley	Oat	Rye	Maize	Rice	Sorghum
2,3 %	3,5 %	3,7 %	2,9 %	2,9 %	4,1 %	1,6 %

Cottonseed proteins also lack in methionine (just as soya flour, of which it is the first limiting factor), in isoleucine and in threonine.

Many an author has studied upon laboratory or stock-farming animals, and on man also, the nutritional value of cottonseed flour, supplemented with some amino-acids (mainly lysine and methionine) or mixed with other proteins (soya, cereals for example).

It appears that cottonseed flour nutritional value is lower than soya flour, but can be increased by adding lysine or by mixing it with soya flour ; the result is generally found satisfactory for infant feeding.

In fact, it all depends upon the comparison grounds : there is no doubt that milk proteins are the best, but many tropical countries do not produce enough of them, and can't afford to buy them ; if they grow cotton-trees, they found there an additional source of proteins that considerably increases the cereal flour nutritional value.

We shall give 3 practical examples of these considerations

351. Incorporation into bread

Much research work has been done on the subject : ROONEY and al. (1972), MATTHEWS and al. (1970), TSEN and al. (1971), HARDEN and YANK (1975). The latter searchers replaced 18,8 % of corn flour by cottonseed flour of two different origins : glandless seeds, and LCP processed seeds. The bread thus obtained had a 20 % protein rate, against the usual 10 % of the total weight (which contains some 20 to 22 % of water). The test bread was very similar to whole meal bread by its dark colour, its rough and compact texture, and high density. It determined in young rats a quicker weight increase than ordinary bread.

352. Sorghum flour strenghtening

Sorghum, which comes third in world cereal production, behind corn and rice, contains low nutritional value proteins, due to their lack in lysine : POMERANZ (1966) and BOOKWALTER (1971) have shown that soya flour addition improved them both in quality and quantity. BOOKWALTER, WARNER and ANDERSON (1977) tried to add cottonseed flour instead ; the nutritive value increase was satisfactory, but stayed under that produced by soya flour.

353. Incorporation into millet pap

French ORSTOM (Offiche de la Recherche Scientifique et Technique Outre-Mer) searchers have studied in Chad the physiological impact of cottonseed flour incorporation into millet pap. It appeared that the mixture was accepted, well tolerated, and allowed a quicker growth.

Many other research works have been done all over the world (for instance INCAP in Central and South America - we will see it later), but more detailed information is not necessary for our global overlook

36. COTTONSEED PROTEIN ISOLATES

When the flour protein content increases to reach 90 %, isolates are obtained.

The usual extracting process consists in washing the flour with water so as to remove all soluble matters, then in dissolving the residue in basic environment (with the help of soda) and precipitating the isolate by means of acidification.

The isolate characteristics vary according to the processes used as different studies on the subject have shown.

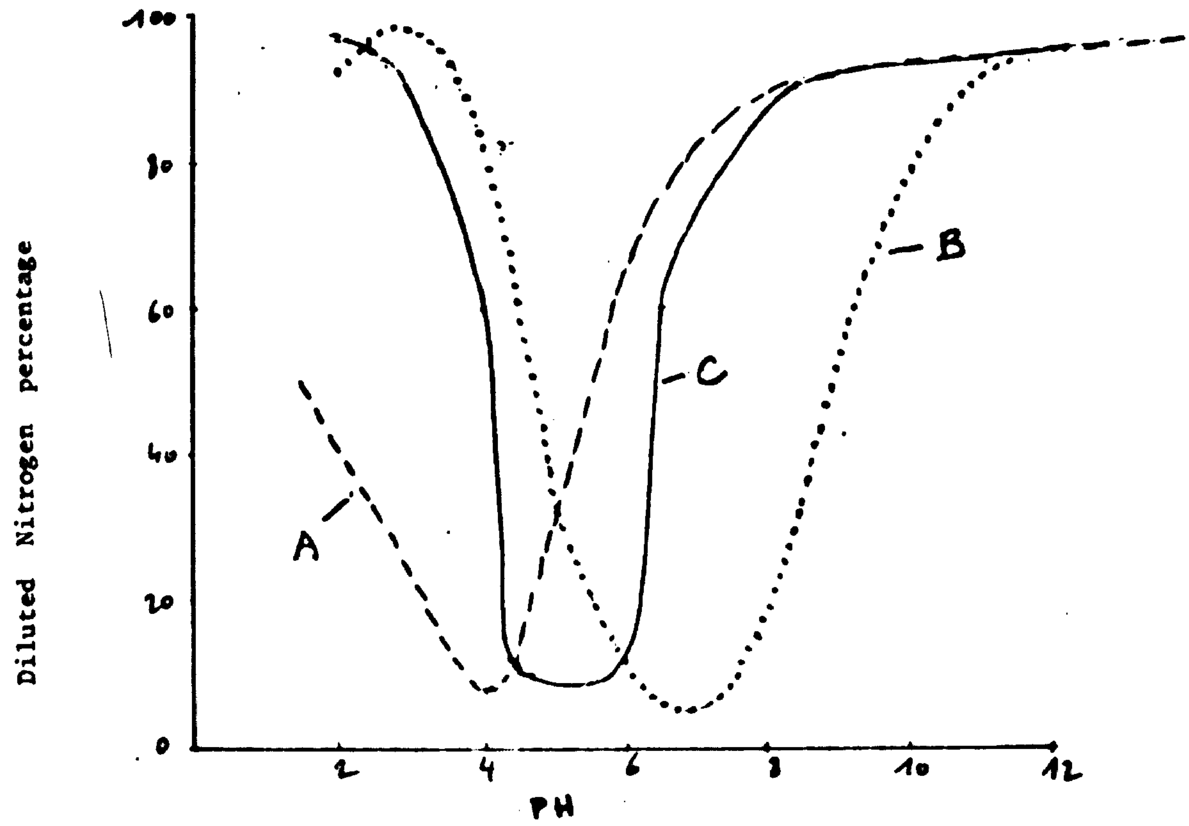
As soon as 1969, BERARDI and al. demonstrated that the cottonseed proteins were made from two fractions :

- a water-soluble fraction that precipitates at PH4, and represents 30 % of the nitrogen total amount,
- a water-insoluble fraction, which gets soluble in basic environment (PH 9), and which then precipitates à PH7. It represents 60 % of the nitrogen total amount.

Figure 2 hereafter shows the solubility graphes according to the pH for each fraction and for the two fractions together .

It is important to draw such discrimination, since the soluble proteins which derive from the seed living tissues and whose molecular weight is light, offer a far higher nutritive value than the insoluble ones, due to their higher lysine and sulphured amino-acid rate (see the following table). On the other hand, the insoluble fraction, deriving from the seed reserve proteins, is a good additive, especially in bread-manufacturing, in which it hardly modifies colour and texture ; moreover, it also offers the rare capacity to dissolve in acid environment which makes it susceptible to be incorporated into acidified drinks.

Figure 2 - Cottonseed protein solubility graphes according to the pH



Legend : A = soluble fraction
B = insoluble fraction
C = the 2 fractions together

TABLE 14 - Aminograms of the two protein-fractions of cottonseed (MARTINEZ and al. 1970 - 43)

Essential and semi-essential amino-acids	Soluble fraction proteins	Insoluble fraction proteins
Arginine	10,4	11,3
Cystine	2,6	0,3
Histidine	2,6	3,0
Isoleucine	2,6	3,1
Leucine	5,1	5,8
Lysine	6,0	3,0
Methionine	1,7	1,0
Phenylalanine	3,7	6,3
Threonine	2,9	2,7
Tryptophane	?	?
Tyrosine	3,3	2,6
Valine	3,3	4,4

It so appears that the soluble fraction contains nearly as much lysine as soya flour and more sulphured amino-acids (methionine/cystine). Its PFR reaches 2,3. The same authors so describe the extraction process :

- if a single step operation is chosen, proteins are dissolved into a soda solution (pH 9,85), then a precipitation in pH5 allows to obtain the two fractions,

- when on the contrary they are to be obtained separately, a two-step operation is necessary. First the soluble proteins are dissolved into water (pH 6 7), and precipitated at pH4. Then the insoluble fraction is solubilized with soda (pH 9,8) and precipitated at pH7. It is also possible to precipitate it at pH3 by using an acid and calcium chlorate.

Cottonseed isolates generally contain some 93 to 98 % proteins, the rate being determined by Kjeldahl method. When the seed used belongs to a glandless variety, the colour is light (1) and the savour swe

(1) It is however darker than soya or groundnut isolates.

37. THE COTTONSEED PROTEIN USES FOR HUMAN FEEDING

371. The main firms on the market

Though such market could have been an easy one for quite a lot mills producing poultry cakes, there are not many producing firms. Among them :

- GRAIN PROCESSING CORPORATION, in Muscatin, Iowa (USA), sells under the brand mark PRO-FARM C 650 the LCP flour (65 % proteins) processed by PLAINS COOPERATIVE OIL MILL (cf. chapter one, 174, d),

- THE TRADERS OIL COMPANY, in Fort Worth, Texas (USA), on the market for more than 30 years, sells under the mark PROFLO a cottonseed flour used as an additive in bread, biscuits, pastry and confectionery. Its protein content reaches 55-60 %,

- NUTTY BROWN MILLS, in Cedar Valley, Texas (USA) has been supplying bakers for a long time with cottonseed flour,

- VACCARINO (ITALY), uses a special acetone oil extracting process, and sells its flour not only in Italy but also abroad.

- DORR OLIVER, a specialist in cyclone processing of pigment glands, tries to extend the technique so as to produce highly nutritive concentrates in developing countries, like India or Pakistan, where cotton trees are largely grown. Local research works made it possible with the help of the governments, to set up pilot-plants to test the different formulations.

Moreover, INCAP (Panama and Central America Nutrition Institute) also has been studying for some twenty years different mixtures containing cottonseed flour (1), and called INCAPARINA. Several formulas exist, that associate cereal flours (rice, maïze, sorghum, corn, etc) to cottonseed flour, to soya flour or to both of then.

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(1) Initially, INCAP used PROFLO flour.

TABLE 15 - INCAPARINA formulas

Components in g/100 g	Three INCAPARINA formulas		
	N° 9	N° 14	N° 15
- Pre-cooked cereal flour	58	58	58
- Protein concentrate :			
. Cottonseed concentrate	38	-	19
. Soya concentrate	-	38	19
- Additives :			
. Torula yeast	3	3	3
. Calcium carbonate	1	1	1
TOTAL AMOUNT	100	100	100

Source : FAO

The protein content ranges from 25 to 28 %.

INCAP does not manufacture INCAPARINA, but lends the formulas to licensees which are to follow the requirements. The main ones are ALIMENTOS S.A. in Guatemala and PRODUCTOS QUAKER S.A. in Columbia.

372. Use general recommandations

Cottonseed flours, concentrates and isolates (1) may be used either in a nutritive aim, or in a functional aim (food texture, appearance, conservation improving) or for both of them.

We have already indicated their nutritive value.

As concerns their functional properties, it will be noted that cottonseed proteins :

- retain water (cottonseed concentrate absorbs 2,5 times its weight in water) but less so than soya (5 to 6 times their weight) or groundnut proteins,

(1) Though the flours are themselves protein concentrates, such denomination is usually kept for flours that contain more than 50 % proteins thence some 50 to 70 %.

- are less soluble than soya proteins. Their solubility is of course dependent on the pH, and differs for the two fractions (cf. supra),

- offer thus some viscosity and may give out gels due to their water retaining and solubility properties. But here also soya proteins are better,

- absorb oil in quite the same proportion as soya proteins (the concentrate retains 1,5 time its weight in oil),

- emulsify fats better than soya proteins, which is a potential advantage in meat preparations such as sausage fillings.

A very light colour is difficult to obtain. The savour is not very strong. The residual lipids, which get oxyded during storage time, are responsible for rancidity and a dark colouring ; their proportion is thus to be reduced as much as possible.

373. Applications

3731. Baking, biscuit and pastry manufacturing

Numerous tests have been effected by the American Institute of Baking, for replacing, in baking industry, corn flour and/or skimmed milk powder by cottonseed concentrates and isolates. Used at the respective rates of 3 %, 2,6 % and 1,6 % cottonseed flours, concentrates and isolates gave results as good as 3 % skimmed milk powder, if the precaution was taken to reduce kneading time. Flour and concentrates higher replacement rates (some 10 %) still offered acceptable breads, but then bromate addition was necessary. On the contrary, a 10 % and even 15 % rate of cottonseed isolate, without bromate addition, gave out quite good bread.

Some US baking industries use cottonseed proteins in a functional aim (to retain water and improve the crust colour, for instance) in replacement of skimmed milk powder and in very low proportions. In such a case, their nutritional value does not play any part.

In SSR, research work is done in the same direction.

Besides bread, cottonseed proteins can also be added to paste-products. Tests have been held with :

- biscuits, whose protein rate after such addition reaches 10 to 18 %,

- doughnuts, to use the protein, and especially the cottonseed protein, characteristic to fix the fats,

- snacks foods and breakfast cereals.

In such products, cottonseed protein concentrates can replace corn flour, up to a proportion of 20 %.

3732. Other cereal products

- INCAPARINA (cf. supra) can be consumed in "colada", which is a fine gruel well-known in South America, in cakes, soups etc, and in the "atole" drink,

- Infant foods: in Israël, a cottonseed concentrate and corn flour mixture that contains 35 % proteins, is consumed with addition of sugar and water,

- In Chad and Cameroon, ORSTOM (cf. supra) tried balls, paps, doughnuts, noodles and sauces associating cottonseed flour to local cereals (sorghum more especially),

- In some other countries (India, Pakistan, Peru, etc) formulation tests have been effected for infant flours containing cottonseed proteins. But nothing yet seems to be applied on an industrial scale.

3733. Meat products

If cottonseed protein gelifying properties are lower than soyabean, their emulsifying properties rate higher. It is thus advisable to prefer them according to the aim in view.

They can be easily texturised by original techniques which are neither extrusion nor solubilization : in a single step operation with a 80 - 90° C heating, pH adjustment and thorough agitation, mixtures can be obtained that associate cottonseed proteins + lipids + carbohydrates + flavourings, and afford a consistence quite the same as meat.

Extrusion though is possible, and DORR-OLIVER is studying the process.

3734. Other products

The fact that reserve proteins, which represent the main fraction (cf. supra), are soluble in acid environment roused some searchers to use them, at the maximum rate of 6 %, in fruit drinks. But their low nutritive value, as well as their indifferent proportion, makes it hardly interesting.

Last, as a moisture retaining agent, they are sometimes used in confectionery.

3735. Conclusion

The amount of cottonseed flour consumed by man in the whole world does not exceed 10 000 t/ year, which is quite unimportant, especially when one thinks of the huge wants in proteins to be found in most countries that grow cottonseed trees.

The obstables appear to be technical as well as economical, and besides it psychological also.

First, cottonseed flour designed for human consumption must answer, we have seen it, to requirements which are not always easily met with. For instance, an available lysine correct rate is possible only through solvent-extracting, meanwhile in many countries screw - or hydraulic - presses are the only devices used. Glandless seeds may in time improve the situation, but they are not yet largely grown.

Then cottonseed flour must compete with soya flour, whose nutritive value is higher and which is produced industrially on a far larger scale. We had already seen it with the cakes : the prices offered for cottonseed cakes with 45/46 % proteins stay under the prices of soya cakes with 44 % proteins ; though varying, the difference between them often rates to 10 %. As concerns flour, it should be necessary that price advantage be on cotton side ; but the processes required by the PAG regulations are expensive, especially when the seeds used are not glandless.

There won't be thus any appreciable replacement of soya flour by cottonseed flour until glandless seeds are largely grown, and under the following restrictive conditions :

- if used as a functional additive in rich countries, such as USA, cottonseed flour must offer an economical advantage, which is not the case nowadays. In fact, if its price is at the same level that soya flour, or slightly below it, the users will prefer the latter, by habit and for its better functional properties,

- if used as a nutritive supplement in cotton producing countries the inhabitants of which present a lack in proteins, the local governments will have to supply financial help.

CHAPTER FOUR : COTTONSEED OIL AND MEAL RECOVERY

41. STORAGE, CLEANING AND DELINTING OF COTTONSEED

411. Storage

What we have said in chapter 2 about the degrading risks for seed cotton and the means to avoid them also applies to cottonseed, so we won't repeat it.

The optimal moisture rate during ginning is 7 %. When stored for a long time, it is advisable that the seed stays at the same rate, or even at a slightly lower one. As mills get indifferent quality supplies - some of them might even be rotting - it is most important to keep a permanent watch upon the moisture and temperature rates.

With a heat higher than 35° C, overheating is near, and the storage place must then be ventilated (1). Some millers make it a principle to ventilate all the seeds they are supplied with, and keep their temperature in between 15 and 20° C.

If the seeds are damp, they are dried through hot air insufflation, so as to inactivate the enzymes responsible for lipolyse. In such a case, it is advisable to cool them afterwards, to reduce the temperature to its normal rate.

The cottonseeds, especially those which are covered with a thick linter, are difficult to handle, and do not flow easily. It is then necessary to get the necessary handling devices. Pneumatic units cool and aerate them as well, and eventually dry them, but mechanical systems are also used.

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(1) In dry climate countries, the seeds can be stacked up outside, sometimes protected with canvas, upon concrete areas fitted with airing pipes.

412. Cleaning

In some countries, the USA for example, the seed cotton mechanical gathering has increased the amount of extraneous scraps which, after ginning, are still attached to the seed - that is, in fact, to the linter : the proportion reaches some 1 to 4 % of the seed total weight. These impurities are stones, earth, sand, capsule fragments, all sorts of vegetable scraps, metallic shreds and so on. Vegetable matters are apt to mould when the moisture rate is high, and the seed temperature is thus increased. As for mineral matters, they wear away prematurely delinters and dehullers, and give way to sparkles susceptible to set on fire. And last but not least, high quality linters and cakes cannot be obtained without removal of all undesirable substances.

According to its working conditions, ginning (see chapter two, 231) leaves more or less waste.

Pre-cleaning is possible before storage, but it is not always a useful step, since as mill supplying is plentiful in a short time, it can't be done with the necessary care. Part of the sand can easily be taken off, for example, by boring small holes in the feeding pipes. Boll reels may also be used ; they are reeling drums fitted with sieves, whose meshes let pass the seeds but retain bigger particles (especially the seeds still retaining the lint). Sand reels also may be used, with a system much the same, which let only sand pass. Boll reels and sand reels are often set up together, the former upside and the latter downside the same frame. Efficiency is improved by pneumatic seed cleaners. They comprise 2 or 4 vibrating sieves, fed with carefully measured volumes which have already been cleared off, by electro-magnet, from all metallic scraps. The top sieve eliminates the bigger impurities, the down sieve the smaller ones. An air flow helps sieving, and capacity, according to the units, ranges from 25 to 120 tons per 24 hours.

The millers have often to clean anew the seeds that come from ginning. Anyway, it is best, economically speaking, to clean the seeds in the mills, since the ginning places, scattered all over the cotton area, are far more numerous and work far less hours every year.

Besides boll and sand reels and pneumatic cleaners, basket cleaners can also be used at the delinter input, or else more recent plants called "ARS Differenciator or Cleaning Belt" which are based upon the different cinetic principle applying to the normal and unnormal seeds and impurities when projected.

On the whole, boll and sand reels remove only 50 % of extraneous matters ; 55 to 60 % are taken off by pneumatic cleaners, while ARS offers the best percentage with 65 %.

413. Delinting

Delinting consists in taking off linter - whenever it exists (1) - from seed.

The linter medium rates are indicated in the first chapter, 16. In the USA and for Gossypium variety, the lint represents about 10 % of the seed weight.

Delinting is not alway economically justified, since the machines cost a lot, and linter markets are still to be found. For example, in Africa, where there is no market (2), it is preferred, in the new mills, to suppress delinting, which allows to reduce the investment and energy costs, and to dehull directly the linter-covered seed. We shall see it below, when we come to dehulling.

Classical delinting uses saw devices, called "delinters", very similar to the saw-gins (cf. Chapter 2, 232). Approximately, 2,5 % linter is left on the seed to help the ulterior separation of the hull from the kernel.

4131. Saw delinting

(1) As we have seen it, G. Barbadense does not have linter.

(2) There is no local market, and linter long transport is not economically justified.

The saw-delinters are based upon the same principle as the saw-gins. But as linter is shorter than lint, the blades are nearer, the feeders are modified so as to present the seeds correctly in front of the teeth, and generally speaking all fittings must be more precise. Most recent delinters have 141 or 176 circular saws, of 12-5/8 inches diameter (32 cm), which get sharpened every 8 to 36 hours. The rotating speed is about 400 turns/mn. From 15 tons of seed, the plant removes 400 kg linter in 24 hours. Delinting is generally operated in successive passages on several delinters. The operation characteristics - and consequently their quantity and quality yields - are chosen by the millers according to the result they aim at.

It can thus be distinguished :

- "Mill-run linter" which is obtained by a single delinting operation, and comprises all linter which could have been removed by a double-phase delinting.

- "First-cut linter", obtained at the first passage. They are generally 2 to 6 mm long, sometimes more.

- "Second-cut linter", obtained at the second passage. They are generally 1 to 3 mm long.

Three and even four passages may be operated.

As an example, from 15 tons of cotton-seed processed in 2 passages, a delinter will take off 400 kg linter in the first one ; from 7,5 tons of so-processed seeds, two delinters will take off, at the second passage, 450 kg linter each in 24 hours.

The second cut delinters' speed is higher (600 to 750 turns/mn).

In 1965, a high capacity delinter has appeared, the HC2 of CARVER COTTON GIN Co. Its saw diameter is bigger (18 inches, that is 45,7 cm), the unit contains more, its speed is higher. Its general characteristics are higher :

- in a one step operation, it can process about 10 tons of seeds per 24 hours, and leaves only 2,5 % linter,

- in a 2 step operation, the first cut amounts to 25 tons per 24 hours and leaves 7,3 % linter ; the second cut amounts to 12 to 18 tons per 24 hours.

4132. Other procedures

Saw-delinting costs a lot in energy and in plant investment, and gives out dust and noise.

It can either be suppressed (we shall see it below) or replaced :
- linter burning implies to keep a serious watch upon the temperature so as to avoid any seed degrading.
- acid (chlorhydric or sulphuric) delinting has been tried, but it must afterwards be neutralized by a base (ammonia). The process influences upon the seed nutritive quality and the plant corrosion must be carefully looked upon beforehand.
- abrasive delinting has also been tried. It is as expensive in energy and investiment as saw-delinting and gives out as much noise and dust.

414. Linter cleaning

When delinting is over, linter still contains impurities which must be removed to increase the linter grade, since the users need cellulose as pure as possible for the nobler uses.

In modern mills, each delinting unit is fitted with a pneumatic cleaning device, which aspires linter into a condenser where part of the dust is eliminated. Cleaning itself takes place afterwards, in multi-drummed beaters fitted with an air system. Linter is thrown against the beater chamber perforated surfaces, through which the smaller impurities, especially hull dust, can pass.

First cut and second cut linter may be cleaned separately.

42. DEHULLING AND SEPARATION OF HULLS AND MEALS

Dehulling consists in breaking the hull so as to reach the kernel from which the hull scraps are to be removed.

Such operation is not always worked out. It seems justified, nevertheless, for hull main component is cellulose, and its oil and protein rates are low (cf. chapter first, 162). The oil yield would otherwise be reduced (1), like the protein content, while the meal cellulose, lignine and so on rates would increase. Crude oil colouring would also be darker.

Two categories of dehullers may be found : bar hullers and disc hullers.

Bar hullers have two main components : a reeling drum and a fixed frame, both fitted with hard steel mobile blades, perfectly sharpened, and whose clearance may vary.

Their pace ranges from 650 to 950 turns/mn. According to the unit size and to the dehulling desired percentage, the seed quantity that can be processed in 24 hours is variable : it goes from 75 to 150 tons for a 80 - 85 % of dehulled seeds, the 20 - 15 % left over being processed a second time.

Disc-dehullers, less common than the former ones, comprise two sharp-edged circular decks, one of them fixed and the other mobile. They are both concave so as to facilitate seed input in the centre. The seeds are swept along to the periphery by centrifugal force, and they get cut by the deck edges, whose clearance may vary.

Above the dehullers, seed beaters are placed in order to remove impurities (linter, etc) and below the dehullers, separation of kernels from hulls is operated. The operation is most important since it has a direct bearing on :

- the composition of the hull scraps, which must be taken off with the less possible oil, meal or whole seed,
- the kernel composition, from which must be removed linter and dust, and which must contain only the hull proportion consistent with the cake protein rate to reach.

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(1) The hull scraps would absorb oil during the kernel pressing.

The interfering factors are the seed moisture rate, their degradation stage, the residual linter, the oil quantity absorbed by the hull before dehulling and separation, the amount of impurities, the separating plant and its adjustment.

A modern mill supplied with high quality seed (moisture rating from 10 to 12 %, linter below 2,5 %) must give out hulls the retained oil percentage of which is negligible (some 0,5 %).

Three different dehulling processes exist : single-dehulling-separating, double-dehulling-separating, universal-dehulling-separating.

a) The first method uses a single plant that dehulls some 80-85 % of the seeds in a first passage. The kernels are taken away by the means of a shaker-separator, while the hulls and the remaining whole seeds are processed again in a beater and then in a hull and seed separator, from which the undehulled seeds are sent back into the dehuller. The plant is completed with a meal purifier that removes hulls and linter.

b) In the second method , two groups of dehullers and separators are used. The first dehuller has been fitted so as to give out meat scrap as big as possible, and thus avoid all oil absorption by the hulls. The undehulled seeds are conveyed together with the hull and meat mixture to the hull-and-seed separator, through the holes of which the meats pass, while the hulls and the whole seeds go to the beater ; there the small kernel particles still adherent to the hulls are recovered. The seeds and hulls are then conveyed to the second group, where the same operation is done, with a closer fitting of the blades. This method implies more investments than the first one, and the hull speck rate in the meats, as well as the oil rate in the hull are higher, which reduces both the cake quality (at least for non-ruminants) and the oil yield. It is used preferably when linter has not been taken off from the seed or when many seeds are still unripe.

c) The third method is a combination of the former ones. The hulls of the first separator pass again into the second dehuller, with a closer fitting, then into a second separator-beater unit. This last method is interesting when processing seeds on which linter subsists, and that a fair proportion of hull specks is to be left in the meats so as to get cakes with low protein value.

It is generally figured out that in normal extracting conditions, 94 % approximately of the seed nitrogen is to be found in the cakes.

During dehulling, care must be taken that the plant is regularly fed, the blades correctly fitted, and a good maintenance held.

Some units exist that may operate separating, beating and purifying by themselves.

Sometimes, defibrators are used to recover the linter still left with the hull : in the USA, some 60 % of such linter is recovered, which corresponds to 1,2 - 1,5 % of the whole seed weight. A defibrator can process approximately 10 to 12 tons of hulls in 24 hours.

The dehulling of undelinted seeds covered with a thick linter is technically difficult : the feeding is slower, the proportion of oil and kernels gone with the lintered hulls is higher, separation becomes uneasy due to separator cramming. The capacity thus lowers, and the plan must be adapted in order to avoid that the hulls drag away too much oil and kernels. Such problem has been studied in the USA by S.P. CLARK (Texas A & M University), and in France by SPEICHIM. It will be noted that linter agglomerates the hull scraps, so that the kernels are practically void of them. It is advantageous for the flour designed for human consumption, but in the mills, the press work becomes more complicated, and it is unnecessary in cake making.

Calculations made in the USA by S.P. CLARK in 1976 show that if the linter selling price (1) by the millers is 4 cents per lb (that is 8,8 cents per kg) or more, it is best to operate delinting before dehulling, but if the price is below 3 cents per lb (6,6 cents per kg) dehulling can be operated without delinting, or after acid-delinting.

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(1) Weighted average of first and second cuts.

43. FLAKING OR ROLLING OF MEATS

After dehulling and separation, the kernels are subject to moulds, and even when the moisture rate is low (7 %), they can't be stored for long, since acidification appears in a few days time. It is thus advisable to process them as soon as possible.

Flaking is necessary, first to break the layers of the cells containing oil, and also to divise the material so as to expose it as much as possible to heat and steam during the ulterior cooking, which will help for oil extracting.

First the kernels must be moistened to rise their moisture rate to 10-11 %.

Flaking is generally operated in a plant comprising 5 superimposed cylinders, carefully adjusted, made from hardened cast iron Two horizontal cylinders only are sometimes used, but the capacity is of course lower.

A feeder distributes carefully measured amounts of meats all along the higher cylinder ; the meats are then dragged in between the first and the second cylinder and so on until the fifth one, where they bear the four superior cylinders weight.

The cylinder diameters range from 12 to 20 inches (30,5 to 51 cm), their lenghts from 24 to 60 inches (61 to 152 cm). The meat input can't exceed 1,5 tons of seed per 24 hours and per lenght/inch.

The flakes are to be as thin as possible. Some 0,005 inch (0,127 mm) may be reached, but generally the thickness ranges from 0,008 to 0,013 inch (0,203 to 0,330 mm).

The points that must be carefully watched upon are the undehulled seed content, the residual hull proportion, the unit regular feeding, the cylinder smooth surfacing.

44. COOKING OF THE MEATS

Cooking is operated for the following reasons :

- to complete the rupture of the oil cells,
- to increase the oil fluidity by increasing the matter temperature,
- to coagulate and precipitate the proteins, which facilitates oil extraction,
- to coagulate and precipitate the phosphatides,
- to change pectic matters into mucilaginous substances that dissolve in oil,
- to detoxify the free gossypol by binding it to proteins,
- to destroy the moulds, bacteria and enzymes which could harm the oil and the meats, by increasing the free fatty acid development,
- and last, to dry the meats to a moisture rate suitable for the following oil extracting operation.

The meat cooking and drying may be effected in different kinds of equipment, the more common of which comprises 4 to 6 (1) high stack cookers with steam packets for heat transfer and agitator arms for a thorough mixing of the meats. As cottonseed meats are not good conductors of heat, the agitators must be very powerful.

The flakes are put into the top kettle, inside which hot water or steam is added so as to increase their moisture rate to 11-14 %. They are then conveyed down from kettle to kettle with rising temperatures

The oil yield and its colour, the meat nutrive value and its savour much depend on the way the cooking has been operated. The variables are the amount of water added, the different temperatures of the kettles, the cooking time in each of them, the agitation speeds. They are determined according to the raw material characteristics and finished product desired ones. The oil extracting technique especially influences them.

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(1) Sometimes even 10.

As a most important aim is to inactivate gossypol without degrading too much the protein quality (cf. chapter three, 32), a compromise must be found between over - and under - cooking.

Moreover, a temperature of 88° C (190° C) is to be quickly reached, for below it enzymes put together with water are most active, and could be responsible for an undesirable hydrolyse or lipolyse (fatty acid producing).

In a five-stack cooker, the temperatures are the following ones : 1st kettle 79 to 90° C (175 to 195°C),

2nd kettle 82 to 96° C (180 to 205° C)

3rd kettle 93 to 102°C (200 to 215° C)

4th kettle 102 to 107° C (215 to 225° C)

5th kettle 107 to 113° C (225 to 235° C)

In the first kettle, the meat temperature must reach 88° C in some twenty minutes.

As we have seen it above (chapter two, 235), the total cooking time is dependent on the oil extracting process : 80 to 120 minutes when hydraulic presses are used, 75 to 85 mn with expellers, 30 to 40 mn with a solvent after pre-press.

The meat moisture content reduces from the first to the last kettle. Its optimum at the output is from 5,5 to 7 % for an hydraulic press extracted oil, from 3 to 6 % for a screw-press extracted oil, and 4 to 5 % for an hexane-extracted oil.

Such cooker capacity amounts to 125-150 tons of seeds per 24 hours.

When the cooker works at normal capacity pace, it appears that the screw-pressed cake does not contain more than 4,2 %, but when the cooker works beyond its capacity, the residual oil content rises. It is not thus advisable to overpass the normal output.

Other kinds of cookers exist, for example the horizontal cooker-dryers, in which cooking and drying are operated in different compartments.

45. OIL EXTRACTING

Remark : from now on, we won't systematically describe all the extracting and processing techniques. Specialized works can be consulted on the subject (1). The general facts are supposed to be known, and we shall only underline the essential points.

451. Hydraulic press extracting

It is an out-of-date process, still used in some countries. It comprises a moulding preparatory step, then the cakes pass into a boxed hydraulic press (the boxes or spaces are generally 15). If the rate of rise of the press is well controlled, the cakes are progressively drained, the oil contains but few impurities, and the press cloth does not wear out prematurely. The average pressing cycle is some 30 mn, but can last until 45 mn. With a 30 mn cycle, the extracting capacity in 24 hours corresponds to 15 tons of seeds, and the cake residual oil content is some 5,5 - 6,5 %.

The cake can then either be sold as it is, or broken into scraps, or else ground into flour by disc- or hammer- grinders. Sometimes, the flour is moistened, heated and pressed into small cubles.

The advantages of the hydraulic press upon the screw-press are the following ones : the investment cost is lower, the energy cost as well, the oil is lighter in colour, and contains less free gossypol. But drawbacks do exist also : the labour cost is higher, the equipment can't be easily adapted, the oil yield is lower, there is more free gossypol in the cake. But it must be underlined that the screw-press can easily be moved from one oilseed to another. This is why hydraulic pressing is less and less used to the profit of screw pressing.

452. Screw-pressing

Screw-presses work in continuous operation.

The first equipment was built by ANDERSON at the beginning of the 20th century ; many different kinds exist now.

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(1) For example : "Cottonseed chemistry and Technology", KS.MURTI & K.T. ACHAYA

Their capacity depends upon the shaft number, their section and their rotating speed. When figured out in tons of cotton seeds processed per 24 hours, the capacity ranges from 6 to 100 tons and sometimes even exceeds the latter amount. The quicker the shaft is rotating , the higher the output is, but then the cake oil content rises, and reaches a 9 to 15 % rate.

With a well-controlled unit and a normal pace of 45 turns/mn, the cake does not contain more than 3,5-4,5 % oil.

When only a pre-pressing prior to solvent - extraction is looked for, capacity is increased to 100 tons of processed seeds per 24 hours, and the cake approaches a 10 % oil content.

The absorbed energy is partially converted into heat. The meats reach a 150° C temperature (300° F). Such heat, together with the considerable pressure, degrades the protein quality (cf. chapter three, 321 and 322), and darkens the colour as well. It is thus necessary to cool the meats, which is obtained through different devices, the more common of which is a heat exchanger.

The output cake is too dry (1 to 4 % moisture) and too hot. It is cooled and re-moistened in the same time by a cold water stream. It is also ventilated ; it gets then ground by a hammer - or a double disc - grinder : the former costs less in energy, but gives out a more granulated product.

The cake composition is now approximately 3,5 - 4,5 % oil, 41-43 % proteins, 8 % water, 0,04 % free gossypol. The disposable lysine rate of its proteins does not exceed 2,5 - 3 % (cf. chapter three, 321).

As concerns crude oil, it contains insoluble impurities ("feet") and free fatty acids in a proportion of 1,2 %. The refining losses will be some 8,5 %. The feet removal will be achieved by decanting and sieving, then by a clarifying through a press-filter. The best process temperature is about 55° C. Once separated from oil, the feet are recycled either in a special screw-press, either in the first one. In the latter case, the prèalable cooking step is to be left out, otherwise the oil will get a dark colour.

The free fatty acid content of the oil depends upon the seeds used. If they already present high acidity when theyare supplied to the mill, cooking and pressing - both processes, by the way, increasing such acidity by 70 % - will have to be carefully watched upon. More especially, the flakes before cooking will have to contain at least 12 % moisture, and cooking cycle last longer. These acid seeds often give out a high feet percentage.

A rate of 2 % free fatty acids in oil is often met with.

The last oil fractions are generally more acid than the first ones ; thus it is best the extracting does not exceed some limits, or else oil refining won't get good results.

Gums, or more exactly the pectic matters originating from the substances interposed between the cell membranes, pass all the more easily into the oil that moisture is higher. As they delay soapstock deposition (cf. below), they hinder the refining process, and are consequently responsible for bad yields at this stage.

The oil gossypol rate is variable, according to the raw material and the processes. It ranges from 0,3 to 1 %. During neutralization, which is a refining step, gossypol combines with alkali and passes into the soapstock.

In more countries, India for example, undelinted and undehulled seeds are screw-pressed. The oil-yield is reduced,the oil and cakes of a lower grade, the press capacity is reduced, but of course such a simple process costs far less.

It also happens that dehulled seeds are pressed without prior delinting. The oil and cake grades are satisfactory but part of the oil (4 %) is lost.

In SSR, a new method of oil recovery is employed,the SKIPIN process, called after its inventor. It comprises 3 operations : the meats are first moistened to rise the water content to 14,5-20 %, then heated to 70° C, which allows to free the oil ; the freed oil is drained through the screened bottom of the kettle ; the partially defatted meats are then dried to reduce their moisture content to a level permitting solvent-extraction. All gossypol is found out in the oil.

453. Solvent extracting

Solvent extracting may be applied to :
- undehulled, and even undelinted cottonseeds,
- dehulled cottonseeds,
- pre-pressed partially defatted cakes (pre-press solvent extracting process).

Its main advantage when compared to the above process consist in improving the oil yield, since its residual content in the cakes does not exceed 0,5 - 2 %. Moreover, as there is very little heat treatment, the proteins offer a higher nutritional value (cf. chapter three, 321, 336).

There are however some disadvantages :

- solvent extracting is relatively expensive, and involves therefore large tonnages to be processed,
- inflammable solvents, more especially those deriving from hydrocarbures (hexane) entail danger of fire and explosion.
- the meals tend to be dusty.
- if the cooking is too mild, free gossypol can subsist in the meals.

The oil solvent direct extracting from dehulled seeds is somewhat difficult, since as the matter disintegrates readily, small particles get mixed with miscellas (see the definition below), and steps are to be taken to avoid it. If undehulled seeds are used, extracting is easier, but the oil obtainedis darker and the cake grade lower .

The pre-press solvent extracting process offers an oil yield slightly higher than the other processes, and seems to be preferred nowadays.

We won't here describe the detailed process, but will only indicate its principles.

4531. Principles of solvent extraction

The meals and the solvent must be put in contact as deep as possible, which supposes a large quantity of solvent at the adequate temperature (50 to 65° C), meals with the adequate moisture contents (which vary according to the equipment chosen) and a satisfactory granulometric state, and a long mixing between meals and solvent :

- when using batch extractors, it is necessary to have several of them working in line,
- when using continuous extractors, the meals and the solvent circulate in counter-current (1) or cocurrent directions,
- in the filtration-extraction process, the meals and the miscellas are first maintained for some time in a mixer, before they are separated by an horizontal rotary vacuum continuous filter.

Miscella is thus obtained, that is a solution of oil into the solvent, whose concentration varies according to the solvent used, and the meal oil yield. When processed in continuous modern units, the miscellas contain some 20-25 % oil (2). The older units and the batch extractors offer far lower oil yields.

Miscellas get filtered so as to remove the meal particles, then are concentrated and distilled in a simple or double effect evaporator. Afterwards, they are conveyed into a stripping column with a steam ejector for solvent recovery. The hot vapors are condensated, while the oil is cooled and stored. The condensator liquids go into a separator in which the water injected is removed from the solvent.

The solvent still contained in the meals must also be recovered. This is achieved through heating, either in the extractor itself, or in an independant drier, by using live steam here also. In some units, the process is worked with more or less vacuum, which allows the temperature to stay low and so does not degrade the meals too much. After cooling, the meals get crushed.

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(1) Such process nowadays is far less common than in former times.

(2) Sometimes even more.

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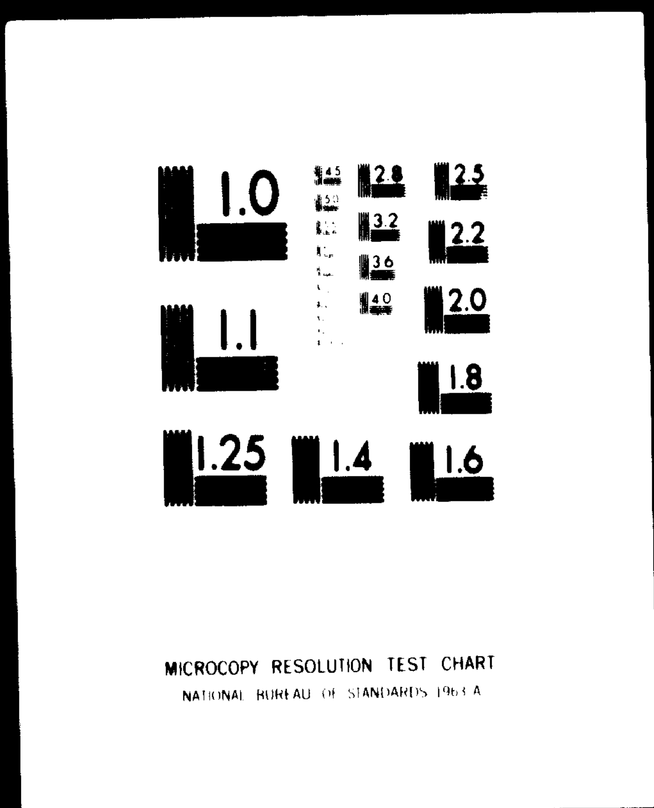

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The remaining uncondensated steams are recovered through charcoal- filled absorbers, or mineral oil packet columns, or refrigerated condensers, or by combining two or several of these means.

We must here insist upon the fact that we have only briefly outlined the different methods, which are quickly developing, especially solvent-extracting for which huge improvements have been carried out the last fifteen years.

The meals can either be completely solvent-freed, or retain some of it (0,1 %) but then appears danger of explosion during storage or transport, besides an unpleasant odour and a nutritive drawback.

4532. Preparations prior to extracting

Cleaning, delinting, dehulling and hull separating are the same as for mechanical extracting processes. Some differences appear though as concerns flake rolling and cooking.

- In pre-press solvent extraction, cooking temperature may not exceed 20° C, the cycle may be shorter and the moisture rate amount to 8 - 9 %. Meal oil content rates from 10 to 12 %. The meals are ground and rolled into flakes, and then conveyed into the solvent extractor, from which they go out with an oil content below 0,3 - 0,5 %, while direct solvent extracting hardly offers such good yield (1). Moreover, they are less crumbly and the miscellas contain less feet. The meal gossypol content is lower, its lysine one also, than with direct solvent extracting.

- In direct solvent extracting, the kernels are crushed under rolls, their moisture rate increased to 10 %. The cooking is done at a far lower temperature than in the other processes (50 to 80° C), they are rolled into flakes as fine as possible (0,006 to 0,010 inch thick, that is 0,15 to 0,25 mm). It involves of course a far larger amount of solvent to be used. The filtration-extraction process, which derives from it, requires a high temperature cooking (93 to 107 ° C, that is 200 to 225 ° F) and a 9 to 20 % moisture rate in the meals during process.

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(1) Its average yield amounts to 1 - 2 %.

4533 - Solvents

The more commonly used in the USA is hexane, a paraffinic hydrocarbure deriving from petroleum distillation.

Its boiling point, under normal pressure, varies from 63,3 to 69° C. Methylpentane boiling points are lower (59,4 to 63° C) and thus cost less in energy, but in spite of that and of their efficiency as cottonseed oil solvent, they are less used than hexane.

Trichloroethylene offers the advantage to be less inflammable than hydrocarbures. It boils at 87° C under normal pressure, and is quite a good solvent. However, it costs more in energy for distillation, which gives out darker oils, difficult to bleach, especially when coming from undehulled seeds. It must also be stabilized before use otherwise it acidifies, and corrosion is to be feared. An last, the un-toxicity of the so-processed meals is questionnable, which explains that it is not used in the USA.

Isopropyl alcohol could solve the problem. It completely removes gossypol as well as oil. Consequently there is no free gossypol left in the meals, but it must be removed from oil with some supplementary steps. It does not seem to be used as yet.

Ethanol could also be used. It could be advisable in some countries, where it derives from agricultural products, and could allow to reduce foreigh currency output.Nevertheless, it is hardly used in the USA.

The VACCARINO process applied in ITALY uses acetone and the SRRL process (see chapter three, 336) uses azeotrope aceton-hexane-water mixing. Both remove almost completely the free gossypol from the meals (the latter event better than the former), but they cost more than the hexane process.

4534 - Equipment - a short survey

As we have seen it, extracting may be continuous or discontinuous. The former procedure is the more modern. Continuous extractors fall into two types :

- in the immersion type, the solide are immersed in the solvent,

- in the percolation type, the solvent flows by graving through a stationnary or moving bed of solids.

For different reasons, the second type is now preferred to the first one.

The filtration-extraction technique belongs to the percolation type, but with its own characteristics.

Capacities, figured out in tons of cottonseeds processed in 24 hours, range from 40 to 120 t. for the immersion type equipment, from 100 to 250 t for the percolation type (1), and is about 100 t for the filtration-extraction units.

Higher capacity (500 to 2 000 t/24hours) extractors can be found, which have been designed for mills processing huge seed amounts (cotton as well as soya, etc...).

In all the plants, care must be taken that the solid and the solvent flows are regular.

With a modern and carefully used equipment, the solvent losses do not exceed 1 % of the input material. Such rate can be reduced to 0,5 and event 0,3 %.

454. Conclusion

As it is now, screw press and pre-prees-solvent extractings appear to be the more interesting processes, from the economics point of view.

Perhaps the breeding of glandless varieties will later on help solvent direct extracting development.

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(1) But smaller units can be found, from 25 to 75 t.

46. OIL REFINING

Besides triglycerides, crude oil contains different impurities: free fatty acids, water, resins, albuminoïd matters, gums, phosphatides, sterols, pigments, cetones, aldehydes, as well as decomposition products. Some of them are fat-insoluble, others are held in colloïdal suspension, or are solved in it.

The refining treatment consists in removing as completely as possible all the non-glycerides so as to produce an edible oil, pleasant to look at, or a finished product suitable for edible fat producing.

We shall now survey the main refining steps, which are :

- degumming
- neutralization
- bleaching
- deodorization.

Two treatments won't be taken into account, which can be attached to the refined oil process : hydrogenation, which converts liquid oil into concrete or semi-concrete fat through partial or total saturation of the double bonds, and winterization which, on the contrary, takes off from oil the high boiling point triglycerides, so that oil stays clear even at low temperature (1).

Generally speaking, cottonseed oil refining is much the same as for the other edible oils, the only tricky point being gossypol removal. Glandless seed breeding development will, here also, much simplify.

461. Crude oil storage

The fat-insoluble impurities such as fragments of oilseeds, dust, water (2), etc, should be removed from the crude oil before it is

(1) Cottonseed oil gets cloudy under 5 to 7° C. After winterization, it stays clear at 0° C.

(2) Nearly all crude oils contain some 0,5 % water.

stored, otherwise the present enzymes could cause lipolyse, entailing free fatty acid development. Moreover, micro-organism growth could be feared, that would help lipolyse and be responsible as well for objectionable putrefaction. The insoluble impurities are removed by settling, filtration or centrifugation, the more commonly used being filtration, for example in filter presses.

During storage, the pigments (gossypol and others) may link irreversibly with the triglycerides. Such reaction develops quickly, and is dependent on the pigment proportion and the temperature. It is thus advisable that cottonseed crude oils, after filtration and dehydration, should be stored for the shortest possible time, and at the lowest temperature consistent with their fluidity.

462. Degumming

Degumming consists in removing gums, resins, proteins, phosphatides (1), and other constituents that can be found in fine colloïdal dispersion, all to be hereafter abbreviated in "gums". After removing, they get added to the cake (2) or to the soapstock, which will be defined later on.

There are several degumming methods. The more classical is based upon hydration, using the gum characteristic to swell and form gels when wetted with sufficient water . These gels of high specific gravity precipitate to the bottom. A small quantity of water - some 2 to 5 % of the oil weight - is injected at a temperature varying from 60 to 90° C according to the methods, and the gums are separated by centrifugation. As the degummed oil still contains 0,4 to 0,8 % water, it is conveyed to a vacuum drier where it is heated to 70° C ; it is then cooled and sent to storage. This dehydration phase is most difficult for it must not darken the oil colour, nor increase its free fatty acid content. A very weak solution of soda ash injected may help as a stabilizing agent.

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(1) Phosphatides (lecithin is the most well-known) rate in between 0,7 and 2,7 % in cottonseed oil. While lecithin is extracted from soya on an industrial scale, it is not interesting to do so from cottonseed oil, since its dark colour will not allow it to be used for human consumption.

(2) They facilitate its granulation, for they increase cohesion.

Degumming may also be carried out by using additives that make gums insoluble : acetic acid, ammonium hydroxide, citric acid, oxalic acid, phosphoric acid, etc...

It is also possible, and simpler,to degum and neutralize in the same unit. The soap solution obtained after the free fatty acid neutralization carries with it, when settling, most of the gums. Consequently, before putting up any independent degumming equipment, one must take care that is justified on economic grounds.

463. Neutralization

Neutralization aim is to remove the free fatty acids, whose rate in crude oil is 0,9 to 2,8 %.

Caustic alkali is the more commonly used, as it is very effective, and bleaches better than the weaker alkalis. On the other hand, it saponifies a small proportion of the triglycerides. Other alkalis such as soda bicarbonate have therefore been used occasionnaly. But they present other drawbacks : they can't reduce the FFA rate below 0,10 % (with caustic soda a 0,01-0,03 % rate is reached) and their action has to be supplemented with other means.

The soluble substances contained in degummed oil comprise, besides FFA, a very small proportion of mono- and di- gycerides, gossypol and other colouring matters, sterols and tocopherols (which it is not necessary to remove, on the contrary), and various other unidentified substances.

During alkali neutralization, gossypol and other pigments react readily with soda and are removed for the main part into soapstock, which represents the operation residue.

Soapstock is a mixture of soap, non-glyceride impurities, water and emulsionned oil.

Neutralization may be divided into 2 main steps : first mixing, during which soda reacts with the substances to remove, then emulsion break and the neutralized substances precipitation.

Soda is efficient only when diluted, and the dilution rate is to be chosen according to numerous variables. Nearly all the dilution water passes, after neutralization, into soapstock.

We won't detail all the differents methods, which can be classified as follows :

- Caustic soda neutralization
  . batch process
  . continuous process
- Weaker alkali neutralization
  . continuous process with alkali carbonate followed by alkali
  . continuous process with ammonia
- Neutralization of miscella by caustic soda
- FFA extracting by other methods (solvents, steam, ion exchange resins, etc).

Neutralization is generally carried out at moderate heat, and in several steps. Residual matters are separated by centrifugation. The oil is then freed from all residual alkali, soap and water. In the same way, soapstock is purified, the neutral oil it contains is recovered which is then processed as necessary.

The amounts of FFA and other substances removed from oil depend upon the raw material and the process applied to it. It is some 3,5 to 9 times FFA rate when the rate is not very high, 1,5 to 2 times when it is high. With a similar acidity, the losses are more important than for other seed oils.

To obtain a good quality oil, neutralization is often achieved in two operations, the second one using a more concentrate alkali. And if caustic soda is retained in that case, this is another cause for oil loss.

As concerns quality, continuous and batch processes offer similar results. But the losses are less important with continuous process for the secondary reactions are better controlled, due to a reduced mixing time between soap and oil, which allows to improve rentability and to process oils containing more FFA. The hands need not be specialized, but the investment gets justified only for a 30 t/24 hours minimum capacity.

Direct neutralization of miscella gives out generally clearer oils, and with a higher yield, but the investment cost is heavier, the hands are to be more qualified, and steps are to be taken to avoid the solvent explosion risks. It is not therefore much in use.

Soapstocks obtained from soda concentrated solution, and mucilages (when they have not been removed beforehand by degumming) are very thick, so the centrifugers are to be powerful and easy to clean without dismantling.

464. Bleaching

The neutralized oil is golden yellow, which is suitable for food uses, but it sometimes happen that the colour appears reddish. Moreover, when designed for shortening manufacturing, a white colour is preferred.

It is therefore necessary to bleach the oil so as to remove the different pigments left over by neutralization.

For so doing, adsorbents are used, which are earths and carbons.

Cottonseed oil bleaching is quite similar to the other oils bleaching. Classical equipments are used, either continuous or batch ones. The highest temperature is some 100 to 105° C, and the bleaching earths must rate 0,5 to 2 % of the oil weight, while the carbons can reach 10 %.

465. Deodorization

Cottonseed oil, more than the other vegetable oils, retains objectionable odour and savour, due to a high content of non-oil matters, mainly aldehydes and cetones. It is therefore essential to deodorize it.

Here again, there is nothing special in the process applied to cottonseed oil.

The treatment is an easy one. As the substances to remove are volatile, the operation consists in heating them to a high temperature, then steam is injected that carries them out. After condensation, they are evacuated.

In Europe, the variables are a 180° C heat, a 5 to 6 mm absolute pressure, a cycle time of 4 to 5 hours. In the USA, the temperatures are far higher (230-240° C), and the time is reduced to 1,5 to 2 hours. The colour thus obtained is lighter, and the cyclopropene acids are more or less destroyed. Nevertheless, it is necessary that the equipment should be made from stainless steel, which is far more expensive.

A deodorizer capacity rates from 10 to 30 tons per 24 hours.

47. GENERAL REMARKS UPON COTTONSEED PROCESS INVESTMENT STRATEGY

The cottonseed process itself begins after ginning and comprises the following operations :

Operations	
. cleaning . delinting . dehulling and hull separation	seed preparation
. rolling of flakes . flake cooking . oilextracting	separation of oil and cakes

- oil refining . degumming . neutralization . bleaching . deodorization	oil refining

For each operation, we have indicated what are the capacities (in tons per 24 hours) of the different existing equipments.

Seed-cotton ginning comes beforehand, which can be carried out indepently, since its aim is to provide fibres for textile uses.

Oil-mills are designed to carry out all or part of the process steps. They may define the capacity of each step, by choosing the unit capacities and number.

Many different solutions are therefore possible.

The first one is complete integration, from the seed cleaning, or eventually ginning, to the refining.

Another one consists in several mills working on line, each one carrying out some part of the process.

Only a detailed survey can allow to determine for each case what is best in the view points of economics, of the seed (1) tonnages, of their geographical situation, of transport costs, of hand and energy local availibilities, of by-products (linters and hulls) valorization, and so on.

It may be profitable to gin and prepare the seed (that is cleaning it, delinting, dehulling, and separating the hulls) in small units (15 t/24 hours) placed near the growing areas.

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(1) We say seed, and not only cottonseed, for some equipments (extracting and refining ones for example) may process several kinds of seeds.

It may also happen, as we have seen it, that delinting or dehulling are not economically advisable.

Rolling of flakes and cooling are not systematically linked to oil extracting. Hydraulic- or screwpress extracting may be achieved by small plants (15 to 50 t/24 hours). But solvent-extracting, with or without pre-press, generally involves high capacities (200 t and more per 24 hours).

The refining works are not always placed in the mills. International trade, however, concerns only neutralized oils. A choice is possible between local refining batch units, of a 30 t/24 hours maximum capacity, and more important continuous units.

It is judicious to provide for the possibility of extracting and refining other seeds. Such polyvalent units get supplied more regularly and on longer periods in the year, at least when harvesting times differ ; the equipments work longer hours, the storage and manufacturing capacities are better proportionned to the tonnages processed ; and last, the total tonnage increasing, the size effect plays its part as well on the investment cost as on the hand cost per ton (1). Polyvalent extracting units may have a capacity of 700 to 2000 t/24 hours, and refining ones of 300 t/24 hours.

48. EQUIPMENT MAIN MANUFACTURERS

481. Seed preparation

a) Storage and drying

- MUSKOGEE IRON WORKS, in Muskogee, Oklahoma 74401 (USA)
- FERREL-ROSS, in Oklahoma City, Oklahoma 73126 (USA)
- BÜHLER BROTHERS Lts in Uzwil (Switzerland) and BÜHLER-MIAG in Braunschwerg (Western Germany)
- ANDERSON IBEC, in Strongville, Ohio 44136 (USA)

(1) In the countries where hands are expensive, cost price decreases when capacity increases, for the necessary staff is nearly the same, the unit be 200 or 1000 t/24 H.

b) Cleaning

- CANTRELL Co, in Fort-Worth, Texas 76109 (USA), exclusive manufacturer of cleaning equipment for BAUER OIL MILL MACHINERY
- MURRAY-CARVER Inc., in Dallas, Texas 75234 (USA)
- HABERMANN (Western Germany)
- ATLANTA UTILITY WORKS, in East Point, Georgia (USA)

c) Delinting

- MURRAY-CARVER Inc. (cf. supra)

d) Dehulling and hull separation

- MURRAY-CARVER Inc. (cf. supra)
- CANTRELL Co (cf. supra)
- CHANDLER

482. Separation of oil and cakes

a) Rolling of flakes

- FERRELL-ROSS (cf. supra)
- HUNT MOORE & Ass., in Memphis, Tennessee 38118 (USA) which sells the equipment BAUERMEISTER
- THE FRENCH OIL MILL MACHINERY Co, in Piqua, Ohio 45336 (USA)
- ROSKAMP Manufactoring Inc., in Cedar Falls, Iowa 50613 (USA)

b) Cooking

- THE FRENCH OIL MILL MACHINERY Co. (cf. supra)
- ANDERSON IBEC (cf. supra)
- BUCKEYE IRON BRASS WORKS, in Dayton, Ohio (USA)

c) Screw-press extracting

- THE FRENCH OIL MILL MACHINERY Co. (cf. supra)
- SIMON-ROSEDOWNS Ltd, in Hull (United Kingdom)
- USINE DE WECKER, in Luxemb urg
- KRUPP INDUSTRIE-UND STAHLBAU, in Hamburg (Western Germany)

- SPEICHIM, in Bondy 93140 (FRANCE)
- ANDERSON IBEC (cf. supra)
- MASIERO INDUSTRIAL, Sao Paulo (Brazil)
- STORK, in Amsterdam (Netherlands)

d) Solvent extracting

- THE FRENCH OIL MILL MACHINERY Co. (cf. supra)
- CROWN IRON WORKS Co. in Minnesota (USA)
- EXTRACTION DE SMET S.A., in Antwerps (Belgia)
- SIMON-ROSEDOWNS (cf. supra)
- KRUPP INDUSTRIE- UND STAHLBAU (cf. supra)
- COSTRUZIONI MECCANICHE BERNARDINI (CMB), in Rcma, (Italy)
- Fratelli GIANAZZA, in Legnano (Italy)

483. Refining

- EXTRACTION DE SMET (cf. supra)
- SIMON-ROSEDOWNS (cf. supra)
- KRUPP INDUSTRIE- UND STAHLBAU (cf. supra)
- SHARPLES
- LURGI (Western Germany)
- DE LAVAL
- CLAYTON
- Fratelli GIANAZZA (cf. supra)

484. Miscellaneous

- BLAW-KNOX CHEMICAL PLANTS DIVISION, DRAVO CORP RATION (USA) : protein extracting equipment
- CALIFORNIA PELLET MILL Co (USA) : cake granulating equipment
- STORK (Netherlands) : jigging conditioner to help oil extracting
- THE DURIRON COMPANY Inc. (USA) : press filters
- DORR-OLIVER (USA) : pigment gland extracting by liquid cyclone

CHAPTER FIVE : COTTONSEED OIL

51 - QUALITY SPECIFICATIONS

511 - Crude oil

The prices to be paid for crude cottonseed oil are based upon the refined oil quantity obtained, and the quality of it, mainly in terms of colour.

They are determined through standard laboratory tests.

Grades have be defined, each one corresponding to a crude oil quality whose loss during refining and colour values must not exceed standard figures.

In the USA, the National Cottonseed Products Association (NCPA) has laid down the governing specifications, which distinguish 5 main categories for crude oil :

- prime crude oil : when the refining loss does not exceed 9 %, the colour AOCS stays below 7,6 Red, the free fatty acid content is under 3,25 % and flavour and odour after refining are pleasant.

- basis prime crude oil : when the refining loss is under 20 % and the colour does not exceed 12 Red.

- "off crude oil" : the refining loss is below 25 %, the colour under 20 Red.

- "reddish off crude oil" : the refining loss is below 40 %, the colour under 30 Red.

- "low grade crude oil" : the oil does not meet any of the above requirements.

512 - Refined oil

5121. Trading usual classification

In ths USA, NCPA recognizes ten different grades for refined cottonseed oil, according to their foreign material rate, their colour, their savour and odour, their free fatty acid (abrev.in FFA), moisture and volatile matter contents.

a) Alkalized oils : - choice summer yellow cottonseed oil : must be without foreign material, clear and brilliant at stearine melting point temperature ; the colour must not exceed 7,6 Red, the flavour and odour are to be sweet. FFA must stay below 0,125 % and moisture and volatile matter under 0,10 %.

- prime summer yellow oil : the specifications are the same as above, except that the FFA content must not exceed 0,25 %.

- prime winter yellow oil : the same as above, and it must stand the cold test laid down in the rules

- good off summer yellow oil : the savour and odour regulations are not so low as above, which is the only difference.

- summer yellow oil : the same regulations as for prime summer yellow oil, except that the colour must not exceed 12 Red.

- off summer yellow oil : the flavour and odour may be off, the colour must not exceed 12 Red, and it must be free from visible foreign material. The maximum for FFA is 0,50 % and for moisture and volatile matter 0,10 %.

- reddish off summer yellow oil : the same as above, the difference being in the maximum figures for colour (20 Red) and FFA (0,75 %).

b) Bleaching alkalised oil : - prime bleachable summer yellow oil : the regulations are the following ones : no visible foreign material - clear at the stearine melting point temperature - sweet in flavour and odour - FFA maximum content 0,25 % - moisture and volatile matter maximum content 0,10 % - after bleaching according to the rules, the colour shall be no higher than 2,5 Red.

c) Bleached oils : - prime summer white oil : same as above, except that the flavour must not be an earthy one.

- prime winter white oil : same as prime summer white oil, but it has also to stand the cold test.

5122. F A O International specifications

The cottonseed oil characteristics are :

- Relative density at 20° C	0,918 - 0,926
- Refractive index at 40° C	1,458 - 1,466
- Saponification value (1) (mg K OH/g oil)	189 - 198
- Iodine value (2) (Wijs)	99 - 119
- Unsaponifiable matter (3)	maximum 15 g/kg
- Halphen test (4)	positive

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(1) Indicates the average molecular weight of oil glycerids.

(2) Indicates the insaturation value, that is the number of double bonds

(3) Or sterols, hydrocarbons, tocopherols, aliphatic alcohols,terpenic alcohols,.

(4) Applied only to cottonseed oil and some other rare oils (kapok oil for instance). The test is based upon the cyclopropenic fatty acids (malvalic and sterculic acids). Their value in cottonseed oil ranges from 0,04 to 2 % (average : 1%), with generally more malvalic than sterculic acid. They offer special biological characteristics, and get most of time eliminated at refining.

The FAO document lays down its quality requirements :

- acid value : maximum 0,6 mg K OH/g oil
- peroxyd value : maximum 10 milliequivalents of peroxydic oxygene/kg of oil
- colour : characteristical of the studied product
- odour and flavour : characteristical of the studied product, without any extraneous odour and flavour, no rancidity allowed
- adulterants (1) (maximum value) :

. volatile matters at 105° C	0,2 % m/m
. unsoluble	0,05 -
. soap	0,005 -
. iron	1,5 mg/kg
. copper	0,1 -
. lead	0,1 -
. arsenic	0,1 -

and indicates the authorized additives names and rates, as well as the sampling and test procedures.

52 - THE COTTONSEED OIL FREE FATTY ACID COMPONENTS

They are much the same, whatever the Gossypium varieties.

The table 16 shows the compared FFA components of cottonseed oil and of 11 other edible oils (either fluid or concrete) among the more generally used.

The cottonseed oil retained percentages are those measured by John L. IVERSON (Food and Drug Administration, Washington, USA) in 1969, with gas - liquid chromatography method (2). In table 20, which sets out the results of former measuring, appears some distortion due as well to different cottonseed oils as to different test procedures.

(1) Gossypol, saponified during refining, is eliminated with soap stock.

(2) As concerns the other oils, we have mainly referred to ITERG documentation.

TABLE 16 : <u>Average percentages of fluid * or concrete vegetable oils in free fatty acids</u>

* in the natural state, that is without hydrogenation

	Cotton-seed	Groundnut	Colza	Maïse	Olive	Grape-seed	Soya	Sun-flower	Copra	Palm	Palm-kernel	Sesame
Saturated acids												
Caprylic C8		-	-	-	-	-	-	-	5-10	-	3	-
Capric C10		-	-	-	-	-	-	-	5-10	-	3-6	
Lauric C12		-	-	traces	traces	-	-	-	45-50	-	50-55	
Myristic C14	0,7-0,9	-	-	1	traces	-	-	-	18-20	1,4	12-6	
Palmitic C16	16,7-24,9	6-8	1-6	10-16	7,5-20	6,4-6,7	6,5-12	3-6	5-7	38-43	6-8	7-9
Stearic C18	0,9-2,4	3-5	-	1,5-2,7	0,5-3,5	2,6-2,8	2,3-4,5	2-3	3-5	1-6	1-4	4-5
Arachidic C20	0,2-0,3	0,2	-	traces	traces	-	0,7-1	0,5-1	-	-	-	1
Behenic C22		5-7	-	traces	traces	-	0-0,1	-	-	-	-	-
Monoinsaturated acids												
Myristoleic C14		-	-	-	-	-	-	-	-	-	-	
Palmitoleic C16 (°)	0,3-0,4	-	-	traces	0,3-3,5	-	-	-	-	-	-	-
Oleic C18	14,4-19,5	55-70	17-40	27-43	56-83	11,6-14,3	21-34	25-34	5	40-50	10-16	45-46
Erucic C22			45-55	-	traces	-	-	-	-	-	-	
Di-insaturated acid												
Linoleic C18	51,8-59,0	14-28	14-30	42-60	3,5-20	73,8-79	49-59	57-66	-	8-11	0,5	35-41
Tri-insaturated acid												
Linolenic C18			1-4	0,1-1,9	-	-	2-8,5	-	1	-	0,1	

(°) Also called hexadecenoïcal

TABLE 16 bis : Cottonseed oil composition compared to 11 other edible oils

Cottonseed oil content in free fatty acids (%)	From P.H.MENSIER, Dictionnaire des Huiles Végétales, Paris 1957	From J.L.IVERSON FDA - 1969 (USA)	From ACHAYA, CHAKRABAPTHY & MEARA (INDIA)	From MITCHELL, 1943 (USA)	Sources appearing in PILETTE & BACOT (FRANCE)
Saturated acids					
C 14 : 0 (Myristic)	1,4	0,7 to 0,9	0,2 to 1,0		
C 16 : 0 (Palmitic)	23,4	16,7 to 24,9	23,1 to 28,1		
C 18 : 0 (Stearic)	1,1	0,9 to 2,4	1,8 to 3,2		
C 20 : 0 (arachidic)	1,3	0,2 to 0,3			
Sub-total saturated acids	27,2	approx. 23,5	approx. 28,7	27,0	25,4 to 29,5
Monoinsaturated acids					
C 16 : 1 (Palmitic)	2,0	0,3 to 0,4	0,6 to 2,5		
C 18 : 1 (Oleic)	22,9	14,4 to 19,5	15,6 to 23,7	19,0	22,2 to 27,3
Sub-total monoinsaturated acids	24,9	14,7 to 19,9	approx. 21,2	19,0	22,2 to 27,3
Di-insaturated acid					
C 18 : 2 (Linoléic)	47,8	51,8 to 59,0	47,3 to 56,5	54,0	42,0 to 46,2

The following table shows the iodine values and solidifying temperatures of the main vegetal fats, classifed in decreasing insaturation rate :

TABLE 17 : Physical characteristics of some edible oils

Oil (in the natural state)	Iodine value	Solidifying temperature (in °C)
Sunflower	115-135	- 18,5 to - 16
Soyabean	121-142	- 18 to - 8
Maïze	111-128	- 15 to 0
Cottonseed	99-119	+ 2 to + 4
Colza	94-105	0
Sesame	100-108	- 6 to - 3
Groundnut	84-105	- 2 to + 3
Olive	78-95	- 9 to 0
Palm	44-56	+ 24 to + 30
Palm-kernel	16-23	+ 19 to + 30
Copra	7-9,6	+ 14 to + 25

Source : FAO - The product policy study - n° 22 - 1967)

The cottonseed oil belongs to the first group, whose extrem ends are held by the sunflower and the colza oils (1). Their linoleic acid contents are rather high (2) (C 18 : 2, which means "free fatty acid with 18 carbon atoms, and 2 double bonds").

Which entails :

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(1) the grapeseed oil also belongs to the first group.

(2) Except for colza oil.

- during storage, they get more rancid than the other oils,
- they are less heat-resistant, and so must be considered as unfit for frying,
- on the other end, their high linoleic acid content is appreciated by nutritionists, since in human consumption it helps fighting against hypercholesterolemy and its deriving diseases,
- such acid is also looked upon as an essential one, more particularly recommended to children

The linolenic acid is also to be studied. It is undesirable, for it becomes oxydized, and the by-products obtained are unsuited for human consumption. Contrary to soya and colza oils, it does not appear in cottonseed oil. Anyway, hydrogenation, which permits to turn fluid oils into concrete ones, helps to reduce nearly to none the linolenic acid, as can be seen underneath in table 22, comparing soya oil (in the natural state) and hydrogenated soya oil components.

TABLE 18 : Comparison between soya oil composition in the natural state and when hydrogenated

Main free fatty acids	Soya oil in the natural state	Hydrogenated soya oil
C 16 : 0	10,2	9,7
C 18 : 0	4,6	4,1
C 18 : 1	25,6	51,1
C 18 : 2	51,8	35,1
C 18 : 3	7,8	0,0
	100,0	100,0

It thus appears that hydrogenation is less necessary for cottonseed than for soya oil, since for the former the advantage is only a technical one (consistance modifying).

Colza oil stands apart. Its linoleic acid content is rather low, but its erucic acid one rates high, and has been charged with provoking human and animal cardiopathies. In some countries, consumption decreased, though research work done on different varieties allowed to breed colza seeds in which the erucic acid has been replaced by the linoleic acid.

Among the first group oils, the grapeseed oil appears. Its production is low, and its content in linoleic acid rates the highest.

As concerns fluid oils solidifying temperature, it will be noted that the highest belongs to cottonseed oil. It is no longer clear at 5-7°, which is a drawback in winter and for storage in refrigerators ; Winterization (see above, chapter four, 5) tries to remedy to it.

The second group oils (sesame, groundnut, olive) - colza oil, by the way, could appear among them - have for main component a monounsaturated fatty acid, the oleic acid. Their stability is better than the first group's, and they can be used for frying.

The other fats mentionned in table 16 are concrete oils, which means they are solid at ordinary temperature. In palm oil, oleic acid rates still high, while in palm-kernel oil, and especially copra oil, the main fatty acids are saturated and short-chained. Both of them are used for making margarines and shortenings, and for cooking and frying.

53 - INTERCHANGEABILITY WITH OTHER OILS

Fats should be chosen according to the use they are meant to.

The characteristics to take into account are :

- the percentage of saturated, monounsaturated, polyunsaturated acids,
- the fatty acid nature,
- the solidification temperature,
- the viscosity at different temperatures,
- the flavour, the odour, the colour,
- etc...

It must not be forgotten that cottonseed oil, which belongs to the group of oils rich in polyunsaturated acids, is less stabilized than the second group oils, and than the concrete oils. But it is also more stabilized than soya oil, and this for two reasons :

- it does not contain linolenic acid, most unstable,
- it contains some tocopherols, which inhibit oxydation (1).

Generally speaking, hydrogenation allows fats to be easily interchangeable, since oils with high polyunsaturated free fatty acid content on one hand can be stored without developing rancidity and get more heat-resistant, and on the other hand get the concrete or semi-concrete consistency enabling them to be used for making margarines and shortenings

531 - Dressing oils

Such are called the oils used directly, or emulsionned, in order to season cold dishes. They have to be fluid, which excludes all concrete oils, except in hot countries (2).

Though interchangeability between oils is quite possible theorically, in fact local habits much limit it. Flavour plays a most important part, and if oils can now get deodorized, artificial flavouring cannot be applied there.

Three patterns are to be distinguished :

- in low purchasing power countries, people go on using the local oil, made from local raw material. If there is none, the more economical oils are then imported,
- in developed countries, the trend is to blend several fluid, neutral-flavoured oils, except in some places where strong-flavoured oils are prefered (ex. olive oil).

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(1) Gossypol could have the same effect, but is almost completely removed at refining.

(2) It must be noted that palm oil, when fractionnated, becomes a fluid dressing oil used in some countries.

- as concerns cold dressings (mayonnaise, etc...), the oil flavour hardly appears through the other ingredients'. In such a case, easy emulsifying is the main quality for oil.

Cottonseed oil does perfectly comply with those 3 patterns :

- traditional consumption (which is not always existing, but can be created or increased) in low purchasing power and cotton producer countries,
- addition to the salad oil blendings in the developped countries. Cottonseed oil allows there to balance the free fatty acid content through its high linoleic acid rate - a dietetic argument, not often met with outside the USA. On such a ground, its main concurrents are sunflower, maïze, grapeseed oils, and also unhydrogenated soya oil (though its linolenic acid rate is rather high)
- use for cold dressings. Though it is easy to emulsify cottonseed oil, the channel is not a wide open one.

532 - Frying and cooking oils

Since frying provokes a temperature rise to 180-220° C, the oils must be heat-resistant, and interchangeability is reduced.

Cottonseed oil, in the same way as the other first group oils, is only fit, in the natural state, for low temperature cooking. Nevertheless, it alters less than soya or colza oils, due to its lower linolenic acid content.

After hydrogenation, the first group oils become interchangeable with the second group and with concrete oils, for cooking and frying as well.

A blend of oils, whose linolenic acid rate is limited on purpose ($\leq$ 2 %), is more and more used.

Pure groundnut, or copra, or palm oil is perfect for cooking and frying ; olive oil is also appreciated in mediterranean countries, in spite or because of the strong flavour it conveys to the dishes.

533 - Spreading fats (margarine)

Margarine must be sweet to the taste, and offers consistency characteristics (plasticity, spreadability, melting point temperature) similar to butterfat.

All fats, due to hydrogenation, can be used for making margarine.

For the time being, the trend is to increase the linoleic acid proportion, according to the nutritionists' recommendations. Abready a small market-which is developing fast - exists for high linoleic acid rated dietetic margarines.

Such a fact could help develop unhydrogenated cottonseed oil use, but it appears that sunflower and maïze oils hold strongly the place.

534 - Shortenings for pastry, cakes, biscuits and other baked materials

The fat being dispersed in an airy and liquid environment and heated, its oxydation and hydrolyse resistance is a most important factor. Important also are its rheological characteristics (plasticity, creamyness, etc...).

Due to technical procedures (hydrogenation as well as interesterification, fractionning techniques), the fat interchangeability is theorically complete. In fact, the main fats used are concrete and animal ones.

The use in the natural state, that is without hydrogenation, of cottonseed and other fluid oils, is not to be retained.

535 - Animal feeding

In the young cattle milk feed replacement, the fats employed are mainly tallow, copra and palm oil, and lard.

For full-grown cattle, fats are added to the dry feed (mixed feed manufactured either industrially, or by the farmer himself). The animal stomach requirements are not similar to those of human kind, which allows to use inferior fats. Price is then the main point, and interchangeability is restricted to animal fats and some concrete oils.

536 - <u>Fat nonalimentary uses</u>

In many industrial uses, interchangeability is limited, and anyway does not involve cottonseed oil.:

- for paints and coatings, siccative oils are used, with high polyunsaturated fatty acid (linolenic type) rate (linseed oil, aleurit, soya oil...)
- for plastic or artificial textile manufacturing, castor oil is used,
- for galvanizing or laminating, palm oil is retained.

As a compensation, interchangeability is applied for :

- soap manufacturing : fats combined with a base give soap with glycerol recovery, or else fatty acids are directly combined with a base. Nevertheless, interchangeability limits are drawn by the different saturated and unsaturated fatty acid quantities that must be used.
- fatty acid manufacturing : in such a case, fats are only chosen according to the quantity of one or several acids obtained by fractionning. If only some determined acids are wanted, the choice is reduced since they can be found only in some determined fats, and even hydrogenation can't produce them from unsaturated acids with the same carbohydrat atoms. The choice possibilities are larger when an acid of the stearic type C 18-0 is wanted : it can be obtained from hydrogenation either of the oleic acid C 18:1, or of the linoleic acid C 18:2 , or of the linolenic acid C 18:3, which means from nearly all fats and oils.

. . .

As a conclusion, oil interchangeability is varying according to the uses, but has been greatly enlarged due to hydrogenation.

Cottonseed oil more direct interchangeability lies of course with the first group oils (sunflower, soya, maïze, colza).

The price problem will be studied later on.

CHAPTER SIX : COTTONSEED CAKES

61. THE CAKE CHARACTERISTICS

Let us first distinguish "cottonseed cake" which is obtained after press oil extracting, from "cottonseed meal", which is obtained after solvent oil extracting.

The composition of the cakes may vary. It depends upon :

- the cotton plant species,
- the care taken for delinting and dehulling. It may even happen that (see chapter four, 413 & 42), that neither operation has been proceeded to,
- the cooking conditions, which affect the free or proteinbound gossypol content,
- the oil extracting procedure, and its work conditions (for example, the press shaft rotating speed or the solvent chosen),
- the proportion of by-products added to the cakes (some hull particles, some impurities separated at the crude oil refining).

The following values can thus be found in proteins (N x 6,25), oil, water, crude fibre, ashes - which are the components usually measured out :

TABLE 19 : Cottonseed cakes and meals composition (in %)

	Proteins	oil	water	crude fibre	ashes
Hulled cakes	20 to 30	5 to 8	5 to 15	23 to 28	9 to 10
Dehulled cakes	37 to 43	3 to 7	7 to 9	10 to 15	7 to 9
Meals	40 to 45	0,5 to 2	9 to 11	10 to 18	2 to 2,5

Source : Miscellaneous

It happens that some values exceed those indicated in the table, but such cakes are not numeroue. We think here of press-extracted cakes, whose oil content may rise to 15 %.

Besidee, cottonseed cakes contain other undesirable elements : free or bound gossypol, aflatoxins, pesticids, solvents, insect scraps (see chapter three, 32, and chapter one, 17).

The USA National Cottonseed Products Association's regulations require a minimum protein rate of 36 % (1). The first quality must be sweet in odour and colour, and free from mouldiness. The cakes can be delivered either just as they are, or ground to different sizes, from a nut size to a flour form. A particular species, called "low gossypol category", is allowed a maximum free gossypol rate of 0,04 %.

62. AMINO-ACID COMPONENTS AND ANIMAL FEEDING USE

We have already said in chapter three, 321, that the available lysine rate, compared to proteins, was :

- 2,50 % to 3 % for cottonseed cakes,
- 3,10 % to 3,60 % for cottonseed meals after oil solvent extracting with pre-press,
- 3,40 % for meals obtained after oil hexane extracting,
- 3,70 % to 4,40 % for aceton-hexane-water mixing extracted meals.

As lysine is the first protein limiting factor in the cotton seed (the other deficient amino-acids are isoleucine, methionine and threorine), the oil extracting process affects mightily the cake nutritive value.

(1) Except for hulled cakes, for which the rate is reduced to 22%.

Table 20 allows to compare tha amino-acid components in cotton-seed cakaa and in 6 othar saed cakes.

As concerns tha lysine contant, it appaars that :

- aoya and colza proteins have a higher nutritive valuo, as wa have already saen it in chapter three, 35.

- groundnut, sunflower, sesame and linseed cake protein rates, compared to cottonseed cake protein rate, have similar or lower values according as the latter results from s press or a solvent extraction.

Other points however are to be considered :

- colza cakes contain sulfureous constituents, the hydrolyzed by-products of which have toxic and antinutritional effects. In spite of physico-chemical or fermentary detoxification process, they have but a limited use. The breeding of new species deprived of such undesirable components, appears to solve the problem, but it has not yet been generalized on a large scale, as has been done for glandless cottonseed. Moreover, colzaseed dehulling has still to be adjusted,

- groundnut cakes, on the other hand, are often contaminated, during gatharing and storage, by moulds which aort out aflatoxins,

- sunflower cakes do not contain antinutritive substancas,

- a caka nutritive value may also be adjusted by addition of industrial amino-acids, especially lysina.But for all that, tha resulting cost should justify it.

Generally spsaking, soya cakea are by far tha more used, and tha other caka markat prices ara fixed according to tha soya pricas.

The animal feeding manufacturers, as they try to increase rentability, consider not only the cakes appearing in table 20, but also lysine supplamentation, non-protein nitrogen (urea), lucern flour, plant silage, beat pulpa, fish flour, bone flour, blood flour, milk powder, lactosarum powder, atc, according to tha ruminant or non-ruminant, young or adult atock neads.

TABLE 20 : Amino-acid composition (%) of some meals

Essential and semi-essential amino-acids	Cotton-seed cake	soya cake	colza cake	groundnut cake	sunflower cake	sesame cake	linseed cake
Arginine	11,2	7,0	5,7	11,0	8,7	10,0	8,9
Cystine	2,0	1,2	1,2	1,4	2,1		1,7
Histidine	2,7	2,8	2,6	2,4	2,4	2,4	2,2
Isoleucine	3,9	4,7	3,9	3,6	4,6	3,6	4,5
Leucine	6,1	7,9	7,0	6,5	6,1	6,1	5,9
Lysine	2,5 to 4,4	6,3	5,9	3,5	3,5	2,7	3,7
Methionine	1,5	1,3	1,8	1,1	1,8	2,1	1,7
Phénylalanine	5,2	5,3	3,9	5,5	4,7	4,5	4,5
Threonine	3,4	3,9	4,4	3,0	3,6	3,5	3,8
Tryptophane	1,4	1,3	1,3	0,9	1,5	1,2	1,6
Tyrosine	3,2	3,8	2,3	4,5	2,3	4,7	2,2
Valine	4,9	5,0	5,0	4,3	5,6	4,8	5,8
Cake average rate in proteins	40 to 45	44 to 50	35	45 to 50	37 to 40	45	34 to 38

As concerns cottonseed cake, it has long been used only as a fertilizer. Such practice is still running on (1), but large developments for animal feeding purposes have appeared, especially in the producing countries.

In addition with cereals, green pasture, etc, it is often used to prepare mixed feed for ruminants ; the free gossypol do not seem to provoke adverse effects upon them, and they even digest some cellulose from the hulls.

But non-ruminants (poultry and pigs) are much affected by the free gossypol, and cellulose do not offer them any nutritive element. As we have said it in chapter one, 173 a, the cyclopropenic acid and gossypol combined action leads to a yolk colour change. It becomes thus necessary to reduce as much as possible the free gossypol rate - without lowering as well the protein quality - and leave few hull fragments. Glandless cottonseed varieties will of course widen the market, in as much as a serious watch upon aflatoxin contamination is kept.

Cottonseed cakes may be stored and carried either in bulk or packed They must not get re-moistured beyond their normal moisture rate, nor recontaminated by moulds, micro-organisms, insects and so on.

63. PELLETING

Pelleting is a process through which a cake finely divided, generally dusty, sometimes with a low density and nearly always difficult to handle, is compacted and extruded in larger particles, due to the heat, moistaning and press combined action.

Modern equipment comprises :

- a conveyor which lifts tha cake on top of the plant,

(1) Another use consisted in feeding the cattle with the seeds just as they were after ginning, without extracting oil.

- a paddle mixing-machine, whose shaft speed is in between 150 to 500 turns/mn. High pression steam is sent in order to heat and moisten the cake, with supplementation of water if it is too dry,

- a pelleting room, with 2 or 3 rollers inside. The perforated drum and the rollers reel in the same direction, at a speed ranging from 160 to 400 turns/mn. The meats are pressed between the drum and the rollers and get out through the dies to be cut by 2 or 3 fixed blades.

When the pellets have been shaped, it is necessary to cool and dry them, since during the process, the moisture rate reaches 15 to 16 % and the temperature rises to 80-90° C. This is done by blowing air through a smooth pellet layer. Their moisture rate then comes down to 10-12,5 % and their temperature is slighty higher than the ambiant one.

The drying and cooling machines may be either of the horizontal or of the vertical type.

The equipment can be competed upside with a cake cleaning device, and downside by a sieve.

Sometimes, corrugated rolls are added, to grind the pellets in smaller particles.

For the time being, nearly all the pellets come from meals, supplemented with the refining impurities, which play a lubricating part to help pelleting and increase pellet cohesion.

The equipement capacity is a ton per hour for every 10 CV, the powers ranging from 30 to 300 CV.

As to the pellets volumes, they vary from 1/4 to 7/8 cubic inch.

CHAPTER SEVEN : BY PRODUCTS AND RESIDUES

We shall indicate how stand the relative parts of the two main by-products : linters and hulls, in relation to the oil and cakes (themselves staple by-products). In the USA in 1970, 1 ton of cottonseed gave the following products :

TABLE 21 - Decomposition of the cottonseed different products and by-products

	(A) Weight (in pounds)	(B) Average price (in cents/pd)	(C) (A x B) Value in $	(D) % of the total value
Oil	325	14,70	47,78	50,5
Cake (41 % protein)	927	3,68	34,11	36,0
Linter	194	3,83	7,43	7,8
Hulls	468	1,15	5,38	5,7
TOTAL AMOUNT	1.914 * (= 868 kg)	4,95	94,70	100,-

(* a pound = 453,59 g)

Source: "US FATS AND OILS STATISTICS

Such figures show that linters and hulls represent in the USA some 8 % and 6 % of the whole cottonseed value after ginning.

71. LINTER

711. Quality grades

We have seen in chapter four (4131) that saw-delinting was the most frequently used process, and could be carried out either in one operation, which gives out "mill-run" linters, either in two successive passages, which gives out "first-cut" and "second-cut" linters, or else in three and even four passages.

As we have said it, the obtained linter weight is dependent as well on its prior thickness around the seed (its percentage varies from 0 to 12 %, according to the species) as on the delinting process chosen and the delinting conditions, and on the following cleaning.

. In the USA, linter grading is based upon four characteristics :

- the distribution of the linter fibre lenght. First-cut linter is generally 2 to 6 mm long, second-cut 1 to 3 mm. If there is only one delinting operation, linter gives out fibres with very different lenghts, which is a drawback for some uses (1),

- the extraneous matter (mainly vegetable scraps, dust, and hull pepper) rate,

- the colour (olive green, creamy white, pinkish, etc),

- their character, which comprises three components : uniformity of fibre lenght, softness or harshness, and smoothness or neppiness. The character depends upon the soil nature, the climate, and the seed species. It has been given the three following names : Western, Valley, Southeastern.

Based upon these characteristics and the users' needs, US classification distinguishes seven linter grades, appearing hereafter in a fibre lenght decreasing order :

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(1) The more different are the fibre lenghts, the less value they reach.

- classes 1 and 2 are generally first cut
- class 3 is first-cut or mill-run
- class 4 is mill-run
- class 5 is mill-run and second-cut
- classes 6 and 7 are second-cut.

Classes 1 to 4 are retained for textile uses, and classes 5 to 7 for chemical applications (cf. below).

For the latter, the linter chemical purity is most important, for they require an as pure as possible cellulose : the material must be very clean, with a minimum content of oxy-celluloses (1), waxes and oils (2), ashes (3), and especially iron (4). Second-cuts are therefore better than first-cuts, since they contain less impurities. Staple lenght nevertheless is not always indifferent, because very short ones might get lost during washing process.

712. Linter uses

7121. Textile applications

They are the most frequently found in the USA.

Linter may be used as it is for chemical cotton manufacturing, for mattresses and furniture etc. Classes 2, 3 and 4 ara retained for such uses.

Textile industries prefer classes 1 and 3 for falt, strings, meshes, dish-clothes, dressings, etc...

Classes 1 and 2, and eventually 3, may be also found in paper-making. An hydroxyethylation treatment improves the lintar characteristics.

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(1) They solve in alkalis. The linter content in oxycelluloses ranges from 10 to 30 %.

(2) They solve in ether and benzene. Their rate must not exceed 2 %.

(3) Their usual rate is some 2,5 to 3,5 %. It should stay under 3 %.

(4) Its rate must not exceed 500 ppm.

7122. Chamical applications

They have been developed in some countries, India for example.

Linter gets preferred to other materials such as wood pulp, for its α-cellulose content is higher, and it is devoid of pentosanes and lignine.

The main markets for chemical applications are :

- cellulose acetate, used in the manufacture of rayon fibre, or as a base for photographic film and for injection moulding,

- nitrocellulose, the well-known explosive. Linter prices therefore rise in war-time, as was seen indeed in 1950 in the USA (Korean war). But besides it, it is also used for automobile lacquer, artificial leather, coating papers, photographic films, etc,

- carboxymethyl cellulose and other organic cellulosa, used as thickening agents in paper-making, in textiles, in the food industry, in the soap industry etc...

In all such uses, linters are not always competitive whan compared to other products with lower valua (printing paste, synthatics etc).

713. Economics

In chapter four (4131 and 42), we have already underlined that saw-delinting was not always advisable, when there was no sufficiant market for tha linter :

- saw delinting requires heavy invastments, costs in energy, and gives out dust and noise,

- other delinting processes (burning, acid- or abrasion-delinting) are possible ; on one hand, they are more economical, but on the other hand they either dastroy linter or lower its grade,

- whan the seeds suppliad to the mill are vary dirty, the linter grade will be low.

However, the delinting influence upon the process other steps must be taken into account :

- the dehulling of seeds which retain more than 4 % linter is technically difficult, and involves oil and kernel losses,
- the kernels obtained after dehulling of undelinted seeds contain less hull scraps.

As we have seen it in chapter four (42), S.P. CLARK's study (USA - 1976 (12)) shows that if linter average selling price exceeds 4 cents per pound, it is best to delint before dehulling, but below 3 cents per pound, dehulling may be carried out without delinting, or after acid-delinting.

In fact, saw-delinting is much used in the USA, in order to lower the linter rate under 4 %.

It can be achieved in one passage (mill-run), in two (first cut and second cut), in three or four, depending upon the process costs compared to the relevant linter prices.

Generally speaking, second cuts sell best, and therefore 2 passages delinting are preferred ; but it happens that price fluctuations, based upon extraneous factors, are so important that all economical results change from one year to the other. According to the prices, it may be best to delint in one or in two passages, and to fit the equipments so as to keep more or less linter on the seeds.

72. THE HULLS

The first chapter (162) indicates the hull components :

- α cellulose	35 to 47 %	- average	44 %
- pentosanes	19 to 35 %	- "	30 %
- lignines	15 to 25 %	- "	21 %
- miscellaneous (proteins, fats, ashes) approximately			5 %
			100 %

After grinding, they can be separated by sieving or cyclone units into 2 parts :

- hull fibres which contain some 70 % α - cellulose. Their average lenght is 3 mm,

- hull pepper (also called "hull bran") with little α - cellulose, and on the contrary high pentosane and lignine rates.

The different components could even be better separated through physico-chemical processes :

- as lignines and pentosanes dissolve in hot (130 to 140° C) alkali solutions, nearly pure α - celluloses could be thus removed and used for rayon fibre manufacturing,

- by processing the hull pepper with water, which removes gums and ashes, then with sulphuric acid, the pentosane molecules are broken, and xylose is obtained. Pentosanes can also be processed into furfurol, used for plastic and paint manufacturing,

- the cellulose acid hydrolyse gives out glucose and leaves a solid residue, lignine, the possible uses of which are not many.

In fact, it appears that hulls, like many agricultural by-products (sugar-cane "bagasse" (1), maïze ears, oat and rice seed coats, coconut hulls, etc...), are not readily valorized.

721. <u>Use as manure</u>

Due to their low density and to their composition, hulls are excellent soil conditioners.

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(1) Sugar cane cellulosic residue.

722. Use as combustible

Their calorific value reaches some 40 % of the fuel. But they must be burnt only in furnaces made from fire-proof bricks with a high alumine content, otherwise the ashes could provoke corrosion.

723. Use as animal feed

It is by far the most frequent use. In spite of a low nutritional value (approximately 50 % of a good quality hay), of a lack in A vitamin and some essential mineral salts, ruminants can easily digest them when mixed to their rations.

In some countries therefore, all the hulls are left with the cakes (there is no dehulling), with, as a consequence, an oil lower yield (cf. chapter four, 42).

The hull nutritive value might also be increased by degrading the crude fibre with acids and alkalis, so as to increase its digestibility.

724. Other uses

Some potential uses may be indicated : preparation of active carbons -paper work - separated extracting (cf. supra) for the different constituents (cellulose, lignine, xylose and furfurol).

73. SOAPSTOCK

Soapstock is the by-product obtained after cottonseed neutralisation.

Its colour is always dark, and its components vary, since they depend upon the crude oil quality before refining, the neutralizing process used (cf. chapter four, 453) and the eventual prior degumming.

It contains water, soda soap, neuter oil, fatty acids, pigments (gossypol especially, whose rate ranges from 0,01 to 11 %), phosphates, resins, carbohydrates and so on.

Its first and simpler use consists in making it the main constituent in soap and detergent manufacturing. This is quite often the case, though it is not advisable because of its many impurities, which is prejudicial to the finished product quality.

The soapstock content in fatty acids (either free or bound under the form of soda soap) makes it interesting to recover them. Soapstock is thus processed by sulphuric acid which combines with the soda and free the acids, in a continuous or discontinuous operation ; then the fatty acids may be, if necessary, distilled so as to remove all residual impurities, and to separate the palmitic acid, relatively pure, from the mixture of oleic and linoleic acids. The distilling residue, or "cotton pitch" is a mixture of polymerized fats, more or less modified fatty acids, unsaponifiable substances and impurities ; this black amorphous matter, as it is waterproof, gets used in varnish, paint, coating, bitumen etc manufacturing.

The fatty acids derived from soapstock are mainly used in soap manufacturing. They also appear as raw material in chemical industry (natural and synthetic rubber, paints, varnishes and coatings plastics, lubricants, cosmetology, insecticids...etc).

74. THE USED BLEACHING EARTHS

The oil contents of the used bleaching earths vary. The rate depends upon the earth nature, and whether there has been or not active carbon, and which process has been applied for the filter-presses drying (air or steam eventual injection). It thus ranges from 20 to 60 %. The oil quickly degrades and oxydes in the air, and can be recovered in two possible ways :

- the autoclave method employing a boiling alkaline solution,
- the solvent process in an adapted filter-press.

In the first case, the recovered oils can be used for soap, distilled fatty acid and cattle feed manufacturing.

In the latter, the oils can be recycled, after solvent removal, into edible oils. The relevant equipment is however very expensive and the explosion risk (especially when hexane is used) involves its location quite far a side.

75. OTHER BY-PRODUCTS

Phosphatides (cf. chapter four, 452) which contain lecithin, may also be recovered, but the latter dark colour makes it impossible for it to compete with soya lecithin.

The deodorizer distillates amount to 0,1 to 0,3 % of the oil yield. They comprise free fatty acids, oxyded fatty acids, aldehydes and a large proportion of unsaponifiable matters, among which sterols. Their recovery has been less studied than that of the soya oil deodorizer distillates.

76. INFLUENCE OF OIL MILLS UPON ENVIRONMENT

Cottonseed oil mills do not pollute much.

Nevertheless, whenever local conditions require that are thrown out only high quality waters, chemical and eventually biological purifying will be necessary, since :

- the extracting waters contain solvent traces when a solvent extracting process is employed,

- after refining, the degumming and washing waters contain, as we have seen it, different substances,

- deodorization waters contain more or less soluble or emulsioned distillates.

All effluents are to be fitted with decanters so as to make possible the fats' recovery.

As concerns atmospheric pollution, an oil-mill is hardly responsible for it, except for the heater chimneys, around which the air is heavy with sulphur if the combustible used derives from petroleum, and with ashes.if the hulls are burnt.

An oil mill is noisy (conveyors, delinters, dehullers, presses) but noise can be lowered with some precautionary steps taken at setting time.

A specific pollution must be noted in cake storage places when the cakes spread on the ground get moistened, they form a sticky paste which may ferment. Therefore care must be takenthat the stores are always scrupulously clean.

CHAPTER EIGHT : THE COTTONSEED MARKET

81. THE MAIN PRODUCING COUNTRIES

In chapter first, 15, we have already indicated, for each country, the cultivated acreages, the fibre productions and yields from 1973/1974 to 1976/1977 (provisional figures).

In the same chapter, will be also found some information upon the cotton plant species which are grown in the main producing countries. This is important as far as the seed processing industry is concerned since, according to the species, linter as well as protein rates change.

Thereafter, appears the seed cotton world production between 1970 and 1976, in millions of tons (source: statistics FAO, 71).

1970	1971	1972	1973	1974	1975	1976
22,1	23,5	24,7	24,9	25,9	22,9	23,6

There is hardly any movement to notice, and the ratio between the highest production (1974) and the lowest (1970) is but 1,17.

Table 22 shows how the production is distributed among the main producing countries, for the years 1973, 1974, 1975, 1976. Four countries together amount to 65 % of the whole world production : SRR, China, USA and India (with a slight reserve for China's statistics).

TABLE 22 : Cottonseed production per country (in 1000 tons)

Source : FAO statistics (71)

PAYS	1973		1974		1975		1976	
	Quantity	% total amount	Quantity	% total amount	Quantity	% total amount	Quantity	% total amount
S S R	4.970	20,0	5.460	21,1	5.130	22,3	5.400	22,9
CHINA	4.295	17,2	4.295	16,6	4.337	18,9	4.900	20,7
U S A	4.550	18,3	4.134	16,0	3.175	13,8	3.661	15,5
INDIA	2.398	9,6	2.580	10,0	2.450	10,7	2.292	9,7
PAKISTAN	1.318	5,3	1.268	4,9	1.020	4,4	1.029	4,4
BRAZIL	1.215	4,9	1.070	4,1	1.015	4,4	795	3,4
TURKEY	821	3,3	958	3,7	745	3,2	750	3,2
EGYPT	862	3,5	753	2,9	730	3,2	680	2,9
SUDAN	358	1,4	432	1,7	432	1,9	208	0,8
MEXICO	572	2,3	852	3,3	335	1,5	369	1,5
IRAN	406	1,6	411	1,6	328	1,4	275	1,2
ARGENTINA	244	1,0	237	0,9	270	1,2	258	1,1
SYRIA	248	1,0	244	0,9	240	1,0	230	1,0
COLOMBIA	243	1,0	283	1,1	210	0,9	215	0,9
NICARAGUA	178	0,7	225	0,8	200	0,9	199	0,8
PERU	148	0,6	125	0,5	141	0,6	135	0,6
OTHER COUNTRIES	2.074	8,3	2.573	9,9	2.206	9,6	2.224	9,4
TOTAL AMOUNT	24.900	100,0	25.900	100,0	22.964	100,0	23.620	100,0

82. COTTONSEED COMPARED WITH THE MAIN OTHER OLEAGINOUS SEEDS

Table 23 - the figures are in millions of tons - shows the main oleaginous seed productions from 1970 to 1976.

TABLE 23 : Main oleaginous seed production for the period 1970/76

SEEDS	1970	1971	1972	1973	1974	1975	1976
Soya	46,5	48,5	52,3	62,3	56,9	68,9	62,1
Cot ton	22,1	23,5	24,7	24,9	25,9	22,9	23,6
Groundnut	18,4	19,2	15,9	17,0	17,3	19,6	18,5
Sunflower	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
Copra	3,6	3,9	4,4	3,7	3,6	4,5	4,9
Lin seed	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

Source : FAO 1976 Production Annuary (71)

The seeds are classified according to decreasing tonnages.

Cotton comes second behind soya, but quite far away.

Moreover, the average proportion in oil and proteins is also to be considered (1).

(1) Linseed won't be studied, since it is not edible for human kind.

TABLE 24 : Some oleaginous seed oil and protein rates

	Oleaginous seed average proportions	
	in oil	in proteins
Soya	20 %	42 %
Cotton	19 %	21 %
Dehulled groundnut	48 %	19 %
Colza	51 %	20 %
Sesame	50 %	25 %
Sunflower	39,6 %	13,6 % (1)
Copra	69 %	7,4 %

Source : ONUDI, 1974

In table 24, cottonseed position is not very brilliant, since :

- if its oil content is practically the same as the soyabean's, the latter contains far more proteins,
- groundnut, colza, sesame and sunflower are much richer in oil (2) which is the seed main valorizing factor,

However, one must bear in mind that the main cottonseed product is fibre (cf. chapter one, 15), and the seed itself is but a by-product (3).

Thus the cottonseed oil and cake market prices are not based upon the specific production cost, but get adjusted to those of the other oils and cakes - soyabean more particularly - through different factors depending upon the oil (cf. chapter five) and cake (cf. chapter six) different compositions ; such adjusting factors also fluctuate according to the market (supply and demand ratio), the stock, the crop and so on.

(1) Higher contents are sometimes found, ranging from 16 to 24 %.
(2) Copra also is richer in oil, but the case there is a little different.
(3) Moreover, yields per ha must also be considered.

83. COTTONSEED INTERNATIONAL TRADE

It concerns only a very small part of the world production : approximately 1 %.

Cottonseed in fact is not very abundant in oil, its hull weighs heavily (40 %) for practically no value, its density is low, the handling difficult. Moreover, local uses either in the natural state for animal feeding, or separated into oil and cakes, have developed in many countries.

The producing countries wishing to export it prefer of course to sell oils and cakes, and avoid high transport costs for goods which offer only 50 % useful material.

The hereafter table shows the main exporting and importing countries in 1976.

TABLE 25 : Main cottonseed exporting and importing countries in 1976

	SEED EXPORT	
	1000 tons	%
WORLD TOTAL AMOUNT among which :	227,3	100,0
1) AFRICA :	63,4	27,9
Mali	(16)	(7)
Ivory Coast	(11,4)	(5)
Chad	(10)	(4,4)
2) AMERICA :	96,3	42,4
USA	(64,8)	(28,5)
Nicaragua	(31,2)	(13,7)
3) ASIA	14,6	6,4
4) EUROPE	2,4	1,0
5) SSR	49,8	21,9
6) OCEANIA ET AUSTRALIA	0,8	0,4

	SEED IMPORT	
	1000 tons	%
WORLD TOTAL AMOUNT among which :	236,3	100,0
1) AFRICA	0,5	0,2
2) AMERICA :	70,6	29,9
Mexico	(64,1)	
3) ASIA :	117,1	49,6
Japan	(95,0)	
Liban	(22,0)	
4) EUROPE :	48,1	20,3
Greece	(46)	
5) SSR, OCEANIA & AUSTRALIA	0	0

Source : FAO (72)

84. COTTONSEED PRICE EVOLUTION

The variables to be considered are of course dependent upon the seed characteristics and quality, the sale conditions (production price, bulk price, import f.o.b. or c.i.f. prices) and the different countries concerned. When the prices are all converted into dollars per ton, the dollar change rate also plays its parts.

All the following figures are taken from FAO documentation, and more particularly from the Monthly Report "Agricultural Economics and Statistics".

1) Production price

a. in Egypt : 44 - 49 $/t from 1975 to 1977 (1)

b. in the USA : 75 - 145 $/t from 1975 to 1977

2) Bulk price

In India : 109 - 216 $/t from 1975 to 1977

3) Import price

a. in Japan : for cottonseed imported from the former French Western Africa, c.i.f. price : 163 - 256 $/t from 1975 to 1977

b. In Europe (Antwerps, Rotterdam) : for cottonseed imported from Sudan, c.i.f. price :

1972	1973	1974	1975
106 $/t	153 $/t	230 $/t	219 $/t

As a comparison, we shall indicate the extreme prices appearing in the same FAO Report, concerning soyabean for the period 1.1.75 - 31.12.77 :

- for the USA producer, 157 to 338 $/t
- for the UK importer, cif, Great-Britain, 186 to 393 $/t.

Which shows the quoting gap all in favour of soyabean.

(1) By "from 1975 to 1977", we mean that we have analysed the prices of each month during there 3 years, and only retained the extreme values.

65. TRANSPORT COST INFLUENCE ACCORDING TO THE DELIVERY

Transport cost influences mightly the cottonseed final price.

When an ocean or part of it is to be crossed, which happens frequently, sailing may be effected in two ways :

- in bulk inside the hold
- in containers.

Container transporting allows no bulk-breaking when lading and unlading, and offers a better seed quality protection. But it is more economical, whenever possible, to sail cottonseed in bulk upon 2 500 to 3 000 t cargoes. Cost might even be lowered by grouping the goods in order to freight a 10000 t cargo.

As an indication, we are detailing hereafter the costs in 1978 of a shipment from the Ivory Coast and from India bound to a French harbour (source : Compagnie Générale Maritime et Barry Rogliano Salles, Shipbroker). They are based upon the "Conference" tariffing (1) now in force and worked out in dollars per ton :

TABLE 26 : Cottonseed shipment costs

FROM	TO	PACKAGE	BASIC FREIGHT COST ($/t)	SUPPLEMENTS ($/t)	TOTAL COST ($/t)
INDIA	FRANCE	in containers	70	30	100
IVORY COAST	FRANCE	in bulk (2500 to 3000 3000 t)	24	8	32
IVORY COAST	FRANCE	in bulk (10 000 t or more)	20	7	27

Sources : Compagnie Générale Maritime & Burry Rogliano Salles

(1) By "Conference" it must be understood the regrouping of all the shipping companies serving the same regular lines. There are for example 2 conferences between the US Eastern Coast and the Northern Europe harbours. Shipping traffic is thus distributed in several "conferences" inside which the companies agree upon similar freight prices.

It so appears that container or even bag shipment, if possible for small quantities (1), involves a far higher cost than a bulk shipment and the latter of course is the more frequently retained.

86. QUALITY STANDARDS

Cottonseed quality standards have been much studied and defined all since the beginning of the XXth century.

In the USA, its grade is determined by multiplying a quantity index by a quality index, and by dividing the result by 100.

861. The quantity index

It can be calculated by using the following formula :

$$i = 4\,p_1 + 6\,p_2 + p_3 + 5$$

in which :

p_1 = oil percentage

p_2 = ammonia percentage

p_3 = corrective term allowing for the linter percantage

p_3 can be thus determined :

Linter % of the seed	Corrective term
10,6 and higher	prime = (% lintar - 10,5) x 1,0
10,5	nona
10,4 to 9,0	remise = (10,5 - % linter) x 1,0
8,9 to 4,0	remise = [(9,0 - % linter) x 2,0] + 1,5
3,9 to 0	remise = [(4,0 - % lintar) x 2,5] + 11,5

(1) Containers 20 or 40 feet long may also be used. Their volumes are then 27 or 54 m3.

862. <u>The quality index</u>

a) Prime quality cottonseed : when the cottonseed does not exceed the following maximum rates : 1,8 % for free fatty acids, 1 % for extraneous matters, 12 % for moisture, their index quality is 100.

b) Below prime quality cottonseed : when the above components exceed the above rates, the quality index is reduced as follows:
- minus 0,4 for each 0,1 % free fatty acid Beyond the limit of 1,8 %
- minus 0,1 for each 0,1 % extraneous matters beyond the limit of 1 %
- minus 0,1 for each 0,1 % moisture beyond the limit of 12 %.

c) Off quality cottonseed : the category covers the cottonseeds which have gone through other processes than the usual ones (cleaning, dehydrating, ginning, sterilization eventually), the heated or fermented seeds, or those comprising more than 12,5 % free fatty acids, or more than 10 % extraneous matters, or more than 20,2 % moisture, or more than 25 % moisture + extraneous matters combined.

d) Below grande cottonseed : when the grade, calculated as above, amounts under 40, the seed is said "below grande quality", and no grade whatsoever is indicated to the buyer.

This US grading method has been established in 1963. It is a rather complicated one and of course involves that the samplings are correct. But its grading scale, based upon a great manu factors, allows a clear forecast for the oil and cake future yield.

Other grading methods, the Indian one for example, are also in use.

CHAPTER NINE : THE COTTONSEED OIL MARKET

91. THE WORLD PRODUCTION

The cottonseed oil world production reaches some 3 millions of tons (table 27).

TABLE 27 : Cottonseed oil world production

	1972	1973	1974	1975	1976	1977 (provisional figures)
Cottonseed oil world production, in millions of tons	2,79	3,01	3,15	3,30	2,83	3,76
% of cottonseed world production	11,3	12,1	12,2	14,4	12,0	-

As the cottonseed oil content average is 19 %, it appears that approximately 65 % only of the seed cotton world tonnage gives way to oil extraction.

Tables 28 & 29 compare cottonseed oil production to the other fats produced. Table 28 shows that cottonseed oil represents, between 1973 and 1977 (provisional figures), 5 to 8 % of the edible and unedible fat world production.

TABLE 28 : Cottonseed oil world production compared to the total fat production

	1972	1973	1974	1975	1976	1977 (provisional figures)
Cottonseed world production, in % of the total fat world production	7,1	6,7	7,2	7,2	5,9	7,8

Besides, cottonseed oil appears far behind soya oil, a little below sunflower oil, and quite on the same level as groundnut oil. The regular rise of palm-derived oil must be underlined : palm oil extracted from the fruit pulp, palm-kernel oil extracted from the kernel. The former world tonnage is 6 times the latter one.

In the USA, from 1974 to 1976, crude cottonseed oil production has been as follows :

	1974	1975	1976
Cottonseed crude oil production, in millions of tons	0,686	0,551	0,446

Source : the US Embassy in Paris

TABLE 29 : Oils and fats world production - data 1973-1976 and forecast 1977 (in millions of tons)

Raw material	1973	1974	1975	1976	1977 (provisional figures)
Soya	7,38	9,30	8,27	10,10	9,53
Sunflower	3,58	4,51	3,97	3,56	4,17
Colza	2,41	2,37	2,50	2,47	2,43
Palm	2,25	2,61	2,94	3,23	3,58
Fish	0,80	1,00	0,97	0,91	0,99
Groundnut	2,91	3,05	3,01	3,45	3,28
Lard	4,26	4,46	4,33	4,30	4,50
Lauraceae (1)	2,95	2,69	3,27	3,53	3,36
Cottonseed	3,01	3,15	3,30	2,83	3,76
Other edible products (2)	7,17	7,22	7,09	7,57	6,66
Tallow and fats	4,43	4,92	4,70	4,70	4,80
Other unedible products (3)	1,51	1,67	1,50	1,52	1,45
TOTAL AMOUNT	42,66	46,95	45,85	48,17	48,51
U S A	10,64	12,34	10,18	11,50	10,83
Other countries	32,02	34,61	35,67	36,67	37,68

(1) Comprises coconut, palm and babassou refuse oils

(2) Comprises sesame, carthame, maïze, olive, butter and whale oils

(3) comprises castor and linseed oils, oiticic oil, tungstene oil, sperm and olive residue oil

92. COTTONSEED OIL INTERNATIONAL TRADE

Cottonseed oil main part is consumed in the producing countries. International trade concerns only 10 % of the world production, that is some 300 000 t/year. The USA are the main exporter, since, on a total exported amount of 280 000 t, they represented 244 000 t in 1976. On the same year, the main importers were Egypt (138 000 t), Venezuela (27 000 t), Iran (20 000 t), Japan (13 000 t), and Turkey (11 500 t).

It might be interesting to compare cottonseed international trade to the other edible vegetable oils.

TABLE 30 : The different oil world trade in 1975

	World exportations in 1975	
	in 1000 tons	in %
Soya oil	1.364	21,1
Palm oil	2.046	31,6
Copra oil	1.031	16,0
	405	6,3
Cottonseed oil	375	5,8
Sunflower oil	624	9,6
Palm kernel oil	259	4,0
Colza oil	353	5,4
Sesame oil	3	-
Miscellaneous	8	-
TOTAL AMOUNT	6.468	100

It so appearr in table 30 that cottonseed oil does not play an important part (some 6 %) in the vegetable oil international trade.

Soya and palm oils together amount to 53 % of the edible vegetable oil world exportations, and it is estimated they could rise to 67 % in 1990. For :

- economics as well as necessity combine to develop soya growing all through the world. The USA are still leading, but soya cultivated acreages are quickly increasing in Brazil and Argentine,

- the main rise however in edible oil production will be due to palm oil. The world export amount is already 2 millions of tons, which means that in the last ten years, it has been multiplied by four.

Malaya mainly is responsible for it. Its production in 1967 was 200 000 t ; it now reaches 1 500 000 t. In 1990, it will probably rise to 5 500 000 t. In the same time, other countries develop their production, especially Ivory Coast and Indonesia. One must also bear in mind that the palm-trees sown all through the world and who haven't yet reached their fructification stage, or don't yet give out their maximum yield, will offer in the 3 or 4 years to come, some one million of tons of supplementary palm oil, which represents a 30 % rise.

The relative part of cottonseed oil will of course be reduced when compared to the vegetable oil world production, and moreover to the exportations. And as concerns the prices of all the oleagineous seeds, a general decrease (1) will certainly take place.

93. COTTONSEED OIL PRICE

931. Crude oil

Crude oil, in tank cars, f.o.b. Valley Points (USA) was sold at the average wholesale price of :

- 600 $/t in 1975
- 514 $/t in 1976
- 578 $/t from January to September 1977
  (source FAO)

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(1) In real value, whatever the currencies' inflation may be.

932. Semi-refined oil

The cottonseed oils appearing in international trade are always semi-refined, and correspond to the PBSY grade (prime, bleachable, summer, yellow).

A definition of it has been given in chapter five (512 b).

Table 31 compares the prices c.i.f. - Europe of the different oils, in between 1960 and 1976.

International trade prices for cottonseed oil are very similar to those of groundnut oil or slightly below them. They are nearly at the same level that sunflower oil (except from 1966 to 1969 included), and quite higher than soya oil. But the price differences may vary both in absolute and in relative values, since oil prices are easily influenced by the factors affecting the yield and demand ratio (1). Currency fluctuations, and speculation also, play their parts.

That a correlation exists between the different oils can be proved by comparing the price lines.

Cottonseed oil trade inside the producing countries concerns generally crude or neutralized oil (India).

Trade, whether national or international, bears thus upon semi-refined oils, for crude oil has to be neutralized very quickly, otherwise the coloured pigments may get irreversibly fixed (cf. chapter four, 451) ; such phenomenon appears in some few days or weeks. This is the reason why long period storage and transport are not advisable for cottonseed oil in the crude state.

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(1) Mainly the climate conditions, which determine the crops.

TABLE 31 : Compared prices of different vegetable oils
(in $ per ton, c.i.f. Europ , from 1960 to 1976)

oil / year	Soya	Sunflower	Cotton seed	Ground-nut	Colza	Olive	Palm	Copra	Palm-kernel
1960	225	243	235	326	219	585	228	312	317
1961	287	311	305	331	280	561	232	254	263
1962	227	246	266	275	221	631	216	251	255
1963	223	236	243	268	215	871	222	286	287
1964	205	255	250	315	252	586	240	297	299
1965	270	294	278	324	263	663	273	348	353
1966	261	263	333	296	244	661	236	324	271
1967	216	212	378	283	206	690	224	328	249
1968	178	172	305	271	161	681	169	399	367
1969	228	213	291	332	200	666	181	361	306
1970	307	331	354	379	293	699	260	397	429
1971	323	375	392	441	295	727	261	371	335
1972	270	326	324	426	232	916	217	234	244
1973	465	480	500	546	395	1,399	378	513	491
1974	795	983	939	1,077	745	2,174	669	998	1,010
1975	619	739	726	857	551	2,436	433	393	439
1976	376	600	645	675	390	2,350	370	340	360

Legend :

Soya oil : crude, USA, c.i.f. Rotterdam
Sunflower oil : all origin, ex-tank Rotterdam
Cottonseed oil : USA, PBSY, c.i.f. Rotterdam
Groundnut oil : Nigeria/Gambi /all origin, c.i.f. Europe
Colza oil : Holland, f.o.b. from mill
Olive oil : Spanish, edible
Palm oil : Malaya, c.i.f. Great Britain
Copra oil : Philippines,Indonesia, in bulk, c.i.f. Rotterdam
Palm kernel oil : Western Africa, c.i.f. Great Britain

94. TRANSPORT COST INFLUENCE, ACCORDING TO THE DELIVERY

The sources are the same as in the preceding chapter (chapter eight, 84).

For small quantities, shipment may be effected in containers, but most of times, special tankers are used. In table 32 below, appear some cost examples :

TABLE 32 : Cottonseed oil transport cost

From	To	Conditioning	Basic cost in $ per t.	Supplements in $ per t.	Total cost in $ per t.
INDIA	FRANCE	in tank	65	25	90
U.S.A. (Eastern Coast)	FRANCE	in containers	180	28	208

(Conference tarification)

Tank transport is thus more economical, and all the more so since even better conditions may sometimes be obtained.

95. QUALITY STANDARDS

They have been surveyed in chapter five, 51.

96. TRADE CUSTOMS

On the local markets, sales take place between millers and refiners either directly or through commercial brokers.

On the international markets, trade is held by the main places' commercial firms and brokers. And the US export regulations determine a certain trading current.

CHAPTER TEN : THE COTTONSEED CAKE MARKET

101. THE WORLD PRODUCTION

Table 33 below presents the main producing countries production in between the years 1974 to 1976 (in thousands of tons of cakes).

TABLE 33 - Cottonseed cake production from 1974 to 1976

COUNTRIES	1974	1975	1976
SSR	1600/1800	1800/2000	1600/1800
USA	1910	1510	1230
CHINA	900/1100	900/1100	1000/1200
INDIA	900/1000	900/1000	900/1000
PAKISTAN	500/600	450/600	300/400
BRAZIL	400/500	350/450	300/400
TURKEY	300/400	300/400	200/400
MEXICO	200/300	200/300	100/200
ARGENTINA	50/100	100/200	90/150
TOTAL AMOUNT (approximative)	7235	7035	6250

Source : INRA, "Tourteaux et autres matières riches en protéines", 1976/87

In this table, some producing countries do not appear, whose production is not negligible, such as Sudan, Egypt, Nicaraga, Guatemala, Colombia, Paraguay.

Table 34 (source : FAO Statistics) allows to compare the different cakes world production, figured out in thousands of tons of proteins.

TABLE 34 - **Different cakes world production**

CAKES	Production of cake proteins (average value in between 1973/1975)	
	in thousands tons	in %
Soya	17.270	63,7
Cotton	3.660	13,5
Groundnut	1.990	7,3
Sunflower	1.630	6,0
Colza	1.340	5,0
Linseed	470	1,7
Copra	280	1,0
Miscellaneous	490	1,8
TOTAL AMOUNT	27.130	100,0

It thus can be seen how soya cakes stand out but cottonseed cakes come second, and reach approximately 13 % of the whole production.

The following fact must be underlined : the average cottonseed world production has reached 24,6 millions of tons in the period 1973-1975 (cf. chapter eight, 81) ; if we suppose their protein content is some 21 %, the potential protein tonnage will be 5,2 millions. Since cake production corresponds to 3,66 millions of tons of proteins, it appears that only 70 % of the cottonseed world tonnage gives out cakes. As we have seen it (chapter nine, 91), a similar reasoning applied to oil led to a 65 % proportion, quite comparable, as could be forecast.

102. COTTONSEED CAKE INTERNATIONAL TRADE

It bears upon far larger amounts than cotton seeds and oil :

TABLE 35 - Cottonseed cake world trade

	1972	1973	1974	1975	1976
Total export of cottonseed cakes (in 1000 tons)	419	1428	1071	1088	894

Source : FAO Statistics 1976

In tables 36 & 37, appear the main exporting and importing countries for the years 1974,1975 and 1976.

It will be noted that Europe is the only continent to import, with Denmark leading before Western Germany.

The exporting countries are better distributed all over the world, since Asia, America and Africa appear as well (1). The main ones are India and Turkey, leading before Sudan, Argentina, etc.

As to table 38, it helps to classify cottonseed cake international trade among the other cakes :

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(1) Among them, appear some European countries, Greece for example, which import seeds, process them, consume oil and export cakes.

TABLE 36 - Cottonseed cake international trade

(from FAO Trade Annuary 1976 (77))

	EXPORTATIONS					
	1974		1975		1976	
	in 1000 tons	in %	in 1000 tons	in %	in 1000 tons	in %
WORLD TOTAL AMOUNT THUS COMPOSED :	1071	100,0	1088	100,0	894	100,0
1) AFRICA :	215	20,1	250,6	23,0	217,2	24,3
SUDAN	(55,8)		(93,7)		(100)	
EGYPT	(23,5)		(38,2)		(17,0)	
TANZANIA	(39,7)		(43,3)		(28,8)	
UGANDA	(26,6)		(16,1)		(16,2)	
ETHIOPIA	(19,8)		(13,0)		(14,4)	
MOZAMBIQUE	(22,8)		(18,4)		(13,0)	
2) AMERICA :	363,3	33,9	289,6	26,6	310	34,7
ARGENTINA	(24,2)		(59,2)		(95)	
COLOMBIA	(29)		(60,4)		(44)	
NICARAGUA	(73,7)		(70,4)		(60)	
GUATEMALA	(61,5)		(27,7)		(35)	
U.S.A.	(44,6)		(14,4)		(29,5)	
PARAGAY	(18,5)		(20,6)		(28)	
BRAZIL	(86,2)		(19,1)		(3,5)	
3) ASIA :	386,5	36,1	444,2	40,8	262,6	29,4
INDIA	(145,9)		(192,4)		(130)	
TURKEY	(152)		(217,8)		(88,9)	
PAKISTAN	(14,7)		(12,5)		(30,1)	
IRAN	(43,2)					
4) EUROPE :	95,8	8,9	98,8	9,1	104	11,6
GREECE	(60,8)		(75,4)		(63,0)	
NEDERLANDS	(0,3)		(0,2)		(10,6)	
WESTERN GERMANY	(0,6)		(0,9)		(12,9)	
DENMARK	(16,9)		(15,7)		(8,9)	
ITALY	(11,4)		(4,3)		(0,07)	
5) SSR	10	1	5	0,5		

TABLE 37 - Cottonseed cake international trade (continued)

	IMPORTATIONS					
	1974		1975		1976	
	in 1000 tons	in %	in 1000 tons	in %	in 1000 tons	in %
WORLD TOTAL AMOUNT THUS COMPOSED :	973	100,0	1046	100,0	879	100,0
1) AFRICA :	14,7	1,5	14,4	1,4	14,8	1,7
RHODESIA	(11,2)		(11,8)		(12,4)	
2) AMERICA :	6	0,6	2,8	0,2	14	6,1
U.S.A.	(3,1)		(0,6)		(12)	
3) ASIA	5,4	0,6	5	0,5	-	
4) EUROPE :	946,7	97,3	1024	97,9	850	96,7
DENMARK	(372,2)		(500)		(433,6)	
WESTERN GERMANY	(160,7)		(178,6)		(170,4)	
SWEDEN	(64,5)		(71)		(56,3)	
GREAT BRITAIN	(68,5)		(34,7)		(32,5)	
POLAND	(46,7)		(70)		(50)	
EASTERN GERMANY	(46)		(58)		(30)	
NORWAY	(26,8)		(20,8)		(20,8)	
IRELAND	(4,8)		(7,5)		(17)	
NEDERLANDS	(3,1)		(2,8)		(11,4)	
5) SSR	-	-	-	-	-	-

TABLE 38 - Comparison between the different cakes world exportations

CAKES	World exportation of cakes in 1975	
	in 1000 tons	in %
Soya	8.745	68,8
Groundnut	1.158	9,1
Cotton	1.115	8,8
Copra	697	5,5
Sunflower	358	2,8
Colza	272	2,1
Palm kernel	374	2,9
TOTAL AMOUNT	12.719	100

Cottonseed cakes rate thus at the 3rd place in international trade, far behind soya bean, but quite in a level with groundnut.

In fact, trade between cake producing and consuming countries represents but the effect of extending traditional habits : for example France still goes on importing groundnut cakes for it used to do so at the time when its colonies spread upon a large part of Western Africa, but as concerns cotton seeds and cake , its imports are very few.

103. COTTONSEED CAKE PRICES

1031. Wholesale prices

Agricultural statistics distinguish cottonseed cake from cottonseed meal (that is press-extracted and solvent extracted cake) whole sale prices.

Danish cottonseed cake, whose protein proportion reaches 46 %, rated (1) in Copenhagen Exchange :

(1) Average prices

174 $/t in 1975
214 $/t in 1976
247 $/t from January to August 1977

US Cottonseed meal, with a 41 % protein proportion, was sold (1) in bulk in Memphis (Tennessee) :

131 $/t in 1975
175 $/t in 1976
212 $/t from January to July 1977

1032. Import prices

The same FAO Monthly indicates the average prices c.i.f. Liverpool of an all origin cottonseed cake with a 43 % protein rate :

172 $/t in 1975
207 $/t in 1976
255 $/t from January to July 1977

In the "OIL WORLD SEMI-ANNUAL" review appears the price c.i.f. Hamburg of a cottonseed cake with 45-46 % proteins : the average price for 1975 was 153 $/t.

1033. Comparison with the other cakes

It could be interesting to compare the wholesale prices (taken from the FAO Monthly) in the USA of a cottonseed meal and of a soyabean meal, both sold in bulk :

TABLE 39 - Comparison between cottonseed cake and Groudnut cake wholesale prices in the USA

	Average 1975	Average 1976	Average from January to July 1977
Cottonseed cake (41 % proteins)	131 $/t	175 $/t	212 $/t
Soyabean cake (44 % proteins)	147 $/t	190 $/t	258 $/t

Which confirms the soya price slight advantage.

As concerns groundnut meals, their prices are generally on the same level as the cottonseed meals.

104. TRANSPORT COST INFLUENCE ACCORDING TO THE DELIVERY

The sources are the same as for seeds and oils.

With regard to the large quantities concerned, cake shipments are nearly always effected in bulk, in the ships' tanks. For a delivery from India to France, the cost is 27 to 32 $/t, including supplements. Charging and discharging are achieved by special handling equipment with high capacity, for which practically no handwork is needed.

Transport in bags is not much used, neither in containers : it is suitable only for low tonnages, and the cost is higher. As an example for a container delivery from India to France, the transport cost, supplements included, rises to 100 $/t.

During transport, care must be taken that the cakes are not remoistened beyond their normal content, nor re-contaminated by moulds, microorganisms, insects, rodent excrements, etc.

105. QUALITY STANDARDS

See chapter six, 61.

106. CAKE INFLUENCE IN THE COTTONSEED COMPONENTS VALUE

See chapter seven, preambule.

107. TRADE CUSTOMS

International trade is generally dealt with by international trading firms, commercial brokers and distributors who get directly in touch with the animal feed manufacturers.

In some seed and cake producing countries, exportations is strictly ruled by government regulations. Trade may either be in the hands of a state monopole, or left to the trading firms within the frame of legal stipulations who can, as an example, determine quotas.

108. THE DEVELOPING COUNTRIES

As for groundnut cakes, transport cost from the producing countries to the main European cousuming countries is very high when compared to the product value. The producing countries had thus better to valorize locally their productions ; but in most developing countries, animal feed industries are practically unexistent, since there is no market under the form of intensive breeding. Local demand is very scarce,and the unexported cakes are either given as they are to the cattle, either simply destroyed.

In such countries, the cake local market development appears linked with cattle-breeding development, which is itself dependent on meat consumption local habits. Generally speaking, extensive breeding is the rule, and in spite of some governments efforts, the industrial level which would entail a cake demand quick increase is still far away.

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