

SOYBEAN OIL REFINING

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1984

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I - INTRODUCTION

The crude oil extracted from soybeans needs further treatment to convert it to a bland, stable, nutritious product that is used in the manufacture of margarine, shortening, salad and cooking oil, mayonnaise, food products, oleochemicals.

Several processes may be used to produce an edible oil. We will deal mainly with the caustic refining process, the most widely used and probably the most reliable to produce a good quality oil.

II - CRUDE OIL QUALITY

Crude oil is normally defined in terms of moisture and dirt, phosphatide content normally expressed as ppm phosphorus, free fatty acids (FFA) or acid value and also in terms of color, oxidation characteristics, and trace components such as iron and copper.

TABLE I shows some typical commercial specifications NSPA trading rules.

TABLE II shows the “desiderable” specifications of a French Oil Milling Refinery and the VERNOF specifications.

TABLE III shows the analysis of the deliveries (LESIEUR-ALIMENTAIRE/FRANCE).

III - FATTY ACID COMPOSITION OF SOYBEAN OIL

TABLE IV indicates the fatty acid composition (wt %)

IV - TRIGLYCERIDE STRUCTURE

Because of the high unsaturated acid content of soybean oil nearly all of the glyceride molecules contain at least 2 unsaturated FA, and di- and tri-saturated glycerides are essentially absent.

The fatty acids are not randomly distributed in a single glyceride molecule, and the glyceride is biosynthesized with a definite configuration.

Each hydroxyl group of glycerol is unique and has been assigned a stereospecifically numbered (sn) position as in the following general structure - Table V (1).

These analyses are determined by a combination of enzyme hydrolysis (lipase) with thin-layer chromatography (TLC) and gas-liquid chromatography (GLC). A typical distribution for the soybean oil triglyceride structures has been given as shown Table V.

V - MINOR CONSTITUENTS

TABLE VI gives a list of the minor components that one has to deal with in the refining of soybean oil.

TABLE VII gives the chemical formulas of three major phosphatides present in the crude soybean oil.

Non hydratable phosphatides are present as calcium and magnesium salts.

Conditions under which the seed is grown and stored and the crude oil recovered from the seed, will influence the oil content of minor constituents.

VI - DIFFERENT PROCESSES

According to the different uses of soybean oil (food and non-food uses) the refining process will be different.

The specifications of the R.B.D. will be more definite and difficult to obtain for the margarine industry, mainly for the Distributive Trade Market.

Different processes can be used

- caustic refining process (conventional process)
- physical refining
- miscella refining
- zenith process...

In fact, miscella refining is used almost exclusively with cottonseed oil and the zenith process (developed in SWEDEN) in the refining of rapeseed oil.

In the U.S.A. and in Europe, for the refining of soybean oil, the caustic refining process is by far the most used.

We have not sufficient time to report on physical refining.

Physical (steam) refining has advantages

- better yields
- better quality of fatty acids (purity and color)
- no splitting losses (soapstock)
- no more waste pollution problems
- cheaper initial investment in equipment.

The physical refining of palm oil, lauric oils and other fats and oils that have a low phosphatide content by dry degumming and bleaching followed by distillation, deodorization, is 20 to 25 years old and common practice today. But for the “soft” oils (soybean, sunflower, rapeseed, corn...) many oil refining experts still reserve their opinion and prefer caustic neutralization for soybean oil.

J.M. KLEIN (2) has made a comparative study of the physical and chemical refining of soybean oil. Below an oleic acidity of 1 % the advantage of physical refining is not apparent.

Cottonseed oil cannot be physically refined because of its color.

CAUSTIC REFINING PROCESS

TABLES VIII and IX indicate the successive steps and the components removed and/or reduced.

The components which are insoluble in fat, mainly entrained seed particles, are in most cases removed from the oil by filtration. The oil, now free of suspended matter, is then degummed to remove the phosphatides.

The oil degumming and soybean lecithin production will not be considered here.

When the oil is to be degummed, it is usually done at the oil mill except when the oil refinery also produces commercial lecithin.

Our starting raw material will be a soybean oil with a maximum phosphorus content of 200 ppm (VERNOF and NSPA specifications)

TABLE X indicates the different steps of an industrial continuous process.

VII - CONVENTIONAL FLOW-SHEET OF THE REFINING PROCESS

DIAGRAM 1 shows the conditioning with phosphoric acid.

DIAGRAM 2 shows the continuous refining process.

DIAGRAM 3 indicates the continuous washing.

DIAGRAM 4 shows a semi-continuous deodorizing “SCD” (heat recovery by direct oil-oil heat exchange).

DIAGRAM 5 shows a double-shell deodorizer modified for heat recovery.

VIII - EFFECTS OF PROCESSING ON THE NUTRITIVE VALUE

1 - Degumming and alkali refining

The degumming process removes phospholipids and other polar hydratable lipids. Alkali refining has little effect on the triglycerides of the oil, and thus on its principal nutritional function. The removal of water-binding phospholipids may be advantageous in preventing spattering and drowning if the product is used for frying operations.

2 - Bleaching

The acidic nature of most bleaching earths does give rise to measurable quantities of conjugated fatty acids derived from the polyunsaturated fatty acids (PUFA) present. Peroxidized fatty acids also break down to yield conjugated compounds -Table XI - The significance of the conjugated acids has not yet been clearly defined.

3 - Deodorization

The passage of steam through layers of oil held in trays under vacuum at temperatures of about 230-240°C in Europe (higher in the U.S.A.) strips the oil of traces of free fatty acids, volatile fat oxidation breakdown products and other odoriferous compounds. But at the same time, other effects occur, such as the partial removal of both free and esterified sterols (β -sitosterol and stigmasterol) and tocopherols.

During deodorization the tocopherol content of the oil is considerably reduced.

TABLES XII and XIII show the tocopherol levels in physically refined soybean oil processed at 28000. Some scientists consider it is necessary to respect a certain balance of PUFA and vitamin E (α -tocopherol).

In practice, this balance is represented in the following ratio

$$\frac{\alpha - \text{tocopherol in mg/100 g}}{\text{PUFA \%}}$$

This ratio should be equal to or more than 0.6. Since increased intake of essential fatty acids increase the tissue content of PUFA, there will be an increased need for tocopherol or vitamin E.

According to the temperatures used during deodorization (higher than 250°C) this ratio is not respected.

The high temperatures used in the deodorization process can cause limited isomerization (changing the natural cis to trans configurations) in both linoleic (C18:2, n-6) and -linolenic (C18:3, n-3) acids.

In fact, the degree of isomerization is a sensitive index of the degree of undesirable changes in the oil.

The total trans content and the level of conjugated acids are shown Table XIV and Table XV. These contents directly depend on the temperature during deodorization.

IX - ANALYTICAL CONTROL DURING REFINING

1 - Crude oil Quality

We have already pointed out the importance of the extinction of a 1 % solution in a 1 cm cell at 232 nm (E 232).

Unfavourable weather conditions, leading to the harvesting of unripe beans, adversely affect the quality of the oil (4). Damage to the bean releases three enzyme systems : lipase, lipoxygenases, phospholipase (5).

Such an oil is characterized by high contents of iron, chlorophyll and oxidized lipids and is difficult to deslime. This adverse effect on the oil quality can only be partially offset by “heavy” refining with corresponding losses in yield.

TABLE XVI indicates the factory analysis on this subject (6).

TABLE XVII indicates recommendations for handling/storing crude, deslimed soybean oil (6).

TABLE XVIII indicates the abuse effect characteristic of crude oil quality (7).

2 - Quality control during industrial refining

Many analyses can be made concerning the oxidation criteria (peroxide value, oxidized lipids, carbonyl value, anisidine value, E.232, E.268, accelerated tests such as the SWIFT test..) and the other minor components to be removed or inactivated during refining (phosphatides, chlorophylls, FFA, soap, hydroperoxides, organochlorine pesticides, trace

metals..)

We only have indicated in Table XIX the control criteria to be made in the factory.

3 - Drying

It is after the drying step that control criteria should be made concerning the neutralization lines.

4 Bleaching

After the filtration, the refined-bleached oil is stored before deodorization. The retention time in the holding tank should be minimum because the oil is, at this time, very sensitive to oxidation. The most important quality controls have to be done after bleaching.

There is a relationship between the chlorophyll content and the stability (shelf-life) of the soybean oil after deodorization ($FFA \leq 0.1 \%$).

X - ENERGY SAVING

Based on the maximum temperature levels indicated, bleaching and mainly deodorization offer greater potential for steam saving than caustic refining.

DIAGRAM 5 shows a continuous neutralizing and bleaching with heat recovery oil-oil heat exchangers are generally applied.

TABLE XX indicates the steam consumption in kg/t of oil neutralizing-bleaching line - with and without heat recovery (8).

When utilizing a heat exchange section located within the deodorizer shell, the basic heat recovery system can economically reduce the heating fuel requirements for the deodorization operation by 45-55 %.

Even higher heat recovery rates up to 85 % can be obtained by using specially designed external heat exchangers. This method results in the preheating of the feedstock oil to rather high temperatures (200°C and more) outside of the deodorizer shell and, therefore, is not always an acceptable technique for all processors.

The U.S. technique (9) - continuous deodorization : EMI CORPORATION, for instance - differs from the European technique – semi-continuous deodorization : DE SMET, for instance.

Shell and tube, plate type and spiral heat exchangers are used for external heat recovery.

TABLE XXI shows the steam, water and heating energy consumption per ton of processed oil (semi-continuous deodorizing plant) - with and without heat recovery (8).

XI - AUTOMATION

The term automation refers to the functions of monitoring and regulating processing operations automatically or remotely to check and maintain the required processing conditions and product quality (10).

The increasing amount of automation applications within edible oil refineries has brought about the need to keep overall production costs at a competitive level, achieve higher product qualities, maximize processing yields and eliminate losses due to accidental operator errors.

Increased investment in continuous processing plants has created the need for more automation compared with the previous requirements for batch type processing. The central control panel, containing process, controlling instruments, chart recorders, alarm annunciators and plant graphic flow diagram has now become a familiar and essential feature in edible oil refineries.

We point out below the main “experimental sensors” tested on the line in a large French oil refinery

1 - Physico-chemical installation

- Free fatty acid analysis (potentiometry)
- Caustic excess analysis (potentiometry)
- Color (photometry)
- Chlorophyll (calorimetry)
- Turbidimetry (nephelometry)
- Accidental presence of moisture (dielectric constant)

2 - Physical installation

- Temperature
- Flow rate
- Control of losses (caustic refining).

XII - STANDARDS OF R.B.D. SOYBEAN OIL

TABLE XXII shows the standards of a commercial soybean oil, produced and sold in FRANCE by several refineries.

XIII - CONCLUSIONS

NUTRITIVE VALUE OF THE LINOLENIC ACID

According to the different usages of refined bleached deodorized (R.B.D.) soybean oil, the quality of the crude oil has to comply with the commercial specifications. We insist on the particular importance of the E.232 value, which is of interest.

None of the analytical values of crude oils seem to have a close enough correlation with taste and organoleptic keepability to predict reliably the quality of a particular batch of refined soybean oil. Some of these crude oil data seem, however, to be of value in predicting keepability within broad statistic limits. E.232 is most convenient for this purpose, according to our own experience and scientific literature (5).

Our guidelines concerning refining differ from standard literature (11) (12) on some points

- We prefer two washings rather than only one washing in order not to “poison” the bleaching earth with soaps. Bleaching, if carried out in the presence of soaps, will also increase the FFA content.
- The chlorophyll content should be less than 0.02 ppm. The literature generally does not mention this point or mentions a less than 0.5 ppm (6).
- It seems unnecessary to add citric acid, in the case of the caustic refining process. A common practice is to add citric acid (0.0005 to 0.01 % based on the weight of the oil), preferably at the cooling stage in the deodorizer, to protect the traces of metal (12) particularly iron and copper, which appear both in the native oil and as a result of processing (therefore the necessity of using stainless equipment)

When added before deodorization, citric acid decomposes rapidly above 150°C and is ineffective as a metal scavenger. The usual practice now is to add the citric acid at the cooling stage in the deodorizer. The literature points out that their effectiveness in soybean oil is increased by a synergistic action with the naturally occurring tocopherols(12).

When very high temperatures (more than 260°C) are applied during deodorization there is a removal of natural anti-oxidants of the oil.

We prefer to recommend lower temperatures (maximum 240°C) in order to keep tocopherols. In this case, according to our own experience, it is not necessary to improve storage stability, to add citric acid and synthetic anti-oxidants. We obviously suppose that there are no more metal traces in the R.B.D. soybean oil (less than 0.05 ppm of iron).

Properly refined, bleached and deodorized (R.B.D.) soybean oil is an excellent salad oil, requiring no winterization or dewaxing.

The utilization of hydrogenated soybean oil in shortenings and margarines has steadily increased these last years, in the U.S.A. and in Europe, despite the fact that hydrogenated soybean oil crystallizes in the beta-form. This beta-tendency can be somewhat overcome by using two or three component base stocks of hydrogenated soybean oil during formulation.

We have not sufficient time to discuss soybean oil flavor. Soybean oil is nearly unique in its content of linolenic acid. The only other common edible oil with a comparable or higher linolenic content comes from the newer varieties of rapeseed oil (about 10 % of C18:3, n-3).

For this interesting subject we recommend reading the excellent paper by E.N. FRANKEL (12).

The AMERICAN SOYBEAN ASSOCIATION is sponsoring research by soybean plant breeders directed toward the reduction of linolenic acid in soybean oil itself.

Standard literature has often discussed linolenic acid in a negative way (flavor stability), but there is growing evidence that it probably is essential in human nutrition.

The class of n-3 polyunsaturated fatty acids, which includes linolenic acid (about 7 % in soybean oil) may be of nutritional importance and desirable in the human diet. At the last IFNA Scientific Symposium, a report on "Nutritional Requirements of Edible Fats and Oils" was given by Pr. H.A. CRAWFORD (London-U.K.).

Alpha-linolenic acid has three similar double bonds, but cannot be synthesized from linoleic acid (C18:2, n-6), because the third double bond is in a position, three carbon from the methyl end (n-3) which cannot be desaturated by animal systems.

Eicosapentaenoic acid (EPA) is the corresponding 20 carbon chain length derivative of alpha-linolenic acid (C20:5, n-3), but it is further converted to the docosahexaenoic acid (DHA) C22:6, n-3 - which is the most highly unsaturated fatty acid found in animal cell membranes.

EPA and DHA are precursors of prostaglandins PGI₃ and thromoxans TXA₃ in blood. PGI₃ has the effect of inhibiting agglutination of blood platelets.

Because villagers traditionally ingesting maritime foods have decreased incidence of cardiovascular disease and thrombotic death, attention is now focused on the dietary balance of n-3 and n-6 acids. This dietary balance, not yet exactly defined by nutritionists, may be beneficial in decreasing the development of coronary artery disease and thromboembolism, according to Dr. W.E.M. LANDS - Chicago/U.S.A - (15).

BIBLIOGRAPHY

- (1) E.H. PRYDE
USDA-PEORIA
Handbook of Soy oil Processing and Utilization
(chapter 2)
- (2) J.M. KLEIN
Research Laboratories – LESIEUR-ALIMENTAIRE
COUDEKERQUE (France)
ASA Symposium on Soybean Processing
June 2nd/4th - Antwerp 1981
- (3) Dietary Fats and Oils in Human Nutrition
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS -
Rome 1977
- (4) C.D. EVANS and al.
JAOCS, 51, 444 - 1974
- (5) F.V.K. YOUNG Consultant
Liverpool (U.K.)
ASA Symposium on Soybean Processing
June 2nd/4th - Antwerp 1981
- (6) Dr. A. THOMAS
UNILEVER, Hamburg, West Germany
ASA Symposium on Soybean Processing
June 2nd/4th - Antwerp 1981
- (7) D.R. ERICKSON
ASA Saint Louis (U.S.A.)
JAOCS, vol 60, Number 2 - Feb. 1983
- (8) A. ATHANASIADIS
DE SMET ENGINEERING N.V. - Antwerp (Belgium) ISF-AOCS – New-York -
April 1980
- (2) A.M. GAVIN
EMI CORPORATION - Des Plaines (U.S.A.)
JAOCS, vol 60, Number 2 - Feb. 1983
- (10) L.T. MOUNTS USDA-PEORIA
JAOCS, vol 60, Number 2 - Feb 1983
- (11) G. HARALDSSON ALFA-LAVAL AB
Tumba (Sweden) - JAOCS, vol 60, Number 2, Feb. 1983

- (12) Handbook of Soy Oil Processing ASA and AOCS - 1980
- (13) BRONGEEST- SCHOUTE
Am. J. Clin. Nutr. 34:1752 (1981)
- (14) IFMA-Scientific Symposium - May 1984 Salzburg (Austria)
- (15) Dr. W.E.M. LANDS - Chicago (USA) "Current Views of Nutritional Aspects of
Linolenic Acids" - DGF - 1983.

TABLE 1

IMPURITIES IN CRUDE DEGUMMED SOYBEAN OIL	
Moisture and Volatiles	NSPA Specification 0.3% max
Dirt	0.3 % max
Free Fatty Acids	0.75% max
Partial Glycerides	--
Phosphatides	0.02% max as phosphorus
Oxidation Products	--
Trace Metals	--
Pigments	--
Unsatifiable Matter	1.5 % max
Flash Point	250° F – 121°C min
NSPA = National Soybean Processors Association	

TABLE II

	<u>LESIEUR</u>	<u>VERNOF</u>
Moisture and volatile matter	<0.20	Maxi 0.20%
Impurities (insoluble in petrol ether)	--	Maxi 0.10%
F F A (as oleic)	< 0.75	Maxi 0.75%
P ppm	< 200	Maxi 200
Sediment (GARDNER Break test)	< 0.1	Maxi 0.10%
Color (1 inch Lovibond cell)	Y. maxi 50 R. Maxi 5	Not darker than 50 Y. and 5 R.
Flash Point (F.P.)	> 121°C	Oil with a F.P. below 121°C is rejectable
E ₂₃₂	< 2.6	--
<u>VERNOF</u> : Vereniging van Nederlandse Fabrikanten van Eetbare Oliën en Vetten Good merchantable quality, solvent extracted, guaranteed unbleached, produced from sound yellow soybeans.		

TABLE III

	Oleic	H ₂ O	Imp.	E ₂₃₂	E ₂₇₀	C _{18:2}	P	C _{18:3}	T ₄₂₀	FP	Hex.
<u>1983 YEAR</u>											
Number of analysis	148	148	148	135	63	135	132	135	2	1	128
Weighed mean	0.6	0.1	0.02	2.6	0.34	54	108	--	--		0.03
Standard deviation	0.23	0.05		0.34	0.11	0.84	55	--	--		0.02
Maxi	1.43	0.25	0.02	3.7	0.6	57	330	9.1	20	135	0.09
Mini	0.26	0.02	0.02	2.1	0.2	52	38	6.5	19	135	0.005
Total weight tons	21000										
<u>1984 YEAR</u>											
Number of Analysis	70	70	70	69	52	70	64	70			43
Standard deviation	0.49	0.08	0.02	2.5	0.3	53	110	7.1			0.02
Maxi	0.17	0.02		0.62	0.14	0.75	23	0.56			0.02
Mini	0.87	0.26	0.04	5.6	0.7	55	180	8.9			0.06
	0.19	0.015	0.02	2	0.04	51	66	6.3			0.004

Source : Lesieur - Alimentaire

TABLE IV : Composition of Consumer-available soybean oils ^a

Fatty Acid	Brand			
	Crisco ^b	Giant ^b	Hollywood ^c	Kraft ^b
	Wt % of total fatty acid methyl esters			
14:0	< 0.1	< 0.1	< 0.1	< 0.1
16:0	8.9	10.1	10.6	10.0
18:0	3.9	4.8	4.1	5.0
18:1	47.2	40.8	24.7	45.8
Unknown	0.1	0.1	--	0.1
18:2	36.7	40.8	52.6	36.6
Unknown	0.2	0.2	--	0.4
18:3	2.7	2.7	7.7	2.0
20:0	0.3	0.3	0.3	--
20:1	< 0.1	< 0.1	--	--
22:0	0.2	0.2	0.2	0.2
P/S ratio	3.0	2.8	4.0	2.6

a Carpenter et al., 1976
b Specially processed (partially hydrogenated) soybean oil
c Cold pressed

TABLE V : Positional Distribution of the Fatty Acids in Commercial Soybean Oil Products

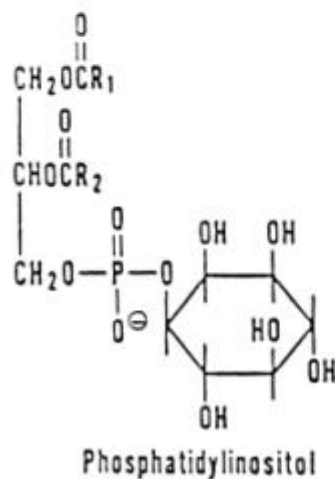
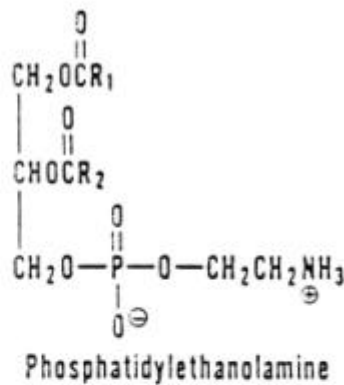
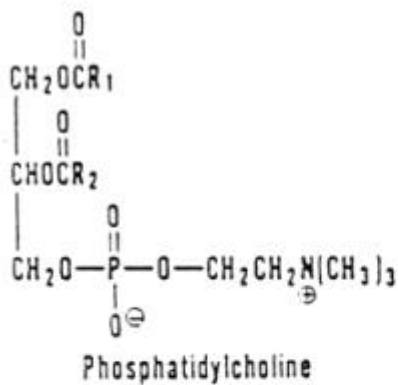
Brand	Fatty acids	Position	
		sn-2	sn-1, 3
Crisco	16:0	0	14
	18:0	1	6
	18:1	51	45
	18:2	46	32
	18:3	2	3
Giant	16:0	1	16
	18:0	0	7
	18:1	44	39
	18:2	52	35
	18:3	2	3
Hollywood	16:0	0	17
	18:0	0	6
	18:1	25	24
	18:2	69	45
	18:3	6	8
Kraft	16:0	0	16
	18:0	1	7
	18:1	52	43
	18:2	46	31
	18:3	1	3
Carpenter et al., 1976			

SSS	0.07
SUS	5.2
USS	0.4
USU	0.7
UUS	35.0
UUU	58.4
TOTAL	99.8

TABLE VI : Minor Constituents

- Hydratable and non-hydratable phosphatides
- Free fatty acids
- Carotenoids, chlorophylls and eventual brown pigments
- Metallic ions, e.g; : iron, copper, calcium, magnesium
- Free sugars and glycolipids
- Oxidized products
- Various flavor and odor compounds
- Partial glycerides
- Unsaponifiable matter – hydrocarbons, triterpene alcohols, sterols
- Tocopherols α , β , γ , δ

TABLE VII Chemical Formulas of 3 Major Phosphatides in Commercial Soybean Lecithin



R_1 and $R_2 = C_{15} - C_{17}$
hydrocarbon chains

TABLE VIII

Fat components altered/added		Components removed/reduced
Solvent extraction	<ol style="list-style-type: none">1. Residual solvents in small amounts2. Minor modification of the oils if heating excessive	
Degumming		<ol style="list-style-type: none">1. Hydratable non-oil materials, mostly carbohydrates and proteins partially removed2. Hydratable non-glyceridic lipids such as phospholipids partially removed3. Chlorophyll (partially removed), especially if phosphoric acid is employed
Alkali refining		<ol style="list-style-type: none">1. Free fatty acids and other materials removed2. Residual phospholipids removed3. Proteinaceous materials reduced4. Colouring matter reduced
Bleaching	<ol style="list-style-type: none">1. Conjugated acids formed and peroxides destroyed	<ol style="list-style-type: none">1. Carotenoids removed2. Chlorophyll and its decomposition products removed3. Gossypol-like pigments removed4. Toxic agents, such as polycyclic aromatic hydrocarbons removed (if carbon is used in quantity)
Deodorization	<ol style="list-style-type: none">1. Formation of geometrical isomers in sensitive acids2. Formation of linear and cyclic dimmers/polymers	<ol style="list-style-type: none">1. Free fatty acids, peroxide decomposition products, colour bodies and their decomposition products eliminated2. Sterols and sterol esters reduced3. Tocopherols reduced4. Pesticide residues and mycotoxins removed totally

TABLE IX : Classical Refining of Soybean Oil

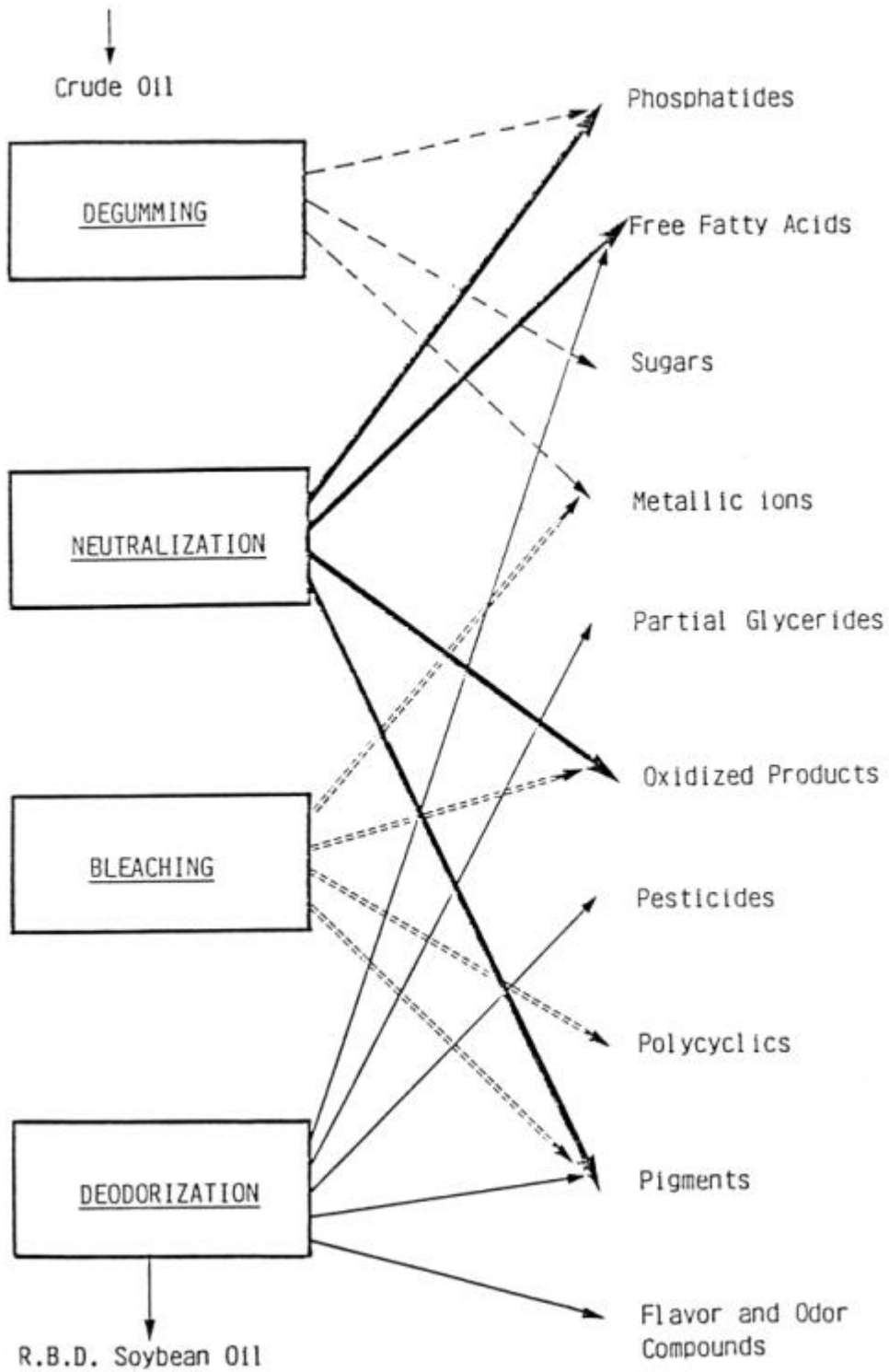


TABLE X : Industrial Refining Continuous Process

1. CONDITIONING

- Add 0.5 p. 1 000 $\text{PO}_4\text{H}_3 = 100\%$ Basis
- Use diluted $\text{PO}_4\text{H}_3 = 20-30\%$
- Add caustic soda : 2 N (80 g/l)
- Temperature $\cong 80^\circ\text{C}$

2. FIRST CENTRIFUGATION

3. FIRST WASHING

- “Soft” water 7.5 %
- Temperature $\cong 90-95^\circ\text{C}$

4. SECOND CENTRIFUGATION

5. SECOND WASHING

- “Soft” water
- Temperature $\cong 90-95^\circ\text{C}$
general US practice : only one washing with 10% “soft” water

6. THIRD CENTRIFUGATION

7. DRYING

- vacuum 30 tors
- Temperature $\cong 95^\circ\text{C}$

8. BLEACHING

- Temperature $\cong 85^\circ\text{C}$
- Vacuum
- 0.7 – 0.8 % earth
- ½ hour
general US practice during the bleaching : more than 1% bleaching earth (complete removal of soaps)

9. FILTRATION

Use enclosed, semi-automatic self cleaning filter units

10. DEODORIZATION

The intermediate “keeping in stock” of the bleached oil, before deodorization, has to be as

short as possible

- Temperature 235-240°C
- Holding time at deodorization temperature (235-240) in a semi-continuous deodorizer : 1 hour ½
- Cooling at 140°C under vacuum with steam injection
general US practice : higher temperatures

11. SATURATION

of the R.B.D. soyoil at 25°C (before storage) with nitrogen.

TABLE XI Bleaching : Conjugated Acids Formed

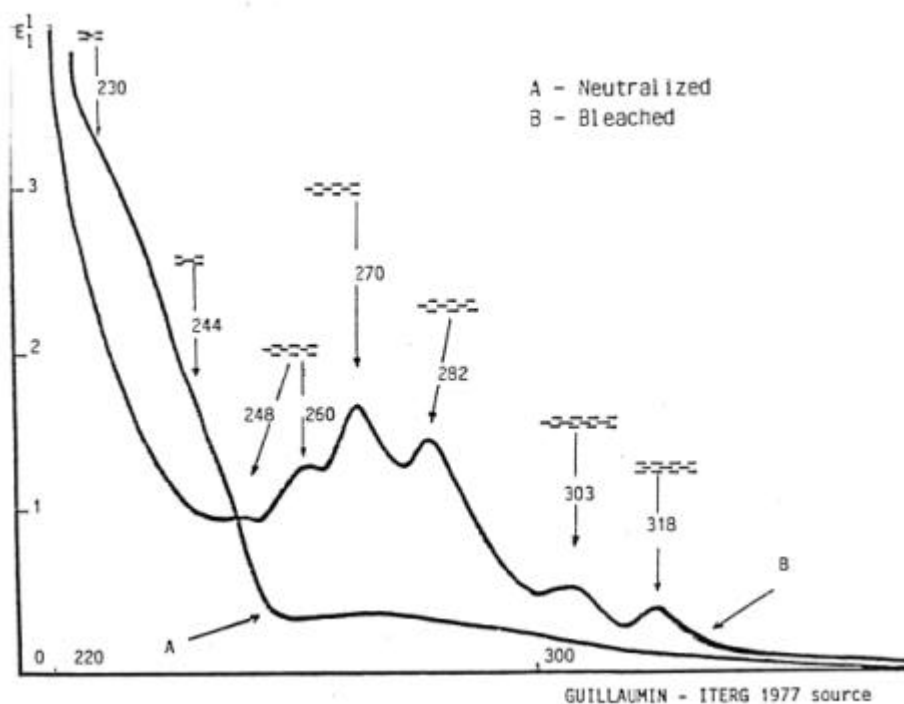


TABLE XII : Tocopherol Levels in Physically Refined Soybean Oil (1/2 hour processing)

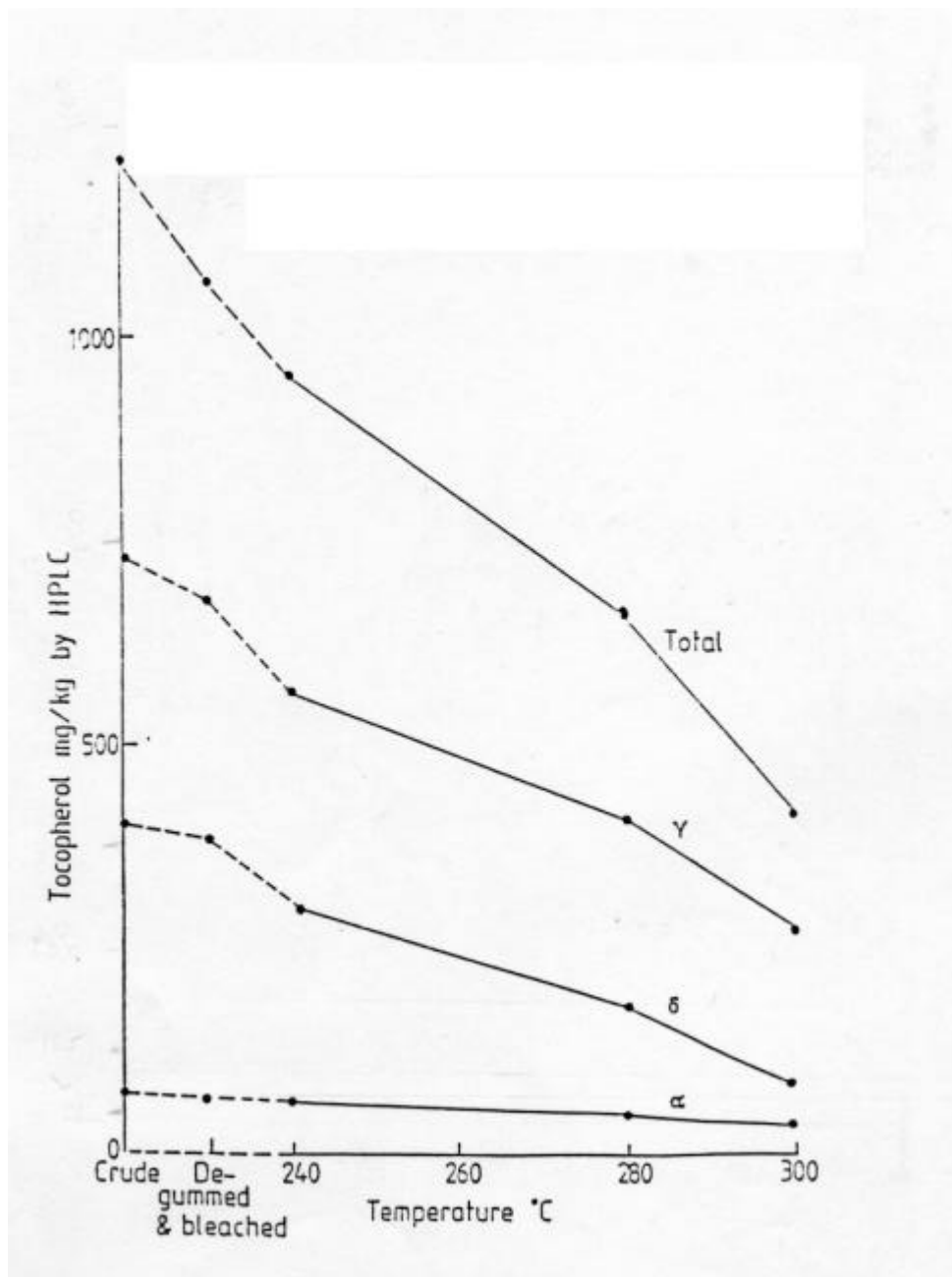


TABLE XIII Tocopherol Levels in Physically Refined Soybean Oil Processed at 280 °C

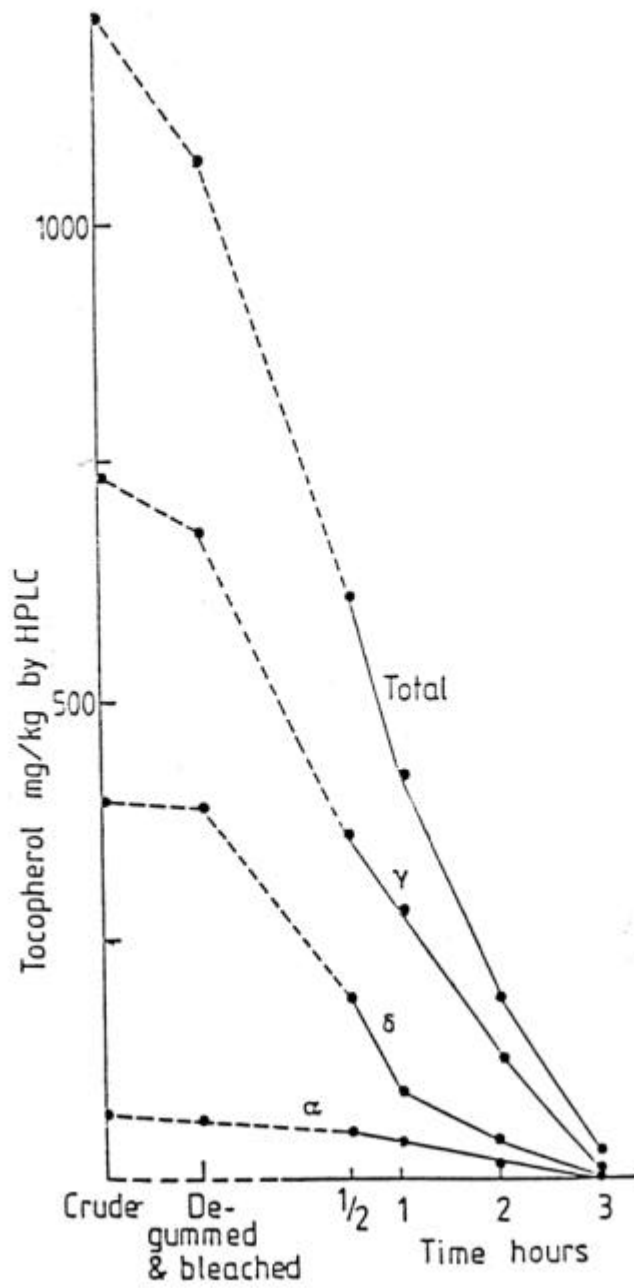


TABLE XIV Soybean Oil Physically Refined at 280 °C

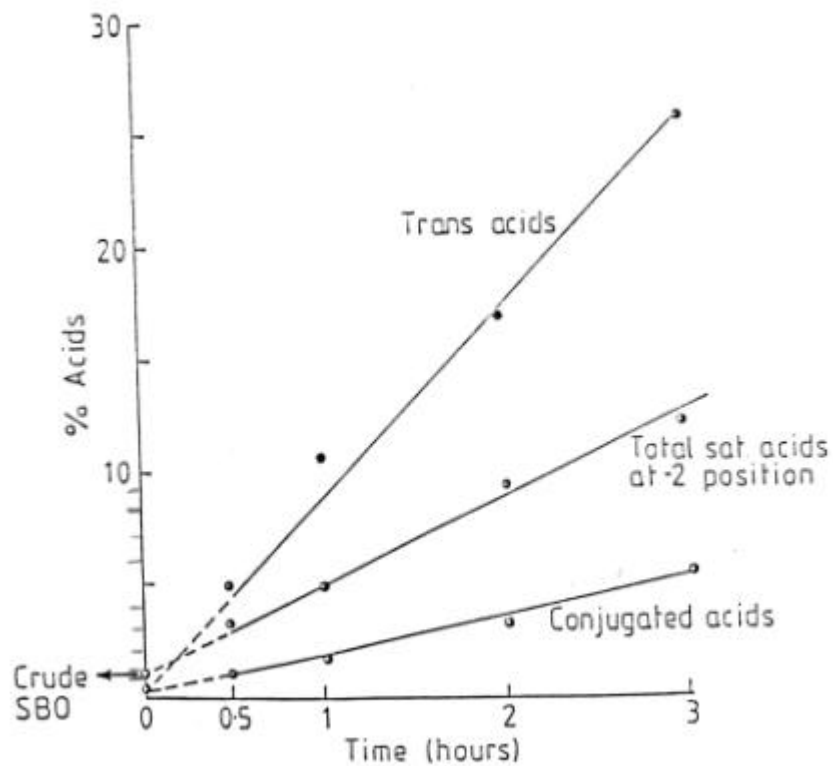


TABLE XV Neutralized & Bleached Soybean Oil Deodorized at 245 °C

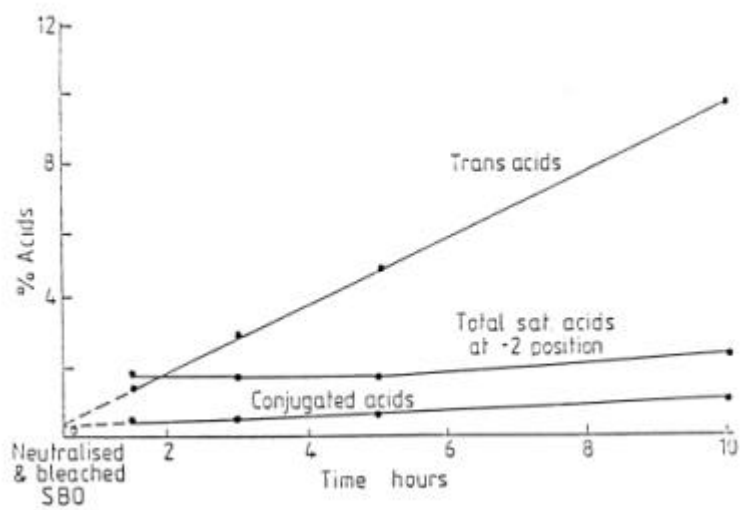


TABLE XVI Factory Analysis of “US II Yellow” Soybeans (38 samples)

Composition	% WT	E 232	% FFA
Sound Beans	85.0	2.4	0.9
Damaged Beans	2.8	6.3	3.5
Splits	9.8	2.9	1.5
Foreign Material	2.4	7.5	10.0
Total	100.0	2.8	1.2

TABLE XVIII Recommendations for Handling/Storing Crude, Deslimed Soybean Oil

1. Moisture level max 0.1 % (no steam-emptying of pipelines into storage tank)
2. Phosphorus Level max. 200 ppm
3. Storage in unheated tanks
4. Excessive pumping and handling to be avoided to minimize repeated saturation of oil with air
5. Sufficient pumping capacity to avoid having to lower oil viscosity by heating
6. Regular removal of sludge from tank or phosphorus level max 30 ppm

TABLE XVIII Crude Oil Quality, Effect of Abuse Characteristics

Abuse characteristics	Increase in
Weed seed	d, f
Immature beans	f
Field damaged beans	a, b, c, e
Splits (loading/transport/unloading)	a, b, c
Bean storage (time/temp/humidity)	a, b, c
Conditioning beans for extraction	a, b, d, e
Solvent stripping oil (overheating)	b, d
Oil from stripper (overheating)	b
Crude oil storage (time/temp)	c, d
a Total gums/phosphatides b Nonhydratable phosphatides c Free fatty acids d Oxidation products e Iron/metal content f Pigments	

TABLE XIX Control Criteria**DRYING**

- F.F.A. \leq 0.1 % (oleic acid)
- H₂O \leq 0.08%
- Phosphorus \leq 5 ppm
- Soap (Wolff method) \leq 50 ppm

BLEACHING

- Soap Nil (Wolff method)
- Phosphorus \leq 3 ppm
- Chlorophyll \leq 0.02 ppm
- F.F.A. \leq 0.1 %

TABLE XX Steam Consumption in Kg/Ton of Oil Neutralizing – Bleaching Line (1% Bleaching Earth)

Neutralizing Washing-drying Bleaching	without heat recovery	with heat recovery
Heating of crude oil from 20 to 110°C and hot water production	88 Kg 30 Kg	38 Kg 18 Kg
Set(s) vacuum eqpt.	50 Kg	35 Kg
Steam blowing of filters	15 Kg	15 Kg
Total	183 Kg	106 Kg

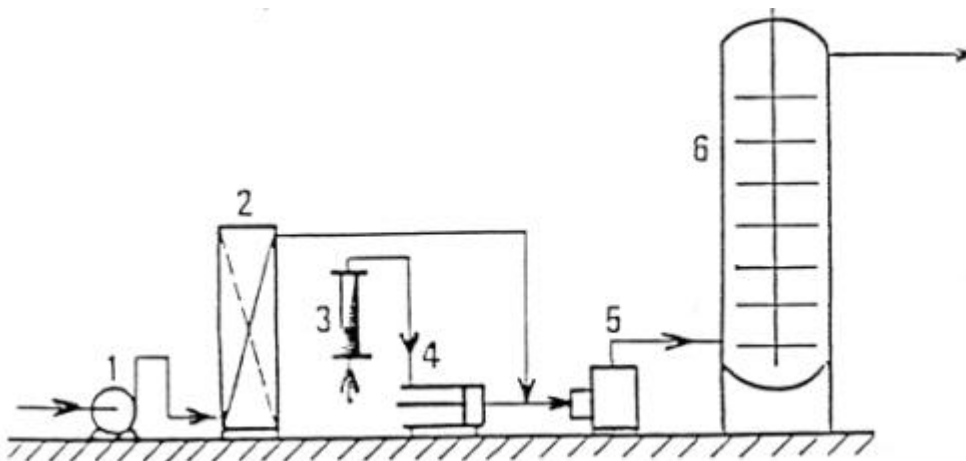
TABLE XXI Steam, Water and Heating Energy Consumption per Ton of Processed Oil Semi-Continuous Deodorizing Plant

	without heat recovery	with heat recovery
Live steam for vacuum production (water at 28°C)	125 Kg	125 Kg
Live steam	17 KG	--
Heating energy (oil at 255°C)	** 500 Mj	* 150 Mj
Cooling water for vacuum production (water at 28°C)	13 m ³	13 m ³
Water for oil cooling (water at 28°C)	25 m ³	2.75 m ³
** 500 Mj = 474,000 BTU = 119,500 Kcal		
* 150 Mj = 142,200 BTU = 35,900 Kcal		

TABLE XXII R.B.D. Soybean Oil Standards

ANALYSIS	SPECIFICATION
Oleic acidity	$\leq 0.07\%$
H ₂ O	$\leq 0.04\%$
Solid impurities	Nil
Soap	Nil
P	≤ 3 ppm
Iron	≤ 0.1 ppm
Copper	≤ 0.05 ppm
Transmission at 420 nm	$\geq 70\%$
Degustation	≥ 8.0
Oxygen content	≤ 80 mm Hg
Peroxide value (after deodorization)	≤ 0.1 m.eq.

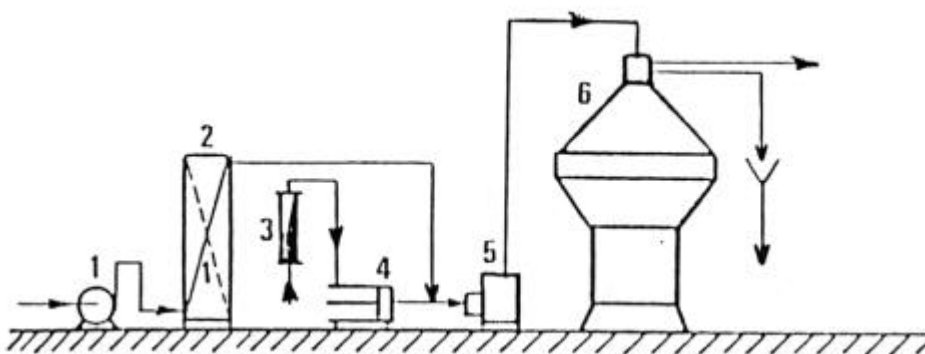
Diagram 1



“CONDITIONING” WITH PHOSPHORIC ACID SOLUTION

1. Crude oil inlet
2. Heat Exchanger oil/steam
- 3-4 Flow-meter and proportioning pump
5. High-speed mixer
6. Homogeniser

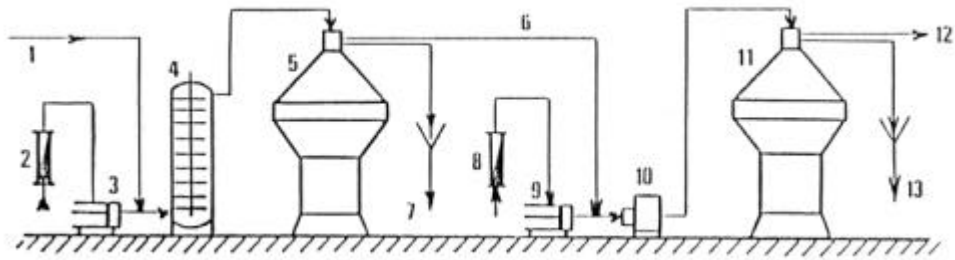
DIAGRAM 2



CONTINUOUS NEUTRALIZATION

1. “Conditioned” crude oil inlet
2. Heat Exchanger oil/steam
3. Flow-meter for caustic soda solution
4. Proportioning pump for caustic soda solution
5. High-speed mixer (or static mixer)
6. Centrifugal separator

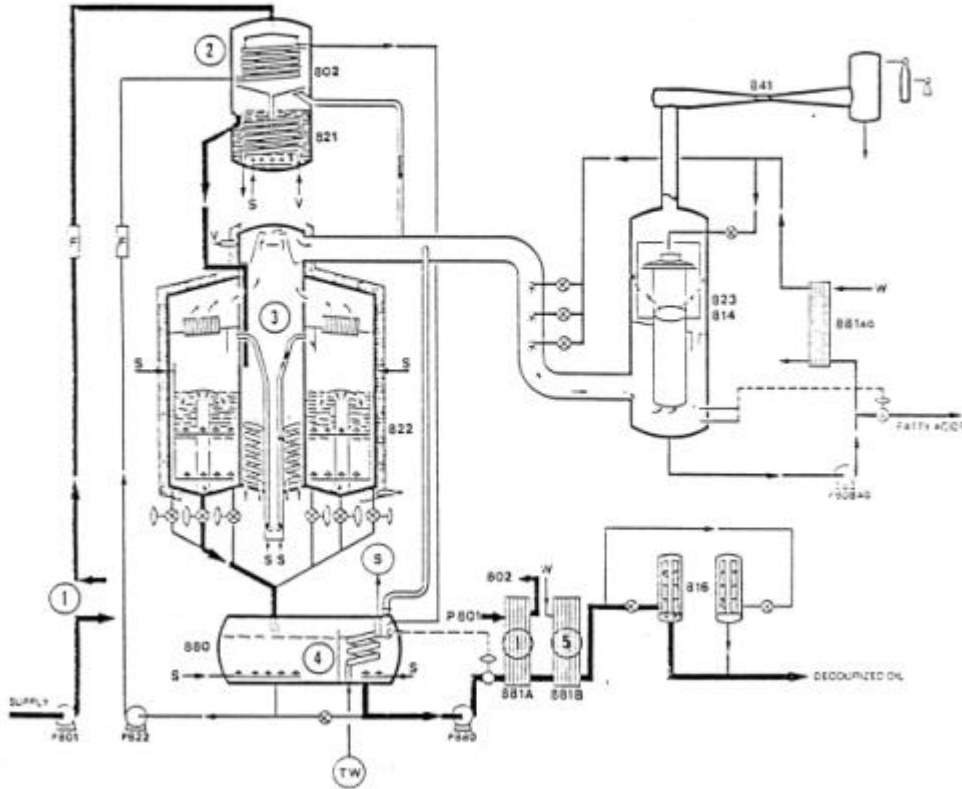
DIAGRAM 3



CONTINUOUS DOUBLE WASHING

1. Neutralized oil inlet
2. Water flow-meter
3. Water proportioning pump
4. Low-speed holding tank
5. Centrifugal separator (N° 1)
6. Washed oil outlet
7. Waste water outlet
8. Water flow-meter
9. Water proportioning pump
10. High speed mixer
11. Centrifugal separator (N° 2)
12. Washed oil discharge
13. Waste water outlet

DIAGRAM 4



- S Sparge steam
- F Flow Meter
- V Heating Fluid
- W Water
- TW Treated Water
- P Pump
- 881B Finished oil cooler
- 881A Oil-oil heat exchanger
- 881AG Fatty acids cooler
- 880 Buffer tank cooler
- 841 Vacuum device
- 822 Deodorizer SCD
- 816 Polishing filter
- 814/823 Fatty acids separator-condenser
- 802/821 Deaerator – heater

DE SMET Semi-continuous deodorizing “SCD”
(heat recovery by direct oil-oil heat exchange)

DIAGRAM 5 Double-Shell Deodorizer Modified for Heat Recovery

