

Technical paper

The refining of soybean oil to optimum quality

By J. Rusell

Consultant to the American Soybean Association. Rue du Commerce 20-22, 1040 Brussels-Belgium

RESUMEN

La refinación de aceite de soja hasta calidad óptima

Uno de los objetivos de la Asociación Americana de Soja en Turquía es mejorar la calidad de la soja y de los productos relacionados.

En orden a conseguir esto, diversas plantas de extracción y refinerías fueron visitadas para permitir obtener de primera mano información sobre el tipo de equipo usado en todas las unidades de proceso, la metodología empleada, los estándares de calidad y los niveles de eficacia.

La culminación de la visita fue un seminario organizado conjuntamente por la Asociación Americana de Soja y la Asociación de Aceites Vegetales Turcos en Estambul el 22 de septiembre de 1989, donde fue presentada una comunicación con el título arriba indicado.

Una reproducción de esta comunicación se adjunta, la cual describe brevemente las áreas críticas del procesamiento de aceite de soja e incluye recomendaciones para las mejoras de la calidad.

Esta comunicación concluye con el comentario de que si se toman las medidas adecuadas y el proceso de refinación empleado es optimizado, incluyendo la hidrogenación donde haga falta, una impresionante gama de aceites, margarinas y grasas plásticas de alta calidad pueden ser producidas.

Al autor le gustaría agradecer al Dr. R. Leysen de la Asociación Americana de Soja su ayuda y consejos, a Mr. Kenon Marasoglu, Presidente de la Asociación de Aceites Vegetales Turcos y a las direcciones y personal de todas las fábricas visitadas.

Expresar también su agradecimiento al Dr. D. R. Erickson y Mr. L. H. Wiedermann de la Asociación Americana de Soja por el uso de información técnica de su trabajo titulado «Soybean Oil Modern Processing and Utilisation» el cual será publicado próximamente.

PALABRAS-CLAVE: Aceite de soja – Calidad – Refinación.

SUMMARY

The refining of soybean oil to optimum quality

One of the objectives of the American Soybean Association is to improve the quality of soybean and related products in Turkey.

In order to achieve this, a number of extraction plants and refineries were visited to enable first hand information to be obtained on the type of equipment used in all unit processes, the methodology employed, quality standards and levels of efficiency.

The culmination of the visit was a seminar organised jointly by the American Soybean Association and the Turkish Vegetable Oil Association in Istanbul on 22nd September 1989, at which a paper with the above title was presented.

A reproduction of this paper is attached which briefly describes the critical areas of soybean oil processing and includes recommendations for quality improvements. It concludes with the comment that provided proper care is taken and optimum refining processes employed, including hydrogenation where appropriate, an impressive range of oils, margarines and shortenings of high quality can be produced.

The author would like to record his grateful thanks to Dr. R. Leysen of the American Soybean Association for all his help and guidance, to Mr. Kenon Marasoglu, Chairman of the Turkish Vegetable Oil Association and to the management and staff of all the factories visited.

Acknowledgement is also made to Dr. D. R. Erickson and Mr. L. H. Wiedermann of the American Soybean Association for the use of some technical information from a paper entitled «Soybean Oil-Modern Processing and Utilisation» which is to be published shortly.

KEY-WORDS: Quality – Refining – Soybean oil.

1. INTRODUCTION

Soybean is now the largest oilseed crop in the world and in 1988 bean production exceeded 90 million tonnes.

Originally a native of China some 5000 years ago, it is now cultivated in many parts of the world and although its oil content of 20% (dry basis) is lower than many other oilseeds, the meal is a very rich source of protein, 40% being regarded as a typical level. These two factors give farmers the prospect of good returns.

A further unusual property of soybean oil is its relatively high level of linolenic acid (typically 7%) and this is shown in Appendix 1 where its fatty acid composition is compared with some other common vegetable oils and fats.

Although considerable genetic research has been carried out with the objective of producing varieties of beans with levels of linolenic acid below 4%, there is no conclusive evidence to prove that fully refined oils from these beans are more stable than the oil obtained from conventionally grown beans.

Appendix 1
Fatty Acid Composition of Some Common Vegetable Oils and Fats

Fatty Acid	Soybean	Palm	Rapeseed		Sunflower	Cottonseed
			HE*	LE*		
C12:0		0.2				
C14:0		1.0			0.1	0.8
C16:0	11.0	45.0	3	4	5.5	27.3
C18:0	4.0	4.6	1	2	4.7	2.0
C20:0	<u>1.0</u>	<u>0.3</u>	<u>1</u>	—	<u>0.3</u>	<u>0.3</u>
Total Saturated	<u>16.0</u>	<u>51.1</u>	<u>5</u>	<u>6</u>	<u>10.6</u>	<u>30.4</u>
C16:1	0.5	0.1			0.1	0.8
C18:1	22.0	37.7	16	56	19.5	18.3
C20:1	1.0		6	2	0.1	
C22:1	—	—	<u>49</u>	—	—	—
Total Monounsaturated	<u>23.5</u>	<u>37.8</u>	<u>71</u>	<u>58</u>	<u>19.7</u>	<u>19.1</u>
C18:2	53.0	10.6	14	26	68.5	50.5
C18:3	<u>7.1</u>	<u>0.2</u>	<u>10</u>	<u>10</u>	<u>0.1</u>	—
Total Polyunsaturated	<u>60.1</u>	<u>10.8</u>	<u>24</u>	<u>36</u>	<u>68.6</u>	<u>50.5</u>

* HE: High Erucic

* LE: Low Erucic

Fatty Acid Range of Soybean Oils

Fatty Acid		Range (%)
Less than	C14	Less than 0.1
	C14:0	Less than 0.5
	C16:0	7.0-14.0
	C16:1	Less than 0.5
	C18:0	3.0-5.5
	C18:1	18-26
	C18:2	50-57
	C18:3	5.5-10
	C20:0	Less than 0.6
	C20:1	Less than 0.5
	C22:0	Less than 0.5
	C24:0	Less than 0.5

Source: Codex Standard 20-1981 Supplement 1 (1983) Amended 1987

2. INFLUENCE OF FOREIGN MATTER AND BEAN DAMAGE ON OIL QUALITY

Although soybeans are relatively easy to store and process, some precautions must be observed if acceptable standards of yields and quality are to be achieved. A further point is that oil extracted from unripe beans has higher levels of chlorophyll and oxidised lipids and as a direct result of this, more difficulties will be experienced in degumming and subsequent refining processes.

Separation of dirt, trash and weeds is also most important and split or damaged beans are more prone to chemical and biological attack. Some quantitative data on these aspects is shown in Table I and rather more detailed information including the influence of

excessive temperatures during processing is shown in Appendix 2.

The very high levels of FFA, E232 (formation of conjugated acids) and Anisidine value (formation of aldehydes) due to the influence of weeds and other foreign matter should be noted.

3. CRUDE OIL STORAGE TANKS

Size must clearly be related to factory requirements.

In the case of smaller tanks (50-150 tonnes capacity) the height may be several times the diameter and this has the advantage of exposing the least surface of the bulk held to air. The ratio of diameter: height in medium size tanks is normally 1:1.5 and in

Table I
Oil Quality Obtained from Different Soybean Components

Component	FFA (%)	E232	Anisidine Value	Lecithin After Degumming %
Whole Beans	0.65	2.1	0.6	0.4
Split Beans	1.47	3.8	0.9	0.4
Foreign Matter	8.7	8.6	47.0	1.2

Appendix 2
Factors Affecting Crude Soybean Oil Quality

Factors affecting	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 Non-Hydratable Phosphatides
 c Free Fatty Acids
 d Oxidation Products
 e Iron/Metal Content
 f Pigments

large tanks (i.e. those exceeding 1500 tonnes) the diameter frequently exceeds the height. Exposure to air will be minimised if the tank contents can be kept at reasonably full levels.

A sketch showing the elevation of a well designed storage tank is shown in Appendix 3 and the important aspects are as follows.

The base should have a slope of at least 1:50 and the flow should be directed to a sump which is located close to a manhole cover to facilitate ease of cleaning. The offtake line should be at least 0.5 m above the tank base.

The oil filling line should be provided with a vent to prevent syphoning effects and the outlet should be located close to the base to avoid splashing and hence entrainment or air.

Rainwater must be prevented from lying in the vicinity of the tank bottom as this will eventually lead to corrosion. In the absence of a suitable concrete plinth, gullies should be installed to allow the drainage of surface rainwater.

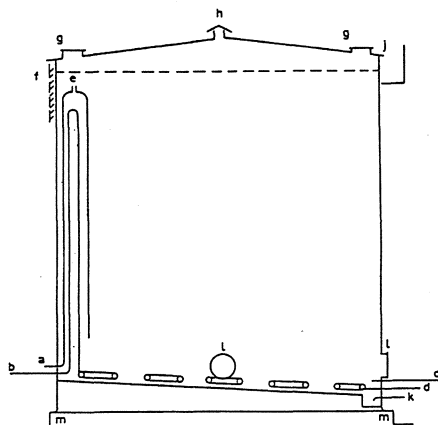
Tank Cleaning

Storage of crude soybean oil in a clean and dry condition is strongly recommended. If deliveries of crude oil are repeatedly transferred to a storage tank and the supernatant liquid oil drawn off, a build up of sludge and water will inevitably occur. This deposit will have an adverse effect in terms of free fatty acid development and oxidation on subsequent transfers to the tank even if these are relatively clean and dry.

Cleaning routines are therefore very important and must be regarded as an essential part of the process if acceptable yields and quality standards are to be maintained.

Attention is also drawn to the advantages of refineries specifying that deliveries of crude soybean oil from third parties should be made on a degummed basis as this will minimise sludge deposit in storage tanks and tank wagon delivery vehicles.

Appendix 3 Storage Tank Design



Elevation of oil store tank: (a) oil in; (c) oil out; (b) hot water or steam in; (d) hot water or steam out; (e) oil filling line vent; (f) protection of insulation top edge; (g) manholes (inspection, measurement (dip), sampling); (h) roof vent cowl, (j) cat walk, (k) sump out, (l) cleaning manholes, (m) protection against water seeping under tank floor

4. INFLUENCE OF OXYGEN, WATER AND PRO-OXIDANTS ON OIL QUALITY

A. Oxygen

It is not generally realised that if a liquid oil is combined with 0.016% of its own weight of oxygen, this will result in a P.V. increase of 20. Additionally,

some aldehydes which can be formed by the oxidation of linolenic acid have a very low taste threshold of 0.01 p.p.m. These factors clearly reinforce the point already made of avoiding the entrainment of air by unnecessary splashing when soybean oil is transferred between tanks.

B. Water

Water is more soluble in fatty acids than in the corresponding neutral triglycerides from which they are derived and in the presence of water the rate of hydrolysis will therefore increase with increasing FFA.

In extreme cases this can lead to the formation of diglycerides (and monoglycerides) which are more polar and have a greater affinity for water than neutral triglycerides.

The solubility of water in both neutral triglycerides and fatty acids will of course increase with increasing temperature, but this is not normally a problem with liquid soybean oil which is usually held at temperatures around 25°C and provided water levels are kept at less than 0.1% few difficulties should be experienced. Care must be taken however with hydrogenated soybean products as storage temperatures are inevitably higher.

C. Pro-oxidant Metals

The two common metals which can promote oxidation most readily are iron and copper and their limits in deodorised products are very low at 0.075 and 0.02 p.p.m. respectively. Amounts above this will have

Appendix 4 Analytical Data for Crude and Refined Soybean Oil

	Crude Oil	Refined Oil
Triglycerides (%)	95-97	Min. 99
Phosphatides (%)	1.5-2.5	0.003-0.045
P (p.p.m.)		1-15
Unsaponifiable	1.6	0.3
Plant Sterols (%)	0.33	0.13
Tocopherols (%)	0.15-0.21	0.11-0.18
Hydrocarbons (%)	0.014	0.01
FFA(%)	0.3-0.7	0.05
I.V.		120-143
S.V.		185-195
Iron (p.p.m.)	1-3	0.1-0.3 (a)
Copper (p.p.m.)	0.03-0.05	0.02-0.04 (b)
Water (%)		(c)

After deodorisation

(a) max. 0.075 p.p.m.

(b) max. 0.02 p.p.m.

(c) max. 0.1%

an adverse effect on flavour and stability and although small quantities of these metals are normally rendered inactive (sequestered) by the use of citric acid after deodorisation (see also section 8) any contact between oil and copper or its alloys, notably brass and bronze should be completely avoided.

5. ANALYTICAL DATA FOR CRUDE AND REFINED OILS

Typical ranges are shown in Appendix 4 and the data shown against the refined product could form the basis for quality standards in refineries. The following comments may be of interest.

Phosphatides

The range of 1.5-2.5% is quoted for crude oils, but for commercially degummed oils a level of 0.3% would represent efficient degumming. After refining a level of 0.003 to 0.045% (equivalent to 1-15 p. p. m. P) should be achieved but for hydrogenation or physical refining a maximum level of 5 p. p. m. is recommended.

Tocopherols

Only a relatively small proportion is lost during refining and this is of obvious benefit in protection against oxidation.

FFA

These may reach 1% or more, but the range of 0.3-0.7% is much more typical for oil extracted from good quality beans.

I.V.

The range of 120-143 quoted is rather wide and a typical figure is 133.

S.V.

A more typical range is 191-193.

Colour

A good quality crude soybean oil may have a colour of 10R (5.1/4" cell) which after degumming, neutralising and bleaching should be reduced to 3.5R. The American Soybean Association envisages that for a degummed, refined, bleached, partially hydrogenated, winterised and deodorised product a maximum Lovibond colour of 2.0R: 20Y in a 5.1/4" cell should be achieved.

6. UNIT PROCESSES

A number of these are involved if soybean oil of optimum quality is to be produced and the use of a «working tank» which is fitted with a suitable stirrer and is of sufficient capacity to provide crude oil for a complete shift (normally 8 hours) is strongly recommended. This will enable the refiner to have at his disposal a good supply of crude oil of known quality for degumming and refining and thus avoid frequent adjustments to these processes.

A. Degumming

This process invariable involves the hydration of phosphatides to make them insoluble in the oil and thus simplify their separation. In this respect some mention should also be made of the Alcon process which involves a specific heat treatment of the flaked soybeans prior to extraction and effectively destroys the enzymes responsible for the formation of non-hydratable phosphatides. The residual hydratable phosphatides are then very amenable to a relatively simple water treatment and the resulting product is sufficiently low in phosphorus for subsequent hydrogenation and physical refining to be carried out with no difficulties.

It has already been stated that degumming is necessary in order to minimise deposits in tanks and delivery vehicles, particularly if lengthy storage or transport times are involved. Other reasons include avoiding problems during hydrogenation and physical refining and the production of commercial soya lecithin.

Gum disposal, where the production of soya lecithin is not appropriate is normally accomplished by two methods. The first involves feeding them back to the toaster in the extraction plant, as in addition to providing additional calories to the meal, this also has the effect of reducing dust in the plant. The second method of disposal is via the soapstock during alkali refining.

The following brief comments on soya lecithin may also be of interest. A typical crude soybean oil will contain up to 3% gums which consists of approximately 25% water and 75% oil soluble material. This oil soluble material will contain about 33% oil and 67% acetone insoluble matter (i.e. phosphatides). If the production of commercial soya lecithin is to be considered, all solid material such as meal etc should be removed before drying. Bleaching is usually effected by the use of hydrogen peroxide.

Although an initial treatment with water is now an established procedure in the process of degumming, there is an increasing tendency, particularly in the United States, for this stage to be omitted and for refiners to dispose of the gums into the soapstock after caustic neutralisation and by subsequent water washing.

If an initial water treatment is applied however, the essential parameters are water: oil ratio, temperature, agitation speeds and perhaps most importantly adequate mixing times to ensure maximum hydration of the gums. The quantity of added water will depend to some extent on the amount of phosphatides present, but the normal level of addition is 2%.

Oil temperatures are not highly critical but separation of the hydrated gums will be achieved much more readily if the oil is preheated to reduce viscosity. A range of 60-70°C has been found to be satisfactory.

Optimum mixing speeds and residence times are dependent on the type of equipment used and for batch processes 30-60 minutes should be sufficient. With continuous processes this can be reduced to 20 minutes, but it is important that with any system adjustments to enable agitation speeds and contact times to be varied should form part of the process.

Acid Pretreatment

It should also be mentioned that the addition of phosphoric acid (0.1-0.2% of a 75% solution) to crude soybean oil in a working tank fitted with a stirrer also promotes the formation of hydrated gums which are relatively simple to remove by the normal water and subsequent refining treatments. Any excess phosphoric acid is neutralised by lye during the refining process, but as with all degumming methods good contact is important. Care must also be taken if phosphoric acid is used, due to its corrosive nature.

Separation is by means of a centrifuge and phosphorus levels of less than 150 p.p.m. should be achieved if optimum conditions are employed.

B. Alkali Refining

The technology in this part of the process is concerned with applying the correct operating conditions and the use of the correct concentration of alkali.

The use of continuous refining equipment for soybean oil is strongly recommended, as results obtained in terms of quality and efficiency cannot be matched by batch methods. Once the correct conditions have been set for a crude oil of known F.F.A. large quantities can be processed with a high degree of efficiency and with relatively little attention. In this respect, the use of a suitable «working» tank mentioned earlier to hold sufficient oil of known F.F.A. for a period of say 8 hours is obviously beneficial.

Lye solution strengths used in refining are measured in terms of their specific gravity expressed in degrees Baume. Some details of this are shown in Table II.

One very important consideration in the refining of soybean oil is the use of lye of 16-18° Baume, as this relatively weak strength will contain sufficient water to promote proper hydration of phosphatides. Recommended excess lye quantities are 0.12-0.15% for undegummed oil and 0.10-0.12% for degummed oil.

Tables showing Baume strengths required for different FFA levels and excess quantities to be used, together with two simple examples are shown in Appendix 5.

Further important considerations in alkali refining are that the lye should be added to relatively cool oil for which a temperature of 30°C is recommended. Adequate contact time is essential and should be for a minimum period of 15 minutes after which the product should be heated to 70°C before centrifugation. Two hot water washes should then be applied, each of 10%, using demineralised water or condensate at a temperature of 90-95°C. It should be stressed that a single wash of say 15% is not recommended as soap removal is far more effective with two washes and levels of less than 10 p.p.m. can be achieved by this means.

Some judgement on the part of the refiner will be required with respect to the merits of drying before bleaching, as if the oil is to be stored for an extended period before this is carried out then clearly drying would be beneficial. If, on the other hand, the holding time is relatively short, i.e. less than 24 hours, then drying can be omitted.

Tabla II
Sodium Hydroxide Content of Lyes in Degrees Baume

Degrees Baume (15°C)	Sodium Hydroxide content (%)
10	6.57
12	8.00
14	9.50
16	11.06
18	12.68
20	14.36
22	16.09
24	17.87

Appendix 5
Recommended Lye Strengths for Refining

FFA (%)	Baume Strength		
	14°	16°	18°
0.3	0.45	0.38	0.33
0.4	0.60	0.51	0.45
0.5	0.75	0.64	0.56
0.6	0.90	0.77	0.67
0.7	1.05	0.90	0.78
0.8	1.20	1.03	0.89
0.9	1.35	1.16	1.00
1.0	1.50	1.29	1.11
1.5	2.25	1.93	1.67
2.0	2.99	2.57	2.23
2.5	3.74	3.21	2.80

Correct Excess of Lye Addition

Excess (%)	Baume Strength		
	14°	16°	18°
0.10	1.05	0.90	0.79
0.11	1.16	0.99	0.87
0.12	1.26	1.08	0.95
0.13	1.37	1.17	1.02
0.14	1.47	1.26	1.10
0.15	1.58	1.35	1.18

Notes FFA is calculated as oleic (282)

Intermediate quantities can be calculated by interpolation.

Example 1 Crude oil with FFA 1.0% using 16° Baume lye

Lye required= 1.29% Excess required (0.15%)= 1.35

Total= 2.64%

Example 2 Degummed oil with FFA 0.6% using 16° Baume lye

Lye required= 0.77% Excess required (0.12%)= 1.08

Total= 1.85%

C. Bleaching

The use of bleaching earth to reduce colour in oils and fats is very well established and the levels and activity of earth used are normally directly related to achieving effective colour removal. This is not the primary objective when soybean oil is processed, as colour reduction is also effected by refining, hydrogenation and deodorisation.

More emphasis is placed on the removal of oxidation products and this can be assumed to have been achieved when the P.V. of a sample taken after filtration has a value of zero. Note however that if the crude oil contains excessive levels of chlorophyll, (e.g. from the extraction of unripe beans) this factor must be

given priority in determining the level and activity of earth used.

The critical characteristics of bleaching earth are shown in Appendix 6 and these should be taken into account when optimum dosing levels are being established or when earths from alternative suppliers are being considered.

The rather loose term «acidity» is more accurately expressed in terms of titratable acidity (mg. KOH/g of earth) and its pH which is measured on an aqueous slurry. Considerably more effective colour and P.V. reductions can be achieved with more acidic earths and there is a clear incentive for refiners to consider this aspect in terms of cost (including dosing levels) and performance.

Appendix 6
Critical Characteristics of Activated Bleaching Earth

Total Acidity (mg KOH/g of earth)
pH (free acidity)
Water content
Apparent Bulk Density
Effective Surface Area
Oil Retention

The water level in active earths is also an important parameter and 10% should be regarded as a minimum; an acceptable range being 10-12%.

Vacuum bleaching is much preferred to atmospheric bleaching as the reaction takes place in the absence of air and thus reduces the risk of oxidation. Other benefits include a lower earth dosage and a lower operating temperature.

Recommended conditions are to heat the oil to 80°C under vacuum. The correct level of earth (normally 0.3-1.0%) is then added, agitation started and the slurry heated to 100-105°C. These conditions are maintained until the moisture has been removed and held for a further 15 minutes to ensure maximum bleach and removal of oxidation products. Agitation is then stopped and the product cooled to 50°C, before the pressure is equalised.

An efficient filtration system is a further important factor as earth «fines» are strongly pro-oxidant and even the use of a polishing filter after deodorisation may not be sufficient to prevent some damage to the finished product.

The final point in this section is that a refined and bleached oil is very vulnerable to oxidation and if immediate further processing is not possible, (hydrogenation or deodorisation) strict attention must be paid to pumping and storage in order to avoid overheating or entrainment of air.

7. HYDROGENATION

A detailed description of the very wide range of products which can be obtained from the

hydrogenation of soybean oil is beyond the scope of this paper, but a considerable amount of technical information is available on this subject. In this respect, attention is drawn to the following two references:

Latondress, E.G. JAOCS 58: 185 (1981)

Erickson, D.R. JAOCS 60: 351 (1983)

Some brief comments on the quality of refined soybean oil produced by the techniques described earlier may however be of interest.

The refined product should be low in FFA (preferably less than 0.05%) virtually soap free and low in P (less than 5 p.p.m.). Soap and phosphorus act as catalyst poisons and low levels of these products will be very beneficial in terms of reaction times and catalyst dosing.

A low water content is also necessary (preferably less than 0.05%) in order to avoid the formation of water vapour in the headspace, but also to reduce the risk of hydrolysis and hence F.F.A. increase during hydrogenation.

8. DEODORISATION

This is the final stage in soybean processing and its purpose is to remove components which have taste and odour, destroy peroxide groups and increase oxidative stability above the level reached after bleaching. Further colour removal is also effected by the process.

Specific processing conditions are difficult to define because of the differences in equipment used, but a strong recommendation is that the deodoriser should be of stainless steel as there is little doubt that considerably superior products are obtained with this compared with plant made from mild steel.

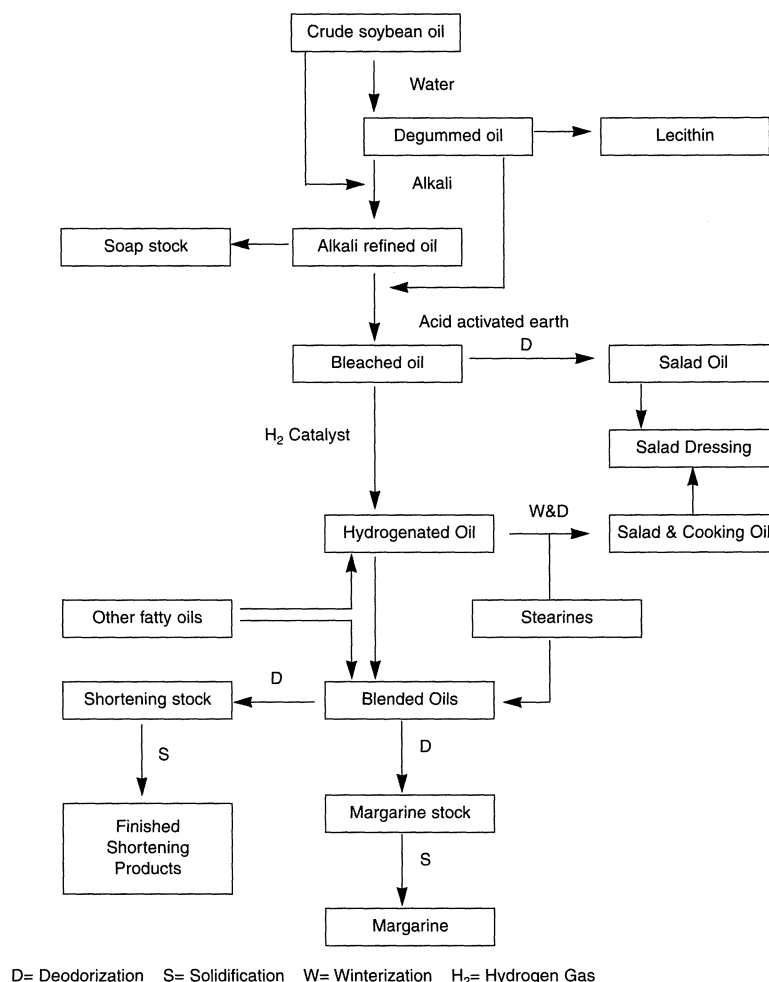
The addition of citric acid at a level of 100 p.p.m. in the cooling section of the deodoriser is also an essential feature of the operation and will act as a further protective measure, as some tocopherols will be lost during the process.

Recommended deodorisation conditions are shown in Appendix 7 and particular attention is drawn to the temperature range of 240-250°C which is lower than for more saturated fat products.

Appendix 7
Deodorisation Conditions for Soybean Oil

Absolute Pressure	1-6 mm Hg
Temperature	240-250°C
Residence time at max. temperature Batch	3-6 hours
Continuous and semi-continuous	15-120 mins.
Stripping steam (as % weight of oil) Batch	5-15%
Continuous and semi-continuous	1-5%

Appendix 8 Manufacture of Edible Soybean Oil Products



Physical refining has not been included in this paper as the stability of the finished product does not always compare with soybean oil which has been conventionally processed by caustic refining and deodorisation.

9. FINISHED PRODUCT QUALITY

The stigma associated with soybean oil some years ago, was associated mainly with its high level of unsaturation and more specifically from its relatively high proportion of linolenic acid, typically 7%. This factor was largely responsible for difficulties with stability and the development of off-flavour, frequently referred to as flavour reversion. As a direct result of this, the production and marketing of refined, bleached and deodorised soybean oil for use as a salad oil presented very real difficulties.

Fortunately this is not the situation today and RBD soybean oil is now completely accepted as a high quality salad oil, notably in the United States and in W. Europe.

This is directly attributable to the considerable amount of research and development which has been carried out and which has led to very significant improvements in all aspects of quality, many of which have been briefly described in this paper.

The versatility of soybean oil in terms of its use as a high quality salad oil, as a cooking oil and its value in an impressive range of margarine and shortening products is now also very well established and this is demonstrated by the flow diagram shown in Appendix 8.

Recibido: Octubre 1995
Aceptado: Marzo 1996