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Technical paper

Production of top quality soybean oil*

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RESUMEN

Producción de aceite de soja de alta calidad

El trabajo presenta las condiciones recomendadas para obtener aceite de soja de la mejor calidad. Es importante evitar las contaminaciones (agua, metales y compuestos oxidados), los sobrecalentamientos, la exposición al aire, así como el adecuado control de los diferentes pasos del proceso de refinación.

PALABRAS-CLAVE: Aceite de soja — Calidad — Información tecnológica — Producción.

SUMMARY

Production of top quality soybean oil

The paper comments the most adequate conditions required to produce to quality soybean oil. It is essential to avoid contaminations (water, metallic, oxidation products), overheating, undue exposition to air, as well as an appropriate control of the different steps of the refining process.

KEY-WORDS: Production — Quality — Soybean oil — Technical paper.

To produce high quality soybean oil there are certain fundamental principles which must be observed. Many quality problems in soybean oil can be traced directly to handling and processing techniques. The basic principles to maintain top quality soybean oil are:

I.- Avoid contamination.
II.- Avoid overheating.
III.- Avoid undue exposure to air.
and IV.- Control each processing step to insure removal of the impurities it is intended to remove.

I. CONTAMINATION

Water is a troublesome contaminant, especially in crude oil. It gains acess into the oil via moist air from the atmosphere during filling and/or emptying the holding tanks or air being breathed in and out with temperature change.

Metallic contamination with heavy metals such as copper and iron are strong pro-oxidants at very low concentrations, less than one part per million (ppm) of copper, and must be avoided at all costs. It is absolutly imperative that no copper or brass containing alloys is introduced into the processing system.

The use of chelating agents, such as citric and phosphoric acids is recommended as they sequester all metallic ions and negate their pro-oxidant effect. They may be effective by used in crude oil, the bleaching step and before and after deodorization.

Another insidious type of contamination is the oxidation products of the oil itself. They develop during the processing of the oil and act as pro-oxidants in subsequent batches of oil.

II. OVER HEATING

Oils should never be heated any more than absolutly necessary for processing. Chemically speaking, the speed of a chemical reaction will double for every increase of ten degrees Celsius. However, with oils, the rate of oxidation of the oil is increased approximately three times for each increase of the same ten degrees Celsius. Hence, process design and operation should keep oil temperature at a minimum such as storage tanks which have heating coils should have fail-safe temperature controls.

Too high temperature in oil will create a "set" color which will render the oil difficult to bleach, in particular with oils which were overheated (above 90°C) in the degumming process.

In practice, oil in the bleacher should be heated no more than necessary to dry enough to get effective bleaching. For atmospheric bleaching of soybean oil a temperature of 105° Celsius and for vacuum bleaching, a temperature of 82° Celsius at 28" Hg vacuum is the recommended practice.

III. EXPOSURE TO AIR

Exposure to air results in oxidation of the oil which can result in low stability, and poor flavor, or in advanced stages, actual rancidity. Several practices on design and operation can help to minimize air contact.

Tanks may be bottom filled so that only the oil surface is in contact with air. Packing glands and suction lines on pumps should be kept tight to avoid sucking air into the oil. Agitators in tanks should be turned off when the oil level in the tank is lowered to where the oil is splashing or the mixer is drawing air into the oil.

In large refineries in Europe and the USA, nitrogen gas is frequently used to protect the oil, particularly, finished deodorized oil, from contact with air. Nitrogen gas may be sparged onto the stream of oil as it leaves the deodorizer or as it is pumped into a tank truck or a rail car. Several patents have been issued for systems developed specifically for sparging nitrogen gas into refined oils.

Addition of antioxidants can be very helpful in protecting the oil from oxidation. For maximum effect it should be added to the finished oil immediately after deodorization as the oil is leaving the deodorizer and before it is exposed to air.

IVa. PROCESS CONTROL

Despite the fact that neutralization is considered the first step in a series of processes conventionally known as "Oil Refining", degumming is practiced for the recovery of lecithin for use as an emulsifier in margarine and other food products. Some oil mills also produce degummed oil for export or domestic sale in the USA, and do not recover the gums but rather return them to the meal.

In a typical degumming system, approximately 1-2% of water is proportioned into the crude oil, pre-heated to 60-70 degrees Celsius and passed through an in-line or static mixer and into an agitated holding tank where it is retained for about 30 minutes (20 minutes is the recommended practice).

The oil is then passed through a disc type centrifuge to remove the hydrated gums. Only a portion of the phosphatides or gums present, are hydratable and removed by this process. Non-hydratable phosphatides (phospholipids) or gums remain in solution in the oil.

The amount of water used is just enough to hydrate the phosphatides and any excess is avoided since it may cause hydrolyses of the neutral oil and increase losses. Another factor to be considered in a continuous degumming process is the disharge pressure of the oil from the centrifuge in order to keep neutral oils to a minimum. Conditions for degumming soybean oil, as reported by various investigators, are summarized below:

Degumming Conditions for Crude Soybean oil From Literature

Parameter	Quantity
Water	Equal to weight of gums
	75% Weight of the gums
	1.0-2.5%
	2.0-3.0%
	2.0-5.0%
	3.0%
	1.0%
	2.0%
Temperature	32-49°C
	50-70°C
	65-75°C
	95°C
Agitation	Vigorous Mechanical Agitation
Contact Time	30-60 minutes
	15-20 minutes

Degummed oil still contains some phospholipids and free fatty acids and must be caustic refined.

IVb CAUSTIC REFINING

This operation is probably the most important of all processing steps in producing high quality finished soybean oil. Poorly refined soybean oil will give problems in subsequent processing operations such as bleaching, hydrogenation, or deodorization and may result in low stability, high color, reversion and the development of fishy flavor. Hence, whether the crude oil is degummed or not, it is caustic refined to remove the gums (phosphatides), free fatty acids and other impurities.

In efficient refining, it is desirable to remove the impurities completely, while loosing as little neutral oil in the soapstock as possible. To achieve both high quality and low losses, the process must be closely controlled. Since crude oil can vary substantially in quality, refining conditions should be selected on the basis of laboratory testing of the specific crude oil to be refined as well as experience with the particular type of oil. For this reason it is recommended that the oil to be refined is kept in a storage tank of sufficient size to accommodate an amount of crude oil for a minimum continuous run of 24 hours. This tank is known as the "Day Tank".

Soybean oil contains a high level of phosphatides. It is usually mixed with from 300 to 1000 ppm of 85% phosphoric acid at ambient temperature and slow or mild agitation for four to six hours before refining. This step is essential for removal of "Non-Hydratable" phosphatides especially these complexed with metal iron, calcium and magnesium since strong alkali reagents used in the neutralization step will remove only some of the non-hydratable phosphatides BUT NOT the trace metals mentioned above. It is a well known fact that phosphoric acid will chelate those heavy metals and help remove them in the subsequent steps of neutralization and washing of the oil in the form of metallic soap.

Batch neutralization of soybean oil, or any other edible oil, is still considered by technichians versed in the process, as the ART of choosing the right chemicals in the right concentration and quantities to be applied in the right way and sequence. The right rate of addition followed by the right mixing, washing and the use of the correct method of separation.

In other words, Batch neutralization is still a matter of mixing the crude oil with solutions of "GRAS" chemicals in the proper concentration and quantities in order that their active ingredients can react with the undesirable substances present in the oil, and subsequently separating the purified oil from the aqueous phase containing the dissolved, suspended or absorbed impurities.

The chemistry involved in the neutralization process is rather complicated. The water activity in the caustic solution re-hydrates the gums and precipitate the phosphatides. The basic moity of the caustic reagent neutralizes the free fatty acids and combines with the previously mentioned impurities in the oil. However, it may chemically adversely affect the efficiency of the process as it also tends to saponify with the neutral oil and increase the refining losses. Also, the colloidal solution of oil glycerides in the soap solution, oil retained dispersed in soapstock and the formation of Oil-in-Water (O/W) emulsion are physical phenomena which take place during the neutralization process and must be kept to a minimum in order to keep the refining losses of saleable neutral oil to a minimum.

Most soybean oil refineries in the USA has found that 16 Degree Baume' (Be') caustic alkali and 0.15% excess treat to be optimum for most soybean oil, however, other conditions may be selected based on experience.

It is recommended that caustic dilution be checked by laboratory titration and adjusted within + 1.0% since it was found that Hydrometer measurements can be substantially in error.

Samples of the refined oil are laboratory tested for Free Fatty Acid (FFA), Color (Red & Yellow), and soap and bleached color for every batch and once every two hours in a continuous refining system. Acceptable oil has an FFA of less than 0.1%, Color Values equal to original laboratory tests on lot and Soap of 50 ppm maximum. Phosphorus content should be less than 5 ppm.

IVc. BLEACHING

Although bleaching implies the removal of color, the removal of other impurities is perhaps of even greater importance in bleaching of soybean oil. Soap should be quantitatively removed and the peroxide value reduced to less than one preferably Zero and phosphorus level should be reduced to less than ONE ppm.

Temperature is usually 95 Celsius at 28" Hg Vacuum for 20 minutes. Removal of chlorophyl is essential however, removal of other red color pigments is not particularly important since they are effectively removed during either hydrogenation or deodorization due to the heat bleaching effect during those two processes.

It is very important that the filters be properly operated and maintained as any bleaching clay which passes through the filter and accumulate in the bleached oil holding tank, rapidly deteriorates subsequent batches of bleached oil because of the oxidation materials that it carries with it.

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