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Soybean Oil Production With Optimization in the Neutralization Process

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Abstract: International edible oil markets are characterized by high competitiveness and increasing quality demands, leading to improved methods for characterization and quality control of raw materials, products and by-products. In addition, the implementation and development of alternative technologies or methods that benefit the processing and storage conditions of the final product is a challenge. The quality and stability of soybean oil, is fundamental to its acceptance and marketing, these properties are influenced by the presence of some minority components that must be removed to give stability to the product.

In the chemical refining of the oil, the first stage is neutralization, a stage of vital importance because it allows the purification and initial elimination of impurities that are not desired and that can affect the taste, smell, appearance and stability of the final product, whose control allows to obtain a edible soybean oil of good quality and competitive in the market.

This work presents a proposal to optimize the quality obtained in the production of edible soybean oil by controlling the parameters of the neutralization stage. Resource-use optimization processes have become a key strategy for addressing the challenges that the current pandemic imposes on the productive sector.

Key words: soybean oil; neutralization; optimization; quality

JEL codes: Q

1. Introduction

In times of stiff global competition, firms construct supply chain that allows customers to supply their products and services in a timely manner. Their practical challenges are how to integrate both internal and external supply chain. Increasingly, customers consider not only functionality, quality and prices of the products but harmony of their lifestyle as their basic purchasing criteria (Park et al., 2012a). Final customers expect the total packages of a product to be compatible with their value systems and life styles. Thus customer's purchasing decisions are based on the harmonious integration of product functional requirements and customer cultural value expectations.

Soy (Glycine max), also known as soya, is an oilseed whose production is of global interest due to its multiple uses, typical of its high content and quality of both protein and oil. On average, a dry-based soybean

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contains 40% protein and 20% oil, which is why the main products of soy industrialization are flour and oil. Flour is mainly intended for the production of balanced food for animal consumption, where around 75% of the world's production goes to this end, especially for poultry and pigs. Oil is used as an edible oil, as an additive in food, cosmetics, soaps and biofuels, among other applications.

The global vegetable oil production sector is constantly growing and soybean oil occupies a leading position in this field as can be seen in Figure 1.

Mexico occupies an important place among soybean importers worldwide. Its imports are equivalent to 3% of the soybean marketed worldwide, mainly used in the livestock sector for the production of protein for the production of balanced foods and the production of edible oil.

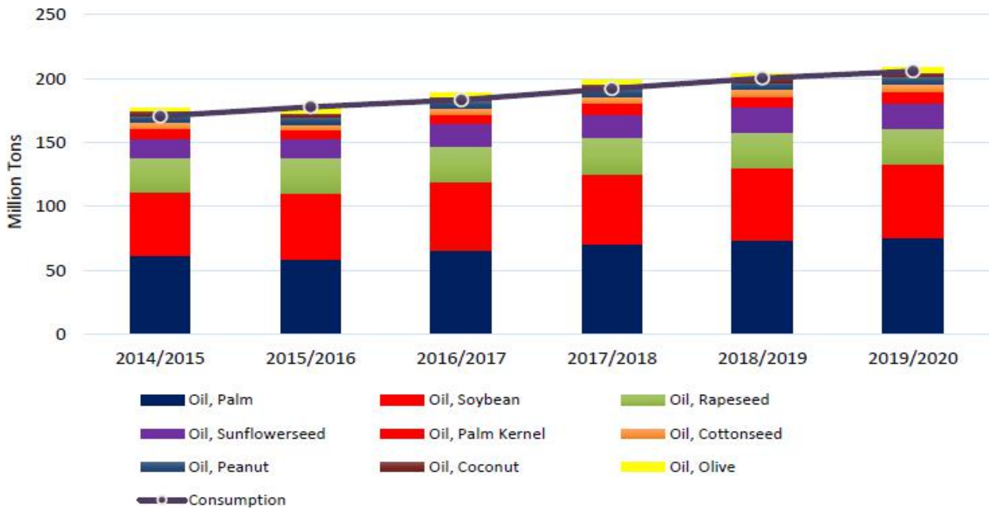

Figure 1 World Vegetable Oil Production (USDA, 2019).

According to the Agri-Food and Fisheries Information Services (SIAP-SAGARPA, 2016) the main soybean-producing states in Mexico are Tamaulipas, San Luís Potosí, Campeche, Veracruz and Chiapas, as shown in Figure 2, however, their total production fails to supply the domestic demand of the country, so there is a high import of the grain to meet the demand of the nation.

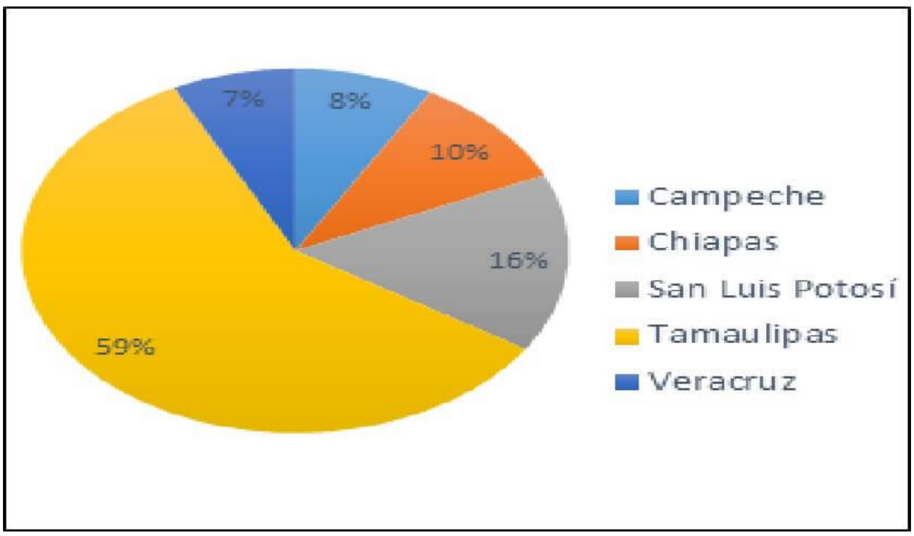

Figure 2 Soybean Producing States in Sown Area per Hectare (SIAP-SAGRAPA, 2016)

2. Literature Review

2.1 Oil Production in Mexico

The production and consumption of edible oils and fats are closely linked to the performance of the Mexican economy, where greater purchasing power for consumers will encourage the inclusion of more oils and fats in their diets.

According to Seale (2017), the oil and fat industry landscape in Mexico has the following characteristics:

- The industry is made up of oil and fat producers in Mexico, including butter, cooking fats, margarine, oil and planting fats and vegetable and seed oil
- The oil and fat market grew 5% compared to 2015, reaching MX$33,834 million in 2016.
- Oils and fats have been struggling to maintain a positive perception of their products due to the new IEPS tax affecting high-calorie products in Mexico.
- The most dynamic categories in terms of value are olive oil and soybean oil, given their growth in 2016 of 6%. Growth can be attributed to healthier eating habits by consumers.
- By 2020, Mexico's oil and fat industry is expected to be worth MXN $38,034 million, with annual growth of 3.6% (Seale, 2017).

About 60% of Mexican vegetable oil production is used for the manufacture of bottled oil, however, in recent years the consumption of oils and fats for other edible industrial uses has grown (Aniame, 2020). Figure 3 shows the Mexican population's high preference for consuming vegetable oils and fats over the consumption of animal fats.

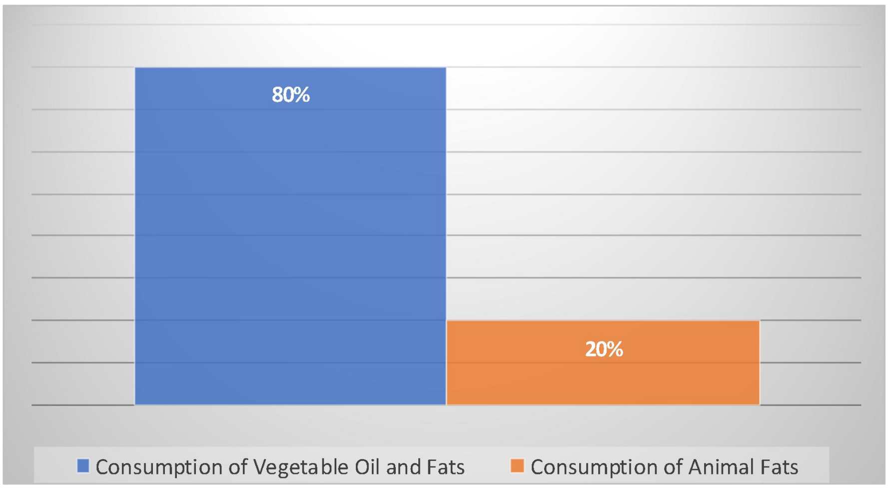

Figure 3 Percentage of Consumption of Vegetable and Animal Oils and Fats (Aniame, 2020)

2.2 Impact of COVID-19 on the Oil Industry

The presence and contagion of COVID-19 generated by this pandemic has Mexico and the world in a crisis with multiple impacts on the health, economic and food sector, among others. In view of this situation, economic revival is slow, in direct relation to the security conditions of the population that allow the confinement measures imposed by governments to be lifted in an attempt to prevent the contagion of the population by COVID-19.

There is certainly still uncertainty about the solution to this situation, and the magnitude and duration of the recessionive impact that will prevail on the national and global economy cannot be specified. The oil, fat and protein sector has been listed in Mexico as an essential activity in this health crisis, in order to enable it to fulfill the responsibility and commitment to maintain its productive activity, supply and guarantee supply to its customers (oil consumer, processed food manufacturers, balanced food manufacturers for the livestock sector, etc.).

This operational continuity must be accompanied by the health care of workers, customers, collaborators, raising the health and safety standards that were established. Every industry and productive organization must strive to strike a balance between production and health measures to meet the challenges of this pandemic.

According to the National Association of Oil and Butter Industries Edible A. C. (Aniame, 2020), Mexico ranks ninth in the world as oilseed paste products and 14th as a country producing edible oils and fats, covering 60% of the requirements of the domestically produced protein paste market and in the particular case of soybean paste, this percentage rises to 72%. This picture in early 2020, however, with the current pandemic situation, there will be falls in oilseed consumption and therefore in the consumption of vegetable oils resulting from reduced activities in restaurants and even domestic consumption due to economic crisis and unemployment. Challenges and uncertainty in the oil industry and the production sector in general continue as the pandemic persists.

This section is devoted to discuss SCM topics in Emerging Markets which include (1) integration between demand chain and supply chain, (2) product/service development fitting emerging markets (such as focusing on disruptive technology and reverse innovation), (3) differentiation of supply management style and inventory management, (4) consideration of marketing channels, (5) logistics strategy different from advanced markets, (6) strategy considering local government policy and institutional rules such as FTA and TPP.

2.3 Research Framework

2.3.1 Removing Soybean Oil

For thousands of years, oil extraction has been a vital industry. During all this time, the equipment and methods used have constantly evolved from the most primitive to the most modern practices and machinery (Valenzuela, 1997). The current trend is aimed at the almost exclusive use of solvent extraction for soybeans. The solvent extraction process consists of three parts:

- Grain preparation.
- Extracting oil from the grain.
- Recovery of oil solvent and ground soybeans.

After recovering the oil is subjected to a refining process, within which is the neutralization stage.

2.3.2 Chemical Refining or Neutralization

Almost all edible oil is refined with some alkaline substance, almost always caustic soda, in a process system continued. When an alkaline solution is added to raw or raw and degumated soybean oil, chemical reactions and physical changes occur. Alkali is combined with oil-free fatty acids to form soaps; phosphatids and gums absorb alkali and clot by hydration or degradation; much of the coloring matter is degraded, absorbed by rubbers or solubilized in water, and insoluble materials are trapped by other coagulable materials. If too much caustic is used, prolonged exposure to heat will result in the saponification of the oil, and the consequent decrease of the final product.

The importance of neutralization lies in the fact that at this stage it defines the economic success of refining oils and fats (Wiedermann, 1981).

3. Case Study

3.1 Soybean Oil Industry in Mexico

Study in an industry producing edible soybean oil from Mexico.

The optimization processes for the correct use of resources have become a key strategy to meet the challenges that the current pandemic imposes on the productive sector, in this case, in a company whose nominal capacity of the Soybean Oil Extraction Plant is 750 ton/day.

3.2 Objective

Generate a proposal to optimize the soy oil neutralization process by determining control parameters that influence its quality.

3.3 Methodology

The development of this research was first based on the diagnosis and analysis of the neutralization process, for which it was applied:

Targeted observation: of the neutralization process to detect important points and parameters of the process, as well as the needs to be improved in order to propose improvements to optimize the process.

Interaction with operators: Checking the three shifts in the refinery area and the activities of the operators. Analysis of log reports of each operator in turn.

Analysis of the Manual of Processes and Verification against the current process, taking into account the intellectual capital generated in the neutralization process.

Proposal for quality optimization in neutralization for soybean oil production.

3.4 Results

From the diagnosis and analysis of the neutralization process was obtained the process diagram, which starts in the homogenizing tanks of crude oil that is sent from the degumeament area, in this area all the minerals contained in the oil are removed to continue with the most important stage of the chemical refining of the edible soybean oil, since according to the quality of the crude oil that is sent from the degumado area is fixed the amount phosphoric acid for the elimination of Ca and Mg, dosage and concentration of caustic soda to basically remove free fatty acids, phosphatids, gums and coloring substances, which are residual impurities that remain after degumeasing and soap stock separation to prevent all these impurities from passing to the next stage of the process.

Crude oil that is sent to homogenizing tanks with slow agitation to homogenize it without aerating to prevent oxidation. The oil in the tanks passes to the lung tank operating at high oil level for continuous feeding of degumated crude oil to the oil refining process, regulating the flow of oil (4000 to 7000 L/Hr) to be processed and heated with saturated steam. The heating temperature is shown in Figure 4.

The mixing of degumated crude oil with Phosphoric Acid is performed for the separation of phosphates and rubbers contained in the oil, checking the appropriate pH value in the reactor tank.

It proceeds to refine with caustic (NaOH) whose concentration and dosage is depending on the flow of oil to be processed. Figure 5 shows the variation in the concentration of NaOH solutions used in the neutralization process.

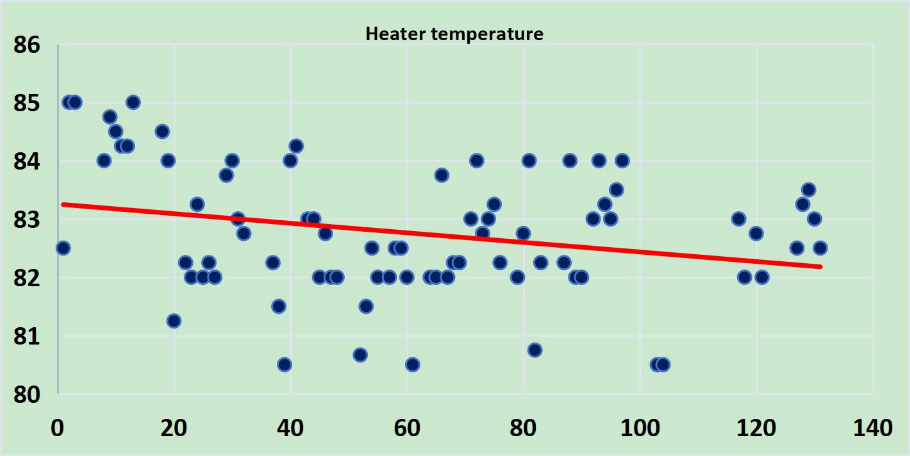

Figure 4 Average Heater Temperature Value

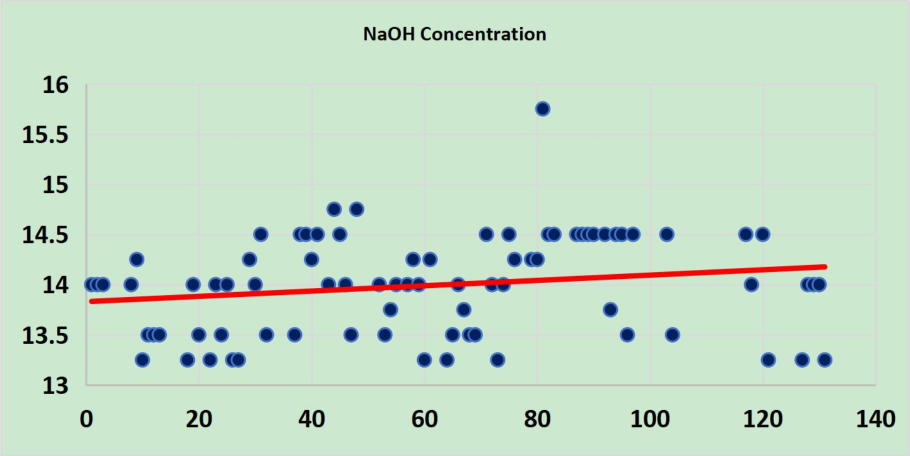

Figure 5 Average Value of Caustic Soda Concentration

In a heat exchanger of stainless steel plates with steam-oil to backflow the neutral oil is heated after being refined with caustic (NaOH) and contains residual soap, the heating of the oil is done by steam. Once the oil has already come out of the heater it passes to the centrifuge, where the separation of the interface (heavy and light phase) is carried out.

The heavy phase is composed of soap stock (soap), free caustics and low portions of residual neutral oil, this interface is the result of a chemical reaction of free fatty acid (A.G.L.) with an alkali or caustic (NaOH) that is hydrolyzed with water to perform a saponification (soap formation).

The light phase is the centrifugated refined oil with low humidity percentage.

The oil once neutralized is sent to an oil dryer in which it is under negative pressure or vacuum which is ideal for obtaining a moisture-free oil. Figure 6 shows the control values for this pressure.

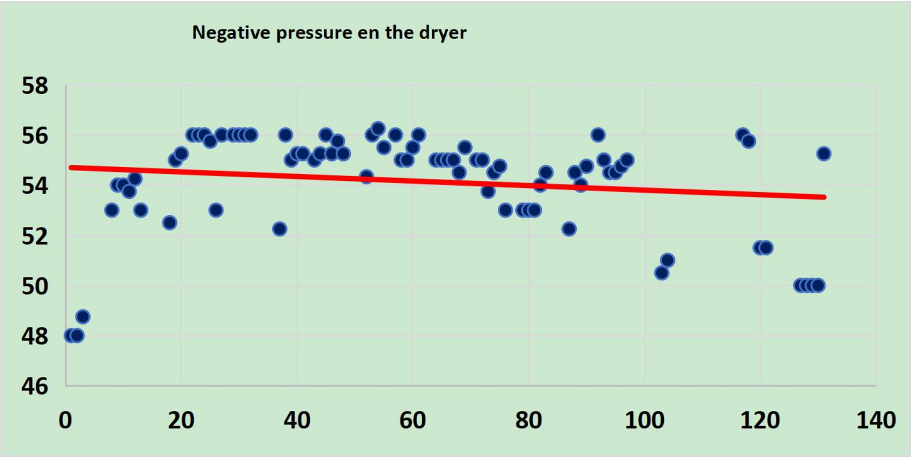

Figure 6 Average Negative Pressure Value in MmHg

4. Conclusion

To produce a good quality edible soybean oil, its refining process must be carried out correctly, it is essential to control the neutralization stage which is the first 4 stages of this process, favoring that the remaining stages be performed correctly.

The contribution of neutralization in the oil purification process is intended to decrease the percentage of free fatty acids and parts per million soap present in raw soybean oil using a Sodium Hydroxide solution prepared in Baume grades.

Eleven parameters were monitored in this study, with the most influencing of the oil neutralization process being the concentration of the caustic soda solution and this is because in the current method, the solution does not always have the same concentration throughout the day due to differences in operator preparation method and that the storage tank of the caustic soda solution is not constant agitation and that causes the sedimentation of the caustic and therefore the variation in its concentration.

The proposal to optimize quality at this stage of the process is to establish a standardized method of preparation of the caustic soda solution taking into account the correct safety measures and the installation of two stainless steel tanks with an agitator of 4 stainless steel pallets of radial flow each and with recirculation pumps so that the caustica soda solution is in agitation all day and thus avoid a sedimentation and so that the concentration of the solution did not change and can remain stable in the neutralization process.

Quality attributes that are influenced by refining, responsible compounds, and operating conditions that are necessary to establish and control in each type of process in order to obtain a quality and competitive product.

This first stage of refining is of paramount importance in the achievement of quality attributes, and of the economy of the operation, even if in the way of the process only a small part represents a small part, the result of it will be definitive in the achievement of these, and that for products of human consumption are very clear and definitive.

Optimizing company-specific processes is a key strategy to be competitive and meet the challenges posed by the productive and commercial sector.

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References:

Aniame A. C. (2020). *Asociación Nacional de Industrias de Aceites y Mantecas Comestibles, A.C.* Año XXXIII, Vol. 22, No. 108, Abril-Junio 2020.

Erickson D. R. (1995). *Practical Handbook of Soybean Processing and Utilization*, A.O.C.S. Press.

Seale J. (2017). "Reporte de la industria del aceite de consumo", *Seale & Associates*, available online at: http://mnamexico.com/wp-content/uploads/2017/08/Aceite-compressed.pdf.

Servicio de Información Agroalimentaria y Pesquera (SIAP-SAGARPA). 2016. México.

United States Department of Agriculture (USDA) (2019). Oilseeds: World Markets and Trade. USDA. Estados Unidos de América.

Valenzuela A. (1997). *Efectos Biologicos y Nutricionales de los Acidos Grasos* Trans, Aceites y Grasas.

Wiedermann L. H. (1981). *Degumming, Refining and Bleaching Soybean Oil*, J.A.O.C.S. March (159/166).