Sustainable Deacidification of Crude Soybean Oil by Thermally Activated Arrinrasho Nanoclay

Edah A.O[1*] , Adeyanju O[1], Awode A.U[1] Kolawole J.A[2] and Solomon A.O[3]

[1]*Department of Pure and Industrial Chemistry, University of Jos, Jos Nigeria.*
[2]*Department of Pharmaceutical Chemistry University of Jos, Jos Nigeria.*
[3]*Department of Geology and Mining University of Jos, Jos Nigeria.*

Abstract: **- The time-contact process technique was employed in soybean crude oil purification. The efficiency of the thermally activated Arrinrasho Nanoclays as an alternate bleaching earth in the Deacidification of free fatty acids and the extraction of trace metals within the brackets 30 minutes and 1-5 % loading of adsorbent. Standard investigations of the free fatty acids after the treatment with the test material were in the range of (0.13 – 0.10) % FFA, the costly conventional adsorbent gave an average of 0.15 % FFA at 1% loading. The atomic absorption spectrometric analyses for Arsenic, Copper, Lead, and Iron in both materials were not detectable at the part per million levels. It is possible to extract (18 - 20) % oil from soybean, this oil contains (38 - 40) % proteins, with insignificant amount of cholesterol and its digestibility. These attributes of the soybean oil has rendered it essential for several health reasons. This oil has been considered as source of biodiesel for generating power in energy circles due to its availability.**

Key words: **Edible oil, Refining Adsorbent, Free fatty acids, Purification, Trace metals.**

I. INTRODUCTION

The Oriental oil seed, soybean has made entries into production lines of several food, feed, pharmaceuticals and cosmetics industries. It is often referred to as "the wonder seed", "protein seed", oil seed, and "miracle" seed. (Arai, 1996., Friedman & Brandon, 2001., Priolli *et al*., 2002, Messina and Messina, 2004., Soyfood Directory,2004., Soares *et al*, 2005., Dixit *et al.*, 2011.). It is the major source for the production of edible vegetable oils. Oils are important ingredient of animal diet, as reported by Singh 2008., Friedman & Brandon,2001., and FDA, 2000. Oils are noted for their high energy content and depending on their origin; they may be naturally endowed with essential fatty acids such as linoleic and fat-soluble vitamins such as vitamin A and E (KeShun, 1997). The soybean production and processing in Nigeria and in several countries across the globe, show large prospects. Endres, 2001 and Eierdang,1992.

The world's production of vegetable oil seeds was estimated in excess of 403.58million metric tons as at 2009-2010 harvest seasons, 60% of this was attributed to soybean as reported by Golbitz in the Soy and oilseeds blue book of 2010. Similar trends were noticed for previous years as reported in the bluebooks for, 2004., 2003 and 2000. The yields of crude vegetable oils produced via oilseed pressing are usually in the domain of 5% or less as traditionally observed. This product is normally associated with gum and undesired compounds which needs to be removed by refining, with respect to Earl *et al.*, 2005. The methods adopted for the crude vegetable oil refining is often related to its character, such as oil acidity, odor, color, moisture content and viscosity, bearing in mind the environmental restrictions that exist within the local area of operation (Wang and Briggs, 2002., Wang and Johnson, 2003). The aspect of physical refining is crucial to most vegetable crude oils. However certain vegetable crude oils such as soybean oil requires additional chemical refining, in order to extract undesirable materials such as water, residue methanol, glycerides, glycerin and soaps (Erickson, 1995). In the vegetable oil refining industry, commercial products such as GlyceRx^{TM} and ECO_2 Pure were used to facilitate the chemical refining of crude edible oils, as inmplied by Medina-Juarez *et al.*, 1998 and Mattil *et al.*, 1964.

Clay materials exhibit sheet and layer orientations. The different possible structural conformation of the elements in clays results in the several classes of clays, such as Kaolinite, Serpentine, pylophyllite(talc), smectite (Bentonite/montmorillonite, saponite), sepiolite and vermiculite (Shichi and Takaji, 2000).

The particle size, surface area and high charge density of clay material are some of the properties that make for the adsorption capacities of these clays (Costanzo, 2001., Alkan *et al.*, 2004., Bahari *et al.*, 2011., Edah *et al.*, 2012.).

The notable advances in the Deacidification of crude vegetable oils have been postulated along chemical and biological directions. Bhosle and Subramanian, 2005. Chemical reesterification, membrane techniques, liquid-liquid solvent extraction and supercritical fluid extraction are highly favored lines. In Biological Deacidification, the frontiers for microbial and enzyme actions are wide. Cho *et al.,* 1990 and Meirelles *et al*., 2007. In large scale membrane approach for the purification of material, considerations are made from the points of industrial application in reverse osmosis, evaporation, micro-, Ultra- and nano- filtrations. Membranes in oil milling and processing are applied in catalytic recovery, degumming operation, free fatty acid recovery, protein purification, solvent recovery, tocopherol separation, tower water recovery, wash water recovery from centrifuge (Lin and

Koseoglu,2005).Considerations for replacing the traditional multiple processes of (degumming, deodorizing, and refining operations with a single operation membrane system are tied to energy saving tendencies.

Research on soybean oil neutralization in the presence of Sodium Silicate gave impressive quality and yield accompanied by excellent extraction of trace metals and soaps. The process of filtration for the separation of the gums and free fatty acids were not cumbersome. The quantity of soap after the filtration were in the range of 80ppm without washing Hernandez and Pathbone, 1999; Farr 2000.

This study was designed to source for cheap, safe and grossly available materials to be employed for the sustainable Deacidification of crude soybean oil that would be edible by FAO, USFDA, EU and NAFDAC standards.

II. MATERIALS AND METHODS

Samples and reagents

The crude soybean oil, (Glycine max wash oil) samples were obtained from Grand Cereal Mills Nigeria Limited (GCMNL) factory in Jos South Bukuru. Storage was not necessary as investigations were carried out the same day. Nanoclay samples were sourced locally from Arrinrasho, Barkin Ladi, both locations are in Plateau state, central Nigeria. The instrumental analysis of these clays are reported by Edah *et al.*, 2012. Analytical grade reagents, Isopropyl Alcohol, Sodium Hydroxide pellets from BDH, Whattmann filter paper were employed in the bench work.

The Flow Chart Below Represents The Design Of The Process Line.

The time – contact/batch process was adopted as a prototype based on the industrial scale model. The system comprised of four sections, with four unit operations. The visible components are the reactor vessel, stirrer, timing device, weighing balance, filtering device and storage containers to receive the treated oils.

Determination of Free Fatty Acids (FFA)

The analyte (Refined soy bean oil) was well mixed; a known weight was taken with the aid of a Sartorius balance. 50ml of hot neutralized Isopropyl alcohol (IPA) is added; three drops of phenolphthalein indicator were added. Proper mixing was ensured. Standardized NaOH solution was used to titrate while stirring by magnetic bar. The end points were noted, at the indication of the first permanent pink color of the solution.

% FFA of Refined oil = Alkali (ml) x N x 28/wt of sample.

Firestone, 1993., GCOMNL standard method of analysis, and Paquot, 1987.

III. DISCUSSION

*Fatty Acids (FAs***)**

Fatty acids serve as building blocks for triacylglycerols. If these FAs interact with metals, oxygen, hydrogen, acids, or radiations, the degenerate into free fatty acids (FFAs)

Free Fatty Acid (FFA)

The %FFA content is the first line indicator of the quality of a given edible oil.

The free fatty acid present in oils serve as good substrates for oxidation and production of ring compounds which are degraded into aldehydes and ketones, these carbonyl compounds have been implicated in generating undesirable flavor from oils. The presence of FFAs in oils can be deleterious when used in pharmaceuticals, Messina, 2010.

It is important to note that the %FFA of the crude vegetable oil is a factor of age, the conditions of grain at harvest and the %Moisture of the seeds. Damaged soybean seeds are known to contain as much as 8%FFA with high levels of copper and iron at 0.08-0.18ppm and 3-7ppm respectively. Evans *et al.*, 1974.

It was observed from the data obtained that the Arrinrasho Nanoclay from Barkin Ladi, Plateau, Nigeria exhibited great potentials for the Deacidification process of crude soybean oil produced at GCOMNL, when subjected to a prototype procedure at the mill. The thermally activated Arrinrasho Nanoclays employed in this work, were characterized instrumentally as reported by Edah *et al.*, 2012. The chemistry of the deacidifying activity of this material may be attributed to the presence of potassium, magnesium, calcium and aluminum oxide species that may have been generated from the thermal activation. These oxide species have high affinity for attacking and neutralizing free fatty acid molecules that may be present in the crude soybean oil, as reported by Pwaliszyn, 1997 and Erickson, 1995. The results of this present work indicates that the Free fatty acids level in the crude soybean oil after its deacidification treatment with Arrinrasho clay, fell to a range of (0.10 - 0.13)%, when employed at a range of (1.0 - 5.0)%, while the standard material employed, gave FFA of 0.15% at 1% loading. Our adherence of the factory operational conditions was a deliberate act, aimed at avoiding any additional production process cost that may be introduced in the application of this tested deacidifying material.

Arsenic (As), Copper (Cu), Lead (Pb) and Iron (Fe), were some of the trace metals that were monitored in the treated soybean crude oil. We adopted atomic absorption technique. This investigation was not detectable at the part per million levels. This team of investigators implicate the thermally activated adsorbent (Arrinrasho Nanoclays) for this level of absence. Bockisch,1998., and Zschau, (2000).

Summary.

The findings of this work indicate that the crude soybean oil Deacidification by contact process employing beneficiated, pulverized and thermally activated Arrinrasho Nanoclays is a feasible and sustainable process. The introduction of this choice material at a range of (1.0 - 5.0)% with subsequent filtration yields clarified edible soybean oil with wholesome character, showing free fatty acid in the range of (0.10 - 0.13)%. The current standard material employed (Standard T.) is used at 1% loading, its resulting Free Fatty Acid under the same conditions was 0.15%. These parameters were within expected values for FAO, USFDA, EU and NAFDAC. The attributes of the Arrinrasho Nanoclay in degumming, dewaxing, deodorizing, and decolorizing of crude soya bean oil in a single step of refining process was investigated closely. The material under investigation is comparatively cheap and readily available.

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