COMPARATIVE STUDY ON THE EFFECTIVENESS OF MORINGA OLIEFERA SEED POWDER AND OKRA BARK AS CLARIFYING AIDS IN SUGAR JUICE CLARIFICATION PROCESS

BY

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(2006/24212EH)

DEPARTMENT OF CHEMICAL ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

NIGERIA

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BACHELOR OF ENGINEERING (B.ENG) DEGREE IN CHEMICAL

ENGINEERING

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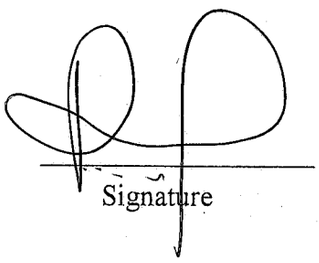
DECLARATION

I **UMAR AHMED GANA** with matriculation number 2006/24212EH do solemnly declare that this particular work, **"Comparative Study on the Effectiveness of Moringa Oliefera seed powder and Fresh Okra bark as Clarifying Aids in Sugar Clarification Process"** was undertaken by me under the supervision of Prof. F. Aberuagba. The authors of any books and publications that became helpful for the completion of this project work were gracefully and gratefully acknowledged. As much as I know, this is the going to be the first presentation of this particular work ever

UMAR AHMED GANA

Name of Student



Signature

Date

CERTIFICATION AND APPROVAL PAGE

This is to certify that the project title "Comparative study on the effectiveness of Moringa oliefera seed powder and fresh Okra bark as clarifying aids in sugar juice clarification" was carried out by UMAR AHMED GANA with matriculation number 2006/24212EH, under the supervision of PROF. F. ABERUAGBA and submitted to the Department of Chemical Engineering, School of Engineering and Engineering Technology, Federal University of Technology Minna, in partial fulfillment of the award of Bachelor of Engineering Degree (B.Eng)

Prof. F. Aberuagba — 2/12/11 — Date

Project supervisor

Dr. M.O Edoga — Date

Head of Department

External Examiner — 22/02/2012. — Date

DEDICATION

I dedicate this work to Almighty Allah and my parents Alhaji umar Ahmed and Hajia Hassanat M. Umar.

AKNOWLEDGMENT

I express my appreciation to my supervisor prof. F. Aberuagba for taking his time to go through my work and handle me with care throughout the period of writing this project. I also thank mallam kudu and malllam mohammed who guided me in the course of my practical work, may Almighty Allah continue to bless them their family.

My special gratitude go to my siblings; Umar Sadiq Abubakar, Umar Mohammed, Umar Fatima, Umar Hassan, Umar Hussainat and my aunty Aisha Issa.May Allah bless them all.

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ABSTRACT

This project is based on studying the effectiveness of Moringa seed powder and Okra bark as clarifying aids in sugar clarification process. The clarifying aids were prepared in four different concentrations ranging from 0.25 g/ml to 1.00 g/ml. Proximate analysis carried on the Sugar cane juice before clarification revealed the raw juice to have a Brix of 23 °*B*, Poll of 10, pH of 5.9, Purity of 43.5 %, colour of 540 and turbidity of 480.The stages involved in the process are crushing of the cane sticks with aid of cane crusher, extraction of juice from the crushed cane, settling of the juice and boiling of the juice using the clarifying aids (clarification).Analysis carried out on the juice after clarification revealed that increase in concentration of the clarifying aids during clarification process showed that brix, Poll, pH, and purity increases for both Moringa and Okra bark while colour, turbidity and resident time reduces as the concentration increased. The use of Okra bark and Moringa seed powder were both effective in sugar juice clarification, with Moringa being the most effective clarifying aid in the process.

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Chapter One

1.0 INTRODUCTION

Sugar cane juice is an extremely complex liquid medium, containing many organic and inorganic constituents in soluble, suspended /decantable and suspended/colloidal form. Cane sugar for human consumption is produced by means of clarification of sugar cane juice using an extraction process, which is then processed and concentrated to obtain sugar. Clarification is therefore an essential step to obtain high yields and high quality of sugar. The clarification process needs to remove components other than sucrose and at the same time minimize loss of sucrose and colour formation (http://www2.dupont.com).

Cane juice has an acidic reaction. It has a pH of 5.0. The juice is viscous owing to the presence of colloids. The colloids are particles existing in a permanent state of fine dispersion and they impact turbidity to the juice .These colloids do not settle ordinarily unless conditions are altered. The application of heat or addition of chemicals brings about flocculation and coagulation. They may be coagulated by the action of electric current and adsorption by attractions using porous or flocculants material some colloids are flocculated easily while some others do so with great difficulty.

Colour of sugar be it raw, direct mill, white or refined is its most important commercial attribute and much resources are spent by the miller and the refiners to comply with market requirement on the colour of their product, crystallization itself apart from producing a stable marketable product is also 95- 99 % effective in partitioning colour. In the production of low colour sugar, supplemented by a number of carbon and ion exchanged resin based adsorption process and to a lesser degree by a method based on the chemical reaction that render colourless the colorant molecules.

The main objectives of sugar juice clarification are to raise pH and elimination of suspended solids, colour removal is at best considered a secondary objective rarely monitored by mill laboratory and to our knowledge never used as criterion to asses, let alone controls the process. The use of So_2 is widespread in clarifying process in the production of white sugar, however

periodic spikes in suphur and sugar quality issues have stipulated effort to reduce or even eliminate it use with that in mind, a carbonation process has been tested and compared with standard sulfitation and defecation. Besides eliminating the use of sulphur, carbonation would also provide a means to utilize and sequester some of the excess Co_2 that may be available cost-free in some sugar factories from molasses or juice fermentation. The traditional double carbonation process was used initially in sugar juice clarification in java (Honig, 1979). A Critical step in the manufacture of either raw sugar or white sugar is clarification of the sugar juice obtained after milling, the procedures is essential in the removal of impurities such as muds, press cake and partial removal of colour which would otherwise interfere with the crystallization of the sugar, in practice the juice is limed so as to produce coagulated suspension. This settles slowly and will require a fair amount of time to thicken. It is therefore a common practice that flocculants such as magna floc or polyacrylamide and coagulants are added as clarifying aids to the limed juice in other to improve the settling time and compaction of the coagulants. Several clarification methods are currently used, including cold liming, hot liming, fractional liming, fractional liming with double heating, and calcium saccharate (sucrate) treatment. The limed juice is typically heated above its boiling point under pressure and flashed to atmospheric pressure to remove non-condensable gases that would inhibit settling of impurities ,and an anionic flocculent is added to improve settling of flocs in the clarifier. Flocculation removes insoluble suspended particles and colloidal impurities by aggregating them into flocs. A typical size range for pre-flocculation impurities in mill-extracted, mixed juices at Louisiana raw sugar factories is 0.1-22 microns. Fluctuations in the rate of settling, the turbidity of the juice, or the filterability of the precipitate can result from different cane varieties, soils, fertilizer applications, climatic conditions, and other conditions. To obtain high quality clarified juices, removal of components other than sucrose should be maximized, and losses of sucrose and formation of color should be minimized. Proteinaceous and waxy matter, some silicic acid, and sesquioxides can be removed by heating, while liming neutralizes acids, forms calcium phosphates, and coagulates colloidal particles. The colloids are primarily anionic and hydrophilic. The colloids are usually surrounded by a water layer, which must be destroyed to

allow removal of the colloids by settling. Hydrophobic colloids (waxes, pectins, proteins) are less hydrated, and have a relatively smaller effect on viscosity.

The presence of colloids in sugar juice tends to increase the hydration of the particles present, making them gelatinous and slow to settle. Colloids must be removed, as they increase the viscosities of syrups and molasses, decrease filtration rates, decrease rates of sucrose crystallization, and tend to increase color. Colloidal particles in sugar juice usually carry a negative charge, which causes them to repel one another, thus inhibiting their coalescence. Divalent and trivalent cations, which bind more tightly to colloidal micelles than monovalent cations, tend to reduce the zeta potential of the colloids, improving the tendency of the particles to form aggregates and to flocculate. In particular, calcium is frequently used to foster flocculation (Clark *et al.,* 1999). High levels of inorganic phosphate in sugar juice promote the removal of silicic acid and waxy-lime material. Sugar cane juice contains both organic and inorganic forms of phosphorus, the latter comprising primarily free phosphate ions. In prior juice clarification techniques, only free inorganic phosphate ions have played a substantial part in reactions with calcium. Generally, good quality clarified juice can be obtained when about 300 mg/l of inorganic phosphate is present. Much higher levels of phosphate (500-800 ppm) not only cause large mud volumes, but they also tend to form light flocs that settle slowly. High sucrose extraction efficiencies (e.g., 95 % in mill tandems and 99 % in diffusers) cause increased extraction of non-sugars. Cane juices contain a considerable amount of silicic acid, typically 10 to 30 % of total mineral ash content, depending on the cane quality and the extraction techniques used. Silicic acid usually forms negatively-charged colloids. Sesquioxides are present in much smaller quantities than silicic acid. Ferric oxide levels typically increase somewhat during clarification due to loss of metal from mill machinery into the juice. The ratio of inorganic phosphate to silicic acid (plus sesquioxides) is the main parameter used to predict the behavior of cane juice during clarification, especially its settling characteristics and mud volume percentage. This so-called "Bogstra ratio," P.sub.2 O.sub.5 /(SiO.sub.2 +Fe.sub.2 O.sub.3 +Al.sub.2 O.sub.3) (measured by mass densities) should be at least about 0.20-0.25 (depending on aconitic acid levels in the juice) to produce a clear clarified juice with low

suspended solid levels. Thus (within limits), higher levels of inorganic phosphate are beneficial to clarification (Vanderbeke *et al.,* 2000).

However in the production of organic food, these synthetic clarifying aids are not permitted as only lime can be utilized, the consequences is that settling of the suspended solids takes a considerable time leading to frequent overflow of juice and mud from the clarifier. Furthermore, with extended settling time, sucrose losses due to inversion may also happen. Recent trials carried out on the possibility of using seed extracts from common tropical plants, Moringa Oleifera and the use of Okra Bark as clarifying aid have given promising results (Wong sak hoi *et al.,* 2001).

1.1 Aims and Objectives of Study

The aim of this work is to study the effectiveness of moringa powder solution and okra bark solution at varying concentrations in clarifying sugar juice.

The objectives of this work are:

1) To get sugarcane, crush it and extract it juice.
2) To prepare solutions of the two clarifying aids at different concentrations
3) To compare the effectiveness of the clarifying aids in sugar juice clarification at various concentrations.

1.2 Justification of Study

In 1999, fresh okra bark was used for the clarification of sugarcane juice from which brown sugar was prepared in Sudan (Chauchan 1999). Recent trials by Mauritius Sugar Industry Research Institute (MSIRI) on the possibility of using seed extract from common tropical plants, Moringa Oliefera have given promising results (Wong sak hoi *et al.,* 2001).There is need to study the effect of concentration variation of each of these clarifying aids in sugar juice clarification process.

1.3 Scope of Study

The scope of this work is limited to extraction, clarification and analyzing parameters such as Brix, Poll, Purity, Turbidity, Colour and pH of the extracted juice and the clarified juice.

Chapter Two

2.0 LITERATURE REVIEW

2.1 Description of Moringa

Moringa is one of the most world most useful plants. Though apparently native to restricted areas in southern foothills of the Himalayas, moringa oliefera is cultivated in all the countries of the tropics, Moringa oliefera is cultivated for its fruits, leaves and roots for a variety of food and medical purposes (Olsen, 1999). The young fruits (sometimes called drum sticks) can be cooked in a number of different ways. Excellent oil is derived from the seed which is useful for cooking and lubrication of delicate mechanisms. The leaves are extensively used as vegetables in many parts of the world and the roots can be made into condiment similar to horseradish (true horse radish, armoiracia, is a member of mustard family, brassicaccae). Moringa oliefera is also of interest because of its production of compound with antibiotic activity such as the glucosinelate a apha-L-thamnosyloxy benzyl isothiocyanate (Olson, 1999). Other research has focused on the use of Moringa Olifera seed and it fruits in water purification and sugar juice clarification (Oslon, 1999).

2.1.1 Chemistry of Moringa Seeds

Per 100 g, the pod is reported to contain 86.9 g H_2O, 2.5 g protein oily fat, 0.5 g total carbohydrate, 4.5 g fibre 2.0 g ash, 30.0 gmgca, 110 mgp, 5.3 g Fe, 184iu vitamin A, 0.2 mg niacin, 120 mg ascorbic acid, 310 mg Cu, 1.8 ugi. Leaves contain 5.7 g H_2O 6.9 g protein, 1.7 g fat 14.3 g total carbohydrate, 0.9 g fibre, 2.3 g ash, 440 g Ca 70 mg P, 7 mg Fe, 110 ug, 5.1 ugl, 1130 iu vitamin A, 8120 ug vitamin B. 0.8mg nicotinic acid, 220 mg ascorbic acid and 704 mg taco feral per 100 g (Hartwell, 1971). Estrogenic substance including the anti tumor compound , B-sitostreral and pectinesteras were also reported leaf amino acid include 6.0 g orginine/16 Gn, 2.1 histidine, 4.3 lysine, 1.9 trytophanme, 6.4 phylalanine, 2.0 methoionine, 4.9 threnine, 9.3 lucine, 6.3 rsoleucine and 7.1 valine (Hartwell, 1971). Pot amino acid enclue 3.6 g organic/16 gN, 1.1 g histidine, 1.5 g lysine, 0.8 g tryptopone, 4.3 g phenglamine, 1.4 g methionine, 3.9 mg threonine, 6.5 g leacine, 4,4 g isoleucine, 5.4 g valine. Seed kernel (70.74 % of seed) contains

83.08 g H_20, 38.4 g ash (Verma *et al.,* 1974). The seed oil contain 9.3 % palmitic acid, 9.4 stenaric, 8.6 behenic acid and 65.7 % oliec acids among the fatty acids. Myristic ligrweeric acids have also been reported. The cake left after extraction contains 58.9 % crude protein, 0.41 CaO, 1.1 % P_2O_8 and 0.8 % K_2O (Duke, 1983). Pterygos permine, a bacterial and fungicidal compound isolated from moringa has an LD80 subcutaneouly injected in mice and rats of 350 to 400 mg/kg body weight. Root barks also yield to alkaloids, Moringine and Moringinine. Moringine acts as cadiac stimulant, produces rise of blood pressure, acts on sympathetic nerve-endings as smooth muscles all over the body and depresses the sympathetic motor fibre of vessels in the large doses only (Duke, 1983).

2.1.2 Description of Moringa Seed

Short, slender, deciduous, perennial tree to about 10 m SShigh, rather slender with dropping branches, branches and stem brittle with corky bark, leaves, feathery pods green compounds, tripinmates, 30-60 cm long, with many leaflets, 1.3-3.0 cm long 0.3 – 0.6 cm wide, lateral ones somewhat elliptic, terminal one above and slightly larger than the lateral ones, flower fragrant, white or creamy white, 2.5 cm in diameter borne in spray of 5 at the top of the flower , stem is yellow, pods pendulous, brown triangular, shifting lengthwise 3m apart when dry, 30-120 cm long, 1.8 cm wide containing about 20 seeds embedded in the pith tapering at both end, a ribbed seeds dark brown with three peppery wings, main root thick, fruit production in March and April (Duke, 1983).

2.1.3 Scientific Classification of Moringa Seeds

Kingdom: plantae

Unranked: angiosperm

Unranked: cudicots

Unranked: rosids

Order: brasssicals

Family: moringalese

Species: moringa oliefera

Biannual name: moringa oliefera (Wikipedia, 2010).

2.1.4 Ecology of Moringa Seed

Ranging from tropical dry to moist though tropical very dry to moist forest live zone, moringa is reported to tolerate annual precipitation of 4.8-40.3 (mean of 53 cases = 14.1), annual temperature 0f 18.7 – 28.5 °C (mean of 48 cases = 25.4) and pH of 4.5 -8 (mean of 12 cases = 6.5) thrives in tropical and sub tropical climates flowering and freely fruiting continuously, grows best in dry sandy soil (Duke, 1983).

2.2 Description of Okra

Okra *Abelmoschus esculentus* L. (Moench), is an economically important vegetable crop grown in tropical and sub tropical parts of the world. This crop is suitable for cultivation as a garden crop as well as on large commercial farms. It is grown commercially in India, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Burma, Japan, Bracil, Ghana, Ethiopia, Cyprus, and the Southern United States. India ranks the first in the world with 3.5 million tonnes (70 % of the total world production) of okra produced from over 0.35 million hectares of land (FAOSTAT, 2008).

Okra is known by many local names in different parts of the world. It is called lady's finger in England, gumbo in the United State of America, guino-gambo in Spanish, guibeiro in Portuguese and bhindi in India. It is quite popular in India because of easy cultivation, dependable yield and adaptability to varying moisture conditions. Even within India, different names have been given in different regional languages (Chauhan, 1972). Okra is cultivated for its green non-fibrous fruits or pods containing round seeds. The fruits are harvested when immature and eaten as a vegetable. Okra fruit can be cooked in a variety of ways. The roots and bark of okra are used for clarification of sugar cane juice from which gur or brown sugar is made (Chauhan, 1972), its ripe

seeds are roasted, ground and used as substitute for coffee in some countries. Mature fruits and stems containing crude fibres are used in the paper industry. Extracts from the seeds of the okra is an alternative source for edible oil. The greenish yellow edible oil has a pleasant taste and odour and it high in unsaturated fats such as oleic acid. The oil content of the seed is quite high at about 40 %. Okra provides important sources of vitamins, calcium, potassium and other mineral matters which are often lacking in the diet of developing countries (IBPGR, 1990).

2.2.1 Chemical Composition of Okra Bark

Per 100 g it is reported to contain Calories 35.0, Calcium 66.0 mg, Moisture 89.6 g, Iron 0.35 mg, Carbohydrate 6.4 g, Potassium 103.0 mg, protein 1.9 g, Magnesium 53.0mg Copper 0.19 mg, Fibre 1.2 g, Riboflavin 0.01 mg, Minerals 0.7 g, Thiamine 0.07 mg, phosphorus 56.0 mg, Nictonic acid 0.06 mg, Sodium 6.9 mg, Vitamin C 13.01 mg, sulphur 30.0 mg, Oxalic acid 8.0 mg (Gopalan *et al.*, 2007).

2.2.2 Geographical, Origin and Distribution

Okra is found all around the world from Mediterranean to equatorial areas as may be seen from the geographical distribution of cultivated and wild species shown below.

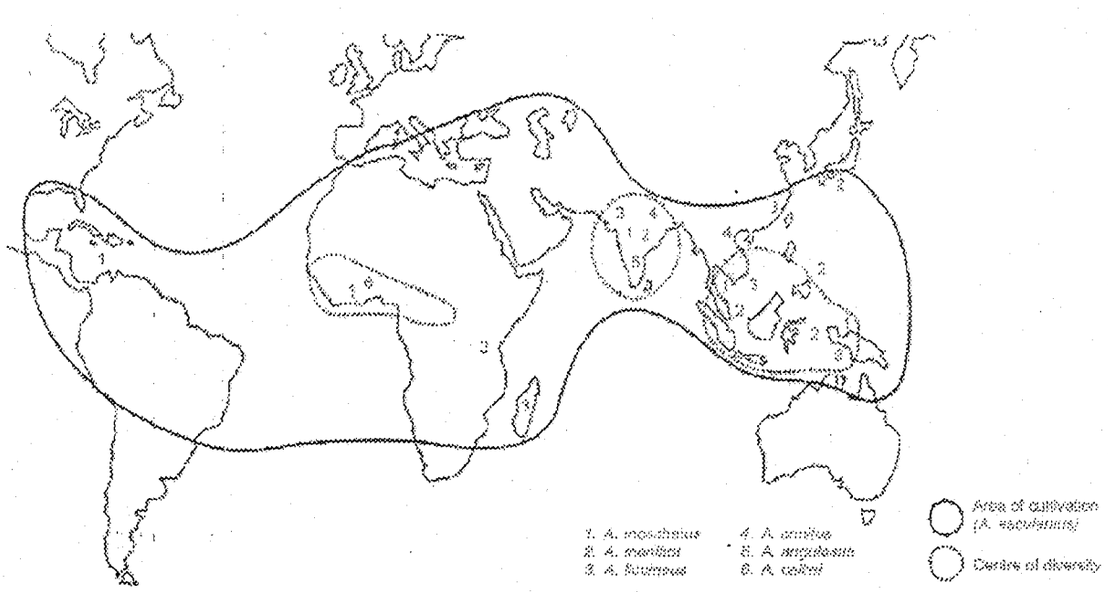

Figure 2.1: Geographical distribution of Abelmoschus species modified from Charrier (1984).

Cultivated and wild species clearly shows overlapping in Southeast Asia, which is consider as the centre of diversity. The spread of the other species is the result of their introduction to American and Africa. There are two hypotheses concerning. the geographical origin of A. *esculentus*. Some authors argue that one putative ancestor (*A. tuberculatus*) is a native to Uttar Pradesh in northern India, suggesting that the species originated from this geographical area, others, on the basis of ancient and cultivation in East. Africa and the presence of other putative ancestor (*A. ficulneus*), suggest that the area of the domestication is north Egypt or Ethiopia, but no definitive proof is available today, For A. *caillei*, only found in the West Africa, it is difficult to suggest an origin outside. Its origin by hybridization with A *manihot* is difficult to accept even if it is presence, mentioned in the Flora of West Africa (Dalziel *et al.*, 1998) was not recently confirmed in this area and herbarium samples are lacking. Eight *Abelmoschus* species occur in India. Out of these, *A. esculentus* is the only known cultivated species. A. *moschatus* occur as a wild species and is also cultivated for its aromatics seeds, while the rest six are truly wild types. The wild species occupy diverse habitats. The species *A. ficulneus* and *A. tuberculatus* is spread over the semi-arid areas in the north and northwestern India; *A. crinitus* and *A. manihot* (*tetraphyllus* and *pungens* types)

in tarai range and lower Himalayas; *A. manihot* (*tetraphyllus* types), *A. angulosus*, and *A. moschatus* in

Western and Eastern Ghats; and *A. crinitus* and *A. manihot* (mostly *pungens* types) in the northeastern region, depicting their broad range of distribution in different phytogeographical regions of the country, Intra as well as inter specific variations do exist in different phyto-geographical areas.

2.2.3 Growth and Development

Okra is mainly propagated by seeds and has duration of 90-100 days. It is generally an annual plant. Its stem is robust, erect, and variable in branching and varying from 0.4 to 0.5 metres in height. Leaves are alternate and usually palmately five lobed, whereas the flower is auxillary and solitary. The botanical features of various plant parts are detailed in Annexure –I. Okra plants are characterized by indeterminate growth. Flowering is continuous but highly dependent upon

biotic and abiotic stress. The plant usually bears its first flower one or two months after sowing. The fruit is a capsule and grows quickly after flowering. The greatest increase in fruit length, height and diameter occurs during 4^{th} to 6^{th} day after pollination. It is at this stage that fruit is most often plucked.

2.2.4 Scientific Classification of Okra

Name; Okra8

Kingdom: plantae

Division; magnoliophyta

Class; magnoliopsidia

Order; malvales

Family; malvaceae

Genus; *Abelmoschus*

Species; *esculentus*

2.3 Description of Sugar Cane

Sugarcane refer to any of six to 37 species (depending on which taxonomic system is used) of tall perennial grasses of the genus *Saccharum* (family poaceae, tribe Andropogoneae), Native to warm temperate to tropical regions of Asia, they have stout, jointed, fibrous stalks that are rich in sugar and measure two to six meters (6 to 19) tall. All sugarcane species interbreed, and the major commercial cultivars are complex hybrids.

Sugarcane is an important industrial crop of tropical and subtropical regions and is cultivated on close to 20 million hectares in more than 90 countries (http://apps.fao.org). Sugarcane belongs to the grass family (poaceae), an economically important seed plant family that includes maize, Wheat, rice and sorghum as well as many forage crops. The main product of sugarcane is sucrose, which accumulates in the stalk internodes. Sucrose, extracted and purified in specialized mill factories, is used as Raw materials in human food industries or is fermented to produce ethanol, a low pollution fuel. Ethanol is produced on a large scale by the Brazilian sugar industry (vettore *et al.*, 2003).

Sugarcane products include table sugar, falernum, molasses, rum, cachaca (the national spirit of Brazil)

Sugarcane is indigenous to tropical South Asia and Southeast Asia. Different species likely originated in different locations, with S. *barberi originating* in India, *S. edule* and *S. officinarum* coming from New Guinea. Crystallized sugar was reported 5,000 years ago in the Indus Valley Civilization, located in modern-day Pakistan and north India. Around the eighth century A.D, Arab traders introduced sugar from South Asia to the other parts of the Abbasid Caliphate in Mediterranean, Mesopotamia, Egypt, North Africa and Andalausia. By the 10^{th} century, sources state, there was no village in Mesopyamia that did not grow sugar cane. It was among the early crops brought to the Americans by the Augalusianas from their fields in the Canary Island and the Portuguese. Boiling houses in the 17^{th} through 19^{th} centuries converted sugarcane juice into raw sugar. These houses were attached to sugar plantations in the western colonies. Slaves often ran the boiling process under very poor condition. Made of cut stone, rectangular boxes of bricks or stone served as furnace, with an opening at the bottom to stoke the first and remove ashes. At the top of each of the furnace were up to seven copper kettles or boilers, each one smaller and hotter than the previous one. The cane juice was then heated and lime added to remove impurities. The juice was skimmed, and then channeled to smaller kettles. The last kettle was where the cane juice became the syrup. The next step was a cooling through, where the sugar crystals hardened around a sticky core of molasses, this raw sugar was then shoveled from cooling trough into hogshead (wooden barrels), and from there into the cutting house (Yamada *et al.*,1998).

Figure 2.2 Pictorial view of Sugarcane Plantation

Sugarcane is extensively grown in the Caribbean. Christopher Columbus first brought it during his second voyage to the Americans, initially to the island of Hispaniola (modern day of Haiti

and the Dominican Republic). In colonial time's sugar formed one side of the triangular trade of new world raw materials in European manufacturers and African slaves. France found its sugarcane island so valuable, it effectively traded it portion of Canada, famously dubbed "a few acres of snow", to Britain for their return of Guadeloupe, Martinique and St. Lucia at the end of the seven years War. The Dutch similarly kept Suriname, a sugar colony in South America, instead of seeking the return of the New Netherlands (New York), Cuban sugarcane produced sugar that received price supports from and a guaranteed market in the USSR; the dissolution of the country that forced the closure of most Cuba's sugar industry. Sugarcane remains an important part of the economy of Guyana, Belize, Barbados and Haiti, along with the Dominician Republic, Guadeloupe, Jamaica and other islands. Sugarcane production greatly influenced many tropical Pacific Islands, including Okinawa and most particularly Hawai'i and Fiji, in this island, sugarcane came to dominate the economic and political landscape after the arrival of powerful Europeans and American agricultural businesses, which promoted immigration of workers from various Asian countries to tend and harvest the crop. Sugar was the dominant factor in diversifying the islands' ethnic make-up, profoundly affecting their politics and society. Brazil is the biggest grower of sugarcane, which goes for sugar and ethanol for gasoline-ethanol blends (gasohol) for transportation fuel, in India, sugarcane is sold as jaggery and also refined into sugar, primarily for consumption in tea and sweets, and for the production of alcoholic beverages. Today, sugarcane is grown in over 110 countries. In 2009, an estimated 1,683 million metric tones were produced worldwide

2.3.1 Cultivation of Sugarcane

Sugar cultivation requires a tropical or temperate climate, with a minimum of 60 centimetres (24 in) of annual moisture. It is one of the most efficient photosynthesizer in the plant kingdom. It is a C_4 plant, able to convert up to one percent of incident solar energy into biomes. In prime growing regions such as India, Pakistan, Peru, Brazil, Boliva, Colombia, Australia, and Hawaii, sugarcane can produce 20 lb (9kg) for each square meter exposed to the sun. Although sugarcanes produce seeds, modern stem cutting has become the most common reproduction method. Each cutting must contain at least one bud, and the cuttings are sometimes hand-planted. In more technologically advanced countries like the United States and Australia, billet planting is

common. Billets harvested from a mechanical harvester are planted by a machine which opens and recloses the ground. Once planted, a stand can be harvested several times; after each harvest, the cane sends up new stalks, called rations. Successive harvests gives decreasing yields, eventually justifying replanting. Two to 10 harvests are usually made depending on the type of culture. In a country with a mechanical agriculture looking for a high production of large fields like in North America, sugarcane are replanted after 2 or 3 harvests to avoid a lowering in yields. In countries with a more traditional type of agriculture with smaller fields and hand harvesting like in the French island sugarcane are often harvested up to 10 years before replanting. (http://www.life.illinois.edu/govindjee/paper/gov.html#58)

2.3.2 Cane Ethanol

Ethanol is generally available as a byproduct of sugar production. It can be used as biofuel alternatinmg to gasoline, and is widely used in cars in Brazil.
It is alternative gasoline, and may become the product of sugercane processing, rather than suger.
A textbook on renewable energy describe energy transformation:

At present, 75 tons of raw sugercane are produced annually per hectare in brazil. The cane delivered to the processing plant is called burned and croped (b&c), and presents 77 % of the mass of the raw cane. The reason for reduction is that the stalks are seperated from the leaves (which are burned and whose ashes are left in field as fertilizer), and from the roots that remain in the ground to sprout for the next crop. Average cane production is, therefore, 58 tons of b&c per heatare per year.

Each ton of b&c yield 740 kg of juice (135 kg of sucrose and 605 kg of water) and 260 kg of moist bagasse (130 kg of dry bagasse). Since the higher heating value of sucrose is 16.5 Mj/kg, and that of the bagasse is 19.2 MJ/kg, the total heating value of a ton of b&c 4.7 GJ of which 2.2 GJ come from the sucrose and 2.5 from the bagasse.

per hectare per year, the biomass produced corresponds to 0.27 TJ. This is equivelent to 0.86 W per square meter. Assuming an average isolation of 225 W per square meter, the photosynthetic efficiency of suger cane is 0.38 %.

The 135 kg of sucrose found in 1 tone of b&c are transcformed into 70 liters of ethanolwith a combustion energy of 1.7 G.J. the practical sucrose-ethanol conversion efficiency is, therefore , 76 % (compare with the theoretical 97 %).One hectare of suger cane yields 4.000 litres of ethanol per (without any additional energy input, because the bagasse produced exceeds the amount needed to distill the final product). This, however, does not include the energy used in trilling, transportation, and so on. Thus the solar energy-to-ethanol conversion efficiency is 0.13 .% (Da Rosa, A).

2.3.3 Scientific Classification of Sugarcane

Kingdom; Plantae

(unranked): Monocots

(unranked): Commelinids

Order: Poales

Family; Poacae

Subfamily: Panicoideae

Tribe :Andropogoneae

Genus: Saccharum

2.4 Sugar Cane Clarification Process

Sugar is a term for a class of edible carbonhydrates namely sucrose, fructose and lactose characterised by sweet flavour. In food sugar almost exclusively refers to as sucrose which primary comes from sugarcane and sugar beet. Other sugar are used in industrial food preparation but are usually known by specific names glucose, fructose, or fruit sugar, high fruit sugar or corn sugar syrup ("iupac Gold book sugae" Goldbook.iupac.org). Three types of sugar that are currently manufactured include raw sugar, refinery sugar, and crystal sugar. For the production of crystal sugar, sulfitation is currently the most widely used process to clarify cane juice. It consists of So_2 (sulphur dioxide) absorption by the juice. Another method to clarify

typically not used in the manufacture of raw or refinery sugar due to their complexity and expence. Sillical microgels are used in water purification and water flow process, A previous patent discloses a process to clarify water streams containing biosolids resulting from processing food and organic residues, which comprises contact of the stream with an anionic colloid, which may be a silicate microgel, and an organic polymer to flocculate the biosolids. During the manufacture of the raw sugar and refinery sugar the removal of dextran, starch amd sources of colour is difficult and costly. Therefore there is a desire to have an enhanced clarification process for the manufacture of raw sugar and refinery sugar which removes excess of dextran and starch while minimizing colour formation and which is simple, efficient and economical. The process of the present invention resolves this problem, the invention comprises of sugarcane clarification process comprising atleast the steps of addition of lime, addition of anionic inorganic colloids and separation of the resulting sugar cane juice. More specifically the invention comprises an improved process to clarify sugarcane juice comprising the addition of an anionic inorganic colloid, according to the following steps: a) heating of the raw cane juice to be clarified; b adding sourcee lime; c) adding an anionic inorganic coloid; d) decanting precipitates formed to yield a further supernatant containing sugar cane juice. the process optionally further comprises a) heating of supernatant from d) above: and b) decanting any precipitate formed to yield a further supernatant containing sugar cane juice. in particular, the present invention provides an improved process for clarifying sugar cane juice using wherein the improvement comprises addition of an anionic inorganic colloid. The preffered anionic inorganic colloid is sillicate microgel. This process is for the manufacture of raw sugar or refinery sugar and does not use sulfitation or carbonation. The present invention further comprisess a process wherein step b) through d) listed above are repeated in subsequent stages in multi-statge decantation process. During step a), raw sugarcane juice is heated to a temperature of 65 °C and about 115 °C, preferably between 80 °C and about 115 °C. Juice heating has the purpose of facilitating downstream process by speeding up chemical reaction and improving the coaguilation and sedimentation of coloids and other non sugars. The liming of step b) is the addition of a source of lime (CaO) to the raw cane juice. Any suitable source of lime can be employed but lime milky ($Ca(OH)_2$) or calcium saccharate are preffered. The addition of the source of lime raises the pH

solids content of the juice, this addition has the purpose of eliminating juice colourants, neutralizing organic acids, and forming calcium phosphate precipitate, which upon sedimentation carries with it the impuritties present in the liqiud between b) and c) it is particulaly advantageous that a time interval of 0.5 and 10 minutes is optionally observed. In step c) of the process of the present invention an anionic inorganic colloid is addded, such colloid is useful in the process of this invention include sillica-based anionic inorganic colloids and mixtures therefore silica- based anionic inorganic colloids include, but are not limited to colloidal silica, aluminium-modifield colloidal silica, polysilicate microgel, polyaluminosilicate microgels, polysilic acids and polysilicic acid microgels and mixtures. For those colloids containg the aluminium, the aluminium can be on the surface and or in the interior of the particles. The anionic inorganic colloids used in the invention can be in the form of a colloidal sillica having an S valus greater than 70 %, generally greater than 75 % and containing about 2 to 60 % by weight of SiO_2, preferably about 4 to 30 % by weight of SiO_2. The process of the present invention results in a high removal of non sugars such as starches, proteins, solids in suspension and dissolved solids. The protein and starch are suprisingly reduced, typically to less than about 200 microgarms/g (ppm) in the clarified juice. The process of the present invention thus yield purer product. Preferably the process of the present invention is used in the manufacture of raw sugar. The lower quantity of impurities is very desirable and benefits the whole operation since it reduces the overall volume to processed throughout the system. Therefore, there is less scaling in the heating equiptment, especially the evaporator, which then does not need to be cleaned frequently. This reduces maintianance and steam energy costs and increase safety for employees who conduct such claening operations at the industrial facility. For all of the above reasons, the process provides increased efficiency overall, fewer impurities are processed under same installed capacity, thus increasing sugar production. In addition to the above advantages, the process of the present invention improves the reduction of juice turbidity, reduction of organic colloid (e.g starch), and improved coagulation and floculation. In particular, the time to form flakes is reduced and the size of the flakes is reduced, thus sedimentation time is reduced overall. A further advantage is the optional elimination of the addition of floculating agents. The fact that

flakes is reduced and the size of the flakes is reduced, thus sedimentation time is reduced overall. A further advantage is the optional elimination of the addition of floculating agents. The fact that the new process generates precipitates/ sediments with easier filtering characteristics than the traditionaal processes is exceptionally advantageous to sugar/ alcohol industry. The sediment resulting from traditional process is difficult to filter, requiring the installation of the pressing filters, representing a large financial investment and a more complicated process. The process of the present invention generates precipitates/ sediment which does not require the installation of the press filters, since vaccum rotating filters can be used. Thus, the process of the invention is a faster and safer process, results in a significant increase in the yield, generates superior quality and avoids the problems in conventional process. It is useful to clarify sugar cane juice more efficiently. As the expert in the art will realise , numerous modificationas and variation of the scope of the invention are possible in the light of the above teachings (http://www2.dupont.com).

2.5 Sucrose Inversion

This is the breaking down of disaccharide molecule (sucrose) into two monosaccharide's (fructose and glucose)

$$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6 \qquad 2.1$$

The reaction is always avoided in the sugar refining process in order to prevent too much of much of dust in the refined sugar .The inversion process can occur from melting unit up to the centrifugation unit if proper measures are not taken.

2.5.1 Causes of Inversion

Low pH: This gives rise to high percentage of acid in the melt

High Temperature: If the temperature exceeds the normal temperature specification for each unit inversion can occur.

Microbial Action: Any moment there is accumulation of the process materials or there are hindrances in the flow of the process materials, the bacteria's called saccharomycetes begins to

react on the materials thereby causing inversion which give rise to non uniform grains and dusts in the final product

2.6 Definition of parameters

- **Brix:** This refers to the percentage of the total dissolve solid in a mixture.
- **Poll:** This refers to percentage of total dissolved sucrose in a mixture.
- **Turbidity:** This refers to quantitative measure of sucrose clarity resulting from suspended matter that scatter or interfere with the passage of light through the sucrose.
- **Colour:** This refer to the sucrose condition resulting from the presence of colloidal materials
- **pH:** This refers to the measurement of the degree of acidity or the basicity in sucrose sample.

Chapter Three

3.0 MATERIALS AND METHOD (METHODOLOGY)

This chapter discusses the materials, procedures and the analysis carried out on the extracted juice samples and the clarified juice samples.

3.1 Materials

Moringa seed powder was obtained in Bida Niger state

Fresh okra bark was obtained in Bida Niger state

Sugar cane (BD – 99- 001) was obtained in Badegi Niger state

Table: 3.1.1 Equipments and Functions

S/N	NAME OF EQUIPTMENTS	MANUFACTURER	MODEL NUMBER	FUNCTIONS
1	Polarimeter	Shenzhen citysunziza precision Co. Ltd	WXG-4	Used to determine the poll of sucrose juice
2	Weighing Balance	Citizen U.S.A	MP300	Used to determine the weight of samples
3	Sucrose scan	Henah=hi tech. instrument Co .Ltd. China.	SC-5	Used to determine to absorbance of sucrose juice
84	Refractometer	Henah=hi tech. instrument Co .Ltd. China.	HSR-500	Used to determine the brix of the juice

5	Cane Crusher	Shanghai Neograw machinery Co. Ltd.	G-6000	Used to crush to cane sticks.
6	Hot plate magnetic stirrer	Shenzhen citysunziza precision Co. Ltd	MS 300/400	Used to stir the juice solution uniformly.
8	pH meter	Extech U.S.A	0741 EIL	Used to determine the pH of the sucrose juice,
9	Mechanical press	Fabricated	------	Used for the extraction of juice from the crushed cane.
10	Aluminum vessel	Fabricated	------	Used as reactor for the clarification process
11	Heating source	--------	------	Used to supply heat during boiling
12	Thermometer	Pyrex England		Used for temperature measurement.

3.2 Experimental Procedure

3.2.1 Preparation of clarifying aids

The moringa seeds were dried for three (3) days and crushed into powder form to increase the surface area, four solutions of different concentrations were prepared by dissolving 100 g of the powder into 100 ml of water for initial concentration of 1 g/ml,75 g of the powder was dissolved

into 100 ml of water for second concentration of 0.75 g/ml, 50 g of the powder was dissolve into 100 ml of water for the third concentration of 0.5 g/ml and the 25 g of powder was dissolved into 100 ml of water for fourth concentration of 0.25 g/ml. The solution was well stirred with the help of hot plate magnetic stirrer.

The Fresh okra plant was harvested, the bark of okra was removed and It was rinsed with clean water, 100 g, 75 g, 50 g, and 25 g of the okra bark was weighed, each was poured into 100 ml of water and it was allowed to soften for 20 minutes after which each of the solution was scrubbed with bare hands in other to extract the mucilaginous fluid out. The resulted solutions were used as clarifying aid.

3.2.2 Crushing

In other to extract the juice conveniently there was need to increase the surface area of the cane, the mechanical crusher was power on the cane sticks were fed into the feed roller and were crushed into soft and press able solids, the process was repeated to crush 50 sticks of the cane.

3.2.2 Extraction

The mechanical extractor consists of piston, jack, vessel which contain numerous pores through which the extracted juice pass through and bolts for tighten or coupling the extractor. Some quantities of the crushed cane were fed into the mechanical press vessel to it maximum capacity, the piston was suppressed on the crushed cane in the vessel and it was well tighten with bolts, the jack was gradually adjusted to raised the vessel against the suppressed piston, which in turn lead to increase in the pressure and reduction in volume, the process lead to extraction of juice this continues until no juice was found in the fibrous residue called bagasse, after the juice was extracted the piston was detached and the bagasse was discharged, this process was repeated until desired quantity of the juice was obtained.

3.2.4 Clarification

The most important unit operation in sugar processing is clarification which involves the process of removing of impurities such as mud and press cake (scum) in the raw juice before the final evaporation and crystallization process. The extracted juice was allowed to settle for an hour such that the larger particles present in the juice can settle at the bottom of the can, two vessels were filled with three (3) litres of the raw juice each and the remaining juice was returned to refrigerator In order to prevent sucrose inversion. The initial pH, Brix and other parameters of the raw juice were analyzed and recorded, the juice solutions were boiled simultaneously at a varied temperature between 75 °C - 85 °C equivalent to 180 °F – 190 °F , 30 ml of moringa solution and okra solution was added to each of the juice samples on boiling at thirty minutes (30mins) interval, the juice solutions were constantly stirred as the scum began to float on the surface of the juice solution the scum was skimmed off to allow more of the scum to come up the process continued for 30 minutes and a sample was taken for analysis at every 30 minutes interval. The solutions were cleared after 83 minutes and 90 minutes of boiling and clarification with reduction in the initial volume of the feed (juice), the clarified juice was filtered with whathman filter paper with the addition of lead acetate as filter aid. The same procedures were repeated for the 0.75 g/ml, 0.5 g/ml and 0.25 g/ml of moringa and okra with variation in time taking.

3.3 Determination of Colour

30 ml of raw juice or clarified juice was weighed and put into 250 ml of clean beaker, marked up with distilled water on a balance to a weight of 100 g which was dissolved and mix thoroughly on hot plate magnetic stirrer for 5 minutes, the diluted brix was determined by pouring little quantity of the mixture on the refractometer sensor, the solution was filter in a vacuum filter, 1cm of the solution was poured into the cuvette which was inserted into the sucrose scan for determination of the absorbance, the temperature was also measured and recorded. The colour was determined as follow

$$\frac{Absorbance\ (filtered\ sample) \times 10000}{(cell\ path\ length \times (diluted\ brix + temperature\ correction\ factor)} \quad 3.1$$

3.4 Determination of Brix

An empty clean beaker was weighed, 30 ml of the test sample was measured and dissolved with distilled water on a weighing balance to attain a weight of 100 g which was mix on a magnetic stirrer for 5minutes, and little of the sample solution was poured on the refractometer sensor to measure the diluted brix. The final brix was obtained as shown bellow

Diluted brix × 2, It is measure in$°Bx$. 3.2

3.5 Determination of Turbidity

30 ml of the sample was measured and poured into a weighed empty beaker which was dissolved in a distilled water, marked up with distilled water to attained a weight of 100 g, The solution was mix on a hot plate magnetic stirrer for 5 minutes, the diluted brix was measured and recorded, the sample was divided into two portions with one portion filter and the other unfiltered there absorbance were then measured. The turbidity is measured or calculated as follow:

$$\frac{Absorbance(filtered\ sample) - Absorbance\ (unfiltered\ sample) \times 10000}{(Cell\ path\ lengt \times (diluted\ brix\ factor + temperature\ correction\ factor)} \quad 3.3$$

3.6 Determination of Purity

30 ml of sample and 30ml of water were weighed and dissolved in an empty weighed beaker which was mix thoroughly on a hot plate magnetic stirrer, the diluted brix was measured and the solution was top with distilled water to the value of the diluted brix, the brix was measured again without multiplication by 2, the solution was filtered through whathman filter paper after adding sufficient clarifying agent (lead acetate) and filter aid (celite). Little quantity was pour into polarimeter tube which was inserted into the polarizer to measure the poll, the purity is calculated as follow:

$$\frac{(Poll \times 100)}{\text{Original Brix}} \qquad 3.4$$

3.7 Determination of pH

30ml of each sample was weighed, put into a clean beaker, the brix was measured and distilled water was added to the solution to top it to the value of the brix measured. The sample solution was cooled in a water bath to attain room temperature before the pH measuring tube was inserted into the sample for pH measurement.

Chapter four

4.0 RESULTS AND DISCUSSION

4.1 Results.

Table 4.1 shows the proximate analysis on raw sugar juice before clarification in comparison to the ICUMSA Standards 2010.

Table 4.1 Proximate analysis on raw sugarcane juice before clarification

Material	Brix °B	Poll	pH	Purity %	Turbidity i.u	Colour i.u
Raw sugarcane juice	23	10	5.9	43.5	480	540
ICUMSA Standards	>12	>5	5.0-6.2	10-45	>400	300-1000

Table 4.2 shows the effect of change in concentration of Okra bark solution on sugar juice during clarification.

Table 4.2 Analysis on Sugar Cane Juice after Clarification with Okra Bark Solution

S/N	Concentration g/ml	Brix °*B*	pH	Poll	Purity %	Turbidity i.u	Colour i.u	Resident time (min)
1	0.25	63	6.84	40	63.4	180	221	193
2	0.50	65	7.01	46	70.8	168	188	152
3	0.75	67	7.11	51	76.1	149	176	123
4	1.00	67	7.16	54	80.05	111	148	105
ICUMSA STANDARD, 2010	----	64-67	6.9-7.2	>25	60-99	<400	<400	

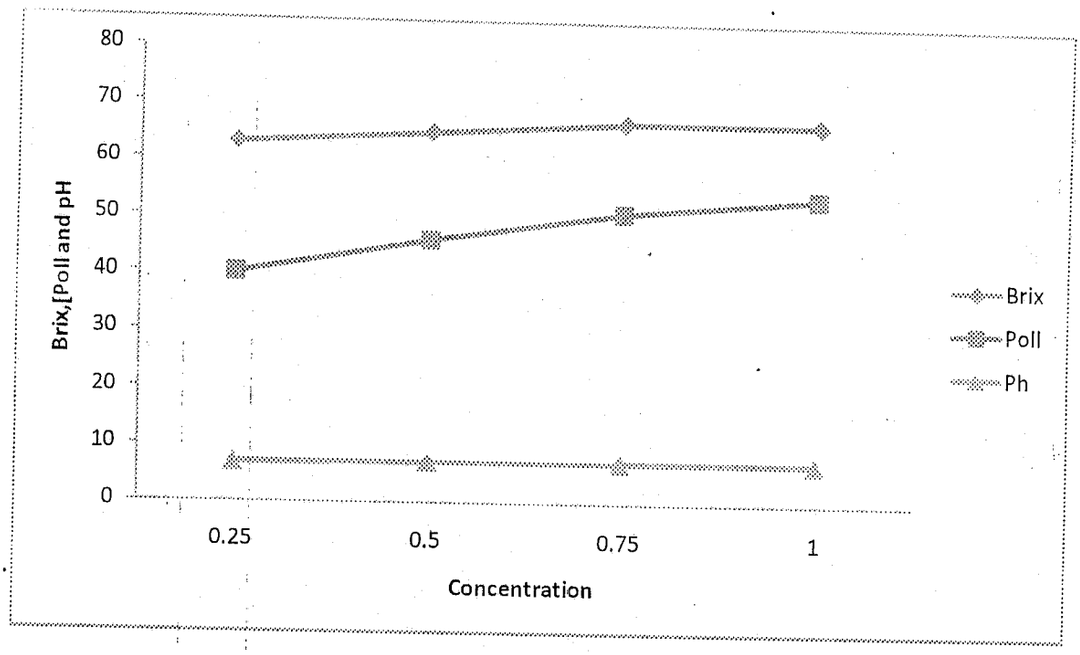

Figure 4.1 Graph of Brix, poll and pH against Concentration

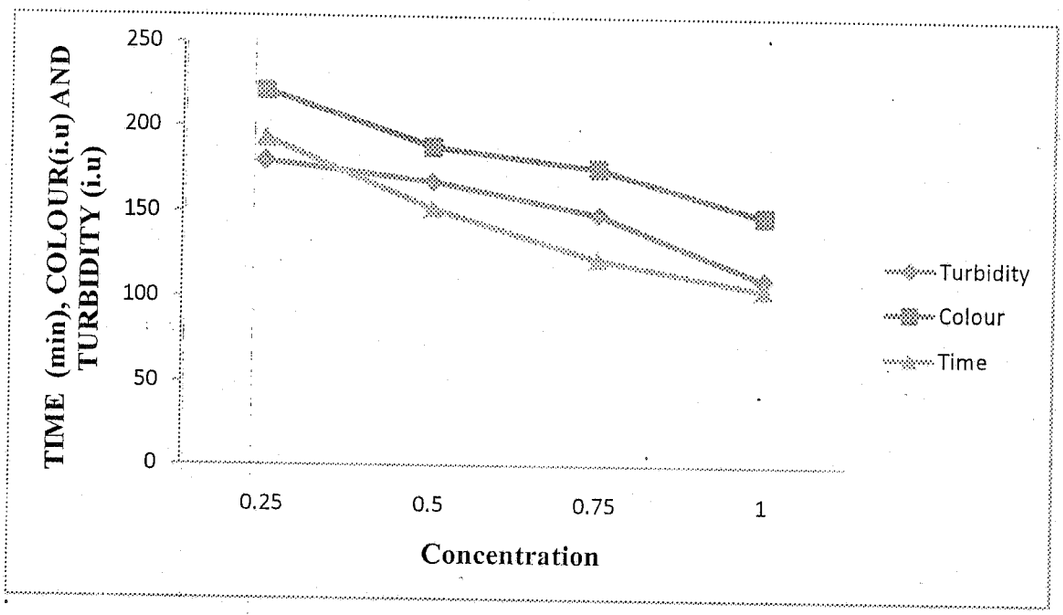

Figure 4.2 Graph of Turbidity, Colour and Time against Concentration

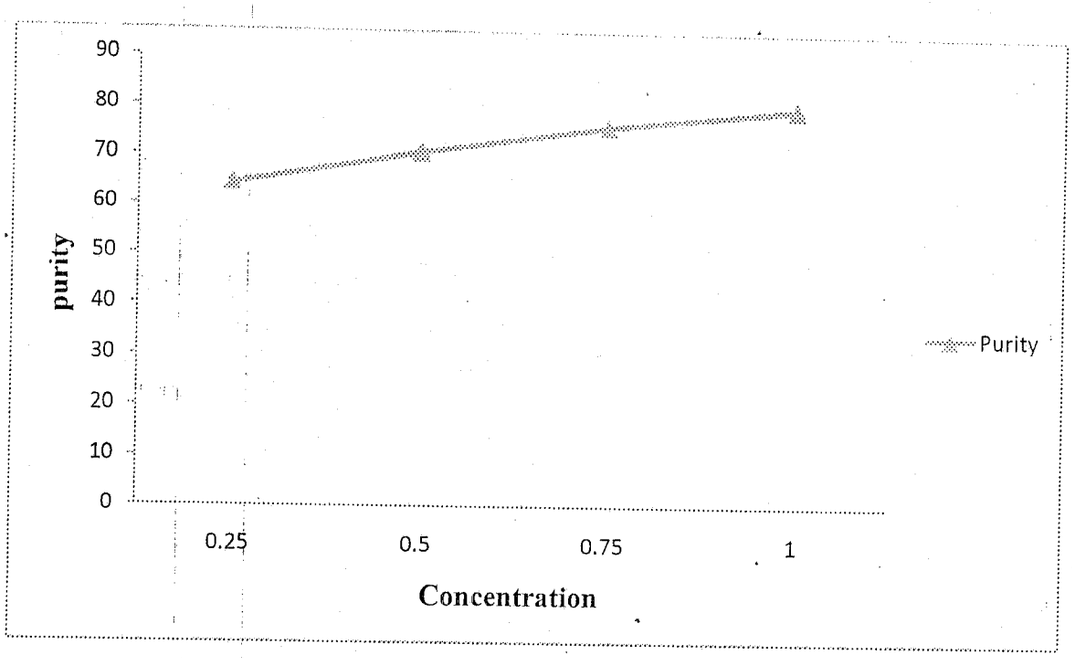

Figure 4.3 Graph of Purity against Concentration.

Table 4.3 shows the effect of change in concentration of Moringa seed powder solution on sugar juice during clarification.

Table 4.3 Sugar Cane Juice analysis after Clarification using Moringa Powder Solution

S/N	Concentration g/ml	Brix °*B*	pH	Poll	Purity %	Turbidity i.u	Colour i.u	Resident time (min)
1	0.25	64	6.89	44	68.75	112	186	145
2	0.50	68	6.97	51	75.00	104	164	125
3	0.75	70	7.01	57	81.43	95	145	106
4	1.00	72	7.10	63	87.50	83	120	96
ICUMSA STANDARD, 2010	--	64-69	6.9-7.2	>25	60-99	<400	<400	

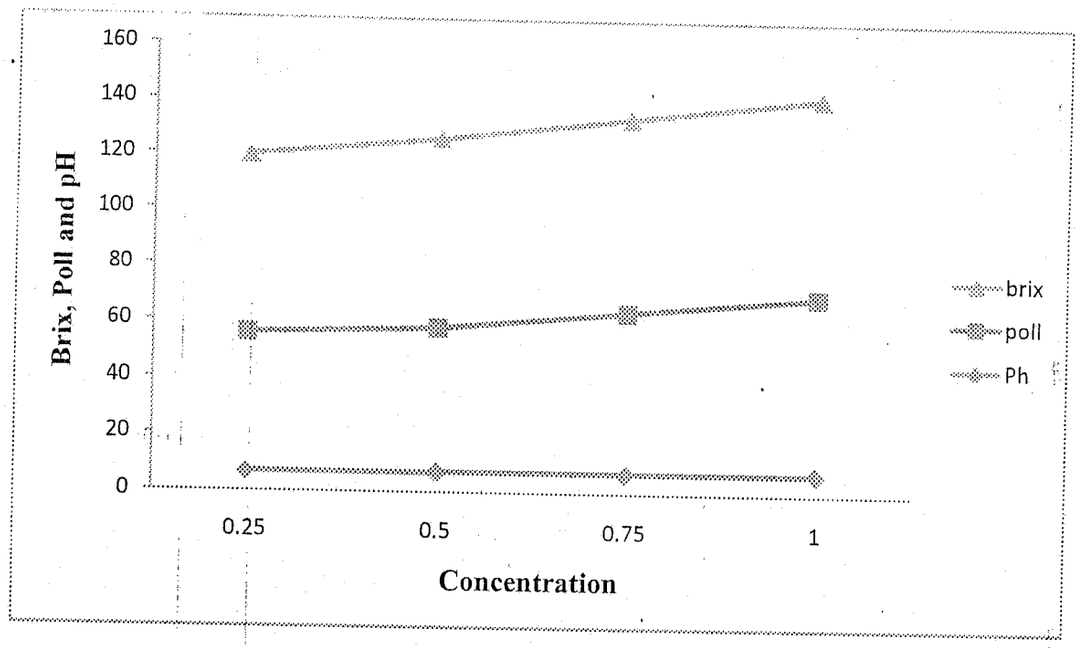

Figure 4.4 Graph of Brix, Poll and pH against Concentration,

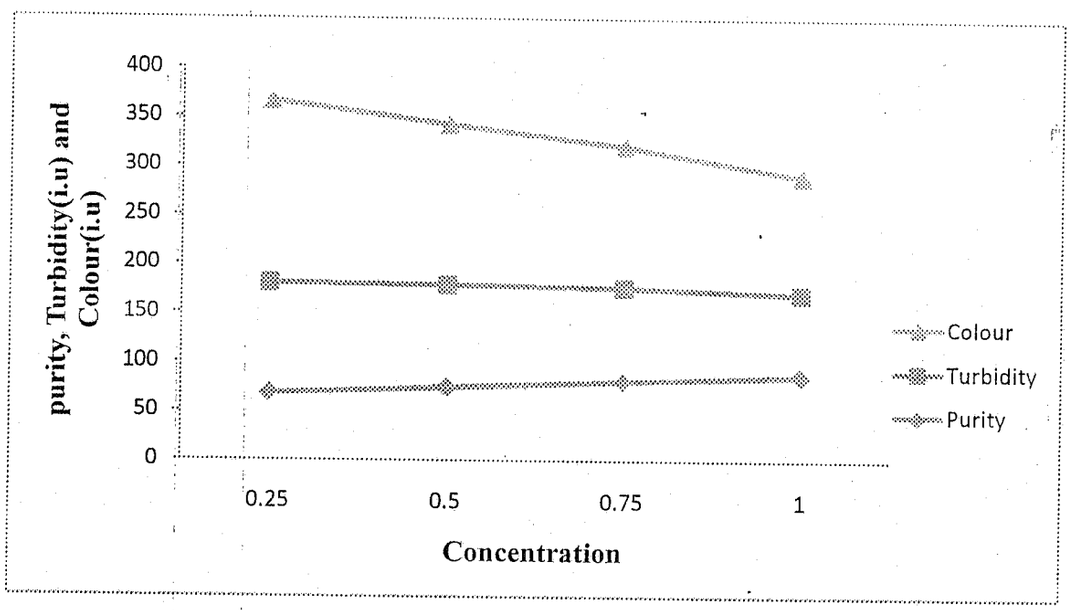

Figure 4.5 Graph of Colour, Turbidity and Purity against Concentration

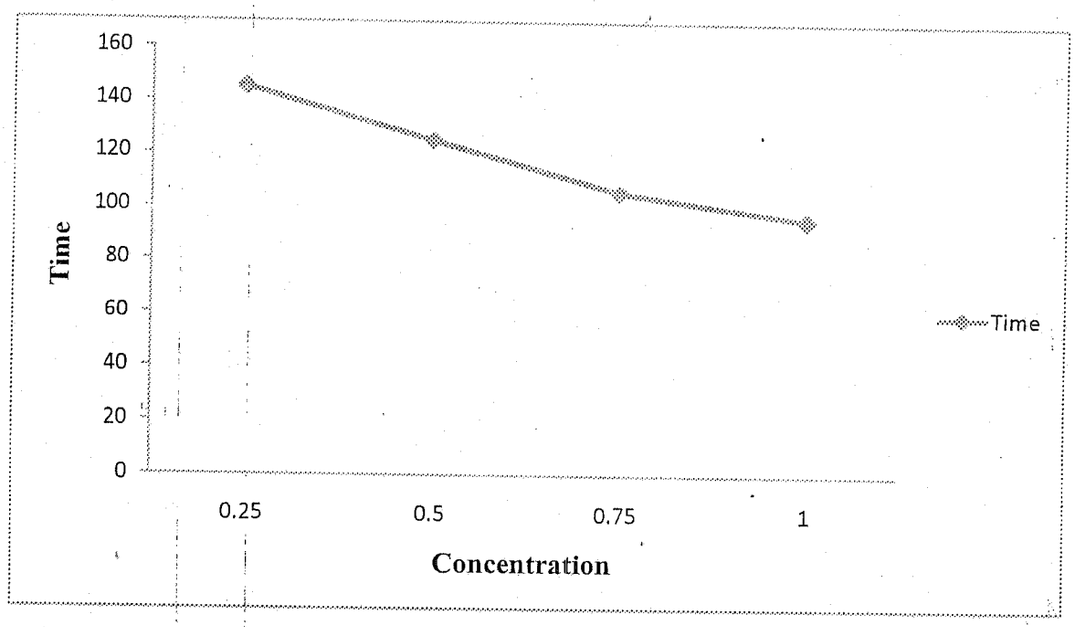

Figure 4.6 Graph of Time against Concentration

4.2 Discussion of result

The proximate analysis results depicted in Table 4.2 shows the raw sugar cane juice to have a Brix of 23 °*B*, Poll of 10, pH of 5.9, Purity 0f 43 %, Turbidity of 480 and the Colour to be 540 i.u that all conformed to the ICUMSA standard 2010.

The result depicted in Table 4.3 above shows that the values of the Brix obtained were 63, 65, 67 and 67 °*B*, at concentration 0.25 g/ml the Brix obtained was below the ICUMSA standards of 2010 (64-69) while change in concentration between 0.75 g/ml and 1.00 g/ml has no effect on the Brix as it remains 67 °*B*.

The pH values obtained were 6.84, 7.01, 7.11 and 7.16 respectively which shows that at concentration 0.25 g/ml, the value was a bit below the standard which could be as a result of fluctuation in the values while taking the readings from the pH meter while others from 0.50 to 1.00 g/ml conformed to the standard.

The values of the poll obtained were 40, 46, 51 and 56 with non –uniform intervals. The values of Turbidity obtained were 180, 168, 149 and 111 respectively which decreases as concentration increases. The values of Colour obtained were 221, 188,176, and 148 i.u respectively which show a slight decolourisation between 0.25 g/ml and 0.50 g/ml while at 0.50 g/ml, 0.75 g/ml and 1.00 g/ml shows a higher percentage of decolourization. The time taken for the clarification

process ranges between 105 minutes to 193 minutes which decreases as the concentration increases.

In summary, from the graphs of Figures 4.1 to Figure 4.3 shows that parameters such as Brix, Poll, pH, Purity increases as the concentration increases with the pH values having the closest intervals while parameter such as colour, turbidity and resident time reduces as the concentration increases.

The result depicted in Table 4.4 shows that the value of Brix obtained were 64, 68, 72 and 78 $^{\circ}B$ which all conformed to standard with a non uniform interval at the various concentrations.

The pH values obtained were 6.89, 6.97, 7.01 and 7.10 respectively while at concentration 0.25 g/ml was 0.1 below the standard this was as result of error due to parallax or fluctuation in the values, other values at various concentration conformed to the standard with non-uniform

The values obtained for poll were 40, 46, 51 and 54 respectively which revealed significant changes of more than 50 % between the Poll of raw juice and the clarified juice. The value of Purity obtained were 68.7, 75.00, 81.00 and 87.50 % respectively which all conformed with the ICUMSA standards , The value of turbidity obtained were 83, 94, 104 and 112 respectively which decreases as concentration increases. The values of Colour obtained were 120,145, 168 and 186 which revealed increase in declourisation effect as concentration increases, with a reduction in colour as concentration increases. The resident time was between 96 and 145 minutes.

Comparing Table 4.1 with Table 4.3 it shows that there was a significant change in all the parameters between the proximate analysis and the results obtained after clarification.

In summary, the graphs obtained in Figure 4.4 to 4.6 shows that the values obtained in all the parameters did not vary uniformly as the concentration vary uniformly. Parameters such as Brix, pH, Poll and Purity increases as the concentration increases while parameters such as colour, turbidity and resident time decreases as the concentration increases.

Chapter Five

5.0 CONCLUSION AND RECOMENDATION

5.1 Conclusion

The effect of Okra bark and Moringa seed powder was studied, the results obtained showed that the use of Okra bark and Moringa Oliefera seed powder as clarifying aid in Sugar Juice clarification process were both effective, with Moringa Oliefera seed powder being the most effective as it gave higher pH, Brix, Purity, lower values of Colour and Turbidity. Time of reaction is key factor in any chemical process or reaction, clarification of the raw Sugarcane juice with the use of Moringa Oliefera seed powder occurred in lesser time than the Okra Bark.

5.2 Recommendation

Further work on Effect of clarifying aids at lower concentration should be study. Effect of change in volume with time should be studied for future works. Decolourisation in sugar juice clarification using different varieties of canes should studied for future work.

Nigerian Sugar Council should consider the use of these clarifying aids in sugar juice clarification in sugar industries as it will reduce cost.

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Appendix I

Determination of purity

$$\text{Purity} = \frac{\text{Poll}}{\text{Original Brix}} \times 100$$

Raw Sugar Cane Juice

$$\text{Purity} = \frac{9.9}{23} \times 100 = 43.05$$

Clarified Juice with Okra Bark

At concentration 0.25 g/ml

$$\text{Purity} = \frac{40}{63} \times 100 = 63.3$$

At concentration 0.5 g/ml

$$\text{Purity} \quad \frac{46}{65} \times 100 = 70.76$$

At concentration 0.75 g/ml

$$\text{Purity} = \frac{51}{67} \times 100 = 76.1$$

At concentration 1.00g/ml

$$\text{Purity} = \frac{54}{67} \times 100 = 80.05$$

Clarified Juice with Moringa Powder

At concentration 0.25 g/ml

$$\text{Purity} = \frac{44}{64} \times 100 = 68.75$$

At concentration 0.50 g/ml

$$\text{Purity} = \frac{51}{68} \times 100 = 75$$

At concentration 0.75 g/ml

$$\text{Purity} = \frac{57}{70} \times 100 = 81.42$$

At concentration 1.00 g/ml

$$\text{Purity} = \frac{63}{72} \times 100 = 87.5$$

Appendix II

Results from Sucrose Scan for Raw Sugar Cane Juice

S/n	Absorbance unfiltered	Absorbance filtered
1	3.6743	1.7292

Results from Sucrose Scan for Clarified Juice with Okra Bark

S/N	Concentration g/ml	Absorbance Unfiltered	Absorbance Filtered
1	0.25	1.4423	0.6479
2	0.50	1.2826	0.6049
3	0.75	1.1685	0.5362
4	1.00	0.948	0.4011

Results from Sucrose Scan for Clarified Juice with Moringa Seed Powder

S/n	Concentration g/ml	Absorbance Unfiltered	Absorbance Filtered
1	0.25	1.0748	0.4042
2	0.50	0.9684	0.3764
3	0.75	0.8652	0.3472
4	1.00	0.7318	0.2986

Determination of Turbidity

Formula

$$\frac{\text{Absorbance}_{(\text{filtered sample})} \times 10000}{(\text{Cell path length} \times (\text{Diluted brix correction factor} + \text{Temperature correction factor}))}$$

Where

Cell path length = 1 cm cuvette

Diluted brix factor = 10

Temperature correction factor = 26 °C

Raw Cane Juice

$$\frac{1.7292 \times 10000}{(1 \times (10 + 26))} = 480.3333333$$

Clarified Cane Juice with Okra

At concentration 0.25g/ml

$$\frac{0.6479 \times 10000}{(1 \times (10 + 26))} = 179.972222$$

At concentration 0.50 g/ml

$$\frac{0.6049 \times 10000}{(1 \times (10 + 26))} = 168.0377778$$

At concentration 0.75 g/ml

$$\frac{0.5362 \times 10000}{(1 \times (10 + 26))} = 148.944444$$

At concentration 1.00 g/ml

$$\frac{0.4011 \times 10000}{(1 \times (10 + 26))} = 111.416667$$

Clarified Cane Juice with Moringa Seed Powder

At concentration 0.25 g/ml

$$\frac{0.4042 \times 10000}{(1 \times (10 + 26))} = 112.277778$$

At concentration 0.50 g/ml

$$\frac{0.3764 \times 10000}{(1 \times (10 + 26))} = 104.5555556$$

At concentration 0.75 g/ml

$$\frac{0.3427 \times 10000}{(1\times(10+26))} = 95.194444$$

At concentration 1.00 g/ml

$$\frac{0.2986 \times 10000}{(1\times(10+26))} = 82.944444$$

APPENDIX III

Determination of Colour

Formula

$$\frac{\text{Absorbance}_{(\text{unfiltered})} - \text{Absorbance}_{(\text{filtered})} \times 10000}{(\text{Cell path length} \times(\text{diluted brix factor} + \text{Temperature}))}$$

Where

Cell path length = 1cm of cuvette

Diluted brix factor = 10

Temperature factor = 26°C

Raw Cane Juice

$$\frac{(3.6743 - 1.7292) \times 10000}{(1 \times (10 + 26)} = 540.3055556$$

Clarified Juice with Okra

At concentration 0.25g/ml

$$\frac{(1.4423 - 0.6479) \times 10000}{(1 \times (10 + 26))} = 220.666667$$

At concentration 0.50g/ml

$$\frac{(1.2826 - 0.6049) \times 10000}{(1 \times (10 + 26))} = 188.25$$

At concentration 0.75g/ml

$$\frac{(1.1685 - 0.5362) \times 10000}{(1 \times (10 + 26))} = 174.88888889$$

At concentration 1.00g/ml

$$\frac{(0.9348 - 0.4011) \times 10000}{(1 \times (10 + 26))} = 148.25$$

Clarified Juice with Moringa Seed

At concentration 0.25g/ml

$$\frac{(1.0748 - 0.4042) \times 10000}{(1\times (10 + 26))} = 186.27778$$

At concentration 0.50g/ml

$$\frac{(0.9684 - 0.3764) \times 10000}{(1\times (10 + 26))} = 164.444444$$

At concentration 0.75g/ml

$$\frac{(0.8652 - 0.3427) \times 10000}{(1\times (10 + 26)} = 145.138889$$

At concentration 1.00g/ml

$$\frac{(0.7318 - 0.2986) \times 10000}{(1\times (10 + 26)} = 120.3333333$$