International Research Journal of Science and Technology *Vol. 1, Issue. 1 (2019) 21-30*

Available online at ttps://www.irjst.com/

International Research Journal of Science and Technology

ISSN:2707-3955

Clarifying Capacity of Eco-Friendly Nano Cao and Okra*(AbelmoschusEsculentus)* Extract on the Processing of Sugarcane Juice: A Review

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Published : 2019

Key Words

CaO nanoparticles, Clarification, Nanoparticles, Okramucilage, Papaya Leaf Extract, pH, Sugarcane

Abstract

Sugar cane is the raw material for sugar factories worldwide that amount to about 70% of both refined and raw sugars with only 30% of sugar from sugar beets. The cane or beets are crushed in the factory to extract juice using crushers and millers. The extracted juice is clarified to remove impurities and raise the pH. The important point of clarificant is to produce clear Juice with the lowest or null concentration of insoluble and soluble impurities to achieve maximum sugar yield Chemicals like calcium oxide, CO_2, SO_2 which are aided with polyamines, bentonite, separanAp 30 and hodag flocculants of high molecular weight polyacrylamide polymer are used to help improve color that is one of the most important parameters in raw sugar quality. The use of SO_2 is discouraged by many countries because of the risk involved with residue in sugar and its importation together with CaO which enforced additional funding on manufacturers. However, chemicals used for clarification are expensive and caused environmental problems in areas around the sugar industry. Therefore, nano and vegetative clarificants were considered as potential clarifier by producers of raw sugar and jaggery and even in water treatment. Also, nanotechnology was reported to have worked well in the treatment of waste water and in food industries to detect chemicals and remove biological substances.

Citation:Majur Mading Makur, Ramesh Duraisamy and Tewodros Birhanu. "Clarifying Capacity of Eco-Friendly Nano Cao and Okra (abelmoschusEsculentus) Extract on the Processing of Sugarcane Juice: A Review", International Research Journal of Science and Technology, 1(1), 21-30, 2019

1. Introduction

Sugarcane is one the world's most established industrial crops that is efficiently grown and harvested to produce both food and bio-energy [1]. The sugar cane is suitable in all types of weather conditions at approximately tropical to subtropical that makes it the best choice for sugar production other than sugar beets. Worldwide sugar cane harvesting covers an area around 23.8 million hectors and the production of sugar cane reached ~1740 million tons at the end of 2009 crushing season. While in 2015 and 2016, the harvest area was estimated to be 26.7 million hectors with production [2]. Worldwide about 30% of sugar is produced from sugar beet and 70% from sugarcane.

Raw Sugar from sugar beet is produced in about 50 countries worldwide; with this some are North America (United States and Canada), South America (Chile), North Africa (Morocco and Egypt), Iran, Spain and Pakistan of which the climate is suitable for both beets and cane. A world largest cane producer such as Brazil producing 672 million tons, likely India and China producing the sugar cane 285 and 116 million tons respectively followed by Thailand

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producing 96 million tons/year, Pakistan 58 million tons and Mexico 50 million tons of cane based on 2008 report of estimates [3].

African continental countries are contributing 5% of world sugar production, of which 30% of this comes from East Africa. Ethiopia is the largest sugarcane producers among sub-Saharan Africa are in South Africa, Mozambique, and Cameroon, whereas, South Africa is the leading producer followed by Sudan, Kenya and Swaziland [4].

Ethiopia has three state-owned sugar production sites which are Metahara, Wonji and Finchaa with development of ten new sugar projects as TanaBeles in the Amhara regional state; Welkayt in Tigray regional state; Kesem; and Tendaho in Afar region; and six factories in the South Omo zone. The three expanded factories (Metahara, Wonji and Finchaa) have a production capacity of 280000 tons of sugar per year in total; and by the end of 2012 or early 2013, the Tendaho estate was reported the annual output of 600000 tons of sugar (crushing capacity of 26000 tons of cane per day) that harvested from 64 000 ha. of cultivation land. With all the expansion and new construction of sugar plants, Ethiopia's aimed to increase its total sugar production beyond800000 tons per year. Two of Ethiopia's main goals of its sugar policy that are the stabilization of sugar supply and the control of consumer prices [5]. Recently the Government of Ethiopia has made investments to boost the country's sugar production because the government envisions the country become one of world's ten largest sugar producers by 2023. But in the meantime, sugar production continues climb to a record of 400,000 metric tons with import of 205,000 [6].

The need for sweeteners has led to high quest worldwide for sugar industries that are playing an important role in the worlds' economy though it is seasonal in nature and can operate only for 120 - 200 days in a year [7] because of the raw materials.

Sugarcane as a feedstock contains 53.6 % juice and 26.7 % fiber and approximately 9.8 % of sugars were present in juice, and mostly 9.6 % of sugar avail as sucrose. The fiber consists of 43.3 % of cellulose, 23.8 % of hemicelluloses, and 21.7 % lignin that reported [8]. Other components are water (75% - 85%), reducing sugar (0.3 - 3.0%), non-reducing sugar (10-21%) [9]. Sugarcane juice is rich in enzymes with many medicinal properties. The cane juice is a great preventive and healing source for sore throat, cold and flu and has low glycemic index which keeps the body healthy. Even the diabetic can enjoy this sweet drink without fear, because it lacks simple sugars. It hydrates the body quickly when exposed to prolong heat and physical activity. It is excellent substitutes for aerated drinks and cola; it refreshes and energizes the body immediately as it is rich in carbohydrates.

The Sucrose is extracted from sugar cane in industries by subjecting it to some physical destruction that led to emergences in the crystal sugar. The process is essentially a combination of separation and concentration. The first step is the separation of sucrose and the impurities in solution from the insoluble impurities called fiber. This is carried out in the milling or diffuser plant by the extraction process. The second step is the treatment of the extracted juice for the removal of some insoluble and dissolved impurities by the clarification method. A considerable amount of water present it is then removed by the evaporation process. Further processes which involve the separation of impurities by crystallization of the sucrose is involved and finally centrifuged to remove molasses from sugar [10].

The extracted juice by mills is dark-green juice which is acidic and turbid. The cane juice contains inorganic metals like Ca, P, Mg, Na, K, Si, S, Al and Cl ions. Organic materials which are non-sucrose such as fat, pectin's, organic acids and nitrogen containing compounds, etc. are also present. Milk of lime is mixed with cane juice to form insoluble lime salts, mostly calcium phosphate that can be removed by filtration [11]. The white sugar is processed by carbonation, sulphitation or activated carbon addition [12]. The process is done to improve the quality of sugar in term of purification is required. The process of all clarification can remove about 85 % of the turbidity, raise the pH, remove suspended solids, color improvement, gives a small ash, and reduces massecuite viscosity etc. [13]. The most common chemical used in sugar industry is calcium oxide which is added into sugar cane juice to raise the pH from 5.5 to 7.8 and remove non-sugars, SO_2 (Sulphitation)to reduce coloring matters, P_2O_5 (phosphitation) and CO_2 both helps in reacting with lime to form phosphates and carbonates [14]. Due to spiking prices, a carbonation process has been tested and compared with standard Sulphitation and defecation processes [15].

Clarification is carried out immediately after juice extraction to avoid enzymatic action that may lead to color formation in either of three processes like coagulation; flocculation and sedimentation [16]. The most common of all are flocculation and coagulation. Among coagulants used to improve clarification of sugar cane juices by employing polyamines, bentonite, separanAp 30 and hodag flocculants of high molecular weight polyacrylamide polymers [17]. Only a few ppm of these coagulants is required because they are highly active. High molecular weight polymers dissolve slowly; therefore require correct installation for the preparation of stock solutions [18].

Modern clarification methods was reported in literature for production of Jaggery and sugars (Fig.1) by using vegetative materials or plant clarificants especially Aloe vera, okra, flax seeds, fenugreek, moringa extracts, etc.These barks of vegetative materials are soaked in water and the resulting solution is added into the juice just before boiling [19]. This is done because conventional clarification needs more chemicals which represent high operating costs of buying consumable chemicals like CaO, sulfur crystals, polymer, phosphoric acid and anticolor, in addition to creating environmental problems [20].There are other studies reported on clarification and decolorization of sugar beet juice, apple juice, date juice, wine and cactus pear syrup that were treated with lime, activated carbon and bentonite [21].

Figure. Photograph of different kinds of Sugar

Figure1a. Photograph of different kinds ofJaggery.

Nanomaterial's (NMs) have gained attention in technological advancements due to their physical, chemical and biological properties. It is made up of three types based on the material such as Carbon nanomaterials, Inorganic nanomaterials like Au, Ag, TiO_2, CaO, ZnO NPs, organic nano materials, Composite-based nano materials (multiphase NPs) like hybrid nano fibers [22].Nanotechnology finds its use in water treatment and food industries in areas of production, processing and preservation processes but there are no literatures reported for the clarification of sugar cane juice either in smaller or in large scale productions. The nanoparticles are used to limit the use of chemicals in food as additives, agricultural chemical residues, contaminants, since new materials and ingredients to maintain or improve health or prevent lifestyle-related diseases, have increased rapidly [23]. Nanoparticles have received special focus in the treatment of waste water where it helps in the removal of chemical and biological substances like metals (Cadmium, copper, lead, mercury, nickel, zinc), nutrients (phosphate, ammonia, nitrate and nitrite), cyanide, organics, algae (cyanobacterial toxins) viruses, bacteria, parasites and antibiotics.

The synthetic polymers are normally used in the coagulation and flocculation on the treatment of waste water is in most cases derived from oil-based, non-renewable raw materials. Consequently, there has been a growing interest in replacing them with more sustainable natural bio-based alternatives. However, derivatives of cellulose, which is the most abundant biopolymer on earth, are still scarce[24]. The nanofiltration process is used as another method of treatment, occurs between ultrafiltration and reverse osmosis that is aimed to highly remove low molecular weights like minerals and salts from complex streams. Typical applications of nanofiltration includes deashing of dairy products, recovery of hydrolyzed proteins, concentration of sugars and purification of soluble dyes and pigments.The treatment of waste water by using nano ferric oxide and aluminum oxide are reported and the results show that, the value of sludge volume in treated wastewater by nano ferric oxide is higher than that is obtained with nano aluminum oxide [25].

2. Review of Literature

2.1 Sugar Producing Crops

Crops like sugar beet, sugarcane, maple trees, dates, fruits or starch-rich crops such as corn, sweet potatoes, wheat and sweet sorghums are sourcesof sugar. Sugarcane is a perennial grass which stores its carbohydrate reserves as sucrose (12-16%) that is used for consumption. Sugarcane is also a multipurpose crop whose components may be used to generate various energy carriers in addition to sugar production [26]. Global interest in sugarcane has significantly increased in recent years due to the large contribution of sugarcane to bioethanol and other alcohols, heat and electricity production [27]. Renewable energy sources are the world's fastest growing energy sources and will play a key role in meeting future energy demands. Biomasses are considered as the renewable energy sources with the highest potential in these respects, are both used in industrialized and developing countries worldwide [28].

Sugar beet (*Beta vulgaris*), together with sugarcane is one of the two most important sources of sugar (sucrose). Sugarcane can grow well in tropical and subtropical regions and sugar beet is grown almost in all over the world, but mostly in temperate regions [29]. Sugar beets have a high content of convertible carbohydrates which make them suitable for renewable energy production. Sugar beets are being considered for biofuel production because they have high sugar content and could potentially doubleethanol production per hectare compared to other feedstocks (corn, cellulose) [30]. In addition, the process to convert sugar beets to biofuel is known and relatively less complex than conversion of other potentially advanced biofuels such as corn stover to ethanol.Sweet sorghum commonly known as *Sorghum bicolor (L.)* is a member of *Andropogoneae* tribe of subgroup *Panicoideae* of the grass family, *Poaceae*. It has three subspecies such as *S.bicolor*, *S.bicolordrummondii*,and *S.bicolorverticilliflorum* [31].

It is also classified into five basic races like bicolor, guinea, caudatum, kafir, and durra which are widely cultivated in USA, Brazil, India, China, Mexico, Sudan, Argentina, and many other countries in Asia and Europe. Sweet sorghum was introduced in USA as Chinese Amber, orange, redtop, gooseneck and honey [32]. Sweet sorghum grains, stem sugars have co-products like bagasse, vinasse, steam, foam, and froth that may have multiple uses. The juice from sorghum stalk is used for making Jaggery and fuel generation; bagasse and grains can be used for biofuel processing to replace conventional fuels [33]. According to United States Department of Agriculture (USDA), the ratio of energy obtained during biofuel extraction from sweet sorghum is estimated at 1:8, which may further be improved using engineering and molecular breeding technologies [34].

2.2 Composition of Sugarcane Stalk

A matured sugarcane plant has two distinct sections of components, which contain various levels of sucrose and soluble (glucose, fructose, inorganic ions, organic acids, polysaccharides, proteins and amino acids) and insoluble (soil, proteins, starch, lipids and wax) non-sucrose components. The trash component is typically separated during harvesting due to the higher ratio of non-sucrose to sucrose components. Trash is typically used as a blanket over the cane fields in order to preserve moisture and to enrich the soil with organic carbon, nitrogen and phosphorus, thereby assisting the growth of the sugar cane plant [35]. The cane variety, maturity, the climatic conditions and the location in which the cane is grown well in are all factors which influence the changes in sucrose and impurity concentrations and colloidal juice particles. Sugarcane plant consists of stalk where most sugars are found based on the range with 12-16 % (Table 1) and leave tops that has fewer sugars. 65 -75 % water and 75 - 88 in juice [36, 37].

2.3 Processing of Sugar Production

Sucrose is everywhere known as common table sugar, and crystalline sucrose is primarily produced in sugar industries from Sugarcane *(Saccharumofficinarum)* and Sugar beet *(Beta vulgaris)*. Commercially sucrose has very high purity about 99.9% making it one of the purest organic substances produced in industrial scale. Industrial sugar production is the separation of sucrose from non-sugar contents and to obtain this product from sugarcane and sugar beet, complex isolation and purification process units are followed in industries as shown in (Figure.3). Accordingly, the cane is transported and goes through washing (to remove dirt, soil and other residues). Then it is cut into small pieces by employing revolving knives containing shredder. Cane stalk containing the sugar juice are ruptured but no juice is extracted at this stage.

After this preparation of the cane, the juice from the sugarcane can be extracted by using mills or diffusers and the fibrous cellulosic matters (called bagasse) get separated, then converted into sugar by further processing [38]. The next step is clarification of juice by addition of chemicals like lime (helps to raise the pH), SO_2 to employ the sulphitation for decolorization, caustic soda (NaOH) and soda ash (Na_2CO_3) to remove accumulated effects of evaporators and vacuum pans then rinse with hydrochloric acid. Other important clarificants are polyelectrolytes which coagulates impurities precipitated during defecation and clarification, lead sub Acetate though toxic helps to analyze sugar content, polyacrylamide, phosphoric acid and anticolor to undergo the clarification of juice. The objective of clarification is to remove maximum possible impurities or dirt and to improve the color and to obtain clean juice. The clarified juice is pumped into evaporators which are used to evaporate the excess water from sucrose as well as inorganic, organic and reducing sugars.

Table 1. The Composition (in %) of Sugarcane stalk and cane juice

Components	Composition in Cane Stalk	Components	Composition in Cane Stalk	Composition in Cane Juice	
Water	65- 75	Ash	0.4 - 0.8	Water	75 - 88
Total sugars	12- 16	Minerals (Fe, Ca, K, P, Na, S, Mg, Cl)	0.01 - 0.25	Sucrose	10 - 21
				Reducing sugars	0.3 - 3.0
Sucrose	11 - 14.5	Fats & Waxes	0.15 - 0.25		
				Organic Matter other than sugar	0.5 - 1.0
Glucose	0.2 - 1.0	Gums	0.15 - 0.25		
		Nitrogen cpds	0.3 - 0.6	Inorganic compounds	0.2 - 0.6
		Free acids	0.06 - 0.1	Nitrogenous bodies	0.5 - 1.0
Fructose	0.5 - 0.6	Amino acids (Aspartic acid)	0.2		
Fibers	8- 14	Albuminoids	0.12		
Cellulose	5.5	Amides (Asparagine)	0.07		
Lignin	2.0	Nitric acid	0.01		
Hemicellulose	2.0	Ammonium	Trace		
Gums	0.5	Other acids	0.1 - 0.15		

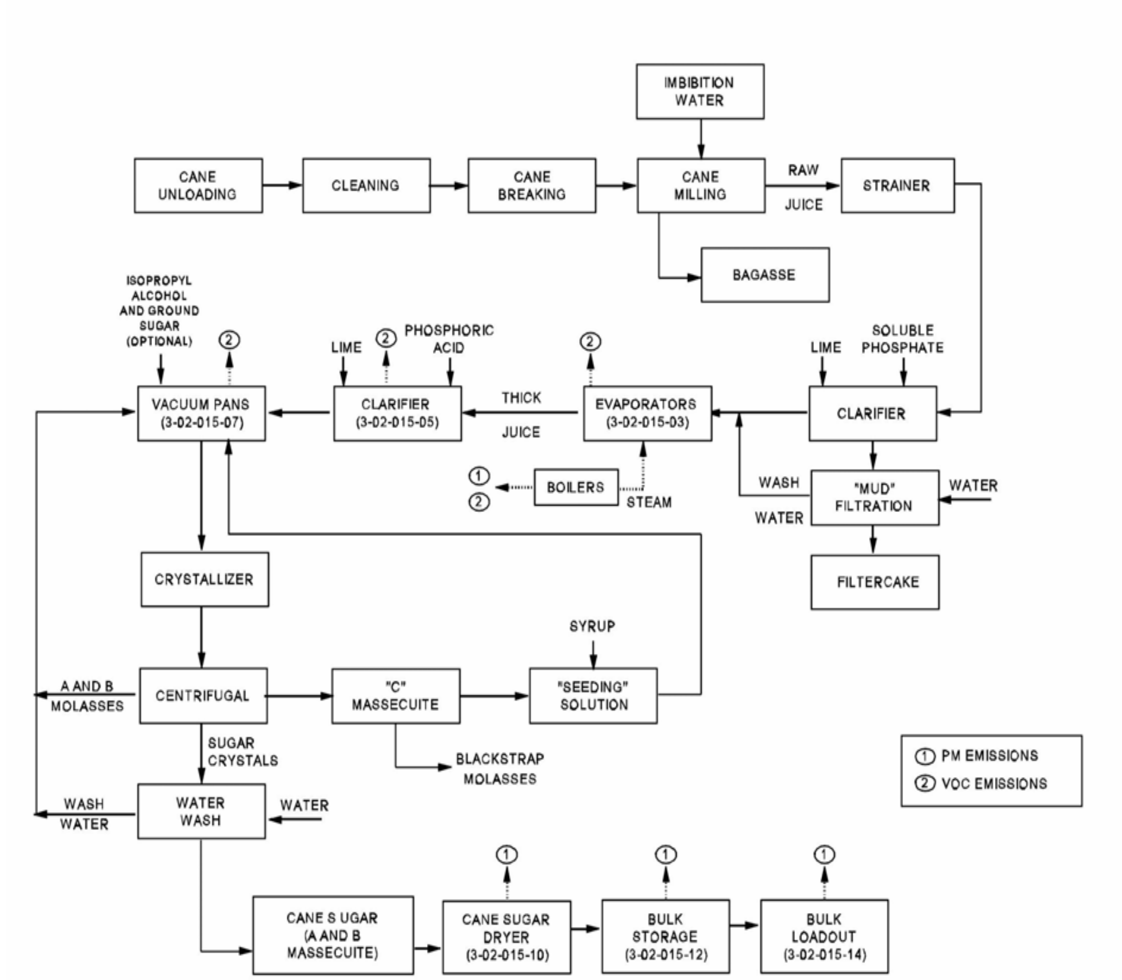

Figure 2. The process flow diagram of raw sugar production [Source: ref.39]

Very small amount of sugar seeds to be feed into the syrup for the processing of crystallization. Finally, the centrifugation takes place where molasses and raw sugar crystals are separated under controlled centrifugal action and then, the raw sugar is dried and stored [39]. The complete processing of sugar production is described in Fig.3

The refined sugar is produced by refining of raw sugar under affination that's combined with centrifugation, melting, clarification, decoloration with ion-exchange resins and activated carbon, and further processing takes place by similar like raw sugar production. Thus, the familiar white, refined sugar (99.9% pure sucrose) might be produced [40].

The fundamental purpose of sugarcane juice clarification is an important process on processing of sugar which is to produce clear Juice with the lowest or least or null concentration of insoluble and soluble impurities to achieve maximum sugar yield. Insoluble materials including soil, starch and wax, and soluble impurities include reducing sugars, colorants, amino acids, organic acids and inorganic ions should be removed. Inorganic materials in sugar cane juice are mainly Ca, P, Mg, Na, K, Si, S, Al and Cl ions and organic non-sucrose materials are organic acids, nitrogen containing compounds, colorants that reported in the literature [41].

The presence of inorganic ions in cane juice was reported to cause the darkness of the sugar color and increase the molasses waste [42]. Chemical clarification, based on modern cold lime sulphitation is carried out to remove impurities which inhibit the formation of the crystals and can discolor the final product. The addition of lime also has the advantage of reducing the natural acidity of the cane juice, limiting the formation of invert sugars [43].

The batches of juice are treated simultaneously with milk of lime, $Ca(OH)_2$ and sulphur dioxide (SO_2) by air forced through a sulphur furnace. After which the juice is transferred into an open boiling pan and quickly heated to 90ºC or above. The lime and heat treatment form a heavy precipitant that called flocculates carrying most of the suspended impurities of the juice.The juice is then filtered and allowed to settle for separation of scum. The clear juice is decanted and transferred to the boiling furnaces.

The separation can lead to formation of press mud or filter cake, bagasse and molasses as a byproduct which are difficult to dispose and hence impact the environment. Waste water from sugar mills depletes oxygen supply when discharged into water bodies, endangering fish and other aquatic life. Suspended solids reduce light penetration into water and that may result into water turbidity which clog fish's gills. Excessive acidity around the industry results into production of hydrogen sulfide to the air. Sludge accumulation can also develop odor problems in and around the industry. Phosphate level is a key parameter of determining quality product, because excess phosphate hinders filterability of juice and scaling of evaporators during sugar processing. Recently, methods for removal of impurities in cane juice where reported such as application of amylase enzyme, membrane separation processes and chemical precipitation processes [44]. The use of enzyme amylase, chemicals and membrane separation processes are common in high tonnage of sugarcane which is expensive to maintain and buy.

This has led to continuous quest for biologically derived flocculants (clarifiers) to avoid chemically manufactured flocculants for cane juice clarification with an attempt to investigate vegetable derived clarifying agents which are substitutes for the imported flocculants. Vegetative mucilage was chosen as clarificants in Jaggery (similar like raw sugar) as reported in literature [45], because chemical clarifiers are reducing the taste and storability of raw sugar. Therefore, the Jaggery producers chose to use vegetative clarificants because they are accessible, eco-friendly, low cost, safe for human health and easily adaptable. Many mucilaginous plants are the resources as organic clarificants like okra, banana, ground nut, moringa extract, soybean, castor seed, and cotton seeds are abundantly available and used in non-centrifugal sugars. *Hibiscus lunarifolius* extract like okra was compared with chemical clarificants and found that the vegetative clarificants extracts perform similarly to chemical clarifiers [45].

Abelmoschusesculentus also known as lady's fingers (in English), bhindi (in Hindi), okra or gumbo, amilahk (in South Sudan), is a flowering plant [shown in Fig. 3] which belongs to family Malvaceae. It is made up of stem, leaves and fruits. The plant originates from Africa and is valued for its edible green seed pods and cultivated in tropical, subtropical and warm temperate regions around the world. Okras pods are eaten as vegetables. In India the green stems of mature plant are used for preparation of mucilage to clarify sugar cane juice for preparation of jaggary. The mucilage binds with impurities in the juice due to its viscous nature and form scum which can be easily removed [46].

Figure 3.Okra (*Abelmoschusesculentus)* plant to be used for preparation of okra mucilage.

Nanotechnology offers the possibility of an efficient removal of pollutants and germs in the water purification. Today nanoparticles, nanomembrane and Nano powder used for detection and removal of chemical and biological substances include metals (e.g. Cadmium, copper, lead, mercury, nickel, zinc), nutrients (e.g. Phosphate, ammonia, nitrate and nitrite), cyanide, organics, algae (e.g. cyanobacterial toxins) viruses, bacteria, parasites and antibiotics. Basically, four classes of nanoscale materials that are being evaluated as functional materials for water purification e.g. metal-containing nanoparticles, carbonaceous nanomaterials, zeolites and dendrimers. Nanoparticles may be used in future at large scale water purification because it has high surface area to volume ratio and functionalize with various chemical groups to increase their affinity towards target compounds. It is also found to help in food colors, flavors, textures and provide manipulation of food polymers and polymeric packaging to improve food quality and food safety especially in dairy [47]. There are no reviews reported about nanotechnology in sugar cane juice clarification but it could work since its effective in other edible foods as proved in many literatures [48].

Application of eco-friendly plant based bio-flocculants such as *Hibiscus/Abelmoschusesculentus, Malvasylvestris, Plantagopsyllium,Plantagoovata,Tamarindusindica*, and *Trigonellafoenum-graecum*[Table 2] used in portable water, domestic or industrial wastewater treatments and on treatment juice clarification on jaggeryproduction has attracted significantly with high removal capability in terms of solids, turbidity, color and dyes [49]. Most of the frequently studied plant-based coagulants include Nirmali seeds (*Strychnospotatorum*), *Moringaoleifera*; tannin and Cactus, there are attempts and investigated vegetable-derived clarifying agents which are substitutes the imported flocculants reported in literature [50].

Natural coagulants produce readily biodegradable and less voluminous sludge that amounts only 20-30% than the alum treated counterpart [50]. Plant extracts are made useful to replace chemicals in the sugar industries. Most of the sugar mills are importing expensive settling aids for settling mud and to improve the clarity of the juice. To avoid the chemicals, it is preferable to introduce alternatives which can be environmentally friendly, less expensive and easily adopted. The plant-based coagulants are extracted in two ways before application as (i) solvent extraction and precipitation and (ii) drying and grinding. However, the identified usage of natural flocculants and their technical viability for industrial wastewater are currently limited in academic researches [51**]**.

Table 2. Vegetative flocculants in water treatment and jaggery [Source: ref.49, 51]

Common name	**Scientific name**	**pH**
Okra/lady finger	*Abelmoschus esculentus*	5.2 - 8
Fenugreek	*Trigonellafoemum-graecum*	7 - 8.6
Tamarind	*Tamarindusindica*	3 - 5
Isabgol	*Plantagoovata*	-
Mallow	*Malvasylvestris*	6.5 -7
Psyllium	*Plantagopsyllium*	7 - 7.8

Table 2a. Vegetative flocculants in water treatment and jaggery [Source: ref.49, 51]

Common name	**Solubility in water**	**Extraction method**
Okra/ lady finger	Soluble in cold water	Solvent extraction, precipitation, drying, grinding.
Fenugreek	Partially Soluble in cold water	Solvent extraction and precipitation
Tamarind	Soluble in cold water	Solvent extraction and precipitation
Isabgol	-	Drying & grinding
Mallow	-	Drying & grinding
Psyllium	Soluble in cold water	Solvent extraction and precipitation

Conclusion

On the processing of sugar, the juice (dark green solution) is to be extracted from the cane or beets by milling or diffusion methods, then the juice is clarified by using CaO, SO_2, polymers, anticolorants and CO_2, that is used to remove sediments from the juice and sugar solution (on refining) called clarification, which is one of the most important parameters for deciding the sugar quality. The unclarified juice can easily undergo enzymatic changes and affects the quality and color of juice during storage. Some raw sugars produced either in large scale industries or small farmers are difficult to decolorize during clarification. Hence, loss of its value and subsequently cause a great lost to the producers. One of the methods of clarifying the juice by addition of synthetic polymer acrylamide base that is aiming to fast settling of impurities present in the juice. However, this input is expensive and may have carcinogenic and neurotoxic actions to humans. The use of SO_2 via the sulphitation process for the production of white sugar is discouraged in many countries because of the health risks surrounding the consumption of contaminated sugar containing residual sulphur. Milk of lime is often used in sugar industries; liming gives lower turbidity but higher mud levels and slower settling flocs if not well handled. However, the clarified juice obtained may have higher calcium level in juice and may resulting the scale on evaporators. CaO nanoparticle was reported to have antimicrobial properties that could

be an advantage to the sugar producers while okra is nontoxic, biodegradable, can be obtained from renewable resources and their applications are directly related to the improvement of quality of lifefor underdeveloped communities. Many literatures have been reviewed to investigate the flocculating properties or behavior of plant-based bio-flocculants in wastewater treatment and jaggery. The results of the studies demonstrated that they are promising as flocculants with high removal of solids, turbidity, color and dye. A clarification of sugar cane juice by vegetative clarifying agents for removal of impurities in processing would lead to lower processing costs.

Acknowledgement

The authors acknowledge the Department ofChemistry, College of Natural Sciences, Arba Minch University for theconstructive guidanceand to conduct the research in the field of sugar technology.

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