Treatment of Raw Cane Juice with Organo Bentonite and Ultrafiltration Membranes for White Sugar Production

Abdel-Aal-M. Gaber[1], Samy I. El-Sayiad[2], Salah. A. Masoud[3] and Mohamed Sh. Ali[4]

[1] *Chemistry Department, Faculty of Science and Faculty of Sugar and Integrated Industries, Assiut University, Egypt*
[2] *Food Science and Technology Department, Faculty of Agriculture, Assiut University, Egypt*
[3] *Egyptian Sugar and Integrated Industries Company (ESIIC), Al-Hawamdeya, Egypt*
[4] *Abo-Qurqas sugar factories, Minya, Egypt.*

Abstract

Polysulfone (PS) ultrafiltration (UF)-membrane with Molecular Weight Cut Off (MWCO) 100kD was examined with the aim of improving the sugarcane juice clarity while a modified bentonite (organo-bentonite) by benzalkonium chloride (BAC) was used as adsorbent for reducing colour and turbidity instead of sulphitation process. Factors influencing the adsorption capacity of organo-bentonite, such as BAC concentration, adsorbent dosage, pH, contact time and temperature beside factors that influence the ultra-filtration process like transmembrane pressure and temperature were systematically investigated and discussed. The results of analysis indicated that the adsorption capacity of organo-bentonite increases with increasing BAC concentration, adsorbent dosage, temperature and with decreasing pH while membrane flux increases with increasing transmembrane pressure and temperature. The optimum conditions were adjusted at a constant reaction time (10 min), temperature 75 °C, pH 5.0, BAC concentration of amount equal to100% of cation exchange capacity (CEC) of bentonite and organo-bentonite dose (0.6 g/L) which were determined on minimization of colour, turbidity, ash content and invert sugar and maximization of purity. At this optimum point: colour, turbidity, ash%, reducing sugars%sugar and purity were found to be 7635 IU_{420}, 3.0 NTU, 0.474%, 4.8% and 85%, respectively. Also the clarified juice quality obtained by the treatment was improved greatly when compared with conventional limed–sulphated juice as the colour and turbidity in the clarified juice were removed by the rate of 32% and 94%, respectively.

Keywords: Raw cane juice, Organo-bentonite, Ultra-filtration, Membranes.

Introduction

Sugar colorants are a very complex mixture of organic compounds from various sources. Colour is a complex mixture of compounds that stems either from the cane plant (e.g., chlorophylls, flavonoids and polyphenolic compounds) and/or produced during processing of juice in the sugar factory (e.g., melanins, melanoidins, caramels and aroma compounds)[1]. Colorants are a class of impurities in sugar cane juice that are difficult to remove and tend to occlude in sugar crystals.

In recent years, ultra-filtration membrane based pressure driven technology has received increasing attention and great importance for sugar production. The environmental issues have come into focus and work is being done to evaluate the possibility for a cleaner raw juice purification operation. Preliming, carbonation, sulfitation, and lime kiln all incur large costs and are pollution concerns. The disadvantages of conventional processing of sugarcane juice include the inefficient removal of substance (e.g., starch, colour, colloids, and other suspended matters) during clarification, which adversely affects the quality of the final product (raw sugar)[2], as well as the use of heavy equipment and chemicals that can lead to high operating costs and related environmental problems[3]. Thus, the sugar industry needs efficient clarifying methods to improve the quality of clarified juice and reduce or eliminate the usage of chemicals. Membrane filtration is an advanced method that ameliorates these issues[4].

Studies on the application of membrane filtration for clarification of sugarcane juice appeared in the early 1970's[5]. Steindl[5] provided a summary of available data from investigations undertaken at a number of sites around the world. Those investigations concluded that membranes would remove polysaccharides, turbidity and colloidal impurities and result in lower viscosity syrups and molasses, provide higher growth rates and improve exhaustion.

The use of ultra-filtration alone will not enable a typical sugarcane factory to achieve white sugar standards. Additional steps to reduce the colour and ash as well as increase the purity of the syrup are required. Chromatographic separation process is one of these steps that aims to reduce the colour content of cane juice, but high construction cost of ion-exchanger units, problems encountered in their use and environmental problems forced researchers to find alternative methods for removing colour and turbidity in sugar industry[6]. One of the available chemical purification methods is the application of clay. Purification of raw sugarcane juice by organo-bentonite can be considered as an alternative purification method.

Bentonite is one type of clay which is cheap and available in many countries like Egypt as it located at El Barqan area Northern Western Desert, Egypt. Bentonite is composed of primarily montmorillonite (Mt) from the smectite group[7], that is generally classified into sodium (Na) or calcium (Ca) types depending on dominant exchangeable ion[8]. The inflation rate and the bleaching properties of bentonite are not desirable in normal and primary form. Therefore, it is necessary to make some modifications to be exacerbated to obtain the desired properties. For example, calcium bentonite can be treated with sodium carbonate, sodium bicarbonate or sodium chloride, which results to ion exchange and substitution sodium instead of calcium and production of modified bentonite with expanding ability. This new compound is called sodium-bentonite.

Bentonite is hydrophilic and ineffective for adsorption of organic molecules[9]. Since there are exchangeable cations on the surface of bentonite layers, hydrophobic cationic surfactants can be substituted by these cations. By substitution of Na^+ with cations of detergent (quartamin) like benzalkonium chloride (BAC), cetyl trimethylammonium bromide (CTAB), hexadecyl trimethylammonium bromide (HDTAB), …etc. Na-bentonite can be modified to absorb organic molecules by organophilic tail of detergent molecules[10]. Modification of Na-bentonite is a method to increase adsorption capacity of cheap mineral sorbent for removal of organic pollutants.

So, this work was designed to apply modified organo-bentonite for removal of organic pollutants from sugarcane juice as an efficient mineral adsorbent.

Materials and Methods

Bentonite clay and cationic surfactant used in this study were obtained from LOBA CHEMIE Co, India. The molecular formula of bentonite was ($Al_2O_3.4SiO_2.H_2O$) and cation exchange capacity (CEC) was 79 meq/100g. Cationic detergent that used to synthesize organo-bentonite was benzalkonium chloride (BAC) 50% w/v aqueous solution.

Preparation of Na-bentonite and organo-bentonite

Na-bentonite was prepared by contacting 100 g of bentonite with 2M NaCl solution by 1:5 (w/v) for 12 h on a magnetic stirring and the produced suspension was rinsed with enough distilled water and stand for 30 min for settling then the excess water was removed. organo-bentonite was made by mixing the suspension of Na-synthesized bentonite in 1L of a solution containing BAC 50%vol at BAC amount equivalent to 50%, 100% and 150% of (CEC) of bentonite. The reaction components were stirred at 60-70 °C for 2 h then left 10 h at room temperature. The obtained organo-bentonite was washed repeatedly with distilled water to remove chloride ions which tested by $AgNO_3$ solution.

Sugarcane Juice and Membranes

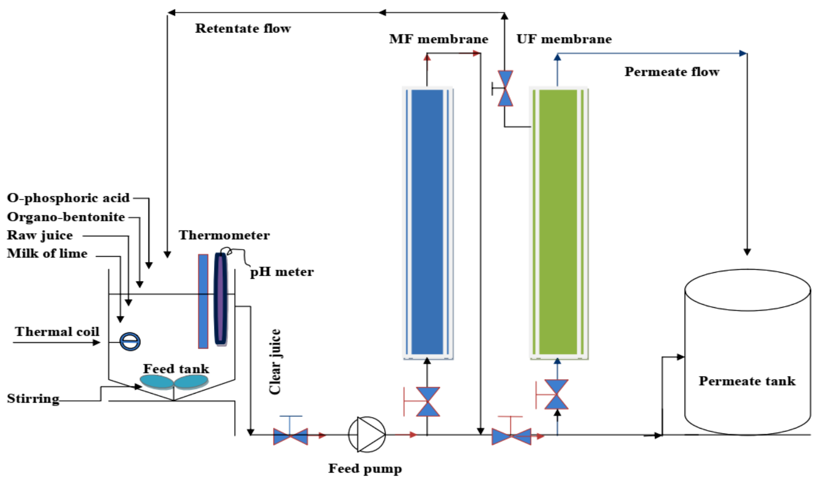
Raw sugarcane juice from the milling station was collected from Abo- Qurkas Sugar Mill, El Minya governorate, Egypt. The raw juice collected sample was heated from 45–50 °C to 70–75 °C then divided into three portions with certain volume where a different doses of prepared organo-bentonite (2,4 and 6 mL) were added to them and left to stand for 10 min for complete adsorption of anionic matters. The three samples were then phosphated with 2% O-phosphoric acid until the P_2O_5 content reached about 300-350 ppm. The phosphated samples were then limed with milk of lime and mixed well by a stirrer to raise the pH to 6.9–7.1. The treated samples were kept standing for 60-70 min for settling and the clear juice was collected and used as feed for the MF/UF membranes (see

Figure 2). UF membranes characteristics are presented in Table 1 and Figure (1) represents a schematic of MF/UF demonstration plant that is used in this study.

Table 1: Characteristics of MF and UF membranes used in this study

Project	Parameter	
Membrane details	MF	HB-11UF
Model	Tubular	Hollow fiber
Supplier	USA	Bangmo,Korean
Design flux (L/m²/h)	4 (L/min)	3 (L/min)
Permeate turbidity(NTU)	<10	<1
Filter type	Outside-In	Inside-Out
Membrane material	PP	PS
MWCO or pore size	5 µm	100 kDa
Transmembrane pressure (MPa)	0.1-0.3	0.1-0.3
Max. operating temperature (°C)	5-45 °C	4-65 °C
pH range	3-10	2-12
Packwash pressure (MPa)	<0.1	<0.2
Membrane area	0.75 m^2	0.73 m2

Figure (1): A schematic representation of MF/UF demonstration plant.



Analysis

Brix, a measure of refractometric dry substance, was measured using a digital refractometer (PTR 46 XP Refractometer)[11]. Pol is a measurement of the total polarized substance in the samples, and it represents the sucrose content in the samples. Pol was measured by a polarimeter (DR. KERNCHEN Sucromate) at 589 nm according to ICUMSA method [11].The purity of the samples was calculated as follows[12] :

$$\textbf{Purity (\%)} = (\textbf{pol} / \textbf{Brix}) \times 100 \qquad (1)$$

Colour, a measurement of the coloured substances in the samples, was measured[13] by a spectrophotometer (JENWAY 6300 Spectrophotometer) at 420 nm, while the turbidity (NTU) of sugarcane juice was measured by the same spectrophotometer at 900 nm according to the ICUMSA method[14]. The colour of the samples was calculated as follows:

$$\textbf{Colour \% Bx} (IU_{420}) = (\textbf{Absorbance at 420 nm} \times 10^5 / {}^{\circ}\textbf{Brix}) \times 100 \qquad (2)$$

The pH was measured by a digital pH meter (JENWAY 3510 pH Meter). Reducing sugar was measured according to the ICUMSA method[15]. Conductivity ash correlates the specific conductance of a solution to the sulfated ash concentration. The conductivity ash was determined with the aid of a conductivity meter (JENWAY 4520 Conductivity Meter) according to the modified ICUMSA method[16]. P_2O_5 (%) was determined according to ICUMSA method[17].

Results and Discussion

Factors Affecting the Ultra-Filtration Process

1- Effect of pretreatment of raw juice

Polysulfone (PS) membrane with Molecular Weight Cut Off (MWCO) 100kD was examined with the aim of improving the sugarcane juice clarity while reducing the colour by organo-bentonite. The behavior of permeates flux during ultrafiltration of raw juice with the membrane, is shown in Figure (2). It shows that the permeate flux decreases rapidly upon increasing time to 20 min and thereafter a nearly steady state is reached . This behavior indicates the formation of fouling layers on the membrane surface that offers an additional resistance to permeate flow[18].

Pretreatment of raw juice before ultrafiltration process is required. Kishihara *et al*[19] studied the pretreatment of raw juice using polymeric membranes in a stirred cell, they found that liming the juice to pH 7.5 doubled the initial permeate flux in comparison with permeate flux of the original juice of pH 5.4.

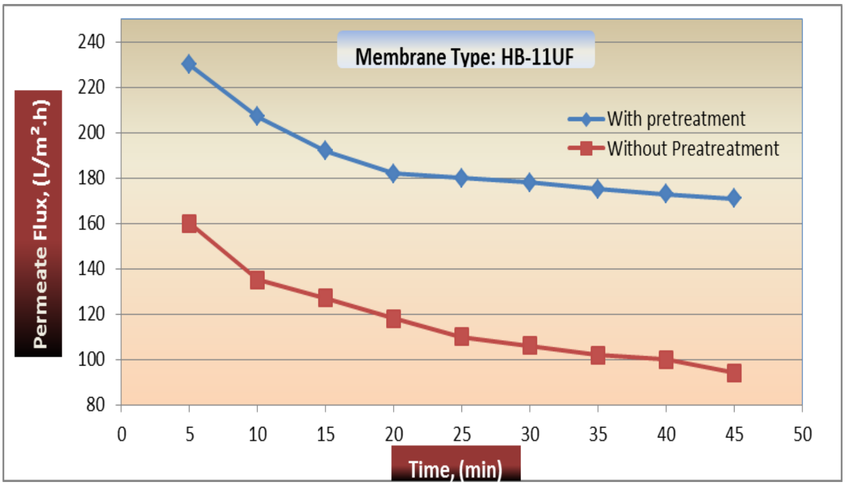


Figure (2): Effect of pretreatment of raw cane juice on flux during filtration of raw cane juice through HB-11UF membrane at pH 7.5, TMP 4 bar and temperature 45-50 °C.

2- Effect of transmembrane pressure

The effect of different transmembrane pressures on the ultra-filtration of raw cane juice was studied using HB-11UF membrane of 100 kDa pore size. The behavior of permeate flux at different transmembrane pressures is shown in Figure (3). It shows that the permeate flux through the membrane increases with the increase of transmembrane pressure and gradually decreases on further increase in pressure. This behavior could be attributed to the formation of fouling layers on the membrane surface that become compacted at high pressures. This layer offers an additional resistance to permeate flow.

According to Kishihara *et al*[19] in the ulrafiltration of sucrose solution, the relationship between flux and pressure was linear, but then gradually decreases on further increase in pressure due to the formation of a gel layer of macro-molecular impurities on the membrane surface. Ghosh *et al*[20] observed an appearance of very fine greenish brown layer of bagacillo particles and non-sugars impurities like proteins, gums, and polysaccharides on the membrane surface during the course of the sugarcane juice ultrafiltration that can easily cause a drop in the permeate flux.

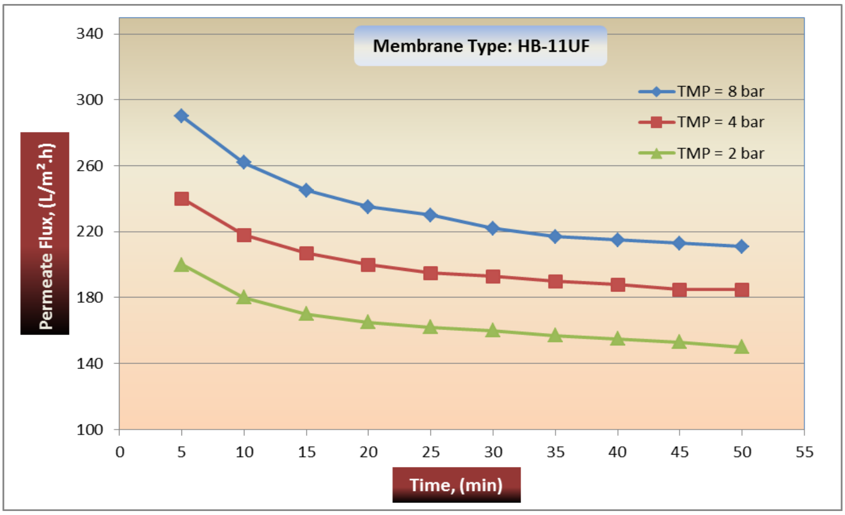


Figure (3): Effect of transmembrane pressure on flux during filtration of raw cane juice through HB-11UF membrane at pH 7.5 and temperature 45-50 °C.

3- Effect of temperature

Progressive changes in the permeation flux at different temperatures are illustrated in Figure (4). It was demonstrate that the permeate flux increases upon elevation of temperature. This increase in the flux might be due to a decrease in the viscosity of sugarcane juice. This is in good agreement with that reported in literature[21]. In addition, **Kishihara *et al***[19] obtained a doubling of the flux upon increasing the temperature from 30 to 60ºC.

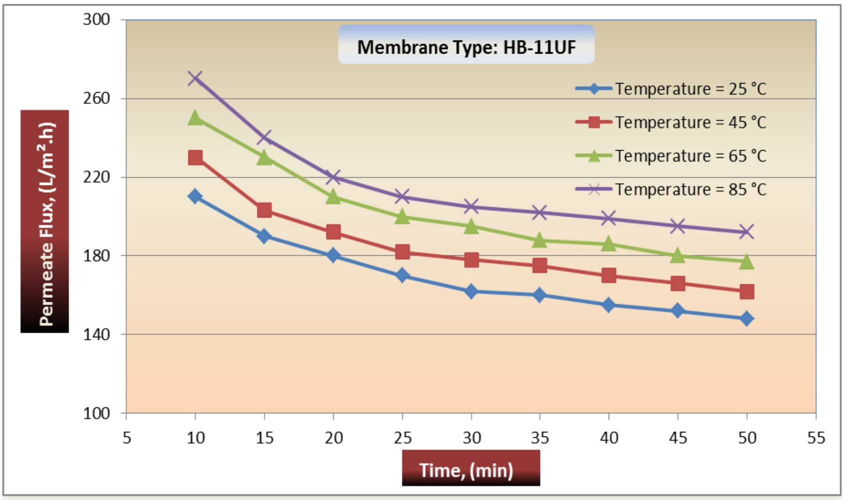


Figure (4): Effect of temperature on flux during filtration of raw cane juice through HB-11UF membrane at pH 7.5 and TMP 4 bar.

Factors Affecting the Adsorption Capacity of Organo-bentonite

1- Effect of benzalkonium chloride (BAC) concentration

Effect of BAC concentration on colour adsorption of raw can juice is shown in Figure (5). It is clear from Fig 5 that the adsorption capacity of modified bentonite (organo-bentonite) by cationic surfactant (quartamin) increases by increasing its content. Using quartamin in combination with bentonite reduced colour more than that obtained with additives alone. When quartamin is added a long chain quaternary ammonium cation is adsorbed on the clay and changes the nature of the surface from hydrophilic to hydrophobic. Thus, adsorption of anionic colourants can occur more easily by interacting with the hydrophobic alkyl group on the mineral surface[22] and colour was reduced to some extent.

Addition of the cationic surfactant with high concentration might precipitate the anionic high molecular weight colourant which appeared as turbidity or flock formation. The concentration of quartamin in the range of 100-700 ppm was previously studied and the concentration of 600 ppm was the optimum concentration which provides about 24% colour reduction[23,24].

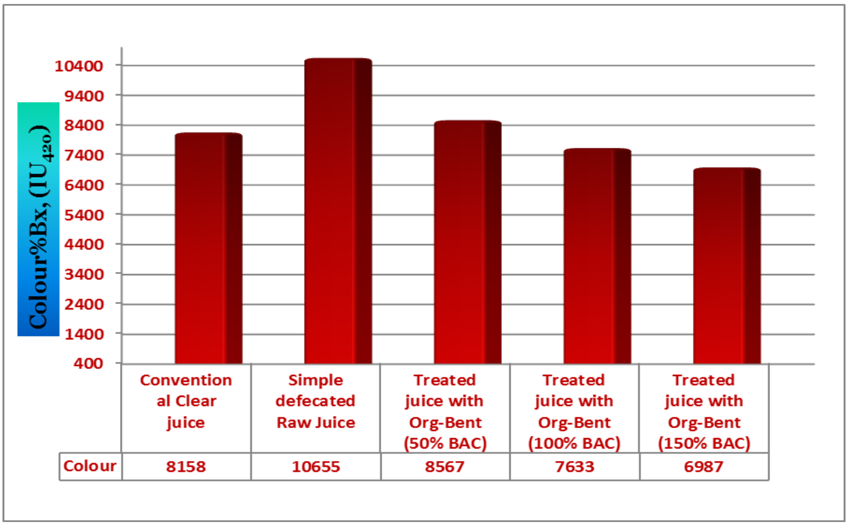


Figure (5): Effect of BAC concentration on colour adsorption of raw cane juice at constant temperature and pH.

2- Effect of organo-bentonite dose

Effect of organo-bentonite dose on colour adsorption of raw cane juice is depicted in Figure (6). It shows that the efficiency of colour removal by the modified bentonite increases by increasing its dose. The reduction in colour is related to the adsorption of colorants by the clay particles. This can be simply attributed to the increase of sorbent surface area and availability of more sites. Colourants in the sugarcane juice have various sized complex structures with mainly nonpolar and somewhat polar characters. Many clay minerals especially montmorillonites readily adsorb organic molecules. Adsorption depends upon various factors including molecular size of the adsorbate, its concentration in the medium, effect of van der Waals forces, chain length and entropy effect[25].

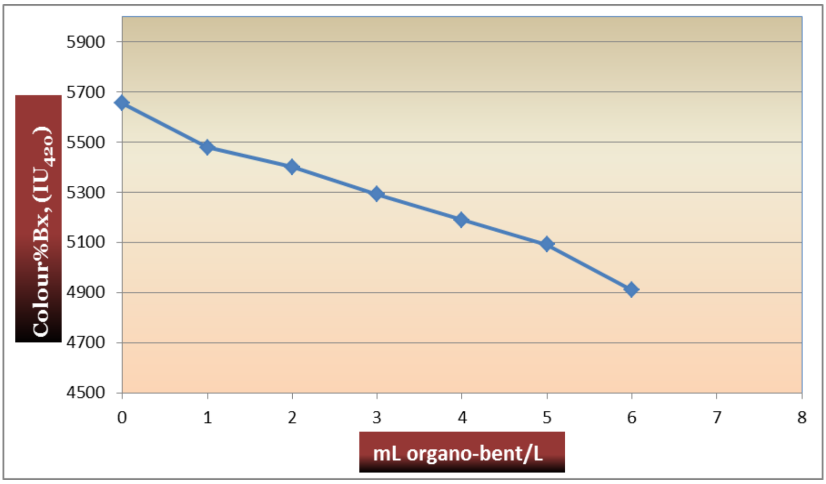


Figure (6): Effect of organo-bentonite dose on colour removal from raw cane juice by modified bentonite at constant temperature and pH.

3- Effect of pH

Effect of pH on colour adsorption by organo-bentonite is showed in Figure (7). It was observed that the efficiency of colour removal by the modified bentonite increases by decreasing the pH of the medium. As shown in Figure (7), the most effective pH range for colour removal was 4.0-5.0. Therefore, when the raw cane juice is pretreated by simple defecation with milk of lime and o-phosphoric acid, it was preferred for the phosphatation process to be before the juice liming process.

Li *et al*[26] carried a series of experiments on the adsorption of anionic matters by various bentonites. The results revealed that the efficiency of colour removal by bentonite increases with the decrease of pH. They reported that the surface charge of bentonite is positive in the examined pH range of (3–11). At low pH most of the colour molecules can be adsorbed by bentonite. SO_3^- groups are existed in the structure of anionic colour. The higher removal efficiency of colour by bentonite adsorption at low pH values may be due to neutralization of the negative charge $-SO_3^-$ anion, which increased the protonation and the electrostatic attraction between the negatively charged anionic coloured matters in raw cane juice and the positively charged adsorption sites [27]. In alkaline medium, the Zeta potential of the bentonite reduced with increasing pH. On the other hand, there was a competitive adsorption between the OH^- ions and the anion matters. Hence, the removal efficiency of colour decreased with increasing pH[28].

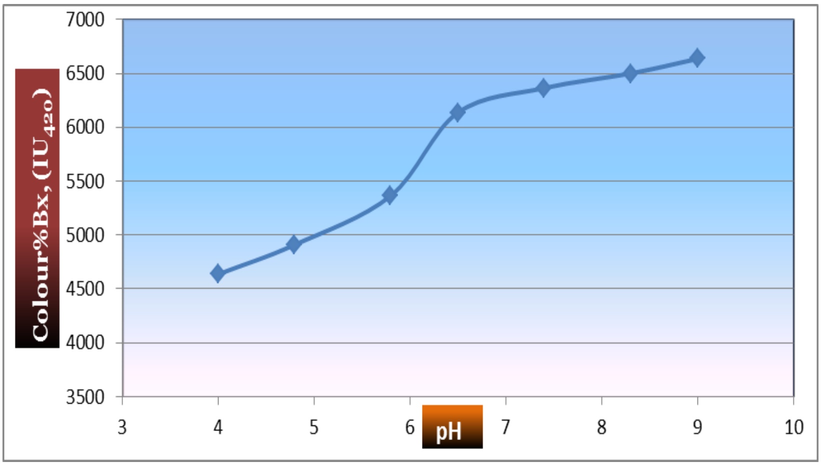


Figure (7): Effect of pH on colour removal from raw cane juice by modifiedbentonite at constant temperature.

4- Effect of contact time

Figure (8) demonstrates the influence of contact time on the adsorption capacity of orgno-bentonite for raw cane juice when concentration achieved 200 ppm. It is evident that the adsorption capacity of orgno-bentonite enhance rapidly by the increase of contact time from 0 to 10 min, and more than 95% of the equilibrium adsorption capacity was executed at 10 min. Above 10 min, the adsorption capacity became quite constant and the adsorption reached equilibrium. Consequently, 10 min was chosen as the best contact time for the adsorption of coloured matters from raw cane juice under our study conditions.

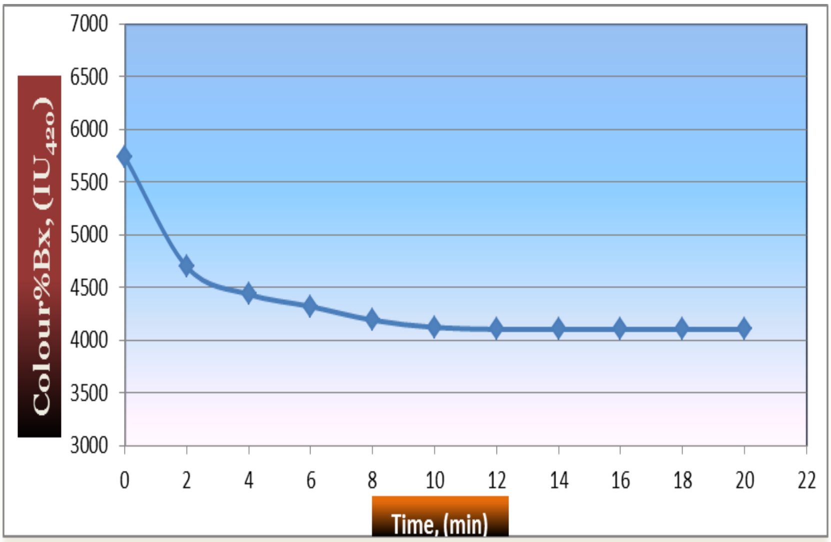


Figure (8): Effect of contact time on colour removal from raw cane juice by modified bentonite at constant pH and temperature.

5- Effect of temperature

The effect of temperature on colour removal from sugarcane juice by orgno-bentonite is presented in Figure (9). It indicates that the efficiency of colour adsorption by the modified bentonite increases with increasing the temperature. Accordingly the raw cane juice was heated to about only 70-75 °C before adding the orgno-bentonite to avoid the destruction of sucrose in acid medium at high temperatures.

Farmani *et al*[30] concluded that with increasing temperature, the removal of coloured compounds and turbidity of raw sugarcane juice by bentonite increased.

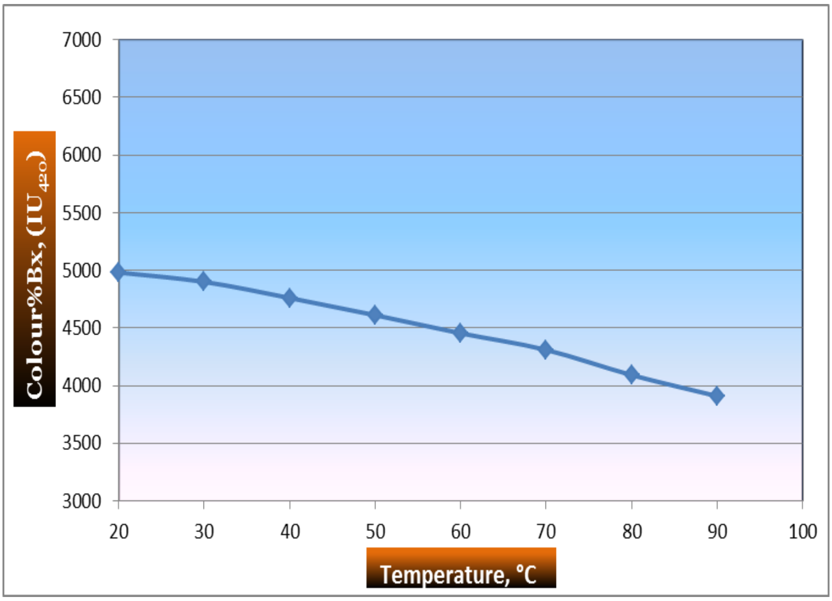


Figure (9): Effect of temperature on colour removal from raw cane juice by modified bentonite at constant pH and organo-bentonite dose 0.5 g/L.

Characteristics of clarified juice obtained by treatment of raw cane juice with organo-bentonite and ultrafiltration process

Table 2 shows the typical values of three experiments of raw cane juice quality in the feed and permeate obtained by treatment of raw cane juice with organo-bentonite and ultrafiltration process as compared to clarified juice obtained by conventional limed-sulphated process.

Table 2: The characteristics of clarified juice obtained by treatment of raw cane juice with organo-bentonite and ultrafiltration process compared with the conventional clarified juice.

Parameter	pH	Brix (%)	Pol (%)	Purity	Colour %Bx (IU_{420})	Turbidity @ 900 nm	R.S %Sugar	Conductivity ash (%)	P_2O_5 (PPm)
Exp No.1									
Raw juice	5.8	14.15	11.80	83.39	—	—	5.3	0.519	180
Treated juice	7.1	—	—	—	10123	—	—	—	336
Clear juice (Feed)	6.9	14.02	11.88	84.74	7265	1 6	4.9	0.478	33
Permeate	6.8	13.84	11.80	85.26	6476	0.9	4.8	0.463	27
Conventional clear juice	6.9	13.76	11.17	82.99	8234	17	5.6	0.472	22
Exp No.2									
Raw juice	5.7	13.72	11.40	83.09	—	—	5.4	0.496	168
Treated juice	7.2	—	—	—	11778	—	—	—	319
Clear juice (Feed)	7.1	13.65	11.49	84.18	8012	22	5.0	0.463	29
Permeate	7.0	13.48	11.40	84.57	6922	1.2	4.9	0.448	24
Conventional clear juice	7.0	13.24	10.91	82.78	8439	13	5.8	0.466	15
Exp No.3									
Raw juice	5.8	14.03	11.73	83.61	—	—	5.1	0.544	177
Treated juice	7.1	—	—	—	11235	—	—	—	340
Clear juice (Feed)	6.9	13.78	11.70	84.91	7628	11	4.8	0.512	36
Permeate	6.8	13.66	11.67	85.43	6744	0.7	4.6	0.491	31
Conventional clear juice	6.9	13.60	11.30	83.12	7122	14	5.4	0.507	18

1- Brix

From Table 1, it can be concluded that the treatment of raw cane juice with simple defecation and organo-bentonite followed by ultrafiltration process leads to decreasing brix value. With increasing temperature and decreasing pH value due to better activity of bentonite and further removal of impurities of raw cane juice, as well as separation of frequently dissolved molecules and small particles from juice by the UF membrane, Brix has been reduced.

2- Purity

As shown in Table 1, it is clear that the purity was increased by 2.1%. Sugarcane juice contains soluble inorganic phosphates that react with available Ca^{2+} ions from the addition of lime/lime saccharate to form a calcium phosphate precipitate, which partakes in floc formation leading to a decrease in the brix value[31]**.** As well as with increasing temperature and decreasing pH value, due to better activity of bentonite and further removal of impurities of raw cane juice, brix has been reduced and thus the purity of the juice increased. The treated clear juice so obtained after settling was then subjected to the UF membrane to give another rise in purity. This can be correlated with the higher nonsugars rejection during the juice ultrafiltration.

3- Turbidity

As shown in Table 1, it is clear that the turbidity was reduced by 94%. Simple defecation by o-phosphoric acid and milk of lime causes formation of a heavy precipitate of complex composition, besides that ultrafiltration of produced clear juice removes suspended solids, colloidal particles and soluble high molecular weight compounds leading to more decrease in turbidity value.

4- colour

From Table 1, it can be observed that treatment of raw cane juice with organo-bentonite combined with the ultrafiltration process leads to colour reduction by about 39%. The study of Farmani *et al*[32] shows that reducing the colour is related to adsorbing the coloured matters by bentonite particles (see Fig 10). Efficiency of bentonites on colour reduction was found to be dependent upon the way of application of bentonite[33]. Direct addition of bentonite decreases the colour a little more than that of addition from the stock suspension of bentonite in water (100 g/L).

Figure (10): Clarified juice quality obtained by treatment of raw cane juice with organo- bentonite/ultrafiltration (organo-bentonite dose 0.5g/L) compared to conventional limed–sulfated clear juice.

5- Invert sugar.

Invert sugar content in juice was directly related to the effect of pH and temperature. With increasing temperature and reducing pH, the hydrolysis of sucrose to reducing sugars in the raw sugar cane juice greatly increased. Accordingly the raw cane juice was heated only to 75 °C and limed with milk of lime to pH ~7.0 to prevent sucrose hydrolysis.

Close inspection of Table 1, one can conclude that invert sugar of the treated juice was significantly decreased compared to raw cane juice. This can be attributed to precipitation of some non-sugars by the simple defecation process. As the cleared juice from the defecation process passed through the ultrafiltration membrane, invert sugars will decrease again owing to the high nonsugars rejection during the juice ultrafiltration.

6- Conductivity ash.

From the data in Table 1, one can deduce that treatment of raw cane juice with simple defecation and organo-bentonite followed by ultrafiltration leads to decreasing conductivity ash by 10.2%. Mohammed[34] reported that the efficiency of removal of Fe^{+3} ions in aqueous solution using natural bentonite increases with increasing temperature. Two main reasons are available for the substantial increase in efficiency of ash removal by bentonite. First, the higher temperature activated the metal ions for enhancing adsorption at the coordinating sites of the adsorbent, and the metal cation moved faster[35], and second, acceleration of some originally slow step(s) and creation of some new activation sites on the adsorbent surface[36]. The similar results about absorption of some heavy metals such as Zn, Cu, Ni and Cr by bentonite at pH 3 were obtained by other researchers[37].

Comparing the characteristics of clarified juice obtained by organo-bentonite/ultrafiltration treatment process with conventional clarified juice from the sulfitation process.

Finally, to evaluate the efficiency of this method in treatment of raw cane juice, characteristics of clarified juice obtained by organo-bentonite/ ultrafiltration treatment process were compared with the conventional clarified juice obtained by sulfitation process. From Table 1, it was observed that the clarified juice characteristics improved greatly by organo-bentonite/ ultrafiltration treatment process rather than by clarified juice from the sulfitation process. Thus, for organo-bentonite/ultrafiltration treatment process, the purity increased by 2.1%, whereas colour, turbidity R.S% sugar and ash decreased by 39%, 94%, 9.3% and 10.2%, respectively.

The quality of the clear juice obtained by organo-bentonite/ultrafiltration treatment process was consistently superior and even lighter in colour in all experiments when compared to that of the conventional clear juice (see Fig 10).

Conclusion

Ultra-filtration of treated raw cane juice with a modified organo-bentonite by benzalkonium chloride was successfully used for removing colour and turbidity from the juice as well as enhancing the clarity and characteristics of the produced clear juice. The adsorption of colour by organo-bentonite was influenced by various parameters such as pH, temperature, BAC concentration and organo-bentonite dose while the ultrafiltration process was influenced by the juice pretreatment, temperature and transmembrane pressure. The results provided that adsorption capacity of organo-bentonite increases with increasing BAC concentration, organo-bentonite dose, temperature and with decreasing the pH value. The ultrafiltration flux was increased by increasing temperature and transmembrane pressure. The raw cane juice treatment process by organo-bentonite and ultrafiltration enhanced the properties of the produced clarified juice as the purity of the juice increased while the colour, turbidity, reducing sugar and ash content decreased. Comparison of the adsorption capacity shows that the clarified juice quality obtained from the treatment method was improved as compared to conventional limed-sulphated clarified juice in colour, turbidity, inverted sugar and ash content. Application of this method can be advisable for production of white sugar in various industries. For some factories of the Egyptian Sugar and Integrated Industries Company (ESIIC) in Egypt like Gerga and Deshna factories, 5 stages for production of white sugar are used due to the high colour of the clarified juice and avoiding the sulphitation process by SO_2 gas. By using organo-bentonite as adsorbing agent for colour removal, it is possible to decrease the number the stages to 3. In addition, using of supran as flocculant agent in these factories can be deleted due to the great efficiency of organo-bentonite in removal turbidity.

References

[1] Doherty, W. O. S. (2011): Improved sugar cane juice clarification by understanding calcium oxide-phosphate-sucrose systems. *Journal of Agricultural and Food Chemistry*. **59**, 1829-1836.

[2] Hamachi, M., B. B. Gupta, and R. Ben-Aim. (2003): Ultrafiltration: a means for decolorization of cane sugar solution. Separation and Purification Technology. **30**: 229-239.

[3] Jegatheesan, V., D.D. Phong, L. Shu, and R. Ben-Aim. (2009): Performance of ceramic micro- and ultrafiltration membranes treating limed and partially clarified sugar cane juice. *Journal of Membrane Science*. 327: 69-77.

[4] Wen, Li., Guo-Qing Ling, Chang-Rong Shi, Kai, Li., Hai-Qin, Lu. (2017): Pilot Demonstration of Ceramic Membrane Ultrafiltration of Sugarcane Juice for Raw Sugar Production. **19**(1):83–88.

[5] Steindl, R.J. (2001): Membrane filtration technology in the sugarcane industry. Proceedings of International Society of Sugar Cane Technologists. 24: 3-10.

[6] Novotny, C.J., J.C.P. Chen. (1985): Cane Sugar Handbook. Wiley, New York, NY. (**1**), 591-598.

[7] Sameh, H.I., Mabrouk, M.S., Ali, A.A., Elwalead, A.A. (2017): Synthesis and Characterization of Bentonite Nanocomposites from Egyptian Bentonite Clay. *Int. J. Nanotechnol. Allied. Sci.*, **1**(1): 16-26.

[8] Zhansheng, W., Li, C., Xofang, S., Xiaolin, X., Dai, B., Jin'e, L., Hongsheng, Z. (2006): Characterization, acid activation, and bleaching performance of bentonite from Xinjiang. *Chin. J. Chem. Eng*. **14** (2), 253-258.

[9] Rosário do, J., A. Miguel, R., F. Rosário do, D., A. Kuhnen, N., C. Riella, H., G. (2019): Factorial design applied to sodium activation of a Brazilian bentonite. **65**, 185-189.

[10] McKay G., Otterburn M. and Aga J. (1985): Fuller's earth and fired clay as adsorbents for dye stuffs equilibrium and rate studies, Water, Air and Soil Pollution. **24**, 307-312.

[11] Kahr G., and Madsen F.T. (1995): Determination of the cation exchange capacity and the surface area of bentonite, illite and kaolinite by methylene blue adsorption, *Appl. Clay Sci***.** **9**, 327.

[12] Brokensha, M., A. and Rein, P., W. (2011): ICUMSA method book, method No. **5/7-1**.(7) Supplement: 1-8.

[13] Jegatheesan, V., L. Shu, G. Keir, and D.D. Phong. (2012): Evaluating membrane technology for clarification of sugarcane juice. *Reviews in Environmental Science and Bio/Technology* **11**: 109-124.

[14] Ghosh, A.M., and M. Balakrishnan. (2003): Pilot demonstration of sugarcane juice ultrafiltration in an Indian sugar factory. *Journal of Food Engineering* **58**: 143-150.

[15] Player, M., R. and Urquhart, R., M, and Keskar, V., S. (2011): ICUMSA method book, method No. GS9/1/2/3-8. **(7)** Supplement: 1-3.

[16] Atherton, P., G. and Carter, M., P. (1994): ICUMSA method book, method No. GS1/3/7-3**.(1)**: 1-4.

[17] Ducatillon, J., P. (1994): ICUMSA methods book, method No. GS1/3/4/7/8-13. **(1)**: 1-3.

[18] Crees, O., L. (1994): ICUMSA method booK, method No.GS7-**15**.(1): 1-3.

[19] Balakrishnan, M., Dua, M., Bhagat, J. J. (2000): Effect of Operating Parameters on Sugarcane Juice Ultrafiltration: Results of a Field Experience, *Separ. and Purif. Technol.*, **19**, 209.

[20] Kishihara, S., Fujii, S., Komoto, M. (1981): Ultrafiltration of Cane Juice –Influence of Flux and Quality of Permeate, *Int. Sugar J.*, **83**(986), 35.

[21] Ghosh, A.M., Balakrishnan, M., DuaA, M., Bhagat, J. J. (2000): Ultrafiltration of sugarcane juice with spiral wound modules: on-site pilot trials, J. Membrane Sci., **174**(2), 205.

[22] Nielse, W. K., Kristensen, S., Madsen, R. F. (1982): Prospects and Possibilities in Application of Membrane Filtration Systems Within the Beet and Cane Sugar Industry. *Sugar Technol. Rev.*, **9**, 59.

[23] Mortland, M.M., Shaobai, S. and Boyd, S.A. (1986): Clay-organic complexes as adsorbents for phenol and chlorophenols. *Clays Clay Miner.*, **34**(5): 581-585.

[24] Bennett, M.C. (1982): The Talofloc/Taloflate process for simultaneous decolorization and clarification of refinery liquors. In: Backow, V.E. (Editor), Manufacture and Refining of Raw Cane Sugar. Elsevier, Amsterdam. **339**-342.

[25] Frank, D., Metcalfe, L.D. and Park, J. (1987): A new sugar decolorization process. *Int. Sugar J.*, **89**(1059): 46-51.

[26] Erdogan, B., Demirci, S., Akay, Y. (1996): Treatment of sugar beet juice with bentonite, sepiolite, diatomite and quartamin to remove color and turbidity. *Appl. Clay Sci.* **11**, 55-67.

[27] Li, Q., Yan Yue, Q., Jian Sun, H., Su, Y., Yu Gao, B. (2010): A comparative study on the properties, mechanisms and process designs for the adsorption of non-ionic or anionic dyes onto cationic-polymer/bentonite. *J. Environ. Manag*. **91**, 1601-1611.

[28] Ozcan, A., Omeroglu, C., Erdogan, Y., Ozcan, A.S. (2007): Modification of bentonite with a cationic surfactant: an adsorption study of textile dye Reactive Blue 19. *J. Hazard. Mater*. **140**, 173-179

[29] Eliza, J., Haddad khodaparast, M.H., Amin M.K. (2014): Bentonite,temperature and pH effects on purification indexes of raw sugar beet
juice to production of inverted liquid sugar, *Appl. Clay Sci.* **9**,36.

[30]_Farmani, B., Haddade khodaparast, M.H., Hesari, J., Rezaii Iraqi, E. (2006): Refining of raw sugarcane juice using bentonite: 2- detemination of optimum quantity of gelatin, time and temperature of process with bentonite. *J. Food Sci. Technol. Res.* **2** (1), 63-75.

[31] Doherty, W. O. S., & Edye, L. A. (1999): An overview on the chemistry of clarification of cane sugar juice. Proceedings of the Australian Society of Sugar Cane Technologists, **21**, 381-388.

[32] Farmani, B., Haddade khodaparast, M.H., Hesari, J., Rezaii Iraqi, E. (2006): Refining of raw sugarcane juice with bentonite: 1- detemination of optimum quantity of bentonite and pH. Iran. *J. Food Sci. Technol*. **2** (4), 1-9.

[33] Baki, E., Sahinde, D., Yener, A. (1996): Treatment of sugar beet juice with bentonite, sepiolite, diatomite and quartamin to remove color and turbidity, *Appl. Clay Sci.* **11**,55-67.

[34] Mohammed, A. Al-Anber. (2010): Removal of high-level Fe^{3+} from aqueous solution using natural inorganic materials: bentonite (NB) and quartz (NQ). Desalination **250**, 885-891.

[35] Babel, S., Kurniawan, T.A. (2003): Low-cost adsorbents for heavy metals uptake from contaminated water, a review. *J. Hazard. Mater. B* **97**, 219-243.

[36] Khalid, N., Ahmad, S., Kiani, S.N., Ahmed, J. (1999): Removal of mercury from aqueous solutions by adsorption to rice husks. *Sep. Sci. Technol.* **34** (16), 3139-3153.

[37] Alvarez-Ayuso, E., Garcia-Sanchez, A. (2003): Removal of heavy metals from waste waters by natural and Na-exchanged bentonites. *Clays Clay Minerals* ***51*** (5), 475-480.

الملخص العربي

معالجة العصير الخام للقصب بالبينتونيت العضوي والترشيح الفائق لإنتاج سكر أبيض

عبد العال محمد جابر[1]- سامي إبراهيم الصياد[2]– صلاح على مسعود[3]– محمد شحاته علي[4]

[1] قسم الكيمياء– كلية العلوم وكلية تكنولوجيا صناعة السكر- جامعة أسيوط

[2] قسم علوم وتكنولوجيا الأغذية - كلية الزراعة – جامعة أسيوط

[3] شركة السكر والصناعات التكاملية –الحوامدية – مصر

[4] مصنع سكر أبو قرقاص – المنيا – مصر

يتمحور هذا العمل حول إستخدام البنتونيت العضوي والترشيح الفائق لمعالجة العصير الخام لقصب السكر وذلك للتخلص من اللون والعكارة والحصول على عصير رائق مرتفع الجودة ومن ثم إنتاج سكر أبيض.

تمت دراسة العوامل الرئيسية المؤثرة على كلا من عملية المعالجة والترشيح وهي درجة الحرارة، الأس الأيدروجينى، زمن التفاعل، تركيز المادة العضوية المضافة وتركيز البينتونيت العضوي المستخدم فى عملية المعالجة.

تم تحديد الظروف المثلى للعوامل الأساسية المؤثرة والمؤدية إلى الحصول على عصير رائق منخفض اللون فكانت النتائج كالتالى (درجة الحرارة : 75 درجة مئوية، الأس الأيدروجينى : 5، زمن التفاعل : 10 دقائق، تركيز المادة العضوية : تركيز يساوى 100% من قدرة تبادل الأيونات الموجبة لمادة البينتونيت وتركيز البينتونيت العضوي : 0.6 جرام/لتر) والتى مكنت من الحصول على عصير رائق لونه : 7635 درجة لون، عكارة : 3 درجة عكارة، أملاح : 0.474 %، مختزلات%سكر : 4.8 % ونقاوة : 85 % وعند مقارنتة بالعصير الناتج من المعالجة التقليدية بالجير والكبريت وجد إنه أفضل من حيث الجودة وذلك نتيجة إنخفاض لونه بمقدار 32 % وكذلك عكارتة بمقدار 94 %.