Assiut Journal of Agricultural Sciences 54 (3) 2023 (41-52) Website: http://ajas.journals.ekb.eg/
ISSN: 1110-0486 / EISSN: 2356-9840 E-mail: ajas@aun.edu.eg

(Original Article)

Improvement of Color Removal by Sodium Metabisulfite and Ammonium Persulphate on Syrup Talodora Clarification Process

Nadia H.A. Ramadan[1]*; Samy I. El-Sayiad[1], Soumia M.I. Darwish[1], El-Sayed A. Ramadan[1] and Mohamed. A. Ahmed[2]

[1]Food science and Technology Department, Faculty of Agriculture, Assiut University, Assiut, Egypt.
[2]Egyptian Sugar and Integrated Industries Company (ESIIC), Hawamdia, Giza, Egypt.

*Corresponding author email: nadiahelal@aun.edu.eg
DOI: 10.21608/AJAS.2023.203862.1246

Abstract

This study aimed to improve the color removal of talodora syrup by using sodium metabisulfite and ammonium persulphate, which have a very important effect in the bleaching process. The behavior of the materials used at different concentrations on Brix and the pH of the syrup was studied, as well as the color removal efficiency. Experiments were carried out at Hawamdia sugar refinery factory, Giza Governorate, in the General Administration for Quality and Control, during September and October 2022. The results showed that the rate of decolorization of the samples increased with the increase the concentration of the additives. The best color removal of the syrup is 60.4% when using Sodium metabisulfite at a concentration of 550 ppm on the processed syrup. While the best color removal of the syrup was 35.2% when ammonium persulphate at a concentration of 800 ppm was added to outlet syrup of talodora when compared to color of outlet syrup of talodora. On the other hand, it became clear that the removal color of the syrup when adding the material at the same concentration to the treated syrup was 70.2%, when compared to the color of the syrup inlet talodora. Through the results obtained, it was clear that ammonium persulfate was better than sodium meta sulfite of its effect on removing the color of syrup.

Keywords: *Decolorization, Sodium metabisulfite, Ammonium persulphate, Talodora syrup.*

Introduction

Producing low color white sugar is the most important objective in sugar factories, there are many methods has been done to develop a simple and economical decolonization process to remove colored impurities. These methods include modified clarification techniques; dissolved air floatation, membrane filtration, chemical precipitation, ion exchange, activated carbon adsorption and chemical oxidation via ozonolysis and hydrogen peroxide (Nguyen, 2014). Decolorization is the key process in refining sugar. Although refining sugar improves in many ways, color is the one property that is immediately obvious and can be easily measured. Therefore, color is often specified sugar users and hence

Received: 10 Mayo 2023/ Accepted: 18 June 2023/ Published online: 1 July 2023

is one of the principal controls in every refinery. The decolorization process removes more than color because colorants interact with color precursors, colloidal materials, organic non-sugars and ash forming in organic constituents, so that they are taken out in the color (Chen, 1985). With increasing customer demands for higher quality, sugar mills and refineries are being forced to produce lower color sugar more cost effectively. A few both traditional and new processes and chemicals are available to process managers to achieve good color removal at a reasonable cost, and with minimum downstream disadvantages. Each process or chemical acts via a different mechanism or pathway on the various types of color present in sugar liquors. Some of these processes complement each other, while others may either duplicate or even counteract each other. This paper, which is based on a recent communication on the topic (Davis, 2001).

There are basically four types of color Plant pigments, Melanoidins, Caramels, Alkaline Degradation Products of Fructose (ADF). The first originates from the sugar cane while the last three are created in factories and prove to be more difficult to remove in a refinery (Rein, 2007). Getaz and Bachan, (2009) showed that sulphurous acid salts, sodium hydrosulphite, sodium metabisulfite and sodium sulphite were tested on a laboratory scale to measure the decolorization that can be achieved when applied to factory products.

The major benefits obtainable from syrup clarification are improvements in syrup quality, with the turbidity of treated syrup decreasing by 80-95 % and a reduction in massecuite viscosities, with the viscosity of final molasses boiled from treated syrup decreasing by as much as 25 % (Rein, 2007).

Materials and Methods

Clarification steps in the phosphatation process

The process of floatation can be divided in three main steps: Phosphate flocculation, Air floatation Scum production, Phosphate flocculation. The objective of the first step is to form a floccule that would occlude, adsorb and absorb the greatest possible portion of impurities. This process is further classified in to three steps. Reaction of phosphoric acid and lime. Primary flocculation, secondary flocculation. The reaction between lime and H_3PO_4 produces a precipitate of tricalcium phosphate, to which is added a flocculent to coagulate it .

$$3Ca\ (OH)_2 + 2\ H_3\ PO_4 = Ca_3\ (PO4\ )_2 + 6H_2O$$

The precipitate is very fine; therefor the liquor is airyated by dispersed air to flotation in a clarifier. The precipitate and other debris are scraped off as a scum. The scum is de-sweetened in several ways, the most popular of which is a series of two or three counter current clarifiers. The clear liquor underflow is led to one or two filtration processes where any carryover is removed.

Experiments of adding sodium metabisulfite for clarification of syrup by phosphatation

Experiments were carried out at Hawamdia sugar refinery factory, Giza Governorate, in the General Administration for Quality and Control, during September and October 2022 .

Initial experiments were done using low concentrations from 1 to 100 ppm and they did not bring the desired results. Addition doses were increased to 200, 250, 300, 350, 400, 450, 500, 550 ppm. It was used in its melted form by adding it to the talodora entry syrup before heating. So, the application was made to the untreated syrup inlet talodora plant by simulating the processing of the syrup at talodora plant in the factory as follows:

Adding a solution of the substance, raising the temperature of the syrup to 80 °C, add a solution of lime milk to the syrup to pH 8, addition of orthophosphoric acid solution until pH 7.0, addition of coagulant aggregate, the melt had let to float for about 40 min .

Experiments of adding ammonium persulphate for clarification of syrup by phosphatation

Use of the substance at concentrations of 200, 400, 600 and 800 ppm. It was also used solution. It was applied to remove the color of the syrup treated with the outlet talodora by raising the temperature of the syrup up to 60 °C.

The application was applied to untreated syrup inlet talodora station, by simulating the clarification of syrup talodora station using this concentration (800 ppm) as follows: Raising the temperature of the syrup to 80°C, adding the substance at a rate of 800 ppm, adding a solution of lime milk at the same time as adding the bleaching agent until pH 8. Addition of orthophosphoric acid solution until pH 7.0. Adding the dose of the coagulant ,

The melt had let to float for about 40 min, until complete sedimentation (the same time of holding the syrup in the Talodora broth.

Analysis

The color of syrup was determined at 420 nm by Spectrophotometer Jenway 7310. Total soluble solids were determined using fully automatic digital refractometer; model ATR-S (04320), 0-95%°brix. The pH was measured using pH meter digital, according to I.C.U.M.S.A (2017).

Statistical analysis

The statistical analysis of the obtained data was performed by analysis of variance (ANOVA) and the results were submitted to Duncan's test according to the program SAS (SAS, 1999).

Results and Discussion

Effect of adding sodium metabisulfite at different concentrations on syrup inlet talodora before and after clarification on color removal.

The results represent in Table (1) revealed adding 200,250,300 and 350 ppm sodium metabisulfite from the standpoint of decolorization efficiency for clarification on syrup talodora. The experiment was conducted according to the previous steps and evaluated the effectiveness of these types on brix, pH, color and color removal. The mean values of brix were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification, they were 65.42,65.21,63.04 and 65.55 when adding 200ppm, respectively. The mean values of brix were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification, they were 67.84,65.62,65.42 and 67.52 when adding 250ppm, respectively. On the other hand, when adding 300ppm on the same previous samples the mean values of brix were affected significantly for the samples, they were 66.86,63.62,63.84 and 65.52, respectively and adding 350ppm it were 64.23,61.41,62.53 and 63.45, respectively on the same previous samples. The mean values of pH were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification, they were 6.8,7.0,7.0 and 6.7 when adding 200ppm, respectively. The mean values of pH were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification, they were 6.8,7.0,7.0 and 6.7 when adding 250ppm, respectively. On the other hand, when adding 300ppm on the same previous samples the mean values of pH were affected significantly for the samples, it was the same readings, while adding 350ppm was 6.4,7.0,7.0 and 6.5, respectively on the same previous samples.

The mean values of color were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification, they were 2673,1879,1529 and 2547 when adding 200ppm, respectively. The mean values of color were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification, they were 2407,1696,1322 and 2273 when adding 250ppm, respectively. On the other hand, when adding 300ppm on the same previous samples the mean values of color were affected significantly for the samples, they were 2126,1495,1116 and 1986, respectively and adding 350ppm was 2197,1545,1142 and 2036, respectively on the same previous samples. It is clear from the data presented in Figure (1). The color removal when adding material and clarification of syrup is higher compared to other syrup samples. Also, the color removal in the syrup increases with increasing the concentrations of added material.

Table 1. Results of adding sodium metabisulfite at different concentrations on syrup inlet talodora before and after clarification

Parameter	Brix°				pH				Color (IU)			
ppm	1	2	3	4	1	2	3	4	1	2	3	4
Melting syrup	65.42^{a}	67.84^{a}	66.86^{a}	64.23^{a}	6.8^{b}	6.8^{ab}	6.8^{b}	6.4^{b}	2673^{a}	2407^{a}	2126^{a}	2197^{a}
Clarification without adding material	65.21^{a}	65.62^{c}	63.62^{d}	61.41^{d}	7.0^{a}	7.0^{a}	7.0^{a}	7.0^{a}	1879^{c}	1696^{c}	1495^{c}	1545^{c}
Adding material and clarification	63.04^{b}	65.42^{d}	63.84^{c}	62.53^{c}	7.0^{a}	7.0^{a}	7.0^{a}	7.0^{a}	1529^{d}	1322^{d}	1116^{d}	1142^{d}
Adding material without clarification	65.55^{a}	67.52^{b}	65.52^{b}	63.45^{b}	6.7^{b}	6.7^{b}	6.7^{b}	6.5^{b}	2547^{b}	2273^{b}	1986^{b}	2036^{b}

1= 200ppm 2=250ppm 3=300ppm 4= 350ppm

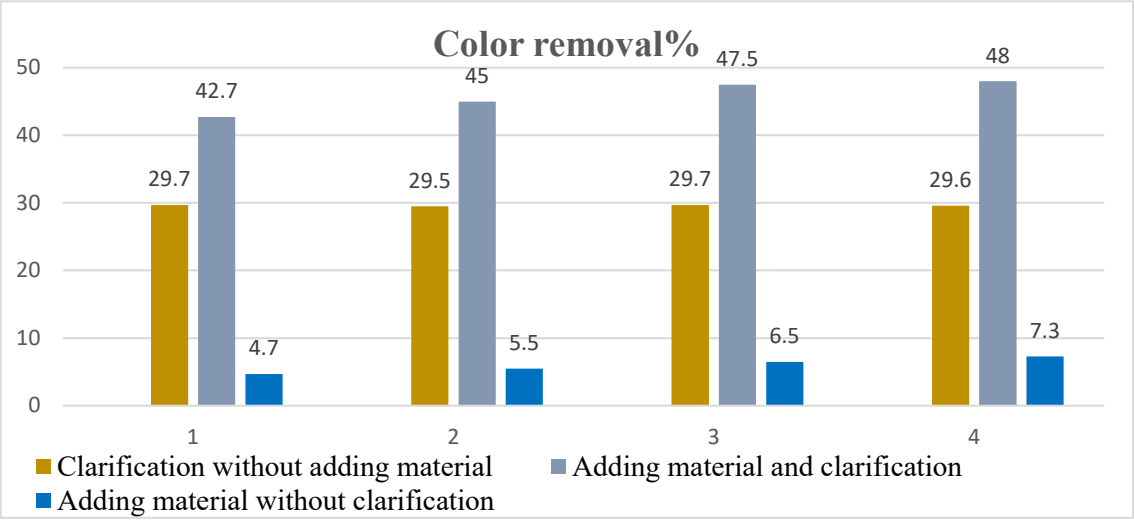


Figure 1. Effect of adding sodium metabisulfite at different concentrations on syrup inlet talodora before and after clarification on color removal. 1=200 ppm, 2=250ppm, 3=300ppm and 4= 350ppm.

Effect of adding sodium metabisulfite at different concentrations on syrup inlet talodora before and after clarification on color removal

The results represent in Table (2) revealed adding 400,450,500 and 550 ppm sodium metabisulfite in syrup talodora. It seems clear from the Table that the mean values of brix were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification, they were 61.43,59.22,59.25 and 61.49 when adding 400ppm, respectively. The mean values of brix were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification, they were 66.15,66.92,66.89 and 67.01 when adding 450ppm, respectively. On the other hand, when adding 500ppm on the same previous samples the mean values of brix were affected significantly for the samples, they were 65.87,65.04,64.63 and 66.45, respectively and adding 550ppm, they were 65.53,65.12,63.08 and 64.62, respectively on the same previous samples.

The mean values of pH were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification, they were 6.3,7.0,7.0 and 6.3 when adding 400ppm, respectively. The mean values of pH were affected significantly for the samples of melting syrup, clarification without adding material, adding material

and clarification and adding material without clarification, they were 6.6,7.0,6.9 and 6.5 when adding 450ppm, respectively. On the other hand, when adding 500ppm on the same previous samples the mean values of pH were affected significantly for the samples, they were 6.6,7.0,6.9 and 6.3, respectively.

The mean values of color were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification, they were 2303,1617,1127 and 2111 when adding 400ppm, respectively, while these values were 3073,2167,1426 and 2773 when adding 450ppm, respectively. On the other hand, when adding 500ppm on the same previous samples it was 2232,1579,932 and 1855, respectively and at adding 550ppm was 1156,813,458 and 892, respectively on the same previous samples. The color removal when adding material and clarification of syrup was higher compared to other syrup samples (Fig 2). Also, the color removal in the syrup increases with increasing the dose of the added material.

Table 2. Effect of adding sodium metabisulfite different concentrations on syrup inlet talodora before and after clarification on color removal

Parameter	Brix°				pH				Color (IU)			
ppm	5	6	7	8	5	6	7	8	5	6	7	8
Melting syrup	61.43^{a}	66.15^{c}	65.87^{b}	65.53^{a}	6.3^{b}	6.6^{b}	6.6^{c}	6.8^{a}	2303^{a}	3073^{a}	2232^{a}	1156^{a}
Clarification without adding material	59.22^{b}	66.92^{b}	65.04^{c}	65.12^{b}	7.0^{a}	7.0^{a}	7.0^{a}	6.9^{a}	1617^{c}	2167^{c}	1579^{c}	813^{c}
Adding material and clarification	59.25^{b}	66.89^{b}	64.63^{d}	63.08^{d}	7.0^{a}	6.9^{a}	6.9^{b}	7.0^{a}	1127^{d}	1426^{d}	932^{d}	458^{d}
Adding material without clarification	61.49^{a}	67.01^{a}	66.45^{a}	64.62^{c}	6.3^{b}	6.5^{b}	6.3^{d}	6.4^{b}	2111^{b}	2773^{b}	1855^{b}	892^{b}

(IU)= ICUMSA units 5= 400ppm 6= 450ppm 7= 500ppm 8= 550ppm

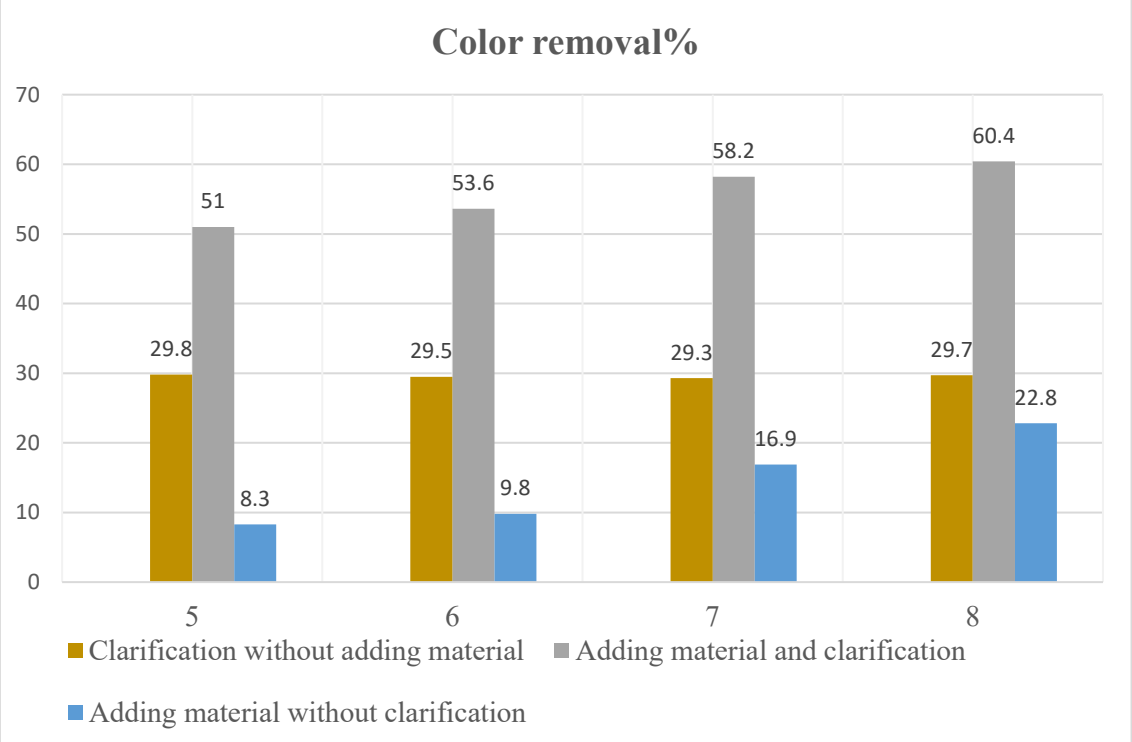


Fig 2. Effect of adding sodium metabisulfite different concentrations on syrup inlet talodora before and after clarification on color removal. 5= 400ppm, 6= 450ppm, 7= 500ppm and 8= 550ppm

1 2 3 4

1. Syrup melting
2. Adding material without clarification 550ppm
3. Clarification without adding material
4. Adding material and clarification 550ppm

Fig 3. Effect of adding sodium metabisulfite 550ppm on syrup inlet talodora before and after clarification on color removal

Effect of adding ammonium persulphate at different concentrations on syrup clarification outlet talodora on color removal

Effect of adding ammonium persulphate at 200,400,600 and 800 ppm on syrup clarification outlet talodora on color removal are listed in Table (3). The experiment was conducted according to the previous steps and evaluated the effectiveness of these types on pH, °brix, color. The mean values of brix, pH and color were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification excepting samples for pH in batch 3, it was not affected significantly.

Based on the obtained results, the effect of some variables for brix outlet syrup talodora was from 59.13-62.70 in different batch. The mean value for brix in syrup with adding 200 ppm ammonium persulphate in different batch it was ranged 58.73-63.16 while at 400 ppm in different batch it was ranged 59.90-63.23, while was ranged 58.16-63.36 at used 600ppm. While at 800 ppm in different batches it was ranged 58.80-63.20. For the pH value, it was ranged 5.2-6.6 in different batches and different concentrations. The color reduction increased with the increase in the concentration of the additives as shown in Fig (4).

Table 3. Effect of adding ammonium persulphate at different concentrations on syrup clarification outlet talodora on color removal

Parameter	Brix°				pH				Color (IU)			
Batch	1	2	3	4	1	2	3	4	1	2	3	4
Outlet syrup talodora	59.13^{c}	62.26^{b}	58.50^{c}	62.70^{c}	6.3^{a}	5.8^{a}	6.6^{a}	6.3^{a}	605^{a}	653^{a}	781^{a}	728^{a}
200 ppm	59.46^{b}	63.16^{a}	58.73^{c}	62.86^{bc}	5.9^{ab}	5.6^{a}	6.3^{a}	6.1^{b}	594^{b}	566^{b}	718^{b}	669^{b}
400 ppm	60.10^{a}	63.23^{a}	59.90^{a}	63.13^{ab}	5.8^{b}	5.5^{ab}	6.3^{a}	5.9^{bc}	544^{c}	545^{c}	673^{c}	626^{c}
600 ppm	58.16^{d}	63.36^{a}	59.23^{b}	63.30^{a}	5.8^{b}	5.6^{a}	6.3^{a}	5.8^{c}	539^{d}	446^{d}	638^{d}	589^{d}
800 ppm	59.76^{b}	63.06^{a}	58.80^{c}	63.20^{a}	5.7^{b}	5.2^{b}	6.2^{a}	5.8^{c}	530^{e}	423^{e}	592^{e}	541^{e}

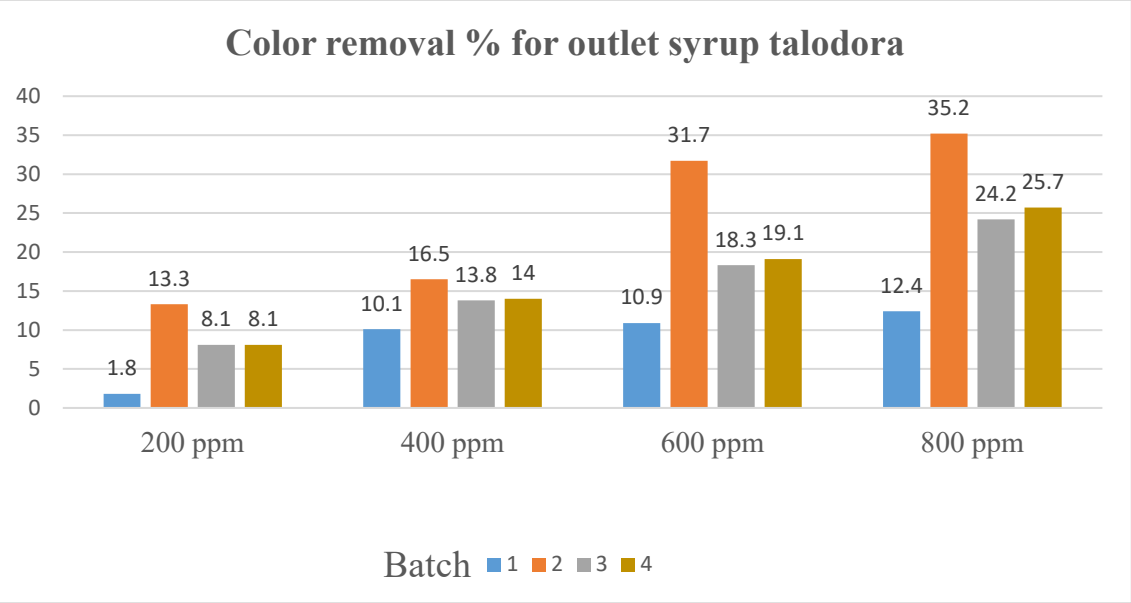


Figure 4. Effect of adding ammonium persulphate at different concentrations on syrup clarification outlet talodora on color removal

Effect of adding ammonium persulphate at 800ppm on syrup inlet talodora before and after clarification on color removal

Results in Table (4) showed that the mean values of brix were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification in batch 1,2 while it was non-significantly in batch 3,4. Data showed that the mean values of brix was 70.23, 69.53, 69.76 and 69.63 for batch 1, respectively. The mean values of brix for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification was 69.40, 69.16, 69.93 and 68.60 for batch 2, respectively. On the other hand, for batch 3, the same previous samples the mean values of brix were 66.63, 67.56, 67.66 and 67.13, respectively and for batch 4, it was 66.26, 66.10, 66.16 and 66.33, respectively on the same previous samples.

Moreover, the mean values of pH were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification it was 6.3, 7.1, 7.1 and 7.0 in batch 1, respectively. Besides, the pH values were affected significantly for the

samples it was 6.3, 7.0, 7.0 and 7.1 in batch 2, respectively. On the other hand, for batch 3, on the same previous samples the mean values of pH were affected significantly for the samples it was 6.3, 7.0, 7.0 and 7.0, respectively. While for batch 4, it was 6.1, 7.2, 7.3 and 7.3, respectively on the same previous samples.

The mean values of color were affected significantly for the samples of melting syrup, clarification without adding material, adding material and clarification and adding material without clarification in batch 1,2,3 and 4. They were 2616, 1569, 970 and 2420 for batch 1, respectively, while they were 1859,1022, 725 and 1705 for batch 2, respectively. On the other hand, for batch 3, they were 2593,1764,870 and 2155, respectively, while for batch 4, they were 2697,1389,804 and 2200, respectively. These results revealed that the adding material and clarification had the best syrup samples because leads to reduction color in good grade (Fig 5). The color removal when adding material at 800ppm and clarification had the best results compared to other syrup samples.

Table 4. Effect of adding ammonium persulphate at 800ppm on syrup inlet talodora before and after clarification on color removal

Parameter	Brix°				pH				Color (IU)			
Batch	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Melting syrup	70.23^{a}	69.40^{ab}	66.63^{a}	66.26^{a}	6.3^{b}	6.3^{b}	6.3^{b}	6.1^{b}	2616^{a}	1859^{a}	2593^{a}	2697^{a}
Clarification without adding material	69.53^{b}	69.16^{ab}	67.56^{a}	66.10^{a}	7.1^{a}	7.0^{a}	7.0^{a}	7.2^{a}	1569^{c}	1022^{c}	1764^{c}	1389^{c}
Adding material and clarification 800ppm	69.76^{ab}	69.93^{a}	67.66^{a}	66.16^{a}	7.1^{a}	7.0^{a}	7.0^{a}	7.3^{a}	970^{d}	725^{d}	870^{d}	804^{d}
Adding material without clarification 800ppm	69.63^{b}	68.60^{b}	67.13^{a}	66.33^{a}	7.0^{a}	7.1^{a}	7.0^{a}	7.3^{a}	2420^{b}	1705^{b}	2155^{b}	2200^{b}

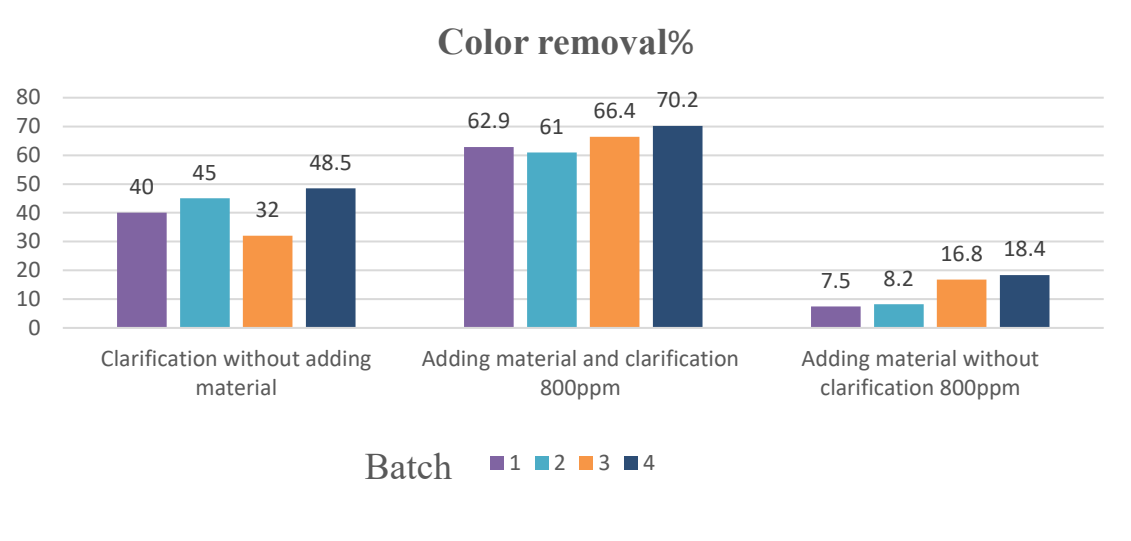
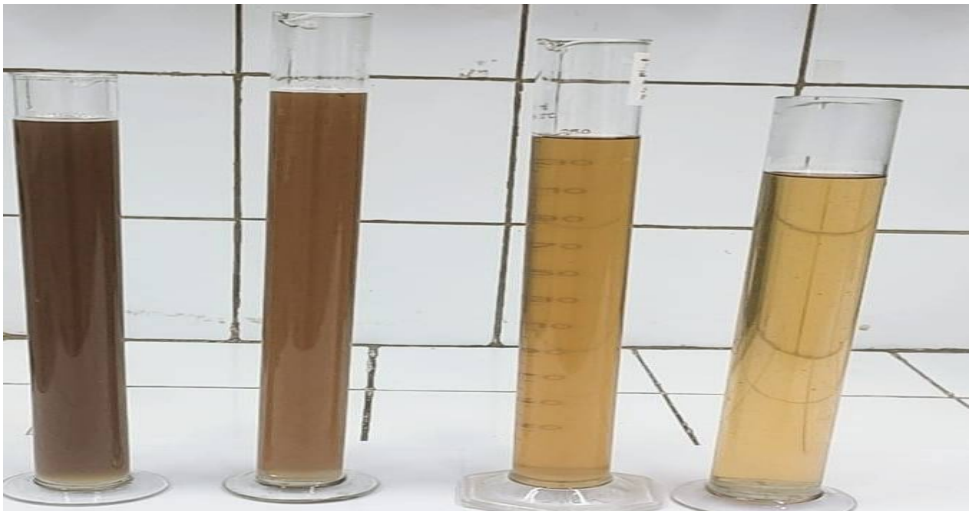


Fig 5. Effect of adding ammonium persulphate 800ppm on syrup inlet talodora before and after clarification on color removal



1 2 3 4

1.Syrup melting
2. Adding material without clarification 800ppm
3. Clarification without adding material
4. Adding material and clarification 800ppm

Figure 6. Effect of adding ammonium persulphate at 800 ppm on syrup inlet talodora before and after clarification on color removal

Discussion

Color removal may be enhanced when syrup clarification is augmented with color precipitants (Madho and Davis, 2008). The original Tate and Lyle patent required the primary flocculation of calcium phosphate. There are, however, unverified claims from sugar mills that the addition of lime and phosphate do not further improve clarification as compared to the process of adding only an ionic flocculant (Steindl and Doherty, 2005). The color removal across syrup clarifiers has been reported to be in the range of 5-10 % (Rein *et al.,* 1987; Steindl and Doherty, 2005). Laboratory sulphitation of the syrup indicated that the syrup color could be reduced by 20-25 % as opposed to 7 % without sulphitation (Rein, 2007), Full - scale trials using 2000 mg sulphur dioxide / kg solids resulted in a 15 % syrup color reduction. The sugar color, however, was reduced by 24 %, suggesting that additional downstream benefits of syrup clarification are available (Smith *et al.,* 2000). Bennett *et al.* (1971) gives extensive results in this regard for a few chemicals, with the optimum addition rate being in the range 200-500 ppm. The range of the optimum dosage is relatively narrow, and it is recommended that periodic testing be carried out in factories to ensure best performance and efficient utilization of the relatively expensive chemicals. Note, though, that Talofloc does not show such an optimum, and color removal increases with increasing dosage up to 2000 ppm .

Conclusion

Color is the first quality attribute of food evaluated by consumers and is therefore an important component of food quality relevant to market acceptance.

Color of raw sugars is one of the important parameters in sugar refining industry. Also, color has long been used in the sugar industry as a measure of impurities. In this study, can be used sodium metabisulfite or ammonium persulphate on talodora syrup to improvement removal color. The results showed that the average decolorization of the dissolved syrup increases with the increase in the concentration of the additive, which is sodium metabisulfite and ammonium persulphate.

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تحسين إزالة لون شربات التالودورا باستخدام ميتا كبريتيت الصوديوم وبيركبريتات الأمونيوم أثناء مرحلة المعالجة

ناديه هلال عبد الحميد رمضان[1]، سامي إبراهيم الصياد[1]، سومية محمد إبراهيم درويش[1]، السيد عبد النبي رمضان[1]، محمد عطيتو احمد[2]

[1]قسم علوم وتكنولوجيا الأغذية، كلية الزراعة، جامعة أسيوط، أسيوط، مصر.
[2]شركة السكر والصناعات المتكاملة المصرية، مصنع التكرير، الحوامدية، الجيزة، مصر

الملخص

تهدف الدراسة الي تحسين إزالة لون شربات التالودورا باستخدام ميتا كبريتيت الصوديوم وبيركبريتات الأمونيوم لما لهما تأثير كبير في عمليه التبييض. تمت دراسة سلوك المواد المستخدمة بالتركيزات المختلفة على بركس ودرجة حموضة الشربات وكذلك على كفاءة إزالة اللون. أجريت التجربة بمصنع تكرير السكر بالحوامدية بمحافظة الجيزة بالإدارة العامة للجودة والرقابة خلال شهري سبتمبر وأكتوبر2022. وقد أظهرت النتائج أن معدل إزالة اللون للعينات يزداد مع زيادة تركيز المواد المضافة، وكانت أفضل ازالة لونية للشربات 60.4% عند استخدام ميتا كبريتيت الصوديوم بتركيز550 جزء في المليون على الشربات المعالج. بينما كانت أفضل ازالة لونية للشربات هي35.2% عند اضافة بيركبريتات الأمونيوم بتركيز 800 جزء في المليون على شربات خروج التالودورا عند مقارنته بلون شربات خروج التالودوا، ومن جانب آخر اتضح أن ازاله لون الشربات عند اضافه المادة بنفس التركيز على الشربات المعالج 70.2% وذلك عند مقارنته بلون شربات دخول التالودورا. ومن خلال النتائج المتحصل عليها اتضح أن مادة بيركبريتات الأمونيوم كانت أفضل من ميتا كبريتيت الصوديوم من حيث تأثيرها على ازاله لون الشربات.