EVALUATION OF OPTIMUM CONDITIONS IN PRELIMING STEP IN SUGAR BEET INDUSTRIES

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ABSTRACT

Juice purification is one of the most important steps in sugar beet industries and the main aim in separation of non-sucrose substances in raw juice and reach to thermo-stable and highly pure juice for the subsequent processes such as concentration and crystallization. In conventional methods, preliming is the first step of juice purification and has an important role in purification process. In this study, the evaluation of optimum condition in preliming step in sugar beet industries in constant temperature (55°C) was conducted. In order to determine the effects of alkalinity (0.16, 0.18, 0.20, 0.22, and 0.24 gCaO/100ml juice) and time duration (20, 25, 30, and 35 min.) on the raw juice, a completely randomized experiment with factorial arrangement and three replications was conducted. Parameters were evaluated include sedimentation rate, color, pH and purification index. The results showed that there is significant difference between alkalinity levels in respect of the effect on sedimentation rate, color and purification index (P<0.01). In addition, a significant difference was seen between time and sedimentation rate, color and purification index (P<0.01). According to these results, the alkalinity value of 0.22 gCaO/100ml juice and pH value of 11.6 with medium value and 30 min. is the best condition for increasing sedimentation rate and purification index and reducing the color.

Keywords: Sugar beet; juice; purification; preliming; alkalinity**.**

INTRODUCTION

Juice purification is one of the most important parts in the sugar industry and determinant of the factory capacity and yield. The aims of researches were carried out to date include:

To maximize the purification rate of the juice (Autorenkollektiv, 1984; Schneider, 1968).

To prevent the sucrose hydrolysis and any color increase in the juice (Vukov, 1976).

To maximize the sedimentation and slurry precipitation rate in decanter and also filtering rate of juice through filters (Autorenkollektiv, 1984; Schneider, 1968).

Eliminating the anions such as phosphates, citrates, oxalates, etc. from the process stream (Schiweck, 1976).

To minimize the hardness and color of thin and thick juice, ash and color of the first grade sugar and molasses amount (Autorenkollektiv, 1984; Schneider, 1968).

To compete the hydrolysis of colorants especially melanoidins and make the juice thermostable (Autorenkollektiv, 1984; Schneider, 1968; Bohn, 1985; Schiweck, 1977; Vasatko & Dandar, 1973; Vukov, 1976).

One of the most important parts of the purification process is the preliming process. Schneider stated that the best pH value for the preliming is about 10.8 to 11.2, so that in larger values, the separated non-sugar substances redissolve into the juice. Morover, a gradually increase in preliming is necessary (Schneider, 1968). Dedek and co-workers presented a time-temperature table for preliming. Based on their table, the minimum and maximum temperature in preliming is 35 and 70°C, similarly, the minimum and maximum intervals for the time are 7 and 23 minute, respectively (Autorenkollektiv, 1984). Ajdari has reported a new relation between time and temperature of preliming (Ajdari & Senge, 2002).

In the preliming step, a large part of salts and non-sucrose compounds will be separated by adding lime. When the maximum quantity of colloids coagulated and precipitation of insoluble lime salt is almost complete, pH value can be considered as an optimal end-point of preliming. A gradual controlled on alkalinity gradient for optimal precipitation of proteins, pectins and insoluble lime salts has to be assured.

The recycling of carbonated slurry to preliming is of great importance in juice purification. More studies have been carried out in this relation, and almost all of the researchers believe that the slurry recycling to the raw juice

must be continuously done until the pH reaches 8.5-9.0. In these conditions, the alkalinity is equals to 0.15 gCaO/100ml juice. Of major characteristics of recycled carbonated slurry is the adsorption of colloidal substances on its calcium carbonate surface, hence the crystals will be larger and the precipitation of slurry in decanter and the filtering rate through filters will increase (Autorenkollektiv, 1984; Baumgarten, 1970; Kohn & Majzis, 1964; Schneider, 1968; Vasatko & Dandar, 1973a; Vasatko & Dandar, 1973b).

Moreover, in pH value about 8.5-9.0, the insoluble salts like phosphoric acid, oxalic acid and part of citric acid will precipitate, but if pH in early stages of purification increase, penta-calcium hydroxide phosphate will occur which corrupts the filtering of juice through the filters (Schneider, 1968). The other important parameter which has a direct impact on purification, is the gradually increase in pH. The colloidal substances in early preliming act as the basic nuclei and the other impurities in the juice will adsorb on their surface, and the particles will grow, so the precipitation rate in decanter and filtering through filters will increase. Reinefeld and co-workers believed that the best indexes for the purification are pectin and protein, which is due to their high content in the juice. Based on their research, it was showed that the pectin will be converted to pectic acid and after interacting with calcium ions, yields calcium pectate, in preliming which is dependent to the existence of enough time and calcium ion concentration in the solution, so in the end of the preliming the precipitation will occur. So one of the important factors affecting preliming's efficiency is the time duration. Reinefeld and co-workers showed that the alkalinity and pH of preliming could not be constant, and it depends the natural alkalinity of the sugar beet, so the higher additive alkalinity in the sugar beet, the higher pH and alkalinity in preliming is needed (Reinefeld, et al., 1980). Based on the high variability in the sugar beet through production seasons, the soil type and texture, seed type, climate, etc., the alkalinity of the sugar beet is varying, and so then, it could not be assured a constant pH and alkalinity for the preliming (Reinefeld, et al., 1980; Vajna, 1968).

MATERIALS AND METHODS

This research was carried out during 2003-4 in four different sugar factories (Torbate-Heidarieh, Jovein, Qahestan, and Shirin). The experiments were done first in pilot scale, and then scaled-up to the factory scale. The experimental design used was completely randomized design with factorial arrangement, for all experiments.

The alkalinity and time were in five (0.16, 0.18, 0.20, 0.22, and 0.24 gCaO/100ml juice) and four (20, 25, 30, and 35 minute) levels, respectively. All experiments were done in triplicate. A sample size of 600ml raw juice in each replication was taken and after purity determination, the carbonated slurry with18º Baumme and pH value equal to 8.5-9 was added.

The preliming temperature was fixed to 55ºC and the lime with 18-20° Baumme added gradually (Autorenkollektiv, 1984). In order to determine the optimal alkalinity of preliming, the alkalinity was adjusted to the appropriate levels and the time was considered too levels, too. In order to increase the lime activity, the lime slurry was stirred for 30 minutes (Autorenkollektiv, 1984; Schneider, 1968).

In each stage, the parameters include alkalinity, pH, brix, sugar percent, color and sedimentation rate were determined and then, the purification index was calculated. Juice color was determined in 560nm wavelength, in Icomsa units. Other experiments were carried out according to the standard methods.

RESULTS AND DISCUSSIONS

Sedimentation index

As can be seen in Figure 1, the sedimentation rate with 0.16gCaO/100ml juice is the lowest and by increasing the alkalinity to 0.22 gCaO/100ml juice, it increases. But in 0.24 gCaO/100ml juice, this rate decreases, which it's difference is statistically significant. These results are in conjunction with the reactions occurring in the juice.

In Figure 2, it can be seen that in the time of 20 min., the sedimentation rate has the lowest value and by increasing the reaction time, this rate will increase, such that in time 30, the rate is in maximum and there is a significant difference between the time levels of 20, 25, and 30.but in the time 35, the rate decreases again, significantly.

This shows that the best alkalinity for sedimentation rate is 0.22 gCaO/100ml juice and 30 min. time duration, which by increasing the alkalinity and/or the time, the rate will be disrupted which is probably due to the re-dissolving of non-sugar substances. The large scale experiments in three factories include Torbate-Heidarieh, Jovein, and Qahestan, also showed that

the filtering rate through filters depends largely on the alkaline conditions of preliming.

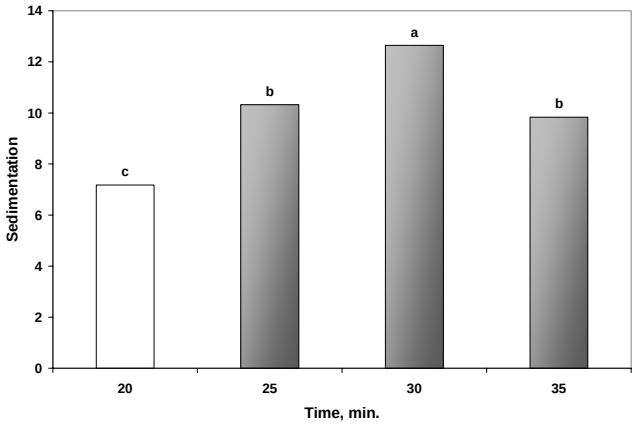

Figure 1. The effect of alkalinity on the sedimentation rate

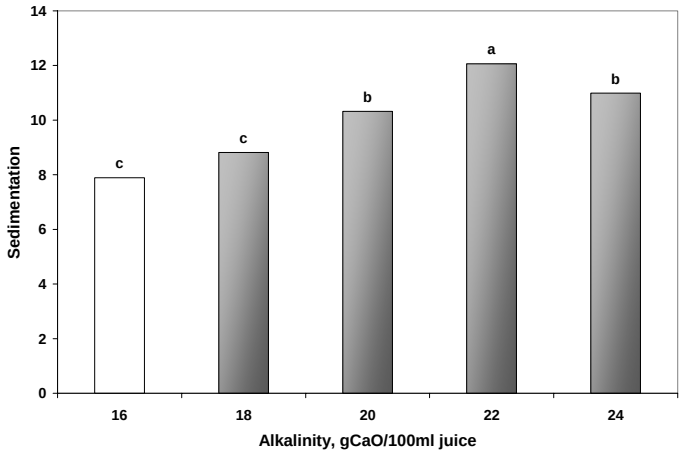

Figure 2. The effect of time on the sedimentation rate

Juice color

The color of juice is an important factor in sugar industry. The lower color of the juice, the greater quality of final product, and the lower production of molasses. The Figure 3. shows when the alkalinity exceeds 0.22 gCaO/100ml juice, the color of prelimed filtered juice decreases significantly, but in 0.24 gCaO/100ml juice, the color will increase again.

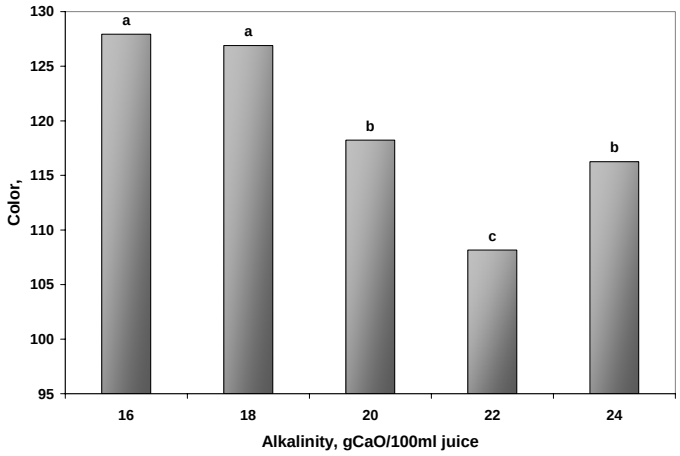

Figure 3. The effect of alkalinity on color

Also, it can be seen in Figure 4., that the time duration to interact is of great importance in color content of juice. The longer time of interactions up to 35 min., the color content increases again, which is probably due to the re-dissolving of non-sugar substances into the juice.

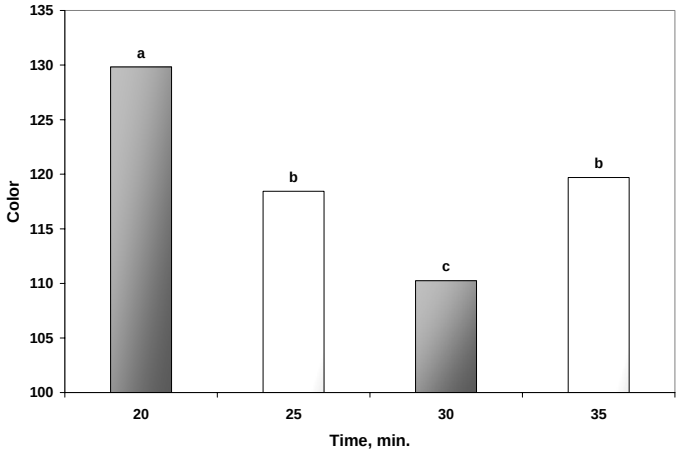

Figure 4. The effect of time on color

Purification coefficient

Purification coefficient is of the most important parameters in sugar industry. The greater purification coefficient, the greater purification efficiency. As one of the most important reasons of factory losses is molasses production increase, and the contrary relation of molasses amount and purification coefficient, by increasing the purification coefficient of juice, the amount of molasses will decrease.

Figures 5 and 6, shows that by increasing the alkalinity to 0.22 gCaO/100ml juice, and time duration to 30 min., the purification coefficient increases significantly, but in 0.24 gCaO/100ml juice and 35 min. duration, it decreases again. Figure6. The effect of time on purification index

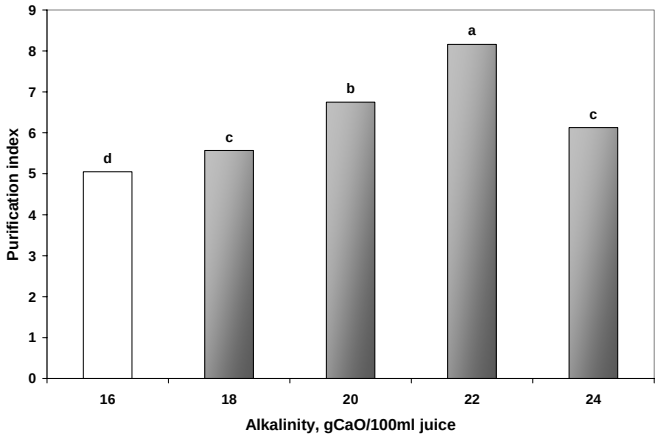

Figure 5. The effect of alkalinity on purification index

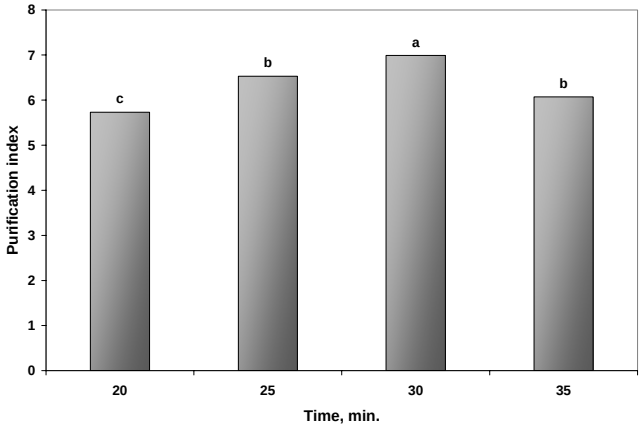

Figure 6. The effect of time on purification index

CONCLUSIONS

The comparison between Figs. 1-6, shows that in the appropriate alkalinity conditions in preliming, the juice will be of great quality, the color will be in minimum, and the sedimentation rate will increase. The experiments

showed that in constant temperature of 55°C, the best alkalinity in preliming in 0.22 gCaO/100ml juice and time duration of 30 min., but it must be noted that the pH increase must be gradually. The experiments in Torbate-Heidarieh, Jovein, and Qahestan factories showed that the preliming alkalinity can not be constant, and it depends the natural alkalinity of sugar beet, so of this reason, the preliming alkalinity is in a range of 0.16-0.24 gCaO/100ml juice. It is concluded that the optimal alkalinity of preliming must be determined daily and based on it, the alkalinity must be adjusted. In other words, the optimal preliming alkalinity as the alkalinity in which the sedimentation rate and purification coefficient are maximal and the color is in minimum

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