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# Study on the performance of sugarcane juice clarifier

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**Abstract**

The investigation was undertaken in order to find out the performance of continuous type sugarcane juice clarification. Because sugar cane juice darkens quickly after extraction due to the oxidation of some of its constituents harming its commercialization thus requiring rapid consumption. If stored, sugar cane juice must be clarified since it darkens minutes after extraction due to the oxidation of some of its components (especially chlorophyll and polyphenolic compounds), which can negatively affect its consumption. About 50-60% of the cane produced, which is utilized for the production of jaggery and khandsari. The quality of this sweetener depends on the efficiency of clarification process of sugarcane juice. Like any other colloidal solution, cane juice is heterogeneous in nature and due to various sized particles colour of juice is developed. The quality and price of jaggery is governed by its external features like colour and texture and hence the production of good quality jaggery depends on its juice composition and extent of clarity of sugarcane juice used. In jaggery industry, the cane juice is generally clarified in batch process which is very unhygienic. Hence to avoid this drawback, the continuous type sugarcane clarifier is developed. The pH and Optical density obtained 5.2 and 2.003 for fresh cane juice as well as pH for clarified juice 7.6 and 0.44 through continuous type sugarcane juice clarification.The degree brix of fresh cane juice was obtained 25° and 21° found for clarified juice.

**Keywords:** Sugarcane juice clarifier, cane juice, performance, pH and optical density

## 1. Introduction

Sugarcane is as an important agro-industrial crop in our Indian agriculture. Botanically, sugarcane belongs to the Andropogonae tribe of the family Gramineae, order Glumiflorae, class Monocotyledoneae, subdivision Angiospermae, and division Embryophitasiphonogama. The subtribe is Sacharae and the genus, Saccharum, derived from the Sanskrit word “sarkara” meaning white sugar.Around the world, sugar cane is one of the important commercial crops used to manufacture several types of sweeteners such as white, refined, brown, and raw sugar (Shakunthala and Devraj, 1991). The main by-products of sugar industry are bagasse and molasses. Molasses, the chief by-product, is the main raw material for alcohol and thus, for alcohol-based industries. Excess bagasse is now being used as raw material in the paper industry and eating utensils. Besides, co-generation of power using bagasse as fuel is considered feasible in most sugar mills.

Sugarcane is an industrial crop with average of about 4 million hectares and production to the tune of 300 million tonnes in India. Over the past 65 years, the yield of sugarcane in tonnes per hectare has more than doubled. Every tonne of cane cultivation requires approximately 60-70 tonnes of water under controlled conditions. The sugar industry is the second largest agro-based industry in India, next to cotton textiles (Kadlog et al, 1994), involving nearly 50 million farmers, their dependents and a large mass of agricultural labourers (Bhatt and Shukla,1990). Sugarcane juice is the juice extracted from pressed sugarcane. It is consumed as a beverage worldwide, and especially in regions where sugarcane is commercially grown such as South-East Asia, South Asia, and Latin America.The quality of sugarcane improves with age, reaches a peak, and then gradually starts declining. A rapid deterioration begins from the moment of harvest. To make the most of your sugarcane crop, the cane has to be crushed within 8 to 10 hours of cutting.

Sugar cane juice is the raw ingredient which sugar manufacturers' process into the familiar granulated white sugar sold as a sweetener. Out of the total white crystal sugar production, approximately 70% comes from sugarcane and 30% from sugar beet **(**Vaidya et al, 1984).In most countries where sugarcane is cultivated, there are several foods and popular dishes derived directly from it, such as; raw sugarcane, chewed to extract the juice; sugarcane juice, a combination of fresh juice, extracted by hand or small mills, with a touch of lemon and ice to make a popular drink;*Cachaça*, the most popular distilledalcoholic beverage in Brazil; *Jaggery*, a solidified molasses , known as *gur* or *gud* in India; *Panela*, solid pieces of sucrose and fructose , a food staple in Colombia and other countries; molasses, used as a sweetener and a syrup accompanying other food (Asfaq and Chand, 2020).Turbidity, impurities and color are all factors that reduce yields from sugar processing, with decreased sugar quality and high levels of sugar in molasses. Eliminating impurities efficiently at the start of the process will generate exponential gains in sugar color, quality and factory yields. Clarification of sugarcane juice is therefore an essential step to obtain high yields and high quality of the sugar. The clarification process needs to remove components other than sucrose and, at the same time, minimize loss of sucrose and colour formation (Gallardo and Gallardo, 2001)**.**

The non sugar impurities present in the juice, both suspended and dissolved has to be removed for obtaining both better quality crystal sugar and jaggery. Clarification is therefore an essential step to obtain high yields and high quality of the sugar. To guarantee satisfactory cane syrup quality, it is critical to ensure that the clarification step results in a juice of consistently high clarity and right taste and flavour. The clarification process needs to remove components other than sucrose and, at the same time, minimize loss of sucrose and color formation. Thus, juice clarification process aims at removal of maximum of non-sugar and colouring matters. Inadequacies of process efficiency at this stage are reflected in impurities in the products and lower exhaustion and production of molasses (Gupta and Malik, 2004). The process of clarification also aims at preventing the formation of non-sugars during heating due to the acidity of juices (Rao, 1973).

Sulphitation is currently the most widely used process to clarify cane juice, but it has problems which the sugar/alcohol industry would like to be solved, including (a) sucrose inversion due to low pH during the process; (b) potential environmental and external corrosion problems in the area, caused by any emission of $SO_2$/ $SO_3$; (c) incrustation and corrosion of the evaporation equipment; and (d) presence of sulphite in the final sugar (Deben, 1976). Therefore, there is a desire to have a clarification process which is superior to the sulphitation process, but which avoids the problems with carbonation. Although there is immense possibility, very few studies have been reported on mechanical clarification of sugarcane juice.

## 2. Material and Methods

The fresh sugarcane juice was procured from a private crusher at Pantnagar Farmer's fair. The cane juice was brought in the laboratory for the experiment in two lots of 30 litres each then the juice was passed through a screen for removal of suspended solids present in the juice. This process is an important pretreatment process for effective clarification of juice.The stems of Deola were used as vegetative clarificant. The Deola stems were cut into pieces of almost equal size and these pieces were then soaked in the water for three hours and then they were pound and rubbed in water to obtain a mucilaginous liquid and was used as clarificant.

### 2.1 Experimental Procedure

The fresh cane juice was taken after crushing of sugarcane in the sugarcane crusher. Then it was filtered by the Stainless steel strainer. Optical density, pH and temperature were taken for fresh juice. Optical density has an inverse relationship with transmittance of an optical medium for a given wavelength. Higher OD, lower transmittance and vice versa e.g.; optical density of 1 means 90% of incident light is absorbed.

The fresh cane juice was filled in the sump of 30 litres capacity. After that the juice was pumped into the boiler tank (30lt) with the help of submersible pump (model no. SP-2300 with discharge of 2100 liters/hour) of 40 watts. The boiler tank is placed at maximum height (4ft) and is connected to the clarifying tank (2ft,) in series. After getting heated in the boiler, juice is passed into the clarifying tank of 30lit capacity and vegetative clarificant i.e. mucilaginous liquid of Deola stem @ 45g per quintal (i.e. 30ml) was added and (manually) agitated properly for thirty minutes. Our main objective was to maintain the temperature and holding time in the clarifying tank, respectively by voltage regulation (by using dimmer stat) and flow rate regulation (by the control valves). The desired temperature (85˚C) and holding time (60 min) in the clarifying tank are controlled by the manipulated variables (heat flow rate and flow rate respectively). This control is known as feedback control. During experiment, juice was held for 60 min, with the flow rate (0.525 lit/min) in the clarifying tank at desired temperature (Singh and Singh, 1954). Time for different stages of clarification given in Table 1. The juice from clarifying tank was collected in the collecting tank after straining (by removing scum) and got clarified juice. Juice samples were collected for the measurement of optical density, pH, temperature, and degree brix and the whole process for clarifying cane juice mentioned in Figure 1.

**Table 1:Selection of time for different stages of clarification**

| S.No. | Stages of Clarification | Time (min) |
|---|---|---|
| 1. | Filling starts in boiler | 0 |
| 2. | Filled up to discharge level in boiler | 60 |
| 3. | Discharge starts from boiler | 90 |
| 4. | Filling starts in clarifying tank | 90 |
| 5. | Discharge from the clarifying tank | 150 |

| | | |
|---|---|---|
| 6. | Discharge from the collecting tank | 160 |

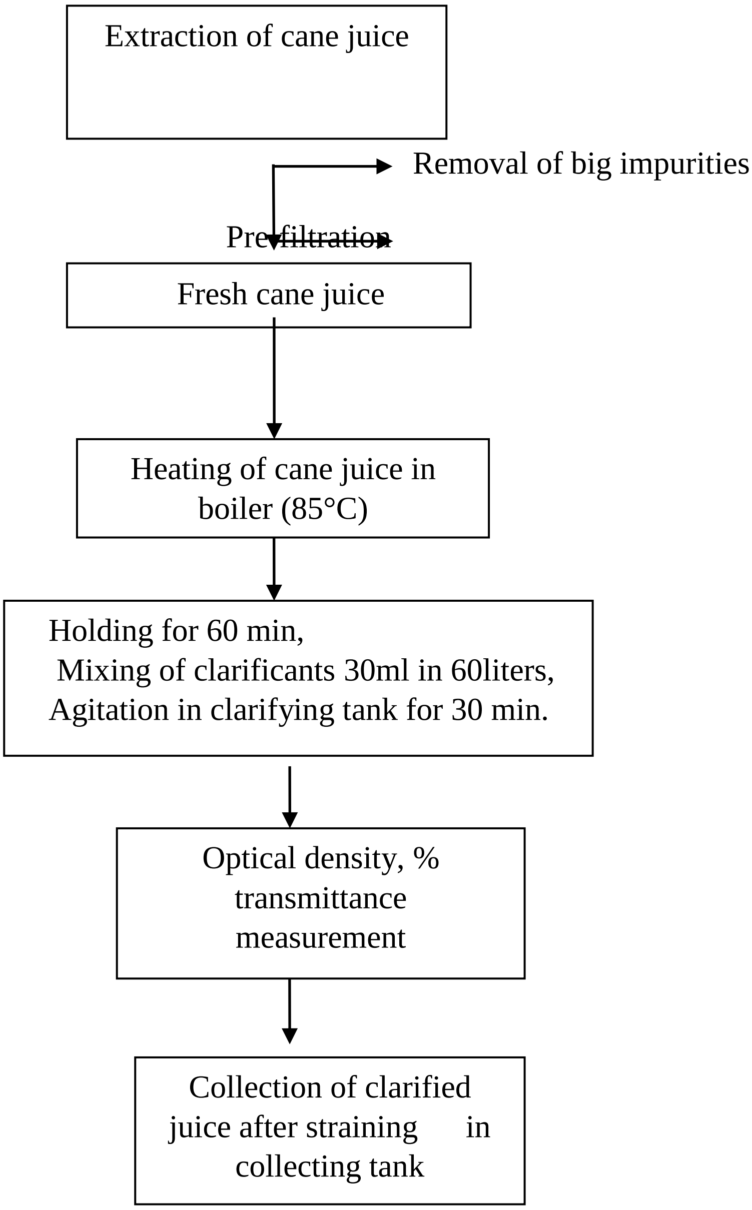


**Fig. 1** Process for clarification of sugarcane juice

**2.2 Primary Properties**

**2.2.1 *Measurement of degree brix***

The Brix is the per cent by weight of soluble solids in a solution. Further, brix may be defined as spindle brix (measured by a brix hydrometer) or refractive brix (measured by a refractometer). The clarified cane juice is re-collected in the sump and the brix hydrometer is dipped in it. The brix hydrometer remains partially submerged in the liquid and the reading which it shows at the surface is recorded (Asfaq and Chand, 2020). Certain precautions must be taken while using brix hydrometer. These are:

- Part of the spindle which is not immersed should be dry.
- Any froth which may be present at the surface should be blown off whilst lowering the spindle in the solution.
- Allow sufficient time to elapse so that the spindle is at the same temperature as that of the juice.

The brix spindle is designed to give correct reading at 20°C. when the brix reading is to be taken at higher temperature, the reading must be corrected to get true brix at 20°C. for this correction, 1° Brix is added for every 11°C.

**2.2.2 *Measurement of flow rate***

Flow rate was calculated by using the equation (1).

a. Capacity of clarifying tank ($C_c$)

$$(C_c) = \frac{\pi}{4} (d_c)^2 h_c \ (cm^3) \qquad (1)$$

where,

$h_c$= Difference of height between input and output of clarifying tank(cm) and $d_c$ =Diameter of clarifying tank(cm)

b. Flow Rate ($F_{in}$) by equation (2).

$$(F_{in}) = \frac{Cc}{1000 \times 60} \ l/min \quad (2)$$

where,

Holding time of the heated juice in clarifying tank = 60 min.

The flow rate has to be maintained constant throughout the process once and computed. For controlling the flow rate, the flow control valve has been provided which is opened when the flow exceeds the calculated value and the juice starts flowing back thus giving a constant flow rate.

**2.2.3 *Measurement of optical density of juice***

The optical density of the juice has an inverse relationship with its transmittance. More the optical density lesser will be the transmittance of any solution. The optical density is proportional to the concentration of the solids and depth of the solids and depth of solution. A UV Visible Spectrophotometer was used to measure the optical density of the juice sample before and after clarification. The readings were recorded digitally in a wide range of wavelengths with the peak value and the corresponding wavelengths were different for juice before and after clarification. For the measurement the juice sample was filled in a glass cuvette and the cuvette was placed on the spectrophotometer and the O.D. value displayed digitally were read and noted.

**2.2.4 *Measurement of pH***

The pH of an aqueous solution is a measure of the hydrogen ion concentration and is defined as common logarithm (base 10) of reciprocal of the hydrogen ion concentration. A handy pH meter is used for the measurement of pH of the juice sample before as well as after clarification. A necessary precaution needs to be taken while measuring the pH, i.e. the sample must be at room temperature when the pH is determined. The pH of initial sample should be taken as soon as the juice is procured.

**2.2.5 *Measurement of Temperature***

Initial temperature of the juice is recorded soon after the extraction of cane juice. The temperature in the boiler has to be risen above 85°C so that a temperature of 85°C can be maintained in the holding tank. Temperature is maintained constant by voltage regulation. For the measurement of temperature, a simple Celsius scale thermometer is used.

**2.3 Secondary properties**

These are the properties which are dependent on primary properties and are determined by making the use of various formulae.

**2.3.1 *Specific heat* (S)**

When concentration decreases specific heat increases. The Brix is related to the specific gravity of the sucrose solution (Pujari and Mehta, 2010). It is calculated by using the following formula (3):

$$S = 0.9938 - (0.005963 \times b_f) \qquad (3)$$

where,

$b_f$ is the Degree brix and S- Specific gravity (dimensionless quantity)

**2.3.2 Thermal Conductivity ($T_c$)**

The thermal conductivity is measured using the following formula (4)

$$T_c = 0.2774 + (0.00213 \times T_{av}) \qquad (4)$$

where, $T_{av}$ is the average of initial and final temperatures in °C.

**2.3.3 Viscosity (μ)**

The viscosity of the sample depends on the solid concentration in the sample and the temperature of the sample (Pujari and Mehta, 2010). Viscosity of cane juice is quite near the viscosity values for cashew drink, litchi juice, pineapple juice etc. viscosity is measured by the following formula (5):

$$\mu = 16.719 - (0.0837 \times T_{av}) \qquad (5)$$

where, $T_{av}$ is the average of initial and final temperatures in °C; and μ is the viscosity in poise.

**3. Results and Discussion**

The experiments were conducted for one hour holding time and at desired temperature (85˚C) in the clarifying tank to clarify the cane juice. Both parameters were maintained by flow rate and heat flow rate. By using these parameters, the results were just better than traditional controlled methods shown in the Table 2 and somewhat compared with mechanical clarification. The resultant values of various properties for initial as well as clarified cane juice along with the experimental requirements were described below in different sections:

**3.1 Degree Brix**

The value of °brix as recorded was 20° and a correction of 1° was added for the temperature variation from the standard temperature for which the hydrometer was calibrated. So, the resultant value of °brix for the clarified juice was 21° which is lesser as compared to the initial value of °brix for non-clarified juice 25° it indicates that good quality sucrose present in juice (Chand and Pandey, 2012). The value of degree brix should lie in between 18-25° for getting good results (sucrose) as per the data obtained are in the range.

**3.2 Flow Rate**

The difference of height between input and output of clarifying tank was 38cm and the diameter of the holding tank was 32.5 cm. so the calculated capacity of the clarifying tank was obtained 31508 $cm^3$. Now for holding time to be 60 min and the calculated flow rate comes out to be0.525l/min for getting the best performance of the cane juice clarifier.

### 3.3 Optical Density

The results of optical density at different wavelengths of fresh cane juice as measured using spectrophotometer were mentioned in the **Table 2**.

**Table 2: Optical density at different wavelengths for non-clarified juice**

| Wavelength (nm) | Optical Density |
|---|---|
| 463 | 2.97 |
| 472 | 2.89 |
| 481 | 2.84 |
| 490 | 2.75 |
| 499 | 2.64 |
| 508 | 2.53 |
| 517 | 2.44 |
| 526 | 2.37 |
| 535 | 2.33 |
| 544 | 2.29 |
| 553 | 2.26 |
| 562 | 2.23 |
| 571 | 2.21 |
| 580 | 2.18 |
| 589 | 2.16 |
| 598 | 2.13 |
| 607 | 2.11 |
| 616 | 2.09 |
| 625 | 2.06 |
| 634 | 2.04 |
| 643 | 2.02 |
| 652 | 2.01 |
| 661 | 2.00 |

The value of optical density is varying from 2 to 3 for non-clarified juice. The maximum value of O.D for non-clarified juice is 2.97 for the wavelength of 463 nm and the minimum value was 2.00 for the wavelength of 661 nm whereas at wavelengths 400nm and 696nm, the O.D. for clarified juice obtained were 2.86 and 0.284 (as shown in the Table 3), which is quite low. This is an indicator of effective clarification (Mackiney and Chichester. 1954).

Here mainly due to heating effect and holding time, optical density decreases due to removal of impurities from the cane juice.

**3.4 pH**

The pH of the non-clarified juice as measured came out to be 5.2. The clarificant must raise the pH of juice as at higher pH the flocculating property of juice improves to a great deal (Chand and Pandey, 2012). The pH of clarified juice came out was found to be 7.6 this value is quite satisfactory and indicates good clarification of the cane juice as it lies in the range of 7.5-8.5.

**3.5 Temperature**

The initial temperature of the fresh cane juice was found 21.6°C and the final temperature as measured in the collecting tank was obtained as 80.5°C. These values of temperatures were used for the measurement of thermal conductivity and viscosity of the juice (Pujari and Mehta, 2010).

**3.6 Specific heat**

The specific gravity calculated for non-clarified juice came out to be 0.844and for clarified juice, specific gravity calculated was 0.869. The value of specific heat can vary between 0.6366-0.9370 kcal/kg/°C.

**3.7 Thermal Conductivity**

The thermal conductivity was found to be 0.386kcal/h/m/°C. At 18° brix, thermal conductivity can vary from 0.339 kcal/h/m/°C to 0.403 kcal/h/m/°C which was in the range and result was good (Pujari and Mehta, 2010).

**Table 3: Optical density corresponding to different wavelengths for clarified cane juice**

| Wavelength (nm) | Optical Density |
|---|---|
| 400 | 2.86 |
| 409 | 2.171 |
| 418 | 1.717 |
| 427 | 1.421 |
| 436 | 1.186 |
| 445 | 1.108 |
| 454 | 0.937 |
| 463 | 0.865 |
| 472 | 0.789 |
| 481 | 0.733 |
| 490 | 0.689 |
| 499 | 0.659 |
| 508 | 0.629 |
| 517 | 0.605 |
| 526 | 0.582 |
| 535 | 0.563 |

| | |
|---|---|
| 543 | 0.544 |
| 552 | 0.528 |
| 561 | 0.512 |
| 570 | 0.497 |
| 579 | 0.483 |
| 588 | 0.468 |
| 597 | 0.452 |
| 606 | 0.433 |
| 615 | 0.419 |
| 696 | 0.284 |

**4.8 Viscosity**

The viscosity of fresh cane juice was found to be 12.45 cP. The value of viscosity varies with temperature and the concentration of liquid. Experiment was mainly conducted for one hour holding time and at desired temperature (85˚C) in the clarifying tank. Both parameters were maintained by flow rate and heat flow rate. The values of optical density of clarified sugarcane juice obtained from mechanical method was in the range of 0. 92 to 1.63 (depending on the height of the agitator), Panda *et al.* (2006). This shows that the results obtained from continuous type sugarcane juice clarifier were some better than this method because the value of optical density at 540 nm is about 0.523, which is quite lower than the above-mentioned value and is independent of any physical factor. Also, continuous type process scores over most commonly employed sulphitation technique. Sulphitation has problems which the sugar/alcohol industry would like to be solved, including (a) sucrose inversion due to low pH during the process; (b) potential environmental and external corrosion problems in the area, caused by any emission of $SO_2$/ $SO_3$; (c) incrustation and corrosion of the evaporation equipment; and (d) presence of sulphite in the final sugar. Therefore, continuous type clarifier (Figure 2) was better as along with the problems of sulphitation it also avoids the problems of carbonation. Continuous type process is versatile and can be employed to perform a multitude of process. It may be a better choice over batch type process. Some of the benefits observed, during the experiment were: i) Cost-effective process ii) Hygienic process iii) Process combination iv) Reduced changeover times

**Fig 2: Continuous type sugarcane juice clarifier**

**Conclusions**

The quality and price of jaggery were governed by its external features like colour and texture and hence the production of good quality jaggery depends on its juice composition and extent of clarity of sugarcane juice. In the jaggery industry, the cane juice was generally clarified in batch process which is unhygienic. Hence to avoid this drawback, the continuous type sugarcane clarifier was used and tested. The following conclusions were drawn as the Optical density was 2.00 for fresh cane juice and was 0.44 for clarified cane juice for continuous type sugarcane juice clarification and the pH for fresh cane juice was 5.2 and that for clarified juice was 7.6.The degree brix was 25° for fresh cane juice and was 21° for clarified juice for getting best clarification of fresh cane juice.

**References**

1. Asfaq and Chand Khan (2020). Effect of Moisture Absorber and High-Density Polyethylene Bags on Shelf Life of Edible Coated Jaggery Cubes During Storage, Sugar Tech, 22(6):1130–1137.
2. Bhatt S and Shukla R.P. (1990). Studies on the classification of sugarcane juices with a new setting and MAFLOC-985. Bhartiya Sugar. 23-29.
3. Chand Khan and Pandey R.K. (2012).Optimization of Foam Mat Drying Process Variables for Malta Powder. International Journal of Food, Agriculture and Veterinary Sciences, 2(2):67-73.
4. Deben J.G. (1976). The chemistry of calcium phosphate precipitation in cane juice clarification. Int. Sugar, 98(925): 3-7.
5. Gallardo C.C. and Gallardo H.F. (2001**)**. Clarification of sugarcane juice for the manufacture of "Panela". Faculated National de Agronomic Medallion. 54(12):1211-1239.
6. Gupta D.P. and Malik D. (2004**)**. CaO rise from mixed juice to clear juice. Indian sugar. 54(2): 101-110.
7. Kadlog A.D., Surve S.P. and Durgude A.G. (1994). Clarification of juice in jaggery making a review. Bhartiya Sugar: 33-35.
8. Mackiney and Chichester (1954). Colorimetric analysis. AVI Publishing Co., Inc., London.
9. Panda T.C. (2006). Performance evaluation of sugarcane juice clarifier. M.Tech. Thesis, Department of Post Harvest Process and Food Engineering, G.B.P.U.A.T., Pantnagar, Uttarakhand, India.
10. Pujari N.K. and Mehta N.S. (2010).Development of continuous type sugarcane juice clarifier.B.Tech. Thesis, Department of Post Harvest Process and Food Engineering, G.B.P.U.A.T., Pantnagar, Uttarakhand, India.
11. Rao P.J. M. (1973). Administration in the Indian sugar Industry. Sugar Technology, 52(9):19.
12. Singh H. and Singh P.G. (1954). Comparative efficiency of clarificants. 2$^{nd}$ Biennial conference of Sugarcane Res. & Dev. Workers, Jallandhar.
13. Shakunthala V.A. and Devraj G. (1991). Hibiscus abelmosschus Linn. A new vegetable clarificant in jaggery manufacture. Presented in National Seminar on Increasing Productivity, Quality and Storability of jaggery (Gur) at IISR, Lucknow.
14. Vaidya B.R., Kadlage A.D. and Hapse D.G. (1984). The efficiency of different vegetable clarificants for quality jaggery preparation. Maharashtra Sugar, 9(4): 65-71.