CHAPTER 3

Analytical Determination and the Effect of Several Variables on Juice Clarification
CHAPTER 3 Variables on Juice Clarification

3.1. Introduction:

The juice extracted from sugar cane by crushing in laboratory three roller mill. The juice is filtered through cotton wool in order to remove bagasse fragments and other suspended matter. Clarification performance aims to obtain perfect clear juice. During the process, of clarification maximum amount of non-sugars are precipitated and these non-sugars are eliminated in the filter cake along with the dirty juice.

Examination of cotton-wool filtered juice under the microscope reveals something of the nature of the system to be studied, for the juice is seen to contain a very large number of particles of diameters up to 5\(\mu\) or 6\(\mu\). The particle density may be readily determined by direct counting using a haemocytometer. The juices so far studied densities have varied between \(2.5 \times 10^6\) and \(1.2 \times 10^9\) particles per ml i.e, of the order of a thousand million particles per ml. There is no doubt that the presence of these particles in suspension largely accounts for the opacity of raw juice.

The filtered juice is dark green in colour and opaque, generally it may be clarified by boiling after the addition of milk of lime to a about pH 8. The copious precipitate formed settles out on standing, to leave a clear amber supernatant liquid. This is essentially the defecation process which is used commercially, though sometime it is found desirable to add a substance which will increase the extent of calcium precipitation, for instance phosphoric acid, sulphur dioxide gas.

Besides the beneficial influence of heat, the most important factor for precipitation is the pH of the juice, in the sulphitation practice the pH is regulated by lime addition and sulphitation or by sulphitation and lime addition. The sulphitation process can be considered to take place in two steps. first step is neutralization of juice acidity this being a juice defecation. The other step is neutralization of the excess
lime with sulphur dioxide. The precipitation initiated by the lime addition comprises a series of complicated processes that can be distinguished into chemical reaction and physical phenomenon occurring in colloidal state.  

Physical precipitation of juice colloids is a matter of destroying the solubility of colloidal system with water as the dispersions medium and are differentiated into hydrophobic and hydrophilic systems. The stability of hydrophobic colloids is caused by the electric charge of the particles preventing them from becoming attached to each other. Neutralization of the electric charge results in agglomeration of a great number of the minuscule colloid particle until an aggregate (floc) has grown large and heavy enough to be removed from solution by sedimentation or filtration. Neutralization of electric charge is exerted by adsorption of ions with opposite charges. As the presence of ions in a solution is highly dependent on the pH, this value also greatly influences the flocculation. Hydrophobic colloids are mainly of inorganic nature for instance siliceous compounds ferrous hydroxide and aluminum hydroxide.

The state of stability of hydrophilic colloids is mainly due to the salvation of particles. Flocculation occurs by removing heavy water molecules that form a protective wall around the colloidal particles. This process of dehydration, in juice purification is accomplished largely by the influence heat. Hydrophilic colloids mainly consists organic compounds such as hemi cellulose, nitrogen containing substances, starch etc.,

Another important phenomenon occurring at the removal of colloidal matter from solutions is adsorption. Adsorption is the attachment of molecules of colloidal particles to the surface of solid matter. Precipitates with large surface area may show high adsorption capacity. Calcium phosphate precipitation plays a most important
role in juice clarification. (for instance, the burnt cane juice with low Phosphate content commonly show normal behavior during the sulphitation process after the addition of soluble phosphate to mixed juice). The pH value of solution has definite influence on the maximum quantity of adsorbed matter.

The physical behavior of the juice is concerned, the heterogeneity of the dispersed phase is not important. Adsorption of material from solution in the continuous phase must render the surface of each particle identical with all others in that system and the juice should behave as homogeneous dilute suspension, similar to a (diluted) natural latex with in certain limits. The quantity of material in suspension is also relatively unimportant, for it is the nature and state of the particles present, which must determine the behavior of the system as a whole.

3.2. Review of Literature:

Investigations into the composition of cane juice have been reviewed by Binkely and Wolfrom and by Honig but there is little published information concerning the physical relationship of the various constituents with each other and the role played by these substances in the clarification of the juice. Occasionally, indeed in some parts of the world frequently, juice are obtained which are not clarified satisfactorily by the methods in common use, and although various additives have been used with success, for instance, formaldehyde, mineral clays and synthetic polyelectrolytes, no explanation of their action has been offered.

GunduRao et al studied the effect of various constituents on mud settling at lab scale. Their findings are as follows:

* Settling rate improves with the addition of sodium silicate in juice
* Addition of 1% nitrogen (Urea) disturbed the settling rate.
**Addition of tannins disturbs the settling rate abnormally**

Gundurao and Scharma described a case study of difficult settling the case of padrauna factory has been reduced considerably to 50% to improve the conditions. Authors conducted various experiments and concluded as follows. Pre liming has shown better results as compared to straight liming or presulphitation but mud volume was above 80% even after 60 minutes settling.

Pre liming to 6.9 pH and total 2% milk of lime dose has shown better settling rate & lesser mud volume as compared to lower (1.2% - 1.8% milk of lime dose)

Pre liming in cold with 0.6% milk of lime & total milk of lime dose 2.5% at 70°C gave better results than all other cases.

Pre liming to 0.6% with total doses of 3% gave lesser mud volume in comparison to straight liming and sulphitation with same lime dose.

Increase in reaction temp to 85°C & 3 - 3.5% milk of lime dose, considerably improved mud settling rate and final mud volume after 60 minutes reduced below 30%.

From the above experiment, the process was modified i.e., cold liming with 1.5-1.6 milk of lime, reaction temp 82°C - 83°C, and total lime dose 3.0 - 3.1%. This reduce mud volume considerably.

Gundurao reported a case of higher pH drop of the order of 0.4-0.8 from sulphited juice to clear juice. The problem could not be closed even after various permutation & combination. After completion of season, serious sagging and bulging of clarifier trays was noticed. To avoid this problem & for efficient mud squeezing, a new mud sweeper was designed. As a result of this sagging of clarifier tray was reduced as well as pH drop from shilphited juice to clear juice also reduced.

Gundurao reported have that there is an increased mud volume & reduced mud settling rate due to cane staling. This might be on account of reduction in phosphate & gum content the settled juice after staling have shown considerable
development of colour in the clear juice due to increased reducing sugar content. The mud volume may be reduced with addition of higher dose of phosphate to some extent.

Bhandari and Srivastava\(^{101}\) reported that preliming at 8.5 pH at 70\(^0\)C & then neutralisation results clarified juice of higher purity, lower colour & turbidity as compared with juice not prelimed mud settling rate also improved.

Ashok misra\(^{102}\) studied the effect of inorganic constituents on sugar cane juice clarification. The harmful inorganic constituents present in cane juice are nitrogen, potassium, sodium and magnesium, while calcium and phosphorous play a significant positive role during clarification. The result of their experiment concludes that maximum removal of potassium along with increment in calcium occurred from raw to clear juice. During clarification process no significant difference was noticed in behavior of juice of different sugarcane varieties.

Bennett and Schmidt\(^{17}\) studied as a further illustration of the ways in which certain types of material, when adsorbed at the particle surface, can completely change the expected response of the cane juice system to a simple reagent. There can be no question of the commercial use of positive detergents as clarification aids; their outstanding values lie in their application to the study of abnormal conditions like the existence of an abnormal charged layer on the flocculated particles and, an abnormal incompressibility of the particles in a floc.

Suresh chandra Gupta\(^{103}\) studied processing problems of Co1148 variety of sugar cane. He observed that Co-1148 variety gave higher colour content in raw juice, poor settling & filtration, higher purity of final molasses for obtaining crystalline precipitate after juice liming and sulphitation.
Sharma et al\textsuperscript{104} studied the effect of cane lodging on its constituents & mud settling. Their finding & suggestions are as follows:

Lodged canes accumulate more starch in relation to erect ones. The mud volume of unlodged cane juice was much lesser than lodged cane. Slight haziness, turbidity and very small amount of scum were observed in case of clear juice obtained from lodged cane juice. With increased lime dose to 2.5% and employing pre-liming technique, difficulties experienced in clarification of lodged cane could be considerably reduced.

Sharma and Johary\textsuperscript{105} reported clarification difficulties due to BO-70 variety in East U.P & Bihar. Marhourah sugar mill experienced difficulties such as hazy, turbid & dark coloured clear juice reddish, blackish or grayish tinge with sugar crystals resulted in which.

For showing problem author studied juice characteristics of Marhowrah as well as other neighboring mills namely Barachakiya, Chanpatia, Kathkuiyan & Padrawna. The juice was treated with 1.0 to 2.5 % Milk of lime and further observation were made. Their findings and suggestions are as below;

Best suited lime dose was observed in the range of 2.5-3.0% by using this dose juice behave nicely. Addition of 75ppm phosphate was also found improving clarification. Best clarification and settling was obtained when both operation, Viz. ;additional P_2O_5 and pre liming were adopted.

Schmidt\textsuperscript{106} discussed details of cane juice settling process during a symposium on cane juice clarification in 9\textsuperscript{th} ISSCT congress 1956. Some of the important points of this discussion are as follow.

The total settling process is divided as settling and thickening. Floc settling at fast rate is called as settling while the increase of mud in compartment in later part is
reed as thickening. The rates of settling have been observed 3-12cm per minute while initial rate of thickening will be about 0.25-1cm/min.

The settling & thickening process are greatly affected by the variety & growing Condition. Certain varieties are more difficult to clarify; draught conditions were also reported as one of the causes of slow settling mud.

A 1% increase in brix value will decrease the rate of thickening by approximately 20%. Settling rate of one time lime addition & slow liming were very similar but final mud volume was about 10% higher in case of one time lime addition.

Polanco et al studied analyzing weekly composite samples of juice, syrup and molasses from different mills in Louisiana over the last few years.

Juice analysis over 2004 and 2005 seasons have provided a good comparison between the quality of juice from a milling tandem and from a diffuser. Juice purity and glucose / ash ratio in both raw juices are very similar, inspite of the higher temperature during wet weather. These conditions promote the activity of leuconostoc both between harvesting and grinding and in the milling tandem.

The microorganism activity in the diffuser is eliminated by the higher temperature (about 80°C) obviating the need for biocide use. However the concentration of degradation products lactic acid and acetic acid are substantially higher than expected in the raw juice from both the mills and the diffuser, as a result of cane wash water entrained into the extraction plant with the cane.

Londhe and Pendse studied the various factors responsible for mud troubles. The observations reported by author are as follow.

Shock liming system yields faster mud settling when compared to simultaneous liming and sulphitation or pre-sulphitation. Lower shock pH (below 9.0). Higher rpm
Variables on Juice Clarification

of stirrer in reaction tank may lead to slow settling. Insufficient capacity of clarifier & vacuum Filtration station. Faulty distribution from flash tank to clarifiers (when more than one clarifier is in operation)

Poor quality of lime disturbs the settling of mud one unit drop in availabl calcium content in lime increases 0.5 % mud level in treated juice. Higher bagacillo (More than 0.2 % w/w) result in difficult settling. Fluctuation in crush rate & variation in mixed juice floc sent to reaction tank. Low temperature of treated juice sent to clarifier for settling. Short circuiting in juice in juice sulphitor, juice passage from absorption tower to outlet of reaction tank or short circuiting in juice sulphitor. Faculty operations of clarifier and inefficient juice and mud removal vents from clarifier.

Mittal reported that mud trouble was most difficult problem in sugar manufacturing process, which result in higher sugar loss in filter cake, affect adversely overall efficiency and also slow down crush rate. He reported his finding and some suggestion to avoid mud trouble and are as follow;

Mud trouble starts generally after winter rain. Need for separation of cane and soil from cane juice, washing of cane cycloning of juice are the alternatives.

Efficient removal of cush cush is essential, suggested to reduce cush cush from 2 g/liter to 0.7 g/litre. For this use of vibratory screen of 15 x15 perforation per sq. inch is recommended.

Settling rate of mud is almost independent of reaction temperature but mud thickening is comparatively faster at higher temperature. Juice low in pH and rich in glucose should not be heated beyond 60° C. Pre sulphitation or simultaneous sulphitation may be preferred in such case. The precipitation of re circulate increase with increase in phosphate concentration up to 0.25 gm / 205 per liter. About 0.30 gm
phosphate per liter flocs tends to break. Some juices showing satisfactory phosphate may not necessarily clarify easily. In such case further phosphate dose addition is needed.

3.3. Scope of the Work:

The present work deals with the study of various aspects of cane varieties in a particular factory zone with special reference to chemical composition, response to clarification including purity rise, settling characteristics, extent of mud settling, nature and colouring matter of clarified juice along with the pH sensitivity of colorants, based on the results of the analysis and clarification properties.

3.4. Experimental:
The detailed procedure of mud settling of cane juice, and colour measurement have been mentioned in the chapter-2

3.4.1. Preparation of Buffer solution: Weighed 27.8g of monobasic sodium phosphate was transferred into a clean 1000 ml standard flask and made upto the mark using distilled water. And weighed 71.7 g of di basic sodium phosphate was transferred into a clean 1000 ml standard flask and solution made up to mark using a distilled water. These two solution in different proportion provide solutions of different pH values.

3.4.2. Preparation of Sulphur dioxide: 1 gm of copper turning and 10 ml of concentrated sulphuric acid these two are taken in a round bottom flask (reaction flask) fitted with a rubber cork. The flask is gently heated over a wire gauze. Sulphur dioxide is evolved, this sulphur dioxide is passed through 50 ml water, and the sulphurous acid obtained is added to cane juice clarification for the purpose of bleaching the cane juice.

3.4.3. Calcium hydroxide solution: Weighed 1.5 gm of calcium hydride. It is dissolved 100 ml distilled water, then density is found by using the following formula.
Degree of Baume = 145 - \frac{145}{\text{Baume}} = 12^\circ

True specific gravity at 80^\circ C [1.090]

3.4.4. **Experimental Procedure of Lime Application Techniques**: For studying the effect of lime application on mud settling rate and clear juice quality, following method was adopted. The heated raw juice is divided into three parts for various treatment as follows.

**Part A**: The juice is treated by standard shock liming technique keeping shock liming time as low as possible (below 20 sec). The shock pH kept from 10.3 to 10.6. The shock-limed juices is neutralized with sulphur dioxide gas to 7.1 pH with in 5-6 minutes.

**Part B**: The second part of juice is treated by pre sulphitation technique. The heated raw juice is first sulphited to 3.5 and 3.9 pH and then adjusted to 7.0 pH with slowly addition of milk of lime. The milk of lime quantity was kept 170 ml & 210 ml respectively. The total time for reaction is kept 5-6 minutes.

**Part C**: The third part of juice is treated juice by standard method of simultaneous liming and sulphitation. The sulphur dioxide gas bubling started first and then milk of lime added slowly so as to keep pH of juice always below 8.5 pH. The total milk of lime addition is kept 180 ml, 200 ml, and 260 ml in three cases.

The treated juice is heated to boiling on hot plate and used for estimation of settling rate.

3.4.5. **To Study the effect of Phosphate on Juice Settling the Following Method is Adopted**: Raw juice is collected at 3 roller mill and heated to 70°C and divided into seven parts. Care is taken to maintain the temperature as far as constant
CHAPTER 3 Variables on Juice Clarification

Each part of heated raw juice is sulphited by passing sulphur dioxide. For increasing the phosphate content a precalculated amount of 10% orthophosphoric acid solution is added in raw juice and mixed well with stirring with glass rod. After addition of phosphoric acid, each part of the above samples are treated with milk of lime to 10.0 ± 0.1 shock pH and then sulphited with sulphur dioxide to 7.10 ± 0.05 pH (Standard phosphoric acid solution is added in mixed juice at different dose before treatment so as to adjust the phosphate level in mixed juice in the range of 200-350 ppm)

3.5. Results and Discussion: The raw juice obtained by expressing sugar cane in a power driven laboratory mill is clarified by single sulphitation process. The actual clarification of a given sample of juice is brought about by the separation of precipitated material from clear juice, and this may be achieved very easily in the laboratory by simple hot filtration.

The raw juice is treated with lime and sulphur dioxide gas. Generally it may be clarified simply by boiling after the addition of milk of lime and sulphur dioxide maintaining the pH 8. Initial pH was tested by phenolphthaline paper during clarification the final values of the pH was checked by Beckman pH meter. The pH of the clear juice could be brought down to ≈7.2

Chemical reaction of precipitation taking place.

1. By combination of Ca ions with an ions of inorganic and organic acids to form slightly soluble calcium salts as Ca$_3$(PO$_4$)$_2$, CaC$_2$O$_4$, CaSO$_4$.
2. By combination of OH ions with cations to slight soluble hydroxide, such as Fe (OH)$_3$, Al (OH)$_3$
The completeness of these chemical reaction is influenced by pH. The concentration of the reagents, the temperature, solubility of the precipitates in the solution of the sucrose and non sugars.

**SO₂ gas absorption in water and juice:**

The SO₂ gas when bubbled through the juice is readily absorbed. The dissolved sulphur dioxide reacts with the water according to following reaction

\[
\text{H}_2\text{O} + \text{SO}_2 \rightarrow \text{H}_2\text{SO}_3
\]

If the SO₃ contains traces of SO₃ some sulphuric acid is formed.

According to theory of electrolytic dissociation H₂SO₃ molecules are dissociated into ions. Two steps of dissociation can be distinguished.

\[
\text{H}_2\text{O} + \text{SO}_3 \rightarrow \text{H}_2\text{SO}_4
\]

The sulphurous acid is dibasic and exhibits both normal and acid character.

First step \[ \text{H}_2\text{SO}_3 \rightarrow \text{H}^+ + \text{HSO}_3^- \] Hydrosulphite ion

Second step \[ \text{H}_2 \text{SO}_3 \rightarrow 2 \text{H}^+ + \text{SO}_3^- \] Sulphite ion

The first i.e hydrosulphite is acid salt while the sulphate is the normal salt. Sulphurous acid or sulphur dioxide in solution possess reducing action and acts as electron donar in conjunction with water as follows

\[
\text{H}_2\text{O} + \text{SO}_2 \rightarrow 2 \text{H}^+ + \text{SO}_3^{2-}
\]

\[
\text{SO}_3^{2-} + \text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 2 \text{H}^+ + 2\text{e}
\]

The Sulphite ion is oxidized to sulphate ion \( \text{SO}_4^{2-} \).

An important reaction from the point of sugar manufacture, the reduction of coloured ferric compounds. Brown colour of iron compound is removed by reducing ferric salt to ferrous
Sulphure dioxide in cane juice clarification

In juice sugar manufacturing sulphur dioxide gas is so far invariable and one of the main clarifying agent for juice clarification.

The sulphur dioxide in juice clarification serves three purposes namely

1. It neutralizes excess quality of lime added
2. It bleaches juices by acting on the clouring matter
3. It decrease the viscosity of juice
4. It is also a disinfectant

Neutralising Effect:
Sulphur dioxide acts on lime and forms a precipitate of calcium sulphate according to the following reaction.

\[ \text{Ca (OH)}_2 + \text{H}_2 \text{SO}_3 \rightarrow \text{Ca SO}_3 + 2\text{H}_2\text{O} \quad \text{Calcium sulphite} \]

The correct proportion of sulphur dioxide converts the excess of lime into the insoluble calcium sulphite, which can be separated by filtration.

If more gas is passed and the juice is made highly acidic part of calcium sulphate is converted into soluble calcium bisulphate according to the following reaction

\[ \text{Ca SO}_3 + \text{H}_2 \text{SO}_3 \rightarrow \text{Ca (HSO)}_3 \]

On the other hand we start from a solution of sulphurous acid and neutralize the acid with milk of lime, the initial pH is low, say 3.8 pH as it happens in the case of pre-sulphitation process when half of the neutralization is complete. The solution contains the soluble calcium bisulphate. Further addition of lime increases the pH, and the
precipitation of calcium sulphate starts. The precipitation is complete when all the
d acidity is neutralized by lime.

The following reaction takes place.

\[
\text{H}_2 \text{SO}_3 + 2 \text{Ca(OH)}_2 \rightarrow 2\text{CaSO}_3 + 4\text{H}_2\text{O}
\]

This is the same total result as attained when excess of milk is neutralized with
sulphurous acid.

**Bleaching effect**

*Zerban* gives a probable explanation of the bleaching action of sulphur dioxide.

He stated that sulphur dioxide combines with reducing sugars and blocks the carbonyl
function which is essential for carmel and melnoidin formation

Anthocyanin, another coloured body is only partially bleached by sulphur
dioxide and is not removed. *Harloff* proved that sulphur dioxide cannot decolourise
coloured organic lime salts resulting from the decomposition of the glucose in alkaline
juices.

Sulphurous acid is a strong bleaching agent, it bleaches the colouring matters
originally present in the cane juice. If present and slows down the colour formation in
the later stage of the processing viz evaporation and crystallization. It reduces the ferric
salts (which highly coloured compounds formed by the action of iron of the equipment
with poly phenols) into colourless ferrous compounds.

The bleaching action of sulphurous acid is however temporary and the colour is
again restored on exposure to air.

**Viscosity effect:** Sulphur dioxide reduces the viscosity of juices and syrups which, helps
in better crystallization of sugar.
Precipitation and solubility of calcium sulphate:
A slightly soluble salts precipitates if its solutions is supersaturated or in other
words if the product of its ion concentration exceeds the solubility product. The
probable chemical reactions in cane juice clarification with lime and SO₂ is well
illustrated by P. Honig.¹⁵

The saturated lime water on sulphitation the Ca(OH)₂ molecules are completely
dissociated into calcium ion (Ca²⁺) and hydroxyl ion (OH⁻) ions. The pH of saturated
lime water is about 12.6 at 30°C. When sulphur dioxide gas bumbles through the liquid
sulphurous acid (H₂SO₃) is formed. The high initial pH of the solution causes the
formation of H ions and SO₃ ions. Very soon (Ca⁺⁺) X (SO₃⁻) exceeds the solubility
product of the CaSO₃ and precipitation of this salt starts. The OH⁻ ions from the Ca
(OH)₂ combine with H⁺ ions of the dissociated H₂SO₃ to form un-dissociated water
molecule, causing the pH of solution to decrease. Continuing the sulphitation more and
more solid CaSO₃ precipitated resulting in gradual decrease of the Ca ion concentration.
Eventually Ca ion concentration is so small that Ca²⁺ X SO₃⁻ Just equals the solubility
product CaSO₃. At that moment the precipitation is completed and Ca ion concentration
in the solution reaches a minimum, the mentioned reaction can be written as below.

\[
\begin{align*}
\text{Ca(OH)₂} & \leftrightarrow \text{Ca}^{2+}2\text{OH}^- \\
\text{SO}_2 + \text{H}_2\text{O} & \rightarrow \text{H}_2\text{SO}_3 \\
\text{H}_2\text{SO}_3 & \rightarrow 2\text{H}^+ \text{SO}_3^{2-} \\
\text{Ca}^{2+} + \text{SO}_3^{2-} & \rightarrow \text{CaSO}_3 \\
2\text{OH}^- + 2\text{H}^+ & \rightarrow 2\text{H}_2\text{O}
\end{align*}
\]

The concentration of the ions involved in this equilibria are very small. But at
the same moment the ions are taken away from equilibrium, more number of unsplit
molecules dissociate. In this way large quantities of reagents are transformed in a short time. The results of the total transformation, running via the ion equilibria is given by

\[ \text{H}_2 \text{SO}_3 + \text{Ca} (\text{OH})_2 \rightarrow \text{CaSO}_3 + 2\text{H}_2\text{O} \]

If we continue to pass sulphur dioxide gas through the solution, complete neutralization is reached. The pH moves further on acid side, with decreasing pH more HSO\textsubscript{3}\textsuperscript{-} ions come into solution and the SO\textsubscript{3}\textsuperscript{2-} ion concentration decreases.

However, the system tries to maintain the SO\textsubscript{3}\textsuperscript{2-} concentration belonging to the solubility product of the CaSO\textsubscript{3} and can do so, only by dissolving solid CaSO\textsubscript{3} precipitate. The process can be put down in the following format.

\[ \text{H}_2 \text{SO}_3 \rightarrow \text{H}^+ + \text{HSO}_3^- \]

Dissolved molecule \[ \text{CaSO}_3 \rightarrow \text{Ca}^{2+} + \text{SO}_3^{2-} \]

\[ \text{H}^+ + \text{SO}_3^{2-} \rightarrow \text{HSO}_3^- \]

Precipitated CaSO\textsubscript{3} \[ \rightarrow \] dissolved CaSO\textsubscript{3} molecules by combining these reaction we get.

Precipitated CaSO\textsubscript{3} + H\textsubscript{2}SO\textsubscript{3} \[ \rightarrow \] dissolved Ca(HSO\textsubscript{3})\textsubscript{2}

If on the other hand we start from sulphurous acid and neutralize the acid with lime water, the initial pH is low is about 2. The solution contains undissociated H\textsubscript{2}SO\textsubscript{3} molecules and HSO\textsubscript{3} ions. The addition of lime water means the introduction of Ca and OH ions into the liquid, each Ca ion comes into equilibrium with two HSO\textsubscript{3} ions. The OH ions combine with H ions to form water molecule, thus increasing the pH. With rising pH more and more HSO\textsubscript{3}\textsuperscript{-} ions come into equilibrium with Ca ions, this goes on until all the H\textsubscript{2}SO\textsubscript{3} is spilt up into HSO\textsubscript{3} and H ions. At this moment half of the neutralization completed, the solution contains the soluble calcium bisulfite. Further lime addition and increase in pH brings SO\textsubscript{3} ions into the liquid. These ions comes into equilibrium with Ca ions and as soon as (Ca\textsuperscript{++}) X (SO\textsubscript{3}\textsuperscript{2-}) exceeds the solubility product.
the precipitation of CaSO₃ starts. The precipitation is completed when SO₃ ion concentration becomes so small that the solubility product cannot exceed any more.

The following equation illustrates the above mentioned reactions.

\[
\begin{align*}
2\text{SO}_2 + 2\text{H}_2 & \rightarrow 2\text{H}_2\text{SO}_3 \\
2\text{H}_2\text{SO}_3 & \rightarrow 2\text{H}^+ + 2\text{HSO}_3^- \\
\text{Ca(OH)}_2 & \rightarrow \text{Ca}^{2+} + 2\text{H}_2\text{O} \\
2\text{H}^+ + 2\text{OH}^- & \rightarrow 2\text{H}_2\text{O}
\end{align*}
\]

This is the first part of neutralization or the bisulphate formation combining the reaction we get

\[
2\text{H}_2\text{SO}_3 + \text{Ca(OH)}_2 \rightarrow \text{Ca (HSO}_3)_{2} + 2\text{H}_2\text{O}
\]

The second part of the neutralization comprising the precipitation of the CaSO₃ can be represented as below

\[
\begin{align*}
\text{Ca (HSO}_3)_{2} & \rightarrow \text{Ca}^{++} + 2\text{HSO}_3^- \\
\text{Ca(OH)}_2 & \rightarrow \text{Ca}^{++} + 2\text{OH}^- \\
2\text{HSO}_3^- & \rightarrow 2\text{H}^+ + 2\text{SO}_3^- \\
2\text{H}^+ + 2\text{OH}^- & \rightarrow 2\text{H}_2\text{O}
\end{align*}
\]

The reaction is \( \text{Ca(HSO}_3)_{2} + \text{Ca(OH)}_2 \rightarrow 2\text{CaSO}_3 + 2\text{H}_2\text{O} \)

Finally, a combination of the first and the second part of the neutralization leads to

\[
2\text{H}_2\text{SO}_3 + 2\text{Ca (OH)}_2 \rightarrow 2\text{Ca SO}_3 + 4\text{H}_2
\]

This is the neutralization of limewater with sulphurous acid. Our aim is to precipitate the CaSO₃ as completely as possible, but a certain Ca ion concentration remains in solution corresponding to the value of the solubility product of CaSO₃ for the given condition.
It is clear that the original particle density of the raw juice will greatly affect the final mud volume obtained. Nevertheless variations in floc sizes, subsidence rates and settled mud volume have been observed in the same particle density and therefore must depend on factors, which have not yet been taken into consideration, for instance the other minor constituents of the juice.

**Effect of Heat**

It has been mentioned that only 50% of the soluble impurities in cane juice is coagulated by heat, the effect being attributed partially, if not wholly, to the presence of sucrose.

Farnell\textsuperscript{118} found that 70% of the non-dialysable nitrogenous material in raw juice was coagulated on boiling.

It is clear that impurities coagulation is brought about before the final phosphate precipitation. So that in this system the heat coagulated non-sugars layer is presumably converted with calcium phosphate.

The above factor considers the effect of heat on the soluble macromolecular constituents of cane juice, it can be concluded, proteins and polysaccharides provide the best example of natural lyophilic solution. The true colloidal state material is complete removal is very difficult. So that we (applying) add synthetic polyelectrolyte flocculant solution to cane juice, all most all macromolecular constituents are removed.
CHAPTER 3  Variables on Juice Clarification

Table-3.1. Effect of Temperature of juice on mud settling rate.

<table>
<thead>
<tr>
<th>Time in minute</th>
<th>Mud settling level at different temperature after sulphitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>60°C</td>
</tr>
<tr>
<td>0</td>
<td>1000</td>
</tr>
<tr>
<td>5</td>
<td>790</td>
</tr>
<tr>
<td>10</td>
<td>470</td>
</tr>
<tr>
<td>15</td>
<td>410</td>
</tr>
<tr>
<td>20</td>
<td>360</td>
</tr>
<tr>
<td>25</td>
<td>335</td>
</tr>
<tr>
<td>30</td>
<td>315</td>
</tr>
<tr>
<td>35</td>
<td>305</td>
</tr>
<tr>
<td>40</td>
<td>285</td>
</tr>
</tbody>
</table>

Fig-3.1. Effect of juice temperature on mud settling rate
Effect of Temperature: Table-3.1. Shows settling data. The best settling rate is obtained in the range of 70°C to 80°C; the mud settling level is considerably higher at 75°C.

The figure-3.1 shows the relationship between impurities settled at different temperatures and time intervals. In fig 3 it is seen that 25% of impurities are settled at 75°C. For in any given juice sample there is a certain quantity of heat coagulable impurities of non-sugars, which do not dependent pH above 4.5. Below pH 4.5 liming the juice below the temperature of impurities coagulation, followed by heating above that temperature ensures that coagulated impurities comes down after the bulk of the calcium phosphate precipitate has been formed.
Table-3.2. Effect of Settling Rate and Colour on Mixed Juice Adding Milk of Lime in Different Dosage

Brix  = 15.90  
Pol   = 13.01  
Purity = 81.82

Raw juice heated 65°C limed and sulphited using 1.8% milk of lime of 12 Be

<table>
<thead>
<tr>
<th>M.O.L in ml</th>
<th>R. J</th>
<th>75</th>
<th>100</th>
<th>130</th>
<th>180</th>
<th>220</th>
<th>260</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock pH</td>
<td>8.18</td>
<td>8.48</td>
<td>8.70</td>
<td>9.26</td>
<td>9.95</td>
<td>10.30</td>
<td>10.70</td>
<td></td>
</tr>
<tr>
<td>Sulp juice pH</td>
<td>7.15</td>
<td>7.14</td>
<td>6.99</td>
<td>7.03</td>
<td>7.03</td>
<td>7.16</td>
<td>7.18</td>
<td></td>
</tr>
<tr>
<td>Juice Temp</td>
<td>75°</td>
<td>75°</td>
<td>75°</td>
<td>75°</td>
<td>75°</td>
<td>75°</td>
<td>75°</td>
<td></td>
</tr>
</tbody>
</table>

Time in min | Mud settling level in ml after boiling

<table>
<thead>
<tr>
<th>Time in min</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>15</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>30</td>
</tr>
</tbody>
</table>

Brix %   | 18.92 | 18.72 | 19.18 | 18.68 | 18.77 | 18.70 | 18.50 | 18.30 |
Purity %  | 83.19 | 83.29 | 83.79 | 83.94 | 84.28 | 84.55 | 84.16 | 84.26 |

Colour raise

| Colour 560nm | 11829 | 2775 | 2043 | 2670 | 1958 | 1948 | 1820 | 2408 |
| Colour 420nm | 21741 | 9586 | 8860 | 7779 | 8840 | 8690 | 8450 | 8102 |
Fig-3.2. Effect of different dosage of M.O.L on mud settling in cane juice clarification

Fig-3.3. Effect of different dosage of M.O.L on mud settling in cane juice clarification
Effect of Milk of lime: The effect of milk of lime addition pH on cane juice clarification is measured in terms of settled mud volume and colour of the clarified juice maintaining temperature constant. The milk of lime dose was varied from 75 ml and 300 ml without any addition of flocculant. The pH variation was minimal (0.01 to 0.18) and maximum level of mud settling obtained at 220ml of milk of lime dosage. The purity rise recorded was also high at this dosage due to better mud compaction. The colour measurement of the supernatant clear juice shows a minimum absorption both at 560nm and 420nm wave length of incident light.

The addition of different dosage of milk of lime is determined by the pH rather than by calcium considerations. It has naturally been assumed that the calcium content after liming is always in excess of that required for complete inorganic phosphate precipitation.
The chosen wavelength of 420 & 560 nm for most comparisons (based on the ICUMSA method) does not reflect the activity of the human eye. The absorbance is affected by pH to a varying degree depending on the nature of the colorants. These problems are discussed in more detail in relation to the data presented in table-3.2 and figure-3.4.

In most of the Indian sugar industries the imbibition temperature varies from 65°C to 85°C. It is argued that at higher temperature (85°C) the raw juice is more contaminated with colorants which in turn enhance the colour of the clarified juice. After conducting the lab trials, factory trials were conducted, at the imbibition temperature i.e. 72°C and 85°C for 6 hour duration each. It was found that at higher imbibition temperature (85°C), the colour of the clear juice is marginally less, probably due to additional flocculants that may have been extracted in the juice which adsorbed the colour. This is also supported by a similar increase in turbidity of the clear juice (9.49 at 85°C) as compared to 9.42 at 72°C. However excess proved advantageous as the sugar recovery increased due to increased extraction of sugar at higher temperature.
Table 3.3. Effect of Mud settling rate in different liming technique method:

<table>
<thead>
<tr>
<th>Particular</th>
<th>Simultaneous and sulphitation</th>
<th>Liming Pre sulphitation</th>
<th>Shock liming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Set-I</td>
<td>Set-II</td>
<td>Set-III</td>
</tr>
<tr>
<td>M.O.L used in ml</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>170</td>
<td>200</td>
<td>260</td>
</tr>
<tr>
<td>Shock pH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.6</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Shock liming time/Sec</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphitated juice pH</td>
<td>7.21</td>
<td>6.98</td>
<td>7.1</td>
</tr>
<tr>
<td>Juice temperature at sulphitat</td>
<td>80°C</td>
<td>80°C</td>
<td>80°C</td>
</tr>
<tr>
<td>Time in Minute</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>5</td>
<td>610</td>
<td>570</td>
<td>680</td>
</tr>
<tr>
<td>10</td>
<td>510</td>
<td>420</td>
<td>550</td>
</tr>
<tr>
<td>15</td>
<td>410</td>
<td>380</td>
<td>450</td>
</tr>
<tr>
<td>20</td>
<td>350</td>
<td>310</td>
<td>390</td>
</tr>
<tr>
<td>25</td>
<td>305</td>
<td>285</td>
<td>350</td>
</tr>
<tr>
<td>30</td>
<td>275</td>
<td>250</td>
<td>320</td>
</tr>
<tr>
<td>35</td>
<td>245</td>
<td>220</td>
<td>295</td>
</tr>
<tr>
<td>40</td>
<td>220</td>
<td>210</td>
<td>275</td>
</tr>
<tr>
<td>Colour at 560 nm IU</td>
<td>2788</td>
<td>2500</td>
<td>3043</td>
</tr>
<tr>
<td>Colour at 420 nm IU</td>
<td>12,221</td>
<td>10,742</td>
<td>12,573</td>
</tr>
</tbody>
</table>
CHAPTER 3
Variables on Juice Clarification

Fig -3.5. Effect of mud settling on simultaneous liming and sulphitation

Fig -3.6. Effect of mud settling on pre-sulphitation
CHAPTER 3
Variables on Juice Clarification

Simultaneous liming & sulphitation: In this method sulphur dioxide gas is applied to heated raw juice little before the addition of milk of lime. The pH of juice during the reaction period is always kept below 8.0. The final treated juice pH is 7.0.

Shock liming: In this method milk of lime is applied 5-10 second before passing the sulphur dioxide gas. The pH of juice just after addition of milk of lime is called as shock lime pH and generally varies from 9.0 to 10.5 depending on juice characteristics and process constraints. The pH of the final juice is 7.

Pre-Sulphitation: In this method sulphur dioxide gas is applied first and juice is sulphited to 3.5-4.0 pH and then neutralized with milk of lime. The final treated juice pH is 7.
Pre-liming and Shock liming: In this method the raw juice is first prelimed (paratically lime) to 6.8 to 7.4 pH, the retention time for preliming generally kept 2 minutes and then pre-limed juice is subjected to shock lime treatment to 9.0-10.5 pH for 5 to 10 seconds time depending on juice characterization. The final treated juice pH is 7.

All the above methods are being adopted in Indian sugar industry but the comparative study of effect of these methods on mud settling on similar characteristics of juice is not available. To study these effects we have conducted laboratory trials.

The few important observations are as follows

Fig-3.5. Shows simultaneous liming and sulphitation, mud settling rate and final mud volume is found considerably lower but at the same time the clear juice quality was observed lower as compared to shock limed juice

However in case of simultaneous liming and sulphitation, the mud settling rate was observed very slow and final mud volume was found increased by about 50%, when the lime quality increased to 260 ml

Fig-3.7. shows the settling rate, flock conditioning as observed during settling test and final mud volume was found excellent in case of shock limed juice. The clear juice clarity was also found superior as compared to all the methods.

This experiment clearly highlights the superiority of the shock liming system as compared to all other methods such as simultaneous liming as well as presulphitation technique. The figure indicates the effect of various liming techniques on clear juice colour.

The method adopted for milk of lime application is also one of the important parameter in getting better settling rate and efficiency of juice clarification. The above
comparative study of simultaneous liming & sulphitation, shock liming & presulphitation process studied at constant lime dose shows that

Fig.3.6 shows pre sulphitation yields higher mud level while simultaneous liming and sulphitation yields lowest mud level.

Shock liming method gives better clarity of clear juice and low colour of clear juice as well as better settling rate:

**Table-3.4. Effect of sulphured juice pH on mud settling rate**

<table>
<thead>
<tr>
<th>Particular</th>
<th>Effect of sulphured juice pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.O.L used in ml</td>
<td>210 210 210</td>
</tr>
<tr>
<td>Shock pH</td>
<td>10 10 10</td>
</tr>
<tr>
<td>Sulphited juice pH</td>
<td>6.91 7.18 7.44</td>
</tr>
<tr>
<td>Juice Temperature at sulphitation</td>
<td>75 75 75</td>
</tr>
<tr>
<td>Time in Minute</td>
<td>Mud settling after boiling</td>
</tr>
<tr>
<td>0</td>
<td>10000 1000 1000</td>
</tr>
<tr>
<td>5</td>
<td>650 620 700</td>
</tr>
<tr>
<td>10</td>
<td>460 440 500</td>
</tr>
<tr>
<td>15</td>
<td>410 370 400</td>
</tr>
<tr>
<td>20</td>
<td>370 330 350</td>
</tr>
<tr>
<td>25</td>
<td>350 320 330</td>
</tr>
<tr>
<td>30</td>
<td>340 310 320</td>
</tr>
<tr>
<td>35</td>
<td>330 300 310</td>
</tr>
<tr>
<td>40</td>
<td>330 290 300</td>
</tr>
</tbody>
</table>
In cane sugar manufacture control of hydrogen ion concentration has a profound influence on sugar losses in process, particularly in the production of direct consumption white sugar from cane, employing sulphitation. The aim of correct pH control is to maintain both sucrose and reducing sugars intact, and to avoid conditions under which these sugars undergo decomposition. A thorough knowledge of the effects of pH conditions on the composition of sugarhouse products in various stages of the process is essential, and the present work deals with some aspects of pH control in sulphitation cane juice under Indian condition.
The pH of cane juices an varies with temperature and very often the process control is based on pH values measured at room temperature.

The elevated temperature to which these juices are subjected, either during heating or boiling operations, were kept in view during these studies. The results are presented in table-3.5. Table-3.5 deals with changes of sulphited pH at constant temperature. In this case of raw juice was treated by the single sulphitation process.

In case of raw juice, limed juice and limed and sulphited juice, the temperature rise might change the original composition and the pH, temperature relationship for these products does not have the same significance as in the case of other products studied.

The final sulphured juice pH is also one of the important factors in deciding mud settling rate. To study the effect of sulphured juice pH on mud settling rate the shock limed juice of pH 10 was further sulphited to different final pH (6.91, 7.18, 7.44). The highest mud level was noticed in case of acidic pH 6.91

1. During initial period the mud settling rate in case of acidic sulphited juice was found better
2. But as settling continues, the settling rate of juice in slightly alkaline medium increases.
3. The final mud volume in case of slightly alkaline medium juice is high as compared to high alkaline or slightly acidic sulphited juice.
### Table-3.5. Effect of addition phosphate in mixed juice on mud settling

<table>
<thead>
<tr>
<th>M.O.L used in ml</th>
<th>200</th>
<th>200</th>
<th>200</th>
<th>200</th>
<th>200</th>
<th>200</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphited juice pH</td>
<td>7.13</td>
<td>7.04</td>
<td>7.16</td>
<td>7.16</td>
<td>7.22</td>
<td>6.95</td>
<td>7.02</td>
</tr>
<tr>
<td>Juice Temperature</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>P₂O₅ in mixed juice in ml/l</td>
<td>175</td>
<td>210</td>
<td>240</td>
<td>270</td>
<td>300</td>
<td>330</td>
<td>360</td>
</tr>
<tr>
<td>ml of dil phosphoric acid in mixed juice in ml/l</td>
<td>0</td>
<td>2.5</td>
<td>5</td>
<td>7.5</td>
<td>10</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Time in minute</td>
<td>Mud settling after boiling in ml</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>670</td>
<td>650</td>
<td>595</td>
<td>590</td>
<td>597.5</td>
<td>640</td>
<td>720</td>
</tr>
<tr>
<td>10</td>
<td>510</td>
<td>520</td>
<td>480</td>
<td>410</td>
<td>462.5</td>
<td>510</td>
<td>655</td>
</tr>
<tr>
<td>15</td>
<td>425</td>
<td>410</td>
<td>405</td>
<td>362</td>
<td>440</td>
<td>455</td>
<td>545</td>
</tr>
<tr>
<td>20</td>
<td>335</td>
<td>350</td>
<td>345</td>
<td>282</td>
<td>375</td>
<td>400</td>
<td>480</td>
</tr>
<tr>
<td>25</td>
<td>290</td>
<td>290</td>
<td>325</td>
<td>250</td>
<td>365</td>
<td>370</td>
<td>420</td>
</tr>
<tr>
<td>30</td>
<td>260</td>
<td>260</td>
<td>307</td>
<td>230</td>
<td>345</td>
<td>355</td>
<td>380</td>
</tr>
<tr>
<td>35</td>
<td>245</td>
<td>240</td>
<td>297</td>
<td>225</td>
<td>330</td>
<td>340</td>
<td>360</td>
</tr>
<tr>
<td>40</td>
<td>230</td>
<td>235</td>
<td>280</td>
<td>225</td>
<td>325</td>
<td>330</td>
<td>350</td>
</tr>
</tbody>
</table>
Fig 3.9. Effect of phosphate in mixed juice on mud settling

Fig 3.10. Effect of phosphate in mixed juice on mud settling
Phosphorus in sugar cane is present in both inorganic and organic forms. The inorganic phosphorous\(^{122}\) in cane exists as free phosphate ions while the organic phosphorous is in the form of phospholipids, phosphoroutiens, nucleotide phosphates and hexose phosphates. Such organic phosphorous compounds are considered vital for
various metabolic processes and their presence in the cane plant is indispensable for its growth.

Since phosphate bonding with organic moieties particularly adenosine, uridine nucleosides, nucleoproteins and hexoses, is energy-rich and essential for certain biochemical reactions, there is always a possibility for the conversion of organic phosphorous to inorganic phosphorous and vice-versa. In sugar cane the contents of both organic and inorganic phosphates are higher in the regions of active growth.

The utilization of phosphates in cane juice clarification is of extreme importance. Here it is only the inorganic phosphate which is concerned, however. Since, it is the free phosphate ions which take part in the reactions. If the inorganic phosphate level in raw juice is less than 300 ppm W/V, additional phosphate may be required for good clarification and for production of good quality plantation white sugar.

Bond\textsuperscript{114} has stated that the lime-heat defecation depends largely upon the quantity of calcium phosphate precipitated; he concluded that “defecation is primarily a function of the phosphate content of the raw juice”. Since that time much work has been carried out on the inorganic precipitate formed during the clarification process, and it is now well established that the minimum phosphate level for satisfactory clarification is generally about 300 mg/liter phosphate.

Kynch\textsuperscript{119} has demonstrated that the phosphate dosage should be optimum. Large addition of results in increased mud precipitation and decreased rate of settling. The effect on settling behavior of juices with in the total phosphate content of the were studied in seven different juice samples. It is evident from table-3.6 that the phosphate levels for optimum settling behavior are not necessarily those for perfect clarity: but for rapid settling rate and fair colour of the clarified juice. Optimization of the phosphate
dosing was carried out settling the hot juice treated with 200 ml of milk of lime and sulphited to an approximate neutral pH followed by addition of dilute phosphoric acid.

The rapid initial settling at 5 minutes time is observed in case of juice dosed with 270 ppm of phosphate. This continues till the end of 40 minutes duration and the final compact mud volume is minimum when compared to all the other cases. Mud volume has increased considerably at and above 300 ppm of phosphate dosages, which is in favor of the Kynch theory as discussed earlier. The quantity of mud settling in case of the unphosphited juice (jar No-1) is comparable with that of the juice in Jar-4 (270) ppm expect for the rapid initial settling within 5 minutes of time, which in very significant from the point of view of actual process conditions in the industry.

In this study for the juice considered, the optimum phosphate dosage is found to be 270ppm. But, this varies according to the cane variety, soil conditions and cultivation practices adopted. Hence in every practical care the dosage has to be optimized.

The additional of phosphate in mixed juice above 270 ppm is not economical if the original phosphate content is bellow 200 ppm. In general about 8 Kg phosphoric acid per 100 MT cane crushing is needed for increasing 50 ppm dose of phosphate.

### 3.6. Conclusion

This chapter discusses the various experiments conducted and various techniques applied to improve mud settling characteristics and to improve clear juice clarity.

Many sugar factories face mud trouble mainly in peak recovery period. This affects the crushing rate as well as sugar quality. During the study various shortcomings were noticed in sugar manufacturing process. There are some important factors which
Variables on Juice Clarification

were be paid attention to were discussed in this section. All such points to be adopted for avoiding mud trouble as well as for increasing mud settling rate are as follows.

The juice temperature 75°C was found to be optimum for achieving better mud settling, below 65°C the final mud volume was found to be increased.

The presulphitation technique has increased the difficulties in mud settling and should be avoided as far as possible

Mud settling rate increases as shock pH increases but only up to optimum shock pH range

The optimum shock pH was found in the range of 10.2 ±0.2, better settling rate in addition to good quality clear juices was observed at optimum shock pH.

The juice should be neutralized to a pH 7.0 to avoid inversion of sucrose during settling.

Final pH of treated juice is kept at 7.1-7.3. High pH of treated juice results in dark coloured juice and increased viscosity. Low pH of treated juice inversion of sucrose

In all these cases the optimum clarification conditions were determined largely by the quantity of calcium phosphate precipitated and the calcium content of the clarified juice.

The phosphate content of 270 ppm was found helpful for getting better quality clear juice as well as better mud settling rate.

The use of single or triple super phosphate shall be avoided and only use of ortho phosphoric acid is to be preferred for industrial applications, use of single super phosphate is almost out dated due, to the addition of higher impurities mainly inorganic ions. While using triple super phosphate the risk of addition of higher impurities to clarification process is reduced many fold but not eliminated completely.
Initially we have tried the treatment without adding phosphoric acid to filtrates. This practice increases juice turbidity by 23% and up to 3000 units than conventional clear juice, which prohibits mixing of filtrates with raw juice. The principal reason for this was low phosphate content (90-95) ppm in raw filtrates. This phosphate content may not be available in free form for precipitation of tri calcium phosphate. Hence, the P$_2$O$_5$ was supplemented at 20 and 40ppm doses. The purity rise was 2.49 for without addition and 3.52 for 40 ppm phosphate addition.

The lowest mud settling rate as well as higher final mud volume was found at 360ppm P$_2$O$_5$ in mixed juice while fast mud settling rate as well as lowest mud level is observed at 270ppm phosphate in mixed juice.