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Research Article

EFFECT OF PLANT MUCILAGE CLARIFICANTS ON PHYSICAL AND CHEMICAL PROPERTIES OF JAGGERY

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ABSTRACT

Five plant mucilage clarificants namely *Aloe vera,* Flax seeds, Fenugreek seeds, Purslane and Malabar spinach at three different concentrations (0.1%, 0.2% and 0.4%) were used for sugarcane juice clarification and jaggery production. Physiochemical properties namely colour, pH, a_w, insoluble solids, moisture, ash, protein, reducing sugars, non-reducing sugars, minerals and vitamin C of prepared jaggery were evaluated. At 0.4% concentration results indicates reduced moisture (1.77%), reducing sugars (4.15%) and insoluble solids (1.78%) in prepared jaggery samples while an increase of colour (14.56%), non reducing sugars (5.48%), minerals and vitamins C were evident in plant mucilage clarificants treated jaggery resulting in better quality jaggery compared to control jaggery. Among the plant mucilage clarificants treated *Aloe vera* followed by fenugreek had better clarification efficacy compare to rest of plant mucilage clarificants. From the above findings, it is evident that plant mucilage clarificants may find use as potential alternative to chemical clarificants.

INTRODUCTION

Jaggery is an unrefined sugar obtained by processing of sugarcane (*Saccharum officinarum* L.) and regarded as 'whole sweetener' because of its nutritional value. Many organic and inorganic compounds present in sugarcane juice are retained along with sucrose and hence more nutritive than that of refined sugar (Kumar and Tiwari, 2006). Jaggery contains approximately 60-85% sucrose, 5-15% glucose and fructose, along with 0.4% of protein, 0.1 g of fat, 0.6 to 1.0 g of minerals and traces of vitamins and amino acids. 100 g of jaggery gives 383 Kcal of energy (Ragavan *et al.,* 2011). Jaggery is the main source of sugar in rural India and backbone of the rural economy. It is produced in all sugarcane growing states of India under different names such as 'Gur', Gud (Hindi), Bella (Kannada), Vellam (Tamil) etc. It is not only used as sweetener in diet but also included in many ayurvedic and traditional medicinal formulations (Pattanayak and Misra, 2004). The micronutrients present in jaggery exhibit antitoxic and anti-carcinogenic properties (Sahu and Paul, 1998). In addition, Jaggery has potential antioxidant activity owing to the presence of polyphenolic compounds in cane juice (Nayaka *et al.,* 2009). The applications of jaggery are reported in cattle feed, distilleries, medicinal syrups and also has a place in confectionary items (Nath *et al.,* 2015).

Traditionally, jaggery processing involves juice extraction from sugarcane, clarification, concentration, cooling, moulding and packing. The quality of jaggery mainly depends on clarification process. During clarification, the non-sugar impurities are removed as scum to obtain light coloured clear juice (Gangwar *et al.,* 2015). Jaggery manufactures use chemical clarificants such as sodium hyrdosulphate (Hyrdos), sodium carobonate, sodium bicarbonate, alum, sodium formaldehyde sulfoxylate, tri sodium phosphate etc., in excess than the permissible level. These chemicals compounds are widely used in view of low cost and ready availability to obtain golden colour jaggery with enhanced market value. But these chemical clarificants alter the

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aroma and natural taste of jaggery in addition to promoting faster detoriation, inversion of sucrose, solidification or crystalline structure of jaggery (Baboo and Solomon, 1995). The sulphur based clarificants are known to give better colour to jaggery and hence use of such compounds is extensive resulting in presence of more residual sulphur content than safe limit. 'Bureau of Indian Standards' (BIS) has prescribed that sulphur (as sulphur dioxide) content in jaggery should not be more than 70 ppm. Hence, it is advisable to avoid chemical clarificants as far as possible (Ragavan *et al.,* 2011). Plant mucilage serves as an excellent alternative to synthetic clarificants because of local accessibility, ecofriendlyness, low cost and easy adaptability. Many herbs and vegetables have the properties that assist clarification of juice. But the precise method of utilization of these organic mixtures is still an individual's skill which is not reported in literature (Verma *et al.,* 2014). Therefore, exploring clarificants of organic origin for jaggery production has gained importance (Rao *et al.,* 2007; Ragavan *et al.,* 2011). There are many mucilage plant resources occasionally used as organic clarificants in India especially in jaggery industry. The principle vegetable clarifying agents used clarification of sugarcane juice are *Hibiscus ficulneus* (deola), *Hibiscus esculentus* (bhindi), *Cadia celcina* (sukalai), *Bombax malabarium* (semal bark), *Grewia asiatica* (falsa), *Arachis hypgea* (ground nut), *Recinus communis* (castor seed), *Manihot esculentum* (tapioca), *Glycine max* (soybean), *Tamarindus indica* (tamarind), *Cyamopsis tetragonoloba* (guar) and *Abelmoschus moschatus* (kasthuri). The vegetable clarificants are more effective in removing colouring matter when compared to chemical clarificants (Laxmikantham, 1973; Singh and Gill, 1954). Vegetable clarificants also showed good results with immature, water logged and infested sugarcane (Shakuntala, 1985; Baboo, 1991). Effect of vegetable and chemical clarificants on quality of jaggery has been reviewed by many researchers in India (Joshi and Pandit, 1959; Laxmikantham, 1973; Agarwal and Ghosh, 1983; Mungare *et al.,* 2000). The qualities of the prepared jaggery, such as aroma, texture, colour and taste is largely dependent on controlling various physical and chemical parameters during concentration. Singh (1992) has reviewed physical properties of jaggery produced by different vegetables, fruits and its juices as clarificants. Guerra and Mujica (2010) have evaluated the physical and chemical properties of granulated sugarcane jaggery. A few researchers have evaluated different sugarcane varieties for physico-chemical characteristics of jaggery (Khana and Chacravarthy, 1955; Uppal and Sharma, 1999; Hussain *et al.,* 2003). However, there are no research literatures available on the application of plant mucilage from *Aloe vera,* flax seeds (*Linumus itatissimum* L.), fenugreek (*Trigonella foenum-graecum* L.), purslane (*Portulaca oleracea* L.) and malabar spinach (*Basella alba* L.) as clarificants for jaggery preparation. Hence, the present research work is aimed to determine the physical and chemical properties of jaggery prepared using selected plants mucilage as clarificants.

MATERIALS AND METHODS

Samples

Sugarcane variety Co 86032 was selected for the study and all the samples were of the same age (10 months) and from the same plots with similar management regime. The plants such as malabar spinach, purslane and *Aloe vera* were collected from field, flax seeds and fenugreek seeds were purchased from a local market. The plants materials were taxonomically identified and authenticated by Dr. Shiddamallayya at Regional Ayurveda Research Institute for Metabolic Disorder (RARIMD), Bangalore.

Extraction of plant mucilage

The extraction of mucilage from the plant sources was carried out as per our earlier standardized method (Chikkappaiah *et al.,* 2017). The mucilage from *Aloe vera* was extracted from leaf by peeling and kept overnight at below 20^0 C. The slurry/mucilage was obtained by filtering the extract through muslin cloth (Shaif *et al*., 2000). Flax seeds and fenugreek seeds were crushed and soaked in water in the ratio of 1:5 (w/v) for 6 hours, then boiled in waterbath for 5 hours and allowed to cool below 20^0 C. The extract was filtered through muslin cloth to obtain mucilage/ slurry (Inamdar *et al*., 2012). Cleaned leaves and stem of purslane and malabar spinach plant were chopped into small pieces and soaked in water in the ratio of 1:3 (w/v) for 6 hours and boiled in waterbath for 5 hours, then cooled below 20^0 C. The extract was filtered through muslin cloth to obtain mucilage/slurry (Chattoraj *et al.,* 2010; Hameed *et al*., 2014). After extraction, the mucilage was preserved at 4^0 C for further studies. The mucilage was subjected to chemical tests such as Molisch test and ruthenium red test to confirm its identity (Kulkarni *et al*., 2002). The mucilage was used for jaggery production at three different concentrations namely 0.1%, 0.2% & 0.4% on sugarcane juice (Table 1).

Table 1 Description of samples prepared using plant mucilage as clarificants

Sample code	Description
Control (JNC)	Jaggery with No clarificants
JAV1	Jaggery with *Aloe vera* mucilage at 0.1%
JAV2	Jaggery with *Aloe vera* mucilage at 0.2%
JAV4	Jaggery with *Aloe vera* mucilage at 0.4%
JFS1	Jaggery with Flax seed mucilage at 0.1%
JFS2	Jaggery with Flax seed mucilage at 0.2%
JFS4	Jaggery with Flax seed mucilage at 0.4%
JFG1	Jaggery with Fenugreek mucilage at 0.1%
JFG2	Jaggery with Fenugreek mucilage at 0.2%
JFG4	Jaggery with Fenugreek mucilage at 0.4%
JPS1	Jaggery with Purslane mucilage at 0.1%
JPS2	Jaggery with Purslane mucilage at 0.2%
JPS4	Jaggery with Purslane mucilage at 0.4%
JMS1	Jaggery with Malabar spinach mucilage at 0.1%
JMS2	Jaggery with Malabar spinach mucilage at 0.2%
JMS4	Jaggery with Malabar spinach mucilage at 0.4%

Preparation of jaggery using mucilage clarificants

The sugarcane stalks were cleaned and washed in water to remove dirt and foreign particles from the surface. A two–roller power crusher was used to extract the juice and the juice collected was allowed to settle in a vessel. The pH of semi clear juice (supernatant) was adjusted to 7.0 with the addition of lime (calcium hydroxide) and kept for boiling on a low flame (Shahi, 1999). At this stage mucilage clarificants of selected plant sources were added in three sequences with continuous boiling. The scum formed was collected from time to time using strainer until the juice attains a temperature of 118^0 C (Roy, 1951; Agarwal *et al.,* 1988). The hot syrup was allowed to cool and transferred into moulds of different shapes

and sizes for solidification. The jaggery without any clarificants was also prepared in the same manner that served as control. The solid jaggery prepared was stored under dry conditions for further analysis.

Colour

The colour of the jaggery was determined as per method described by Mandal *et al.*, (2006) with using spectrometer (Systronics India Ltd. India). The test sample was dissolved in distilled water (10%) and filtered through Whatman No.2 filter paper. The filtrate was used for colour measurement. The percentage transmittance of the jaggery sample was recorded at 540 nm.

pH

The pH was measured as per the method followed by Ranganna (1986), using a digital pH meter (model Cyberscan 510). Buffers of pH 4.0 and 7.0 were used to calibrate the instrument. 10% of Jaggery solution was prepared in distilled water and the pH was determined.

Water activity (a_w)

The water activity of jaggery sample was measured at room temperature using a water activity meter (Aqualab Water Activity Meter, Decagon, Washington, USA).

Insoluble solids

The Insoluble solids of the jaggery was determined as per the I.S.I Handbook of Food Analysis-Part-II (1984). Ten gram of jaggery was added to 100 ml of distilled water and heated until it starts boiling and then the solution was cooled .The solution was filtered through sintered glass filter. The sintered glass filter with residue was dried at 135 ± 20^0 C and weighed until a constant weight was obtained. The amount of insoluble solids was expressed on percentage dry basis.

Moisture

Moisture content was determined as per AOAC (1990) following hot air oven method. A known weight of the sample in a dish was kept in a preheated oven maintained at a temperature between 110^0 C and 120^0 C. After 1 hour the dish was removed and transferred to desiccator, allowed it to cool and then weighed. The loss in the weight was reported as percentage of moisture

Ash content

Total ash content was determined as per AOAC (1990). Five grams of sample taken in silica crucible was ignited on a heater until fumes ceased. The silica crucible was transferred to a muffle furnace and temperature of furnace was raised to 550 ± 15^0 C until clean ash was obtained. The ash content was determined by the differences of weight expressed in percentage.

Reducing sugars

The amount of fee reducing sugars in sample was estimated by Dinitrosalicylic (DNS) method (Miller, 1959). To 1 milliliter of jaggery sample in water (10%), 3 ml of DNS reagent was added and incubated in boiling water bath for 5 minutes. The colour developed was read at 575 nm. A calibration graph of glucose (0-30 mg/ml) was also prepared using standard glucose stock solution. The amount of free reducing sugars determined was expressed in percentage.

Total reducing sugars

Total reducing sugars in jaggery was estimated by phenol-sulphuric acid method (Dubois *et al.,* 1956). To 1 milliliter of sample (10% of jaggery), 1 milliliter 5 % (w/v) phenol was added followed by 5 milliliter concentrated sulphuric acid. The sample tubes were kept in ice while adding sulphuric acid. The mixture was incubated at room temperature for 20 minutes and the absorbance was read at 490 nm. The standard curve for glucose was prepared taking concentration of glucose on x-axis and absorbance on y-axis. The amount of total reducing sugars determined was expressed in percentage.

Non-reducing sugar (sucrose)

Non-reducing sugar (sucrose) percent was calculated from the difference between total reducing sugar (TRS) and the free reducing sugar (FRS) or glucose using the following expression (Mandal *et al.,* 2006).

$$\text{Sucrose} = (\text{TRS-FRS}) \times 0.95$$

Protein

Total soluble protein present in the sample was estimated by Folin Lowry method (Lowry *et al.,* 1951). One milliliter of jaggery solution in water (10%) was added with five milliliter of reagent (2 % Na_2CO_3 in 0.1 N NaOH and 0.5 % $CuSO_4$ in 1 % Potassium sodium tartarate in the ratio of 50:1) and mixed well. The mixture was incubated at room temperature for 10 minutes. then 0.5 ml of 1N Folin-Ciocalteau reagent was added and kept in dark for 20 minutes. The resulting colour was measured at 660 nm. Bovine Serum Albumin (BSA) was used as the standard for preparing the standard graph. The concentration of protein in the jaggery samples were determined using standard graph and expressed in percentage.

Minerals and Vitamin C

The ash obtained from the combustion of the jaggery sample in the muffle furnace was used to prepare the ash solution, which in turn used for the estimation of minerals by atomic absorption spectroscopy (AAS) as per the methods of AOAC (1990) and Vitamin-C content in jaggery sample was determined as per AOAC (1990) method using 2-6, Dichloro phenol Indophenol dye.

Statistical analysis

All the experiments were carried out in triplicates and the results were expressed as mean ± standard deviation (n=3).

RESULTS AND DISCUSSION

The results of physical properties like, color, pH, water activity (a_w) and insoluble solids of jaggery prepared using plant mucilage as clarificant are represented in Table 2.

Table 2 Colour, pH, a_w and Insoluble solids in jaggery prepared using plant mucilage clarificants

Sample	Colour (%)	pH	Water activity (a_w)	Insoluble solids (%)
JNC	42.67 ± 0.61	5.07 ± 0.06	0.62 ± 0.02	2.96 ± 0.02
JAV1	52.90 ± 0.10	5.60 ± 0.20	0.46 ± 0.01	1.87 ± 0.13
JFS1	51.63 ± 0.06	5.30 ± 0.00	0.52 ± 0.04	1.97 ± 0.02
JFG1	52.17 ± 0.49	5.47 ± 0.06	0.48 ± 0.03	1.95 ± 0.09
JPS1	48.90 ± 0.10	5.27 ± 0.06	0.53 ± 0.03	2.02 ± 0.08
JMS1	49.53 ± 0.31	5.30 ± 0.00	0.54 ± 0.02	2.03± 0.03
JAV2	54.57 ± 0.21	5.77 ± 0.15	0.44 ± 0.02	1.35 ± 0.04
JFS2	52.13 ± 0.06	5.53 ± 0.06	0.49 ± 0.01	1.58 ± 0.07
JFG2	53.10 ± 0.10	5.63 ± 0.06	0.46 ± 0.01	1.47 ± 0.06
JPS2	50.33 ± 0.45	5.43 ± 0.06	0.51 ± 0.02	1.61 ± 0.08
JMS2	51.07 ± 0.06	5.47 ± 0.06	0.52 ± 0.04	1.68 ± 0.04
JAV4	57.23 ± 0.38	6.20 ± 0.20	0.38 ± 0.02	1.18 ± 0.05
JFS4	53.37 ± 0.49	5.77 ± 0.06	0.47 ± 0.02	1.40 ± 0.02
JFG4	54.80 ± 0.20	5.97 ± 0.15	0.41 ± 0.02	1.31 ± 0.01
JPS4	51.17 ± 0.67	5.57 ± 0.06	0.48 ± 0.02	1.55 ± 0.03
JMS4	52.10 ± 0.70	5.53 ± 0.06	0.50 ± 0.03	1.57 ± 0.07

Values are the mean ± SD of three replicates

Color has been the primary factor in accessing the quality of the jaggery and in India it is used as the criterion for the classification. In the present study all the mucilage clarificants significantly improved the color of jaggery in a dose depended manner. Several researchers have reported that the light colored jaggery is preferred by consumers (Tiwari and Chatterjee, 1998; Patil and Adsule, 1998; Rodríguez and Segura, 2004). The color of the jaggery depends on the amount of dark compounds generated during extraction and heating of the cane juice, which could be derived from: i) oxidation of phenolic compounds; ii) caramelization of sucrose, glucose and fructose; iii) maillard reaction; and iv) alkaline decomposition of sucrose (Chen, 1991; Damodaran, 2000). All the plant mucilage clarificants showed maximum transmittance (%) at 0.4% concentration, JAV4 recorded maximum transmittance (%) of 54.23% and JNC showed least transmittance (%) of 42.67%.

pH is the most important factor that effects the clarirification process. It plays an important role in the stability and storage quality of the jaggery (Mandal *et al.,* 2006). The pH of jaggery was in the range of 5.07–6.20 similar to that reported by Guerra and Mujica, 2010; Nayaka *et al.,* 2015. Mucilage clarificant obtained from *Aloe vera* significantly increased pH of the jaggery when compared to control (5.07±0.06) at dosage as low as 0.1% (5.60±0.2). With increase in dosage (0.4%), pH was further elevated to 6.20 from 5.60. However, clarificants obtained from flax seeds (5.53±0.06) and fenugreek (5.63±0.06) significantly elevated the pH at 0.2% or higher concentration. This range was broader than that was reported by Garcia (2003) between 5.6 and 6.47. Lower pH values can be related to a deficient quantity of lime in the clarification process of the juice and also might be because of moisture absorption and sucrose inversion which in turn facilitates production of organic acids that are responsible for fall in pH (Mandal *et al.,* 2006). The Indian standard does not regulate pH.

Water activity (a_w) represents the water status in the food system that governs the microbial growth (Beuchat, 1987; Troller and Christian, 1978). Water activity of jaggery prepared using plant mucilage as clarificants varied between 0.38 to 0.62, similar to the results reported earlier (Guerra and Mujica 2010; Nayaka *et al.,* 2015). The lower water activity observed in jaggery prepared at 0.4 % concentration of *Aloe vera* mucilage may results in better shelf-life and quality of jaggery during storage. The high water activity (a_w) values promote microbial deterioration and biochemical degradation reactions (Guerra and Mujica, 2010). However, water activity (a_w) in the range 0.60–0.65 is suitable for growth of osmophilic and xerophilic microbes and results in spoilage (Beuchat, 1981). Therefore usage of plant mucilage as clarificants may be effective in maintaining keeping quality of jaggery.

The insoluble solids (%) were found to be lower in all the plant mucilage clarificants treated groups compared to control. The ranges of insoluble solids (%) were from 1.18 and 2.96% Jaggery prepared using *Aloe vera* mucilage showed lesser insoluble solids. It was observed that, as the concentration of mucilage clarificants increased, the percentage of insoluble solids (%) decreased. Therefore it is very evident from the observed results that application of plant mucilage as clarificants helps in removal of maximum amount of impurities.

The results of moisture, ash, protein, reducing and non reducing sugar content in jaggery prepared using plant mucilage as clarificant are shown in Table 3. High moisture percentage in the jaggery adversely affects the quality. Significant differences for moisture content among various experimental groups were observed (Table-3). These observations are similar to that reported by Patil *et al.,* (1994). Moisture percentage is an important parameter to determine the quality, stability and shelf-life of foods during storage. It was observed that the moisture content was decreased with increased concentration of all mucilage clarificants. The moisture content in 0.4% clarificants added jaggery was as lower as 3.7% than that of control (4.9%). The ash content varied between 0.732 - 0.997 % (Table-3), with significantly high content in control. Excess of ash adversely affects the jaggery quality. The ash content is higher than the values recorded by Bureau of Indian standard (1990) 0.3% and lower than the values recorded with those observed by Garcia, 2003; Rodriguez and Segura, 2004. However, our results coincide with Colombian technical standard NTC 1311 (1991) establishes a range for the ash content between 0.80 to 1.90 g/100 g.

Table 3 Moisture, ash, protein, reducing sugar & non reducing sugar in jaggery prepared using plant mucilaginous clarificants

Sample	Moisture (%)	Ash (%)	Protein (%)	Reducing sugars (%)	Non reducing sugars (%)
JNC	4.90 ± 0.08	0.997 ± 0.002	0.787 ± 0.008	11.16 ± 0.43	80.13 ± 0.71
JAV1	3.80 ± 0.10	0.901 ± 0.001	0.796 ± 0.003	8.58 ± 0.43	83.18 ± 0.98
JFS1	4.17 ± 0.06	0.953 ± 0.015	0.813 ± 0.032	9.59 ± 0.25	81.04 ± 0.80
JFG1	4.07 ± 0.15	0.927 ± 0.002	0.795 ± 0.013	8.87 ± 0.25	82.54 ± 0.96
JPS1	4.30 ± 0.10	0.966 ± 0.003	0.785 ± 0.001	9.87 ± 0.43	81.47 ± 0.37
JMS1	4.37 ± 0.15	0.973 ± 0.004	0.785 ± 0.003	10.01 ± 0.25	81.40 ± 0.85
JAV2	3.41 ± 0.09	0.817 ± 0.018	0.792 ± 0.003	7.44 ± 0.50	84.33 ± 0.56
JFS2	3.90 ± 0.10	0.852 ± 0.010	0.787 ± 0.008	9.01 ± 0.43	81.84 ± 0.24
JFG2	3.60 ± 0.10	0.838 ± 0.001	0.803 ± 0.006	7.58 ± 0.25	83.92 ± 0.41
JPS2	4.10 ± 0.10	0.864 ± 0.002	0.789 ± 0.008	8.87 ± 0.25	81.79 ± 0.63
JMS2	4.15 ± 0.05	0.901 ± 0.015	0.791 ± 0.005	9.16 ± 0.25	81.03 ± 0.61
JAV4	3.13 ± 0.03	0.732 ± 0.013	0.832 ± 0.010	7.01 ± 0.25	85.61 ± 0.69
JFS4	3.50 ± 0.10	0.792 ± 0.006	0.827 ± 0.006	8.38 ± 0.64	84.05 ± 0.79
JFG4	3.33 ± 0.15	0.772 ± 0.009	0.857 ± 0.021	7.15 ± 0.25	85.38 ± 0.54
JPS4	3.57 ± 0.06	0.837 ± 0.021	0.810 ± 0.010	8.01 ± 0.25	83.93 ± 0.62
JMS4	3.70 ± 0.10	0.872 ± 0.010	0.815 ± 0.005	8.30 ± 0.25	83.64 ± 0.78

Values are the mean ± SD of three replicates

The protein content varied between 0.785-0.857 g/100 g, being significantly higher in mucilage clarificants treated samples at 0.4%, hhowever, protein content in the 0.1% and 0.2% experimental groups had similar values and among these two groups, no significant differences were detected. The purslane and malabar spinach clarificants treated group showed little variation, while it significantly increased in 0.4% of *Aloe vera*, flaxseeds and fenugreek clarificants. The results coincide with those found by Guerra and Mujica (2010) in the range of 0.75-1.30 g/100g.

Reducing sugars are already present in jaggery as well as produced by the process of sucrose inversion due to acidity. The results of reducing sugars, non-reducing sugars of jaggery are represented in Table 3. Reducing sugars ranges from 7.01%-11.16%. The Ecuadorian technical standard (NTE INEN 2 332, 2002) dictates that reducing sugars must be between 5.5-10 percent, while the upper limit for the Colombian technical standard NTC 1311 (1991) is 12 percent. However, Bureau of Indian standards (1999) specify 10 percent by mass for Grade I and 20 percent by mass for grade II. A high content of reducing sugars is undesirable because they increase the hygroscopicity of the jaggery, affecting its texture and stability during storage (Verma and Maharaj, 1990; Tiwari and Chatterjee, 1998; Patil and Adsule, 1998).

Reducing sugars were significantly reduced in all the experimental groups at higher mucilage concentration.

Non-reducing sugars estimated in jaggery samples were in the range of 80.13% and 85.61%. As the concentration of mucilage increased, the non-reducing sugars (%) also increased. *Aloe vera* mucilage treated samples showed maximum non reducing sugars (%) at all concentrations compared to other mucilage clarificants. Control jaggery (JNC) had the least non-reducing sugar (80.13%). The observed results are well within the limit set by Indian Standards of 80% for grade –I. The non –reducing sugars observed were similar to the results obtained by Prada (1997) in the range of 84-86 g/100 g and by Garcia (2003) in the range of 84.4-85.8 g/100 g. the addition of these clarificants enhance purity of jaggery through removal of impurities.

The minerals content of jaggery samples are shown in table-4. The mineral content of jaggery sample increased with the treatment of plant mucilage clarificants compared to control. Potassium was the abundant mineral quantified in jaggery (Chen, 1991; Salgado, 2003) with control containing 120.65 mg/100 g. High potassium content 124.8 mg/100 g was observed in fenugreek clarificant treated jaggery. All the mineral components including Vitamin C in different mucilage clarificants treated samples showed marginal increase at all concentration compared to control.

Table 4 Mineral and vitamin C content in jaggery prepared using plant mucilage clarificants (mg/100g)

Sample	Calcium	Magnesium	Potassium	Phosphorous	Sodium	Iron	Vitamin C
JNC	68.66 ± 0.02	76.52 ± 0.02	120.65 ± 0.13	76.63 ± 0.03	22.18 ± 0.02	8.28 ± 0.01	6.72 ± 0.002
JAV1	69.17 ± 0.02	77.74 ± 0.03	122.50 ± 0.27	78.35 ± 0.05	24.35 ± 0.01	9.11 ± 0.08	6.85 ± 0.002
JFS1	69.28 ± 0.01	76.77 ± 0.03	121.85 ± 0.08	74.34 ± 0.02	23.63 ± 0.01	8.39 ± 0.03	6.92 ± 0.001
JFG1	70.08 ± 0.01	77.77 ± 0.03	123.05 ± 0.38	83.55 ± 0.04	25.18 ± 0.02	8.53 ± 0.16	7.20 ± 0.003
JPS1	69.14 ± 0.07	75.54 ± 0.02	121.22 ± 0.13	78.34 ± 0.02	23.13 ± 0.01	8.26 ± 0.02	6.88 ± 0.005
JMS1	68.74 ± 0.01	78.13 ± 0.03	121.28 ± 0.09	76.83 ± 0.03	23.45 ± 0.01	8.35 ± 0.03	6.92 ± 0.001
JAV2	69.52 ± 0.01	78.13 ± 0.01	123.17 ± 0.04	78.53 ± 0.03	25.35 ± 0.19	9.25 ± 0.55	7.31 ± 0.010
JFS2	68.14 ± 0.02	76.53 ± 0.01	122.42 ± 0.35	75.14 ± 0.02	24.51 ± 0.28	8.82 ± 0.03	7.05 ± 0.001
JFG2	70.41 ± 0.04	76.62 ± 0.02	123.75 ± 0.20	84.23 ± 0.03	25.86 ± 0.02	9.52 ± 0.06	7.42 ± 0.004
JPS2	69.39 ± 0.19	77.92 ± 0.01	122.40 ± 0.22	78.64 ± 0.02	24.23 ± 0.17	8.37 ± 0.05	6.85 ± 0.001
JMS2	69.19 ± 0.13	76.13 ± 0.02	122.26 ± 0.09	76.84 ± 0.03	24.78 ± 0.36	8.51 ± 0.26	6.97 ± 0.014
JAV4	70.03 ± 0.06	79.17 ± 0.01	124.17 ± 0.09	80.35 ± 0.03	26.13 ± 0.75	10.20 ± 0.08	7.42 ± 0.007
JFS4	68.76 ± 0.02	78.26 ± 0.01	123.85 ± 0.10	78.42 ± 0.02	25.85 ± 0.02	9.55 ± 0.03	7.33 ± 0.003
JFG4	70.82 ± 0.07	77.34 ± 0.02	124.86 ± 0.14	86.86 ± 0.02	26.85 ± 0.03	10.28 ± 0.02	7.46 ± 0.006
JPS4	69.75 ± 0.10	78.24 ± 0.02	123.46 ± 0.08	80.23 ± 0.02	25.73 ± 0.03	8.68 ± 0.54	6.93 ± 0.001
JMS4	69.57 ± 0.20	77.16 ± 0.01	123.60 ± 0.08	79.52 ± 0.01	25.78 ± 0.38	9.41 ± 0.10	6.94 ± 0.022

Values are the mean ± SD of three replicates

These variations may be attributed to the added plant mucilage extracts during clarification process. Thus in addition to clarification efficiency the resulting jaggery has increased mineral content and there by enhanced health benefits.

CONCLUSION

The physicochemical properties plays vital role in guarding the quality of jaggery. The selected plant mucilage clarificants were found to be efficient in manufacturing quality jaggery as per required regulatory standards. Among the plant mucilage clarificants treated *Aloe vera* followed by fenugreek had better clarification efficacy to produce quality jaggery. These plant mucilage clarificants may serves as a potential alternative to chemical clarificants. With the introduction of Food Safety and standard authority of India (FSSAI) the regulatory standards have become more stringent and hence it is very much essential to renew the traditional method of jaggery production using hazardous chemical clarificants with plant based clarificants.

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References

1. Agarwal ML, Duam SP, Dixit GC (1988) Manufacture and storage of gur in india- A review, *Bharatiya Sugar* 13: 45-50.
2. Agrawal MD, Ghosh AK (1983) Effect of cane maturity, nitrogen fertilization, clarificants and additives on keeping qualities of gur. *Indian Sugar* 33: 97-104.
3. AOAC (1990) Official methods of analysis. 15th edn. Association of official Analytical Chemist. Washinton, DC, USA.
4. Baboo B (1991) *Journal of Agricultural Engineering* Special issue: 252-263.
5. Baboo B, Solomon B (1995) Nutritive sweeteners from sugar crops: development of Jaggery, Khandsari and Syrup Industries in India. Sugarcane Agro-industrial alternatives: 289-312.
6. Beuchat LR (1981) Microbial stability as affected by water activity. *Cereal Foods World* 26: 345-349.
7. Beuchat LR (1987) Influence of water activity on growth, metabolic activities and survival of yeasts and molds. Jou*rnal of Food Protection* 46: 135-141.
8. Bureau of Indian Standards (1990) IS 12923, (Clause 4.3 and 6.1), New Delhi: India.
9. Chattoraj S, Bandyopadhyay AK (2010) Development and evaluation of Donut matrix tablets of bracofen using mucilaginous polymer from *Portulaca oleracea* Linn, *Pharm Ind* 72:11.
10. Chen J (1991) Manual del azúcar de caña. Ed. Limusa. México DF.
11. Chikkappaiah L, Nayaka HMA, Manohar MP, Santhosh C (2017) Properties of Liquid Jaggery Prepared Using Plant Mucilage As Clarificant. *International Journal of Recent Scientific Research* 8: 19590-95.
12. Damodaran S (2000) Aminoacidos, peptidos y proteinas. In: Fenemma, O. (ed.). Quimica de alimentos. 2 edn. Espana: Acribia.
13. DuBois M, Gilles KA, Hamilton JK, Rebers PA, Smith F (1956) Colorimetric method for determination of sugars and related substances. *Analytical chemistry* 28: 350-356.
14. Gangwar LS, Solomon S, Anwar SI (2015) Technological and policy option for modernization of jaggery industry in India. ICAR- Indian Institute of Sugarcane Research, Lucknow
15. García HR (2003) Mejoramiento de los sistemas de moldeo y de presentación de la panela a nivel de pequeño y mediano productor. Colombia: CIMPA.
16. Guerra MJ, Mujica MV (2010) Physical and chemical properties of granulated cane sugar ‘‘panelas’’. *Cienciae Tecnologia de Alimentos Campinas* 30: 250-257.
17. Hameed AM, Ramzy S. Hamied, Zainab Y. Shnain (2014) Drag-Reducing Agent for Aqueous Liquid Flowing in Turbulent Mode through Pipelines. *Al-Khwarizmi Engineering Journal* 10:15- 22.
18. Hussain F, Anwar M, Malik IA, Chattha AA, Sarwar M, Zafar M (2003) Evaluation of sugarcane varieties for gur quality. *Pakistan Sugar Journal* 18: 10–12.
19. Inamdar M, Abhang P, Momin M (2012) Isolation and evaluation of fenugreek, flaxseed mucilages and its use as a pharmaceutical binder. *International Journal of Pharmaceutical Technology* 4: 4766-4777.
20. Instituto Colombiano De Normas Técnicas Y Certificación - Icontec. NTC 1311 (1991) Productos agrícolas: panela. Colombia.
21. Instituto Ecuatoriano De Normalización-Inen NTE INEN 2 332 (2002) Panela granulada: requisitos. Ecuador.
22. ISI Handbook of Food Analysis-Part-II (1984) Sugar and Honey. Bureau of Indian Standards, New Delhi.
23. Joshi KK, Pandit SN (1959) Improved technique of gur manufacture and the role of various clarificants. *Indian Journal of Sugar Research and Development* 42-49.
24. Khanna KL, Chakravarti AS (1955) Scientific monograph researches on technical aspects relating to gur industry in Bihar. New Delhi, India: ICSC: 53-68.
25. Kulkarni GT, Gowthamarajan K, Brahmajirao G, Suresh B (2002) Evaluation of binding properties of selected natural mucilages. *Journal of Scientific and Industrial Research* 61: 529-532.
26. Kumar A, Tiwari GN (2006) Effect of shape and size on convective mass transfer coefficient during greenhouse drying (GHD) of jaggery. *Journal of Food Engineering* 73: 121-134.
27. Laxmikantham (1973). Importance of jaggery in Andhra Pradesh. Technology in Sugarcane growing, Andhra Pradesh Agril. University Hyderabad (India): 60-70.
28. Lowry OH, Rosebrough NJ, Farr AL, Randall RJ (1951) Protein measurement with the Folin phenol reagent. *Journal of Biological Chemistry* 193:265.
29. Mandal D, Tudu S, Mitra SR, De GC (2006) Effect of common packaging materials on keeping quality of sugarcane jaggery during monsoon season. *Sugar Technology* 8: 137-142.

30. Miller GL (1959) Use of dinitrosalicylic acid reagent for the determination of reducing sugar. *Analytical Chemistry* 31: 426-428.
31. Mungare TS, Jadhav HD, Patil JP, Hasure ILR, Jadhav BS, Singh J (2000) Clarification technique for production of quality jaggery. *Co-operative Sugar* 32: 283-285.
32. Nath A, Dutta D, Kumar P, Singh JP (2015) Review on recent advances in value addition of jaggery based products. *Journal of Food Processing & Technology* 6: 1-4.
33. Nayaka H, Sathisha UV, Manohar MP, Chandrashekar KB, Dharmesh SM (2009) Cytoprotective and antioxidant activity studies of jaggery sugar. *Food Chemistry* 115:113-18
34. Nayaka MA, Vinuta C, Sudarshan S, Manohar MP (2015) Physico-chemical, Antioxidant and Sensory Attributes of Ginger (*Zingiber officinale*) Enriched Jaggery of Different Sugarcane Varieties. *Sugar Technology* 17:305-13.
35. Patil JP, Adsule PG (1998) Studies on various quality parameters for grading of jaggery. *Indian Food Industry* 17: 215-217.
36. Patil JP, Jadhv HD, Wandre SS, Hasabnis AB (1994) Screening of different sugarcane varieties for quality jaggery and storability. *Indian Sugar* 44: 123-127.
37. Pattnayak PK, Misra MK (2004) Energetic and economics of traditional gur preparation: A case study in Ganjam District of Orissa, India. *Biomass & Bio energy* 26: 79-88.
38. Prada LE (1997) Metodología HACCP: una propuesta para el aseguramiento de la calidad en la panela. In: Centro De Investigación Y Divulgación Para El Mejoramiento mDe La Industria Panelera En Colombia – CIMPA. Memorias del II Curso internacional de caña panelera y su agroindustria. Colombia. 325-335.
39. Ragavan T, Thirumurugan A, Sathiya K, Sundra Vadana S (2011) A case study: studies on quality jaggery (gur) production with organic clarificants. *International Journal of Forestry and Crop Improvement* 2: 207–210
40. Rangana SC (1986) (2nd Edn.) Manual of analysis of fruit and vegetable products. Tata McGraw Hill Publishing Company Limited, New Delhi.
41. Rao PVK, Das M, Das SK (2007) Jaggery- a traditional Indian sweetener. *Indian Journal of Traditional Knowledge* 6:95-102
42. Rodríguez AR, Segura ME (2004) Panela granulada ecológica. *Antenor Orrego* 15: 47-55.
43. Roy SC (1951) Gur Monograph, IIST, Kanpur, 285-288.
44. Sahu AP, Paul BN (1998) The role of dietary whole sugar- jaggery in prevention of respiratory toxicity of air toxics and in lung cancer. *Toxicology Letters* 95: 154.
45. Salgado S (2003) Manejo de la fertilización en el rendimiento, calidad del jugo y actividad de invertasas en caña de azúcar. *Interciencia* 28: 576-580.
46. Shafi N, Khan L, Khan GA (2000) Commercial extraction of gel from *Aloe vera* (L) leaves. *Journal of Chemical Society* 22: 47-49.
47. Shahi HN (1999) Sustainability of jaggery and Khansari industry in India. Proceeding of National Seminar on status, problems, and prospects of jaggery and khandasari industry in India, Lucknow, 20-26.
48. Shankunthala VA (1985). Proc. National seminar on jaggery manufacture and storage. Pp-90-93.
49. Singh H, Gill PS (1954) Comparitive efficiency of certain organic clarificants in gur manufacture. Second Biannual Conf. Sug Res and Dev Workers. P: 613-15
50. Singh RP (1992) Heating and cooling processes for foods. In: Heldman, D.R., Lund, D.B. (Eds.), Handbook.
51. Tiwari RJ, Chatterjee A (1998) Evaluation of early and mid-late sugarcane (*Saccharum officinarum* L.) varieties for yield of millable cane and quality of jaggery. *Indian Journal of Agricultural Science* 68:255-257.
52. Troller JA, Christian JHB (1978) Water activity and food. New York: Academic Press.
53. Uppal SK, Sharma S (1999) Evaluation of new sugarcane varieties for Jaggery (Gur) quality and their shelf life in airtight containers during rainy season. *Indian Sugar* 49: 701-704.
54. Verma V, Chauhanand A, Saini DK (2014) Energy Efficient Method for Jaggery production Jaggery: Evolution to Revolution. Souvenir-cum-Proceedings, ICAR- IISR, Lucknow.
55. Verma VK, Maharaj N (1990) Moisture absorption isotherms of jaggery. *Journal of Stored Product Research* 26: 61-66.

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