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Research Article

PROPERTIES OF LIQUID JAGGERY PREPARED USING PLANT MUCILAGE AS CLARIFICANT

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ABSTRACT

Liquid jaggery is a product obtained by clarification and concentration of sugarcane juice. The objective of the research is to study the properties of liquid jaggery prepared using five different plant mucilage from Aloe vera, Flax seeds, Fenugreek seeds, Purslane and Malabar spinach as clarificants at three different concentrations namely 0.1%, 0.2% and 0.4% of raw sugarcane juice. The results showed that all the plant mucilage clarificants showed better efficiency at 0.4% in improving the properties of liquid jaggery such as colour, pH, moisture, reducing sugars, non reducing sugars and insoluble solids. Among all the clarificants mucilage from aloe vera and fenugreek showed better efficiency when compared to other three mucilage (flax seeds, purslane and malabar spinach) and control. Therefore the selected plants mucilage can be used as clarificants in the preparation of liquid jaggery.

INTRODUCTION

Liquid Jaggery is a semi liquid product obtained from concentrating sugarcane juice after clarification. Liquid jaggery is used in many ayurvedic preparations from times immemorial. It is widely used as sweetening agent in Karnataka, Maharashtra, Tamilnadu, Gujarat, Andhra Pradesh and Kerala states (Hunsigi, 2001). It is commercially used in various food industries and pharmaceutical formulations (Jaswath, 1998). The composition of liquid jaggery per 100g is: water 30- 35g, invert sugar 15-25g, sucrose 40-60 g, fat 0.1g, protein 0.5g and total minerals 0.75g. Calorific value of liquid jaggery is 300Kcal/100g (Jagannatharao, 2007). Liquid jaggery is gaining commercial importance due to its nutritive value and treated as an alternative source to honey (Shahi, 1999). In India about 20% of sugarcane is utilized for production of liquid jaggery (Shukla, 2012). The quality of liquid jaggery depends upon the composition of cane juice, clarificants and striking point at which liquid jaggery is collected (Singh *et al.*, 2013).

The clarification of sugar cane juice occurs by coagulation, flocculation, and precipitation of non sugar impurities which are later removed by decanting and filtrated as scum. The clarification of raw cane juice depends on the composition of cane juice and besides sugars, it contains non sugar impurities in suspended and colloidal form (Rao, 1984). In general term clarification means the extraction or separation of desired material and discarding the rest in a particular system (Panda *et al.*, 2008). Clarification/flocculation aids such as clay, activated silica, phosphoric acid, bentonite, polyelectrolytes and magnesium oxide (Moretti, 1999) are added to improve the quality of jaggery. Most of the chemicals affect the taste and storability of jaggery due to the presence of undesirable elements such as sodium, chloride and sulphur left in the jiggery (Ragavan *et al*, 2011). The market oriented jaggery prepared by using excess of chemical clarificants such as hydros will improve the colour but the presence of sulphur as sulphur dioxide in the jaggery should not be beyond 70 ppm from the point of view of consumer's health. Excess sulphur is known to deteriorate the product during storage (Ragavan *et al*, 2011) which affects export potential. Hence, it is advisable to avoid chemical clarificants to the extent possible. The manufacturers in the Cauvery command area of Karnataka are using sodium formaldehyde sulfoxylate, tri sodium phosphate, while majority used magnafloc a polyelectrolyte. Some

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chemicals were found to be unlabelled and safety limits not set by regulatory bodies (Usha *et al.,* 2004).

Plant mucilage serve as an alternative to synthetic clarificants because of local accessibility, eco-friendly nature, low cost and easy adaptability. There are many mucilaginous plant resources reported as organic clarificants such as *Hibiscus ficulneus* (deola), *Hibiscus esculentus* (Bhindi), *Cadia celcina* (sukalai), *Bombax malabarium* (semal bark), *Grewia asiatica* (falsa), *Arachis hypogea* (ground nut), *Recinus communis* (castor seed), *Abelmoschus esculentus* (okra), *Hibiscus cannabinus* (ambadi), *Bombax ceiba* (silk cotton), *Kydia calycina* (shuklai), *Manihot esculentum* (tapioca), *Glycine max* (soybean), *Tamarindus indica* (tamarind), *Cyamopsis tetragonoloba* (guar), *Ricinus communis* (castor), and *Abelmoschus moschatus* (kasthur) etc. (Chauhan, 1972; Shakunthala and Devraj, 1991; Jagganatharao *et al.,* 2007; Chauhan *et al.,* 2012). 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 use of plant mucilage extract as clarificants markedly improved the color and appearance of the product, it was effective in separation of impurities as clarifying agents (Chavan, 2002). Hence, there is a scope for screening new plant sources for utilization in order to replace chemical clarificants. The plant mucilage Aloe vera, Flax seeds (*Linumus itatissimum* L.), Fenugreek (*Trigonellafoenum-graecum* L.), Purslane (*Portulaca oleracea* L.) and Malabar spinach (*Basella alba* L.) are selected for the present investigation. The mucilage has been widely explored as pharmaceutical excipient and has been known since ancient times for their medical uses (Verma and Balkishen, 2003). But there is no reported work on the application of the selected mucilage in the jaggery clarification. Hence the current research is aimed at studying the properties of liquid jaggery prepared by using the selected plant mucilage as clarificants.

MATERIALS AND METHODS

Samples

Sugarcane variety Co 86032 has been extensively cultivated in the Mandya & Mysore Dist, of Karnataka state in India hence the variety was selected for the study. All the sugarcane samples were of 10 months age collected from Zonal Agricultural Research Station, V.C. Farm, Mandya, Karnataka. The plants such as Malabar Spinach, Purslane and Aloe vera were collected from field and Flax seeds and Fenugreek seeds were collected from Shop, Mysore. The plant materials were taxonomically identified and authenticated at Regional Ayurveda Research Institute for Metabolic Disorder, Bangalore, India.

Extraction of mucilage

The method of extraction of mucilage from the plant sources was standardized based on the laboratory trials, Aloe vera mucilage was extracted from aloe vera leaf by peeling and kept overnight at below 20^0 C. The extract was filtered using muslin cloth and stored for further use (Shaif *et al*., 2000).Flax seeds and fenugreek seeds were crushed and soaked in 1:5 W/V of water for 6 hours and boiled in waterbath for 5 hours then cooled at below 20^0 C for overnight. The extract 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 1:3 W/V of water for 6 hours and boiled in waterbath for 5 hours, then cooled below 20^0 C overnight. The extract was filtered through muslin cloth to obtain mucilage/ slurry (Chattoraj *et al* 2010; Hameed *et al* 2014). The mucilage was subjected to chemical tests such as Molisch test and ruthenium red test to confirm its identity (Kulkarni *et al*., 2002).

Liquid Jaggery Preparation

Five samples of liquid jaggery were prepared using Aloe vera mucilage, Flax seeds mucilage, Fenugreek mucilage, Purslane mucilage and Malabar spinach mucilage as clarificants at dosage concentration of 0.1%, 0.2% and 0.4% (Table 1 and Figure 1). The raw sugarcane juice was extracted and filtered to remove dry solid impurities. The pH of the raw sugarcane juice was adjusted by using lime (Shahi, 1999) and boiled. During boiling, plant mucilage was added as clarificant. The scum and other impurities formed during boiling were removed continuously. At temperatures 105^0 C to 108^0 C the thick syrup formed was collected in borosil container. Similarly the liquid jaggery was prepared without using any clarificant and used as control for comparative studies with liquid jaggery using plant mucilage as clarificants.

Table 1. Preparation of mucilage clarificants for 10L Sugarcane raw Juice

Experiment	Sample code	Mucilage concentration	Quantity(g) of mucilage per 10 L of juice
Control	LJNC	No mucilage	Nil
Aloe vera mucilage	LJAV1	0.1%	10
	LJAV2	0.2%	20
	LJAV4	0.4%	40
Flax seed mucilage	LJFS1	0.1%	10
	LJFS2	0.2%	20
	LJFS4	0.4%	40
Fenugreek mucilage	LJFG1	0.1%	10
	LJFG2	0.2%	20
	LJFG4	0.4%	40
Purslane mucilage	LJPS1	0.1%	10
	LJPS2	0.2%	20
	LJPS4	0.4%	40
Malabar spinach mucilage	LJMS1	0.1%	10
	LJMS2	0.2%	20
	LJMS4	0.4%	40

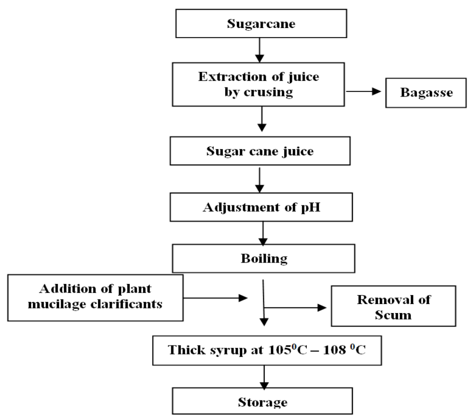

Figure 1 Flow chat of liquid jaggery preparation using plant mucilage as clarificants

Properties of Liquid jaggery

Colour

The colour of the liquid jaggery (10%) was determined as per method described by Chand *et al,* 2012 using colorimeter. The test sample was filtered through Whatman number-2 filter paper and the filtrate was taken for colour measurement. The percentage of transmittance of the liquid jaggery sample was recorded at 540 nm.

Moisture

Moisture content was determined as per AOAC, 1990 by using hot air oven method by putting known weight of the sample in a dish, keeping it in preheated oven maintained at a temperature of 110-120^{0}C. After 1 hour the dish was removed and transferred to desiccator, allowed to cool and then weighed. The loss in the weight was reported as percentage of moisture content which can be calculated as per the following formula.

$$\text{Moisture Content (\%)} = (W_1 - W_2) / (W1 - W) \times 100$$

W= Weight of empty aluminium dish (g)
W1= Weight of aluminium dish+ Sample before drying (g)
W2= Weight of the aluminium dish+ Sample after drying (g)

pH

pH was measured according to Rangana (1986), using a digital pH meter model Cyberscan 510. Buffers of pH 4.0 and 7.0 were used to standardize the equipment. 10% of Jaggery solution was prepared by dissolving 10 g of jaggery in 100 ml of distilled water and the pH was determined.

Determination of specific gravity

The specific gravity of liquid jaggery was determined as per method described in the ISI Handbook of Food Analysis (Part II). Specific gravity bottle was cleaned, thoroughly dried and the weight was recorded. Specific gravity bottle was filled upto the mark with freshly boiled and cooled distilled water maintained at 27±1^0 C and weighed. The procedure was repeated liquid jaggery samples maintained at the same temperature. The specific gravity of the liquid jaggery was calculated as per the following formula.

$$\text{Specific gravity at } 27^0 \text{ C} = C\text{-}A / B\text{-}A$$

C = weight of specific gravity bottle with sample
A = weight of specific gravity bottle (18g)
B = weight of specific gravity bottle with water (46g)

Insoluble solids

Determination of insoluble solids was carried out as per the ISI Handbook of Food Analysis-Part-II (1984). 10 gm of liquid jaggery was added to 200ml of hot distilled water. The solution was boiled and cooled to room temperature. Weight of the sintered glass filter was noted and the solution was filtered using the same. The sintered glass filter with residue was dried at 135 ± 20^{0}C to a constant weight. The insoluble solid was expressed as percentage on dry weight basis.

Insoluble solids = (Weight of the sintered glass filter with residue - weight of the empty sintered glass)

Separation efficiency (Ƞ)

Separation efficacy was estimated using method of Tarak *et al* (2008) with slight modification. One of the objectives of clarification was to remove the insoluble solids in the jaggery. Hence, the separation efficiency (Ƞ) was taken as one of the major index for clarification efficacy. Separation efficiency (Ƞ) was determined by the ratio between insoluble solids in raw juice and clarified liquid jaggery as per below formula. The percentage of insoluble solids in raw juice was determined and found to be 7.32% on dry basis.

$$\text{Separation efficiency } (\eta) = \{(A-B)/A\} \times 100$$

A=Insoluble solids (% on DB) in raw juice
B= Insoluble Solids (% on DB) in clarified liquid jiggery

Reducing sugars

The reducing sugars in liquid jaggery samples was estimated by DNS method (Miller, 1959). To 1 ml of sample (10% jaggery), 3 ml of DNS reagent was added and incubated in boiling water bath for 5 min. The colour developed was read at 575 nm. The standard graph of glucose was prepared using glucose as the standard in the range of 0-30 mg concentration from 100 mg/ml stock solution. A standard graph was plotted with absorbance at 575 nm against concentration of glucose. A blank was also prepared in the same way (0 mg glucose). The amount of reducing sugars was expressed in percentage.

Total reducing sugars

Total reducing sugars in liquid jaggery was estimated by phenol-sulphuric acid method (Dubois *et al*, 1956). To 1 ml of sample (10% of jaggery), 1ml 5% (w/v) phenol was added followed by 5 ml concentrated sulphuric acid. The sample tubes were kept in ice while adding sulphuric acid. The mixture was incubated at room temperature for 20 min and the absorbance was read at 490 nm. The standard curve of Glucose was prepared using glucose as the standard and plotted against absorbance. A blank was also prepared in the same way (0 mg glucose). The amount of total reducing sugars determined was expressed as percentage on dry weight basis.

Non-reducing sugar (sucrose)

Sucrose percent was calculated from the difference between total reducing sugar (TRS) and the free reducing sugar (FRS) or glucose (Mandal *et al*. 2006).

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

Statistical analysis

All the experiments were carried out in triplicates and the results were expressed as mean ± standard deviation (n=3). One-way analysis of variance (ANOVA) followed by post hoc Tukey's test wherever appropriate. p value of less than 0.05 was considered as significant**.**

RESULTS AND DISCUSSION

In Table 2, the results for Colour, pH, Moisture and Specific gravity of liquid jaggery are shown. Color is the predominant factor in the quality of the jaggery, and in India it is used as the criterion for classification. Many researchers have stated that the light colored jaggery is preferred by consumers (Tiwari and Chatterjee, 1998; Patil and Adsule, 1998; Rodríguez and

Segura, 2004). In the present study all the mucilage clarificants used significantly improved the color of the liquid jaggery at a dosage as low as 0.1%. On further increasing concentration of mucilage clarificants, colour of the liquid jaggery improved. 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; v) depends on the amount of insoluble solids (Chen, 1991; Damodaran, 2000). The presence of mucilage clarificants helped in the removal of high amount of impurities along with scum compared to control sample. This in turn decreased the amount of heat required for flocculation process. Thus clarification process might play a significant role in inhibition of caramelization and maillard reaction, which is responsible for dark coloration (Damodaran, 2000). Therefore, the plant mucilage clarificants can be used to improve the colour of liquid. The antioxidative property of mucilages obtained by the listed plants might be helping to improve the color (Damodaran, 2000).

Table 2 Colour, pH, Moisture and Specific gravity of liquid jaggery prepared by plant mucilage clarificants

Sample	Colour	pH	Moisture (%)	Specific gravity
LJNC	55.7±0.82	4.9 ±0.25	23.0±0.90	1.210±0.011
LJAV1	60.5±0.15	5.3 ± 0.10	21.1±0.15	1.270±0.031
LJFS1	59.5±0.20	5.1 ± 0.12	21.6±0.15	1.243±0.032
LJFG1	60.4±0.15	5.2 ± 0.06	21.4±0.15	1.250±0.037
LJPS1	59.4±0.15	5.0 ± 0.10	21.7±0.10	1.233±0.022
LJMS1	59.3±0.21	5.0 ±0.14	21.8±0.10	1.229±0.034
LJAV2	62.2±0.06	5.4 ±0.06	20.3±0.06	1.301±0.014
LJFS2	60.6±0.21	5.3 ±0.10	20.7±0.12	1.260±0.023
LJFG2	61.6±0.20	5.4 ±0.09	21.4±0.15	1.280±0.036
LJPS2	59.7±0.12	5.2 ±0.03	21.2±0.10	1.252±0.039
LJMS2	59.6±0.15	5.1 ±0.06	21.1±0.10	1.245±0.032
LJAV4	63.8±0.10	5.8 ±0.21	19.4±0.06	1.336±0.041
LJFS4	61.4±0.06	5.5 ±0.15	19.6±0.10	1.280±0.041
LJFG4	62.7±0.15	5.7 ±0.06	19.3±0.06	1.300±0.030
LJPS4	60.4± 0.10	5.4 ±0.10	19.8±0.10	1.270±0.043
LJMS4	60.2± 0.15	5.3±0.21	19.7±0.12	1.264±0.022

Values are the mean ± SD of three replicates ($P<0.05$)

Table 3 Reducing sugars, Non reducing sugars, Insoluble solids, Separation Efficacy of liquid jaggery prepared by plant mucilage clarificants

Sample	Reducing sugars (%)	Non reducing sugars (%)	Insoluble solids (%)	Separation Efficacy (η)
LJNC	16.78 ±0.45	41.29 ± 0.16	4.80 ±0.10	34.43
LJAV1	13.60 ±0.39	49.47 ± 0.52	2.18 ±0.18	70.17
LJFS1	14.70 ±0.80	46.77 ± 1.39	2.93 ±0.20	59.93
LJFG1	13.92 ±0.08	47.95 ± 0.67	2.32 ±0.13	68.35
LJPS1	14.83 ±0.39	45.58 ± 0.65	3.02 ±0.10	58.79
LJMS1	14.44 ±0.45	45.55 ± 1.01	3.08 ±0.06	57.88
LJAV2	12.48 ±0.23	52.11 ± 0.63	1.85 ±0.05	74.73
LJFS2	13.66 ±0.45	49.33 ± 1.40	2.38 ±0.08	67.44
LJFG2	13.01 ±0.49	50.48 ± 1.02	2.07 ±0.06	71.77
LJPS2	13.92 ±0.15	48.21 ± 0.78	2.52 ±0.03	65.62
LJMS2	13.66 ±0.39	48.11 ± 0.90	2.68 ±0.08	63.34
LJAV4	11.31 ±0.78	55.24 ± 1.30	1.48 ±0.08	79.74
LJFS4	12.35 ±0.15	51.88 ± 0.58	2.02 ±0.08	72.45
LJFG4	11.83 ±0.30	53.69 ± 0.79	1.80 ±0.10	75.41
LJPS4	13.14 ±0.40	49.83 ± 0.42	2.15 ±0.05	70.63
LJMS4	13.27 ±0.23	49.18 ± 0.65	2.30 ±0.05	68.58

Values are the mean ± SD of three replicates ($P<0.05$)

The pH of the jaggery plays an important role in the stability and storage quality of the jaggery. The pH of liquid jaggery prepared varied between 4.9 to 5.8 and the results obtained are in agreement with those reported by Guerra and Mujica (2010). The observed pH of jaggery was marginally lower than 5.9 as prescribed by Ecuadorian technical standard (2002) for panela. Mucilage clarificant obtained from Aloe vera significantly increased the pH of the liquid jaggery compared to control (4.9±0.25) when used at 0.1% (5.3±0.1). The higher dosage (0.4%) of mucilage clarificants further increased the pH of the liquid jaggery from 4.9 to 5.8. Moisture content is an important parameter to determine the quality and stability of foods during storage (Ergun *et al*, 2010). It was observed that the moisture reduction followed the dosage depended pattern, where higher the concentration of mucilage used higher will be the reduction in moisture. The highest reduction of moisture was observed at liquid jaggery prepared using 0.4% concentration of mucilage and lowest reduction of moisture was found at liquid jaggery prepared using 0.1% concentration mucilage. The moisture content for 0.1% dosage of clarificants was found to be between 21.1% to 21.8%, while control sample had 23% moisture. The moisture content for 0.2% concentration of mucilage was reported to be 20.3% to 21.4 %. There was significant reduction in moisture content to 19.4 -19.8% for 0.4% clarificants dosage. Clarificant used in this study did not alter the specific gravity compared to control in the all the treatment conditions.

The results of reducing sugars, non-reducing sugars, insoluble solids, separation efficacy of jaggery are represented in Table 3. Reducing sugars turned out to be significantly lower in the 0.4% mucilage clarificant experimental groups, compared to their respective low concentrations of mucilage clarificant experimental groups and to the control one. Similarly, the level of non-reducing sugar increased in the 0.4% mucilage clarificant experimental groups, compared to their respective low concentrations of mucilage clarificant experimental groups and to the control one. However, very low amount of reducing sugar (11.31±0.78) and high amount of non-reducing sugar (55.24±1.3) was observed in 0.4% Aloe vera group. The Ecuadorian technical standard (NTE INEN 2 332, 2002) dictates that reducing sugars must be between 5.5-10 % by mass, while the upper limit for the Colombian technical standard NTC 1311 (1991) is 12% by mass. However, as per Bureau of Indian standards (BIS, 1999) it is 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 panela, affecting its texture and stability during storage (Verma and Maharaj, 1990; Tiwari and Chatterjee, 1998; Patil and Adsule, 1998).

Insoluble solids represent an important quality parameter, especially when the jaggery is used in preparation of beverages. Insoluble solids turned out to be significantly lower and separation efficacy is higher in all the plant mucilage clarificant experimental groups compared to the control one. The inorganic compounds of sugarcane can be present as ions, molecules, salts, components of complex organic molecules, or as insoluble compounds (Chen, 1991). The results suggest that the quantity of insoluble solids removed is proportional to the amount of plant mucilage clarificant added during liquid jaggery preparations.

CONCLUSION

The findings of this research suggest that the application of plant mucilage clarificants during jaggery manufacturing plays a vital role in removing impurities, which has a direct bearing upon the liquid jaggery characteristics such as color, pH and reducing sugars. Liquid jaggery has been one of the potential sweeteners with high nutritive value which can be processed much easily from sugarcane. There is a promising market for the liquid jaggery produced using natural/plant clarificants, as organic food products are being preferred by consumers. Hence, the liquid jaggery has the potential to be the 'Indian Golden Syrup' or equivalent of the 'Mapple Syrup'. From the studies, it was found that the use of plant mucilage clarificants was very effective and the natural clarificants are equally performing as their chemical counterparts in removing higher amount of insoluble solids. Further, a sweetener without any harmful chemicals can be prepared using plant clarificants which also reduces the cost of jaggery production.

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