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SCIENTIFIC CORRESPONDENCE

Improved method of liquid jaggery preparation

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Abstract
Liquid jaggery (LJ) is an important intermediate product obtained during the preparation of jaggery from sugarcane juice (SCJ). Unlike the white sugar, LJ is having additional nutritional components which are having wide spectrum of medicinal properties and hence, it is a good nutraceutical. LJ is incorporated in many traditional foods and ayurvedic medicinal compositions. In the present study, five products of LJ were prepared from SCJ with different experimental methods, 1. Filtration, 2. pH neutralisation, 3. Citric acid addition, 4. Without filtration and 5. Control (without filtration and scum removal) to compare their quality and acceptability. pH neutralisation resulted in clear product but showed sucrose crystallization. Citric acid addition, preparation without filtration and control gave turbid LJ products. Organoleptic examination was done using a nine-point Hedonic scale to evaluate the LJ samples for appearance, colour, flavour, taste and overall acceptability. The filtration gave LJ product of good appearance, colour, taste and acceptability with highest score. Product from filtration method was validated by ^{1}H NMR spectrum for major ingredients with prominent characteristic signals of glucose, fructose and sucrose units with the relevant δ values. The best product was obtained with filtration method at the striking temperature of 106°C involving simples steps without incorporation of any harmful chemicals. Hence, filtration method of preparation of LJ is suggested for obtaining good quality LJ.

Keywords: Sugarcane juice; Sugarcane juice clarification; Non-centrifugal sugar; Jaggery, Liquid jaggery

Introduction

In India, about 5.15 million hectares of cultivable area are utilized for sugarcane production of 383 million tonnes (2018-19) with productivity of 74.4 tonnes per ha (ICAR-SBI 2019). 53% of sugarcane produced is processed into white sugar, 36% into jaggery [raw cane sugar called non centrifugal sugar (NCS) or artisan sugar], *khandsari* and liquid jaggery (LJ), 3% for chewing and 8% as seed cane. 80% of jaggery is prepared in the solid form with various shapes and 20 per cent as LJ and granular jaggery (Shukla 2012). India is the largest producer of jaggery in the world and has the share of more than 70% of world production (Rao et al. 2007). LJ is a versatile product finding use in various food compositions as that of honey. LJ is an intermediate product of jaggery preparation from sugarcane juice (SCJ) (Nath et al. 2015). Now-a-days, there is an increased demand for the natural sugar like liquid jaggery, due to its nutritional ingredients, unlike the white sugar which is devoid of all nutrients except sucrose (Shrivastav et al. 2016). Therefore, LJ may be termed as a nutraceutical with its non-sugar ingredients having wide spectrum of medicinal properties. The non-sugar ingredients include pigments, phenolic compounds, vitamins, amino acids, sterol and minerals containing salts of calcium, potassium, magnesium, phosphorus, iron, zinc, sulphur, etc.

LJ helps in blood purification, controls acidity, gives instant energy and so it is used in *Ayurvedic* medicinal preparations (Singh et al. 2011). High content of reducing sugars in LJ is the instant energy provider on consumption. Hence, it is good for students, sportsmen, children, and aged persons. It is used as ingredient in ice creams, *sudharas*, fruit salad, ayurvedic medicines & syrups. It is good for patients for energy recovery. It is also useful as dietary supplement for bread, *chapatti, jowar bhakri, millet bhakri, puranpoli, roti*, etc. With the importance of these versatile properties of LJ, focus has been made to prepare LJ in a simple way which can be augmented for upscale preparation to the market level. Indiscriminate use of chemical clarificants like hydros, super phosphate, phosphoric acid, etc. by jaggery manufacturers results in the low quality sugarcane products. Quality of the product is slowly degraded on storage due to these chemicals and excess residues of these chemicals are harmful to health (Nagalakshmi and Uma 1999). Therefore, the present study was aimed to prepare LJ with no clarificant and preservatives with five experimental methods to compare final products.

The available methods in the literature were surveyed for a standardized method to get the product of good quality and shelf life. The literature methods however resulted in the turbid products, formation of sucrose crystals, crystallization of the whole product after few days and mold formation after one month (Shrivastav et al. 2016; Chikkappaiah et al. 2017; Hossain and Singh 2018). The effect of lime addition, filtration of the precipitate formed after initial heating of SCJ and scum removal were experimented in the present work to study the quality of final products and to get a consistent final product of good acceptability, without use of any chemical clarificant or preservatives.

Materials and Methods

The twelve months old sugarcane variety, Co 86032 from ICAR-Sugarcane Breeding Institute's experimental farm at ECC campus, was used to extract the SCJ. The juice was extracted using the horizontal three roller crusher within 4 h of harvest with an average yield of 50%.

Five methods were followed to prepare the LJ product.

1. Filtration
2. pH neutralisation
3. Citric acid addition
4. Without filtration
5. Control (without filtration and scum removal)

Preparation of LJ

Three litres of SCJ (°B 21.0; 18.86% sucrose) was used for each experiment to get about 19% of LJ yield. The juice was initially filtered with nylon filter bag (40µ) to remove suspended debris like bagasse particles (bagacillo), wax, sand, colloidal particles, etc. The filtered juice was heated to boiling in an evaporating pan. On heating the colloidal matter responsible for viscosity and colour development of SCJ, like hydroxy methyl furfural, dextrans, etc. started to coagulate and separate into a dark grey waxy scum floated on the surface. The boiled juice turned to light brownish yellow colour. Removal of the scum resulted in the uniform boiling of juice up to 100°C. Then different experimental methods were used for the preparation of LJs as given below. All the LJs were prepared at the striking temperature of 106°C.

1. Filtration: After initial heating and scum removal, the upper clear juice was decanted leaving the bottom settled dark grey precipitate. This precipitated slurry was filtered through a fibre filter cloth (1µ) to get a clear brownish yellow filtrate which was combined with

the decanted juice. The combined juice was concentrated by heating to get the product LJ1. The scum formed was removed intermittently.

2. pH neutralization: The initially filtered fresh juice was treated with lime water (calcium hydroxide) to pH 7 and boiled. The juice was then cooled and filtered to remove the settled dark grey precipitate. The filtered juice was then concentrated to get the product LJ2. The scum formed was removed intermittently.
3. Citric acid addition: Citric acid (0.1%) was added to the boiled and cooled filtered juice and concentrated to get the product LJ3. The scum formed was removed intermittently.
4. Without filtration: LJ4 was prepared without filtering the boiled juice and processed to get the product. The scum formed was removed intermittently.
5. Control (without filtration and scum removal): The boiled juice without filtration was processed and the scum later formed was not removed to get the product which was taken as control (LJ5).

These products were tested for acceptability. Organoleptic examination of the products was done by a panel of 10 members using a score card. Numerical score card was used for quality characteristics of the products like appearance, colour, flavour, taste and overall acceptability. A nine-point Hedonic scale was used to evaluate the LJ samples (Peryam and Pilgrim 1957). The product quality of LJ1 was analysed using standard procedures (Muthuvel and Udayasoorian 1999). The analytical methods followed are: moisture and ash content by gravimetric method, pH and electrical conductivity in N/2 jaggery solution using pH meter (Adwa AD1020) and conductivity meter (Systronics Conductivity Meter 306)), respectively, Brix using glass hydrometer, reducing sugar using titration with Fehling's solution, water activity using water activity meter (Decagon devices Inc. Aqualab Pre), sodium and potassium using flame photometer (Systronics Flame Photometer 128). ^{1}H NMR spectrum of LJ1 was recorded in Bruker 300 MHz (Bruker-Avance, Germany) Instrument available at School of Chemistry, Madurai Kamaraj University using D_2O as the solvent. The shelf life was determined based on the appearance of mold at the surface of LJ after three months.

Results and Discussion

The five experimental conditions gave five products LJ1, LJ2, LJ3, LJ4 and LJ5 (Fig.1). LJ1 had settlement of impurities, LJ2 was clear and LJ3, LJ4 & LJ5 were turbid. Treatment of SCJ with lime (calcium carbonate) led to the formation of sucrose crystals in LJ2 after a fortnight on the walls of the container and that of LJ3, LJ4 & LJ5 were turbid without any crystal formation. The

Figure 1. Liquid jaggery prepared in five different methods

product quality parameters for LJ1 were analysed (Table 1). The filtration of the grey precipitate formed after boiling the juice, gave clear product LJ1.

Table 1. Product quality parameters of LJ1

Sl. No.	Parameter	Value
1.	Moisture %	31.83
2.	Ash %	2.64
3.	pH*	4.14
4.	Electrical conductivity (dS/m)*	5.43
5.	°Brix*	9.80
6.	Water activity	0.733
7.	Reducing sugar %*	19.23
8.	Sodium (mg/kg)	109
9.	Potassium (mg/kg)	24

*Analysed in N/2 solution

Sensory score was highest for the LJ product LJ1 with 9 for appearance, 9 for colour, 8 for taste, 8 for flavour and 8 for overall acceptance. The scores for other products were 5, 6, 7, 6 & 6 for LJ2; 7, 8, 7, 7 & 7 for LJ3; 7, 7, 7, 6 & 7 for LJ4 and 6, 6, 5, 4 & 5 for LJ5, respectively (Table 2).

The aim of this experiment was to get the product with good gloss, shelf life and texture without the use of clarificants and preservatives (Patil and Anekar 2014). Filtration of the precipitate formed after heating of the SCJ yielded the LJ product LJ1 with expected quality and the product quality parameters were determined (Table 1). Other products prepared under different experimental conditions for the preparation of LJ like neutralized SCJ, incorporation of citric acid, without filtration after initial heating and without filtration and scum removal were different from LJ1. Although the product LJ2 was obtained with good clarity by the processing of neutralized SCJ, the product after a fortnight developed sucrose crystal formation. This may be attributed to the non-incorporation of citric acid and the non-acidic nature of the juice, as sucrose crystallization was not observed in LJ1, LJ3, LJ4, and LJ5 (Shahi 1999; Chikkappaiah et al. 2017; Hossain and Singh 2018).

Addition of citric acid which acts as both preservative and prevents the sucrose formation yielded the turbid product of LJ3. The removal of the precipitated impurities after boiling of SCJ was crucial to yield the product LJ of desired quality.

The product quality difference was clearly seen when the LJ was prepared without filtration to get the turbid product (LJ4). The boiling temperature and acidic nature of the SCJ were essential to get the LJ without any crystal formation. The highest sensory scores for the product LJ1 indicated the overall acceptability of the product with respect to

Table 2. Sensory score for the LJ prepared in five different methods

Product	Appearance	Colour	Taste	Flavour	Overall acceptance
LJ1	9	9	8	8	8
LJ2	5	6	7	6	6
LJ3	7	8	7	7	7
LJ4	7	7	7	6	7
LJ5	6	6	5	4	5

the sensory parameters (Table 2). From the table, it is clear that the product LJ2 from neutralized SCJ scored less and product LJ5 without filtration and scum removal had the least score, attributing the effect of neutralization and filtration of precipitate with respect to overall score, appearance and flavour in particular.

The analysis of ^{1}H NMR spectra (Fig. 2) of LJ1 validated the major ingredients present with the prominent signal characteristic of glucose, fructose and sucrose units with the relevant δ values. Ring protons of sucrose and reducing sugars contributed the signals with δ values between 3.27 – 4.07 attributing to the mixture of these components. Sharp signal at δ 4.67 can be assigned to the hydroxyl proton of sucrose and δ 5.24 to the proton of anomeric carbon of glucose available as both free form and in sucrose molecule. The abundance of signals was more for LJ than that of sucrose spectrum. This can be attributed to higher composition of reducing sugars with their higher number of protons which are absent in the case of sucrose.

Conclusion

The present method was used to prepare LJ without addition of chemicals or preservatives. Formation of LJ product required the acidic nature of the juice as the neutralized juice led to product which developed sucrose crystal after a fortnight. Although the incorporation of citric acid arrested the crystallization of sucrose, the product LJ2 was turbid. Other products LJ3, LJ4 and LJ5 were also turbid due to the presence of precipitate in the juice after initial boiling. Removal of precipitate increased the clarity of the final product in LJ1 with good acceptability. The product LJ1 was found stable for three months and this method is suggested for obtaining good quality LJ.

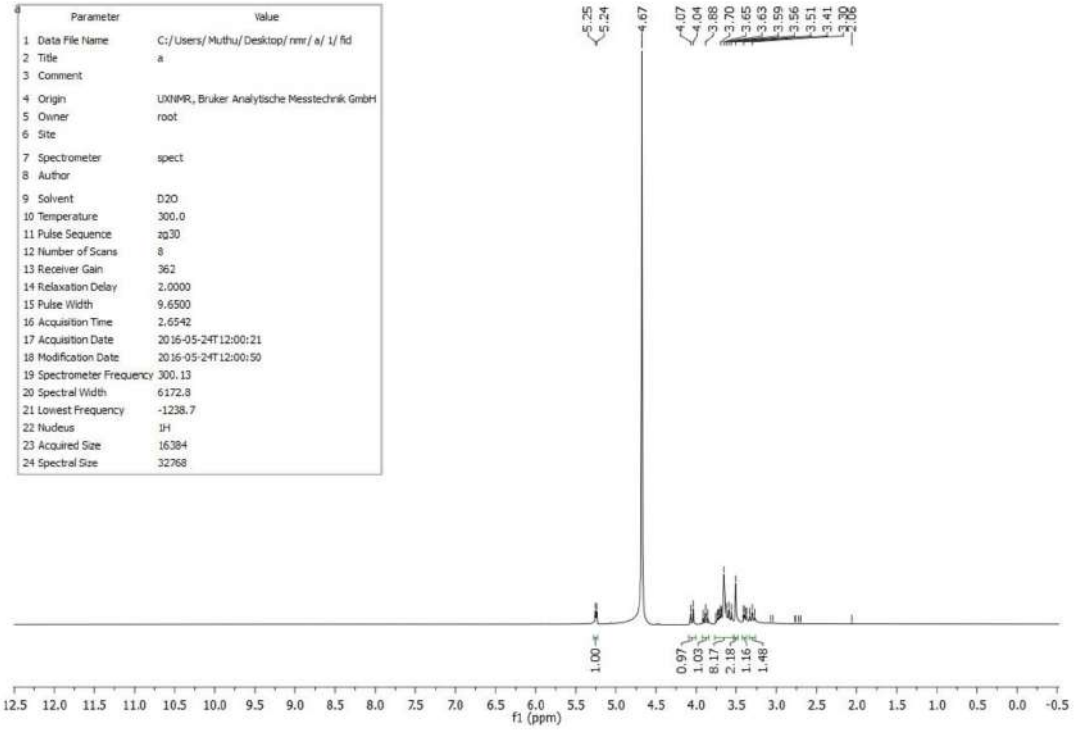

Figure 2. ^{1}H NMR spectrum of LJ1

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