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Storage studies of jaggery prepared using aloe vera, pursalane and malabar spinach mucilage clarificants

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Abstract

The jaggery was prepared using plant mucilage as clarificant extracted from *Aloe vera*, purslane and malabar spinach and control jaggery was also prepared without any clarificant. The mucilage was used at dosage rate of 0.4% of raw sugarcane juice. The jaggery prepared using plant mucilage as clarificants were packed in three packaging materials namely brown paper packs, low density polyethylene (LDPE) Covers & aluminium pouches respectively and stored at room temperature. The jaggery samples were evaluated for storage period of six months at the interval of 30days for moisture, colour, reducing sugars, non-reducing sugars, total viable count evaluation. The results indicated increased moisture, colour, reducing sugar, decreased non- reducing sugars and lower sensory scores for control jaggery packed in brown paper, LDPE covers and aluminum pouches. However, *Aloe vera*, Malabar spinach and purslane plant mucilage clarificants treated jaggery samples showed lesser changes in physicochemical, microbial as well as sensory characteristics compared to control jaggery. This suggests that improper storage of jaggery often leads to altered quality characteristics of jaggery leading to reduction in market value. The best packaging material in terms of preventing ingress of atmospheric moisture and for maintaining the keeping quality of jaggery prepared using different plant clarificants was found to be the aluminum pouches in the current study.

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Introduction

Jaggery is among the major agro-processing products found in the rural sector of India. Nearly 50% of total sugarcane produced in the country is used for the manufacture of about 8–10 million tones of jaggery, which is the most nutritious agent among all sweeteners (Madan *et al.,* 2004). The quality of jaggery is influenced by sugarcane variety, the quantity of fertilizers, quality of irrigation water, clarification method, processing time, storage condition and packaging methods (Kumar *et al.,* 2013). Darkening of jaggery color during storage under the ambient condition is a problem faced by jaggery manufacturers and traders, since dark colour jaggery is not preferred by consumers. Darkening may be due to physical, chemical or microbiological deterioration of jaggery. Reducing sugar, polyphenols, organic non-sugars, proteins, and iron are main factors effecting colour of jaggery (Singh and Singh, 2008).

The keeping quality of jaggery largely depends on the atmospheric humidity and temperature. Jaggery is mostly spoiled during the monsoon period because of higher humidity in the atmosphere resulting in loss of its normal texture, colour, flavour and microbial growth leading to compositional change, undesirable aroma, flavour and quality deterioration (Singh *et al.,* 2009; Kumar *et al.*, 2013). Jaggery samples may be stored in cold storage but it is difficult for small-scale farmers, as the cost involved is the main constraint (Pandey and Kulshrestha, 1999).

Many researchers have used different packaging materials for jaggery storage studies. Shinde *et al.* (1983) reported that colour, moisture absorption and liquefaction of jaggery can be avoided by using polythene film. Low-density polyethylene film (LDPE) absorbs moisture less than 0.01% in 24hr. Kapur and Kanwar (1983) reported that the jaggery stored in tin containers absorbed less moisture compared to earthen pots. Baboo and Shukla (1987) observed that jaggery stored in painted earthen pots could be stored for a longer time as compared to unpainted earthen pots. Singh (1998) reported that the plastic containers recorded good retention of the shape of jaggery with less reduction in hardness.

Roy (1951) noted that jaggery can be stored comparatively well in sealed bottles. Mandal *et al.* (2006) reported that heat sealed LDPE packet of 150 gauges was best suitable followed by a glass jar, PET for storage of jaggery during the monsoon season.

The traditional packaging methods for storage inside a blanket of whey or wheat straw, cloth lined with a polyethylene sheet, aluminum foil, plastic containers, and earthen pots are not satisfactory. Further at retail shops, the jaggery is sold in open and under unhygienic conditions. Hence there is a need for newer effective packaging method to enhance jaggery shelf life. The present study was undertaken for studying the effect of mucilage clarificants and different packaging materials on the quality characteristics of jaggery during storage.

Material and methods

The Sugarcane variety Co 86032 was selected for this study. The jaggery was prepared using plant mucilage clarificants as well as without clarificants (control). The plant mucilage clarificants are used at the concentration of 0.4% of sugarcane raw juice taken for jaggery production as per the method described in Chikkappaiah *et al* 2017. The prepared jaggery were packed in three different packaging material namely brown paper packs, LDPE cover & Aluminium pouches. Samples were evaluated for Physico-chemical changes, microbial count and sensory characteristics at a regular interval of 30 days for six months.

Colour

The colour of the jaggery was determined as per method described by Mandal *et al.* (2006) in a spectrometer (Systronics India Pvt 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.

Moisture

Moisture content in jaggery samples were determined as per AOAC (1990) manual following hot air oven method. A known weight of the sample in a porcelain dish was kept in a preheated oven maintained at a temperature between 110°C and 120°C.

After 1 hour the dish was removed and transferred to a 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.

Moisture Content (%) = $(W_1 - W_2) / (W_1 - W) \times 100$
W = Weight of empty aluminium dish (g)
W_1 = Weight of aluminium dish + Sample before drying (g)
W_2 = Weight of aluminium dish + Sample after drying (g)

Determination of free reducing sugars

The amount of reducing sugars in jaggery sample was estimated by Dinitrosalicylic (DNS) method (Miller, 1959). Briefly, 1mL of jaggery sample in distilled water (10%) was taken in a test tube and then, 3mL of DNS reagent was added, mixed and incubated in boiling water bath for 5 minutes. The colour developed was read at 540nm. A calibration graph for standard glucose (0-30mg/mL) was also prepared. The amount of reducing sugars determined was expressed in percentage.

Determination of total reducing sugars

Total reducing sugars in jaggery was estimated by phenolsulphuric acid method (Dubois *et al.,* 1956). To 1mL of sample (10% of jaggery), 1mL 5% (w/v) phenol was added followed by 5mL 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 490nm. The standard curve for glucose (0-30 mg/mL) was prepared taking concentration of glucose on x-axis and absorbance on y-axis. The amount of total reducing sugars was determined and expressed in percentage.

Determination of non-reducing sugar (sucrose)

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

Sucrose = (TRS-FRS) x 0.95

Microbial count by spread-plate method

The number of viable cells in jaggery sample was ascertained by determining the number of colony forming unit (CFU) using spread plate method (Clesceri *et al.,* 1998). Briefly one gram of jaggery was taken off and dissolved in 9mL sterilized distilled water. It was serially diluted to obtain CFUs counts between 20 and 200. Spread plates of nutrient agar were used to examine bacterial growth. 100 µL of diluted jaggery solution was aseptically dropped on to the surface of nutrient agar and evenly spread across the surface with a sterile L- shaped spreader. The inoculated plates were incubated for 48 hours at room temperature. The petriplates were observed for number of colony forming units per gram of sample. The procedure was repeated using sterile saline (Blank) and jaggery without clarificants (positive control).

Sensory evaluation

The sensory evaluation of the jaggery samples were carried out as per the method described by Amerine *et al.* (1965). The liking of jaggery samples on the basis of colour, aroma, taste, texture and overall acceptability by panel of 10 members on 9 point hedonic scale was used for the determination of sensory scores. The selected panel was briefed with the sensory characteristics that were to be judged, and also with the available scales according to which the samples were to be rated. The panel members were requested to assemble at one place prior to evaluation, as the samples were required to be judged immediately when opened. Each member was provided with the sensory evaluation rating scales based on which the rating was given to various samples. The average values of the ratings given by all the members were then calculated and used for further analysis.

Hedonic scale/Rating

1= Dislike Extremely
2= Dislike Likely
3= Dislike Moderately
4= Dislike Slightly
5= Neither like nor dislike
6= Like Slightly
7= Like Moderately

8= Like Very Much
9= Like Extremely

Statistical analysis

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

Results and discussion

Consumers demand for consistently high-quality jaggery and also expect that the quality is maintained at a high level during the period between its purchase and consumption. IFST guidelines (1993) defined sensory, chemical, physical and microbiological characteristics should be fulfilled with the label declaration of nutritional data when stored under recommended conditions. Microbiological changes are of primary importance for short-life products while chemical and sensory variations for medium to long life food products (McGinn, 1982). The growth of specific microorganism during storage of jaggery depends on several factors like an initial microbial load at beginning of storage, physicochemical properties such as moisture content, pH, storage temperature and processing method. Further, the growth of spoilage organisms can be readily identified by sensory changes like visual mould growth, development of off-flavors and odors and textural changes. Chemical reactions like hydrolytic, oxidative and flavor reversion reaction also limit shelf life of foods.

Sugarcane jaggery deteriorates when stored for a longer time and extensive cloudburst. Jaggery prepared using selected plant mucilage clarificants were stored in brown paper pack, LDPE, aluminum pouches at room temperature. The samples were studied for variations in physical and chemical parameters (Table 1 to 4) and in addition to microbial contamination (Table 5) and sensory evaluation (Table 6)

Storage studies of jaggery prepared using plant mucilage clarificants

Moisture

The moisture content of fresh control jaggery was between 5.41 and 5.79 (Table 1) which lies in the range set by Bureau of Indian Standards (1990).

The moisture content of jaggery stored in different packing materials is indicated in Table 1. The net increase in moisture content in control jaggery at the end of 6 months was 9.47, 8.43 and 7.56% for brown paper, LDPE covers and aluminum pouch packing, respectively. This clearly indicates that aluminum pouches are effective in preventing moisture absorption. Similar trends of results were observed in all jaggery samples prepared using selected clarificants at 0.4% concentration. Among the mucilage clarificants used, the net rise in moisture content at the end of 6 months period was in the order AV<MS<PS. Therefore, use of *Aloe vera* in sugarcane juice clarification for preparation of jaggery and the use of aluminum pouches for its storage may enhance jaggery shelf life.

Singh (1985) reported that 2 and 3 kg capacity polyethylene packs were desirable for storage of jaggery. This value is higher than that reported by Mandal *et al.* (2006) (15 kg pack size) probably due to smaller pack size (approximately 100g). The smaller pack size increases the surface area of the jaggery for moisture absorption. Shinde *et al.* (1983) suggested wrapping with polyethylene film of any form and colour to avoid absorption of moisture and ultimately the running of jaggery (liquefaction). Any kind of wrapping which avoids the maximum possible amount of moisture entry into the packing could possibly reduce the liquefaction. Our study revealed that aluminum pouches were best in avoiding moisture absorption. Water absorption through the aluminum film is less than 0.01% in 24 hours. The second best packing materials in terms of preventing ingress of moisture were LDPE film. Mandal *et al.* (2006) also suggested the same along with glass jar and PET jars with the screw cap. However, in this study slight change in the conventional way of jaggery preparation procedure using plant mucilaginous clarificants was adopted which significantly reduced the moisture absorption under different packaging conditions.

Jaggery prepared using 0.4% of *Aloe vera* mucilage as clarificants absorbed significantly lesser moisture (5.81 & 4.2%) over other plant mucilage clarificants in both LDPE and aluminum packing.

In addition, brown color paper packing was not able to restrict the absorption of moisture from the atmosphere significantly during the storage period. Among all the packing materials, moisture absorption by stored jaggery increased from July onwards till the month of December. This trend probably could be attributed to the seasonal pattern of relative humidity during the period of study (June to December).

Table 1. Moisture content of jaggery prepared using plant mucilage as clarificants stored in different packaging materials.

Moisture content (%) in jaggery packed in Brown paper packs							
Sample	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Net change
J1NC	5.79 ±0.04	7.20 ± 0.06	8.61 ±0.07	10.90 ±0.08	13.36 ±0.10	15.26 ±0.03	9.47 ± 0.02
J1AV	4.83 ±0.08	5.89 ± 0.05	7.46 ± 0.04	8.06 ± 0.06	9.91 ± 0.08	11.39 ±0.11	6.57 ± 0.08
J1PS	5.53 ±0.09	6.61 ± 0.07	8.34 ± 0.09	9.16 ± 0.08	11.65 ± 0.09	13.44 ±0.09	7.91 ± 0.02
J1MS	5.30 ±0.07	6.54 ± 0.09	8.13 ± 0.07	8.93 ± 0.09	11.02 ± 0.06	12.73 ±0.07	7.43 ± 0.03
Moisture content (%) in Jaggery packed in LDPE Covers							
J2NC	5.41 ±0.10	6.54 ± 0.09	7.94 ± 0.09	8.97 ± 0.11	9.73 ± 0.09	13.84 ±0.10	8.43 ± 0.02
J2AV	3.81 ±0.06	4.62 ± 0.06	5.41 ± 0.08	6.33 ± 0.08	8.14 ± 0.07	9.63 ± 0.11	5.81 ± 0.06
J2PS	4.85 ±0.03	5.87 ± 0.09	6.55 ± 0.12	8.30 ± 0.06	9.87 ± 0.07	12.03 ±0.07	7.17 ± 0.05
J2MS	4.54 ±0.09	5.48 ± 0.07	6.26 ± 0.07	8.04 ± 0.06	9.03 ± 0.10	11.41 ±0.14	6.87 ± 0.06
Moisture content (%) in Jaggery packed in Aluminium pouches							
J3NC	5.07 ±0.07	5.88 ± 0.08	7.36 ± 0.10	8.89 ± 0.07	10.27 ± 0.04	12.64 ±0.09	7.56 ± 0.03
J3AV	3.61 ±0.06	4.12 ± 0.08	4.94 ± 0.09	5.63 ± 0.10	6.73 ± 0.09	7.81 ± 0.07	4.20 ± 0.02
J3PS	4.58 ±0.04	5.40 ± 0.05	6.14 ± 0.03	7.93 ± 0.04	9.01 ± 0.04	10.40 ±0.06	5.82 ± 0.02
J3MS	4.28 ±0.04	5.14 ± 0.04	6.01 ± 0.07	7.69 ± 0.04	8.86 ± 0.06	9.75 ± 0.05	5.47 ± 0.02

Values are mean ± SD (n = 3).

Colour

The control jaggery colour changed from yellow or golden yellow to brown colour. This change was measured using a spectrophotometer at a wavelength of 540 nm. Colour of jaggery in terms of percent transmittance was reduced with an increase in storage time (Table 2). About 32% reduction in colour was observed in control jaggery over a period of 6 months. *Aloe vera* clarificants treated jaggery was very effective in retaining colour during storage with a colour reduction of 20, 17.6 and 15.4% for jaggery samples stored in brown paper, LDPE covers and aluminum pouches, respectively. Among the selected plant clarificants, purslane treated jaggery had the least colour retaining ability with colour reduction of 27, 23 and 19.8% for samples stored in brown paper, LDPE covers and aluminum pouches. However, purslane treated jaggery was better than the control jaggery.

Table 2. Colour (% Transmittance) of jaggery prepared using plant mucilage clarificants stored in different packaging materials.

Colour (% Transmittance) in jaggery packed in Brown paper packs							
Sample	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Net change
J1NC	47.42 ± 0.07	42.17 ± 0.06	40.64 ± 0.04	36.59 ± 0.08	34.27 ± 0.06	32.32 ± 0.07	15.09 ± 0.01
J1AV	50.85 ± 0.05	47.27 ± 0.06	45.75 ± 0.05	43.15 ± 0.06	41.37 ± 0.10	40.54 ± 0.04	10.31 ± 0.01
J1PS	48.55 ± 0.05	45.07 ± 0.08	41.24 ± 0.04	39.84 ± 0.04	36.38 ± 0.62	35.34 ± 0.05	13.21 ± 0.01
J1MS	49.04 ± 0.04	45.33 ± 0.03	42.44 ± 0.03	39.64 ± 0.04	36.24 ± 0.04	36.27 ± 0.06	12.77 ± 0.03
Colour (% Transmittance) in jaggery packed in LDPE covers							
J2NC	48.06 ± 0.06	45.43 ± 0.04	42.75 ± 0.05	39.24 ± 0.04	36.82 ± 0.03	34.44 ± 0.04	13.62 ± 0.03
J2AV	52.15 ± 0.04	48.84 ± 0.04	46.79 ± 0.08	44.94 ± 0.04	43.45 ± 0.05	42.94 ± 0.04	9.20 ± 0.01
J2PS	50.45 ± 0.06	47.34 ± 0.04	44.94 ± 0.05	42.83 ± 0.04	41.36 ± 0.06	38.76 ± 0.07	11.69 ± 0.02
J2MS	50.83 ± 0.03	47.74 ± 0.04	45.24 ± 0.05	43.16 ± 0.06	42.66 ± 0.06	39.53 ± 0.03	11.30 ± 0.03
Colour (% Transmittance) in jaggery packed in Aluminium pouches							
J3NC	51.05 ± 0.06	47.84 ± 0.04	44.35 ± 0.05	41.86 ±0.06	40.06 ± 0.06	38.55 ± 0.04	12.51 ± 0.03
J3AV	53.45 ± 0.05	51.84 ± 0.04	49.65 ± 0.04	47.75 ±0.05	46.94 ± 0.04	45.23 ± 0.03	8.22 ± 0.03
J3PS	51.94 ± 0.04	49.53 ± 0.03	46.83 ± 0.03	45.13 ±0.04	43.95 ± 0.05	41.66 ± 0.06	10.28 ± 0.02
J3MS	52.33 ± 0.03	49.84 ± 0.04	47.25 ± 0.05	45.53 ±0.03	44.23 ± 0.03	42.64 ± 0.03	9.69 ± 0.02

Values are mean ± SD (n = 3).

The jaggery stored in aluminum and polythene was lighter in colour, whereas jaggery stored in brown paper was darker in color. The browning of the jaggery is proportional to rise in invert sugar percent and moisture content (Mandal *et al.,* 2006). Under high relative humidity, jaggery absorbs moisture leading to decomposition of sucrose resulting in colour change if anthocyanin is not removed completely during jaggery making process (Nigam and Madan, 1985). The same observation was also substantiated with the outcomes of Uppal & Sharma (1999) in the study of a shelf-life parameter of jaggery in airtight containers during the rainy season.

Reducing sugar

Reducing sugar plays a major role in imparting colour to jaggery. Lower the reducing sugar content better is the colour of jaggery.

Changes in reducing sugar content in jaggery packed in brown paper packs, LDPE covers, Aluminium Pouches over entire storage period, is presented in Table 3. During storage reducing, sugars increased in a time-dependent manner. At the end of storage period 95, 83 and 79% higher reducing sugars were observed in control jaggery samples packed in brown paper, LDPE covers and aluminum pouches, respectively. However, jaggery samples prepared using different plant mucilage clarificants had lesser reducing sugars in comparison with control jaggery during storage in different packaging materials. *Aloe vera* treated jaggery had the least reducing sugar content followed by Malabar spinach, and purslane. Mandal *et al.* (2006) reported that there was 2.57% net rise in reducing sugar content of jaggery, when stored in the plastic container during monsoon.

Table 3. Reducing sugars (%) of jaggery prepared using plant mucilage clarificants stored in different packaging materials.

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Net change
Reducing sugars (%) in jaggery stored in Brown Paper packs							
J1NC	11.16 ± 0.06	12.19 ± 0.08	13.14 ± 0.09	15.49 ± 0.10	18.62 ± 0.09	21.74 ± 0.10	10.57 ± 0.05
J1AV	9.61 ± 0.08	10.76 ± 0.06	11.37 ± 0.03	12.39 ± 0.03	14.65 ± 0.04	16.61 ± 0.03	7.00 ± 0.04
J1PS	10.42 ± 0.03	11.46 ± 0.04	12.30 ± 0.02	13.48 ± 0.04	15.28 ± 0.03	19.50 ± 0.05	9.08 ± 0.02
J1MS	10.19 ± 0.03	11.22 ± 0.04	12.16 ± 0.04	13.25 ± 0.03	14.80 ± 0.03	18.71 ± 0.03	8.51 ± 0.01
Reducing sugars (%) in jaggery stored in LDPE covers							
J2NC	10.58 ± 0.03	11.29 ± 0.03	12.46 ± 0.03	13.86 ± 0.03	15.43 ± 0.03	19.36 ± 0.05	8.77 ± 0.03
J2AV	9.19 ± 0.04	10.35 ± 0.03	10.90 ± 0.03	11.52 ± 0.03	13.10 ± 0.05	14.65 ± 0.04	5.46 ± 0.01
J2PS	10.11 ± 0.02	10.74 ± 0.03	11.92 ± 0.03	13.10 ± 0.05	14.49 ± 0.03	17.15 ± 0.03	7.04 ± 0.01
J2MS	9.90 ± 0.06	11.29 ± 0.04	11.76 ± 0.03	12.93 ± 0.04	14.25 ± 0.02	16.62 ± 0.05	6.71 ± 0.01
Reducing sugars (%) in jaggery stored in Aluminium Pouches							
J3NC	9.96 ± 0.04	10.75 ± 0.04	12.31 ± 0.04	13.48 ± 0.04	14.65 ± 0.04	17.79 ± 0.04	7.82 ± 0.01
J3AV	8.39 ± 0.03	9.98 ± 0.06	10.75 ± 0.04	11.15 ± 0.04	11.68 ± 0.03	13.10 ± 0.04	4.70 ± 0.01
J3PS	9.97 ± 0.05	10.37 ± 0.05	11.53 ± 0.04	12.70 ± 0.03	13.87 ± 0.04	16.61 ± 0.04	6.63 ± 0.01
J3MS	9.58 ± 0.04	11.14 ± 0.04	11.53 ± 0.04	12.69 ± 0.03	14.09 ± 0.09	15.75 ± 0.04	6.17 ± 0.01

Values are mean ± SD (n = 3).

Non-reducing sugar

The non-reducing sugar content in jaggery samples during storage are indicated in Table 4. The loss in reducing sugar content in control jaggery was 23, 20 and 18% in jaggery samples stored in brown paper, LDPE covers and aluminium pouches, respectively.

The non-reducing sugar inversion was better controlled in *Aloe vera* treated jaggery samples followed by Malabar spinach, and purslane. Shinde *et al.* (1981) opined that polyethylene of any form and colour prevented inversion of non-reducing sugar and ultimately the running of jaggery. Shinde *et al.* (1983)

showed that there was almost no change in the nonreducing sugar values of jaggery wrapped in polyethylene. According to the findings of Uppal and Sharma (1999), there was no difference in sucrose content of jaggery stored in glass and plastic containers. There was only marginal difference in the sucrose percent in jaggery stored in LDPE packets, Brown paper packs and Aluminium Pouches at respective time period. It is worthwhile to note that in various packaging materials, the decrease in sucrose or the increase in reducing sugars over a period of 6 months storage period was more or less in accordance with the increase in moisture. Hence, it can be inferred that high absorption of moisture creates conditions for inversion.

Total Viable count

Microbial deterioration is a major problem during jaggery storage. It was noted that moisture absorption of jaggery during storage magnifies the problem of microbial putrefaction (Singh *et al.,* 2009). Since most of the jaggery is produced at the village level, there is a great need to analyze the biological hazards associated with it, to improve its quality. The microorganisms show multiple antibiotic resistances which could be dangerous to humans and animals' health, consuming jaggery in their diet (Singh *et al.,* 2009).

Table 4. Non- reducing sugars (%) in jaggery prepared using plants mucilaginous clarificants Stored in different packaging materials.

Non-reducing sugars (%) of jaggery stored in Brown Paper packs							
Sample	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Net change
J1NC	75.69 ± 0.18	72.22 ± 0.18	70.75 ± 0.08	67.31 ± 0.03	62.40 ± 0.15	57.96 ± 0.09	17.74 ± 0.09
J1AV	80.61 ± 0.18	78.21 ± 0.15	76.64 ± 0.23	75.09 ± 0.19	71.52 ± 0.18	68.40 ± 0.16	12.21 ± 0.03
J1PS	77.86 ± 0.24	76.34 ± 0.13	74.35 ± 0.26	72.07 ± 0.19	69.40 ± 0.15	62.39 ± 0.22	15.48 ± 0.01
J1MS	78.47 ± 0.22	76.74 ± 0.23	74.72 ± 0.22	72.74 ± 0.18	69.79 ± 0.20	63.93 ± 0.21	14.54 ± 0.01
Non-reducing sugars (%) of jaggery stored in LDPE Covers							
J2NC	76.70 ± 0.06	74.90 ± 0.23	72.62 ± 0.21	70.30 ± 0.12	67.91 ± 0.09	61.26 ± 0.02	15.44 ± 0.07
J2AV	82.12 ± 0.23	80.62 ± 0.07	78.26 ± 0.20	76.95 ± 0.26	74.80 ± 0.17	71.76 ± 0.19	10.36 ± 0.03
J2PS	79.93 ± 0.13	77.65 ± 0.14	75.62 ± 0.09	72.71 ± 0.24	71.02 ± 0.22	67.09 ± 0.10	12.84 ± 0.03
J2MS	80.15 ± 0.15	77.15 ± 0.22	75.89 ± 0.27	73.00 ± 0.22	71.53 ± 0.25	68.07 ± 0.15	12.08 ± 0.00
Non-reducing sugars (%) of jaggery stored in Aluminium Pouches							
J3NC	77.69 ± 0.21	75.72 ± 0.22	73.30 ± 0.13	70.93 ± 0.19	69.22 ± 0.12	63.72 ± 0.19	13.97 ± 0.02
J3AV	83.94 ± 0.21	80.95 ± 0.13	79.61 ± 0.22	78.66 ± 0.13	77.15 ± 0.25	74.96 ± 0.16	8.98 ± 0.05
J3PS	80.60 ± 0.22	78.74 ± 0.20	76.73 ± 0.14	74.71 ± 0.23	72.47 ± 0.24	68.68 ± 0.20	11.92 ± 0.02
J3MS	81.31 ± 0.11	77.97 ± 0.11	76.46 ± 0.21	76.91 ± 0.13	72.03 ± 0.12	70.03 ± 0.14	11.28 ± 0.02

Values are mean ± SD (n = 3).

Jaggery prepared using plant mucilage clarificants was evaluated for the growth of microorganisms by spread plate method. The changes in the microbial count were expressed in terms of Colony forming units (CFU/g). The result of total viable count (TVC) of jaggery samples during storage under ambient temperature are tabulated in Table 5. The increase in microbial population in control jaggery packed in brown paper, LDPE covers and aluminum pouches were almost 6, 6.5 and 7.7-fold, respectively. Plant clarificants added during sugarcane juice clarification during jaggery manufacture were effective in controlling microbial contamination.

Since the plant clarificants selected possessed antimicrobial phytochemicals, the reduction in microbial count may be attributed to the residual phytochemicals of plant clarificants present in final jaggery. Further, it was noted that aluminum pouches were better than LDPE and brown papers in controlling the growth of microorganisms during storage. It was also reported that jaggery stored in air tight glass containers totally hindered the microbial invasion of jaggery spoilage (Uppal and Sharma, 1998). It is important that manufacturing and storage of jaggery should be given utmost care, keeping in view of its large-scale consumption by rural community (Singh *et al.*, 2009).

Table 5. Total viable count (CFU/g) in jaggery prepared using plants mucilaginous clarificants stored in different packaging materials.

Sample	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Net change
Jaggery stored in Brown paper packs							
J1NC	1777 ±25	2863 ± 35	5647 ± 50	7207 ± 12	9077 ± 68	12533 ± 58	10757 ± 81
J1AV	967 ± 15	1860 ± 53	4273 ± 25	5457 ± 40	7300 ± 92	8397 ± 47	7430 ± 44
J1PS	1083 ±76	2160 ± 53	4740 ± 53	5860 ± 53	8180 ± 72	9347 ± 50	8263 ± 118
J1MS	967 ± 21	2000 ± 50	4360 ± 17	5590 ± 66	7580 ± 72	8683 ± 29	7717 ± 31
Jaggery stored in LDPE Covers							
J2NC	1447 ±55	2440 ± 53	4793 ± 81	6057 ± 51	8343 ± 51	10817 ± 76	9370 ± 75
J2AV	877 ± 15	1507 ± 179	3293 ± 90	4843 ± 51	6963 ± 55	7670 ± 61	6793 ± 47
J2PS	920 ± 20	1810 ± 101	3757 ± 51	5217 ± 104	7157 ± 40	8317 ± 65	7397 ± 59
J2MS	830 ± 20	1607 ± 51	3437 ± 32	4840 ± 40	7040 ± 36	7820 ± 20	6990 ± 20
Jaggery stored in Aluminium Pouches							
J3NC	1043 ±60	1983 ± 76	3867 ± 42	5007 ± 38	7240 ± 53	9083 ± 35	8040 ± 79
J3AV	705 ± 18	1137 ± 65	2460 ± 53	4147 ± 50	6023 ± 108	6750 ± 50	6045 ± 48
J3PS	853 ± 35	1497 ± 55	2767 ± 29	4510 ± 36	6343 ± 51	7423 ± 25	6570 ± 10
J3MS	690 ± 40	1223 ± 31	2627 ± 50	4273 ± 21	6127 ± 31	6940 ± 53	6250 ± 92

Values are mean ± SD (n = 3).

Sensory evaluation of jaggery prepared using plant mucilage clarificants

The sensory attributes namely visual appearance (colour), aroma, taste, texture and overall acceptability of 6 months old jaggery prepared using selected plant mucilage clarificants were evaluated. The results of all the attributes evaluated are shown in Table 6**.** The sensory scores on a 9-point hedonic scale for all the attributes were least for control jaggery stored in different packaging materials. Based on the overall acceptability results, it is evident that the jaggery prepared using *Aloe vera* mucilage clarificants had higher sensory scores for jaggery packed in aluminum pouches (7.4 & 7.1), LDPE covers (6.7 & 6.5) and brown paper (6.2 & 5.9), respectively.

Table 6. Sensory evaluation of Jaggery prepared using plants mucilage clarificants at the end of 6 months storage period.

Sample	Colour	Aroma	Taste	Texture	Overall Acceptability
Jaggery stored in Brown paper packs					
J1NC	3.6 ±0.84	4.0 ±0.47	3.8 ±0.92	4.6 ±0.52	4.3 ±0.67
J1AV	5.7 ±0.95	5.7 ±0.67	5.4 ±1.07	6.2 ±0.92	5.9 ±0.88
J1PS	4 .0±0.94	4.7 ±0.48	4.9 ±1.37	5.6±0.70	5.1±0.88
J1MS	4.2 ±0.92	4.5 ±0.53	4.7 ±1.42	5.7 ±0.82	4.8 ±0.63
Jaggery stored in LDPE Covers					
J2NC	4.2 ±0.42	4.8 ±0.42	4.2 ±1.03	5.3 ±0.67	4.6 ±0.52
J2AV	6.6 ±0.97	6.8 ±0.92	5.9 ±1.37	6.8 ±0.92	6.5 ±0.97
J2PS	4.8 ±0.92	5.5 ±0.53	4.8 ±1.62	6.1 ±0.74	5.5 ±0.85
J2MS	5.1 ±0.99	5.3 ±0.82	4.5 ±1.43	6.0±0.82	5.3 ±0.67
Jaggery stored in Aluminium Pouches					
J3NC	4.9 ±0.57	5.2 ±0.63	5.2±0.79	5.7±0.82	5.2 ±0.92
J3AV	8.4 ±0.70	8.0 ±0.82	6.9±1.37	7.5 ±0.71	7.1 ±0.88
J3PS	5.4 ±0.84	6.3 ±0.48	5.9 ±1.10	6.5 ±1.08	6.4 ±0.70
J3MS	6.2 ±0.79	5.9 ±0.57	5.6 ±1.07	6.7 ±0.95	6.2 ±0.92

Conclusion

Evaluation of jaggery prepared using plant mucilage clarificants stored in different packaging materials for physico-chemical and sensory characteristics indicated increased moisture, colour, reducing sugar, decreased non-sugars and lower sensory scores for control jaggery packed in brown paper, LDPE covers and aluminum pouches. However, *Aloe vera*, Malabar spinach and purslane plant mucilage clarificants treated jaggery samples showed lesser changes in physicochemical as well as sensory characteristics compared to control jaggery.

This suggests that improper storage of jaggery often leads to altered quality characteristics of jaggery leading to reduction in market value. The best packaging material in terms of preventing ingress of atmospheric moisture and for maintaining the keeping quality of jaggery prepared using different plant clarificants was found to be the aluminum pouches in the current study.

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Abbreviation

J1: Jaggery packed in Brown paper packs
J2: Jaggery packed in LDPE covers
J3: Jaggery packed in Aluminium pouches
JNC: Jaggery with No Clarificants
JAV: Jaggery with *Aloe vera*
JMS: Jaggery with Malabar spinach
JPS: Jaggery with Purslane

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