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Properties of spray dried liquid jaggery powder prepared using plant mucilage clarificant

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Abstract

The effects of different plant mucilage clarificants and packaging materials on the characteristic properties of spray dried liquid jaggery (SDLJ) powder during storage were determined. Three different liquid jaggery were prepared using plant mucilage from Aloe vera, fenugreek (Trigonella foenum-graecum L.) and flax seeds (Linumus itatissimum L.) as clarificants, in addition control jaggery prepared without using clarificants. No preservatives were used during preparation of liquid jaggery. Spray drying of liquid jaggery was performed at an inlet air temperature of 160°C and outlet temperature of 80°C with atomising disk speed of 32000 rpm using maltodextrin as carrier. The prepared SDLJ powder was packed in different covers made up of low density polyethylene (LDPE), high density polyethylene (HDPE) and aluminium pouches and stored for six months for further analysis. At every two months interval parameters such as moisture content (%), bulk density (g/cm^3), hygroscopicity (%), solubility (sec) and total reducing sugars (%) of jaggery samples were evaluated. Comparative study indicated that control SDLJ powder had poor response for all the parameters during storage in all packaging modes. Plant mucilage clarificants treated jaggery samples showed better shelf life response and were in the order Aloe vera > fenugreek > flax seeds. Aluminium pouches showed better stability for all the characteristic properties analysed with least variation upto six months.

Keywords: Liquid jaggery, Clarificant, Spray drying, *Aloe vera*, Fenugreek, Flax seeds.

Introduction

Liquid jaggery is an intermediate product collected during jaggery manufacturing[1,2]. It is considered as alternative sources to honey and other sugar syrups[3]. It is generally used as sweetener in daily diet in Maharashtra, Tamilnadu, Karnataka, Gujarat, West Bengal, Andhra Pradesh and Kerala[4,5]. Its applications were widely recorded in many ayurveda scripts[6] and also used in pharmaceutical formulations[7]. Liquid jaggery is susceptible for microbial growth and fermentation if it was not stored in proper conditions. Also handling of liquid jaggery is difficult during packing, storage and trading. Thus conversion of liquid jaggery into powder by using spray drying technique can reduce this problem and may increase its shelf life[8,9]. Liquid jaggery production involves extraction of juice from sugarcane, clarification and concentration. A good quality liquid jaggery is always determined by the amount of impurities removed during clarification, type of clarificants used and the striking temperature at which concentrated juice was collected. Clarification is a process of eliminating the non- sugar impurities present in juice with the help of suitable clarificants for improving the quality of jaggery[10]. Many researchers reported the effect of vegetable and chemical clarificants on quality of jaggery in India[11-17]. As per BIS[18], it is recommended to use the chemical clarificants within the safe limit but at times these chemical clarificants are added in high quantity in the perception of getting the market oriented jaggery without considering the shelf life of the jaggery but end up in getting low quality jaggery and lose the market potential. Thus application of plant based mucilage in clarification can resolve the problem of chemical residues and found to be effective in maintaining quality of jaggery[19-22]. With this background, the current study is one of those attempts of using mucilage from plant sources such as *Aloe vera,* flax seeds and fenugreek as clarificants in the preparation of liquid jaggery.

Spray drying is a process of conversion of liquid solutions into a dry powder[23]. It is mainly used in food and pharmaceutical products. Liquid jaggery may not be dried directly by spray drying technique because of high content of low molecular weight sugars[24]. Sugars generally have low glass transition temperature which can directly impact on drying[24]. Thus the addition of maltodextrin as a carrier can reduce the undesirable effect during drying of liquid jaggery[25]. Maltodextrin is a high molecular weight and have high glass transition temperature, hence more stable during storage[8,24]. Dried liquid jaggery can be used for direct consumption and can be used as replacement of synthetic sweeteners in food products such as beverages, dairy products, confectionary items, food coatings and in various nutraceutical supplement formulations.

Packaging is the most important process of any dried powder for maintaining quality during storage[24]. Improper packing may leads to moisture absorption which is responsible for detoriation of product and its qualities due to microbial growth[26-27]. The losses during storage can be minimised by using proper packing materials for storage[28]. Thus this study is also aimed at determining the influence of different packaging material such as low density polyethylene (LDPE) covers, high density polyethylene (HDPE) covers and aluminium pouches on the properties of dried powder during storage.

Materials and methods

Liquid Jaggery Preparation: Three kinds of liquid jaggery were prepared as per the method described[29] using *Aloe vera* mucilage (AV), Flax seeds mucilage (FS) and Fenugreek mucilage (FG) as clarificants separately. Sugarcane variety Co.80632 was used for production of liquid jaggery. The juice was extracted and filtered to remove dry solid impurities through filtration. The pH of the raw sugarcane juice was adjusted using lime and started boiling. During boiling 0.4 % of plant mucilage was added as clarificant. The scum and other impurities formed during boiling were removed time to time. At the temperature around 105^0C to 108^0C a thick syrup was formed which was collected in a borosil container with cap. No preservatives were added during liquid jaggery production. Similarly the liquid jaggery without using any clarificants was also prepared and used as control (NC).

Spray drying of Liquid jiggery: The suspensions for spray drying was prepared by mixing liquid jaggery and carrier (Maltodextrin with DE of 20 Make: Ridhi Sidhi) in the dry matter mass ratio 1: 1. The rest was completed with distilled water, so that the resulting solution had a concentration of 20% dry basis. The prepared suspensions were spray dried using a laboratory spray dryer (Buchi Labortechnik AG, Flawil, Switzerland) at an inlet air temperature of 160°C and outlet temperature of 80°C with atomising disk speed of 32000 rpm.

Packaging of spray dried liquid jaggery (SDLJ) powder: The spray dried liquid jaggery (SDLJ) powder was packed in three different packaging materials namely LDPE covers (P1), HDPE covers (P2) and aluminium pouches (P3). The packed SDLJ powder samples were stored for six months at ambient temperature. At every two months interval the characteristic properties of SDLJ powder samples were evaluated.

Determination of Characteristic properties of SDLJ powder:
Moisture content: The moisture content of SDLJ powder was determined[30] by oven method. Approximately 1 g of SDLJ powder was dried at 105°C/4 h. The change in weight after treatment caused by water loss was expressed in percent by weight.

Bulk density: Loose ***(dL)*** and tapped ***(dT)*** bulk densities of SDLJ powders were measured using measuring cylinder[31]. Approximately 30 g of SDLJ powder sample was taken in a 250 mL graduated measuring cylinder. The loss bulk density was calculated by dividing the mass of the powder by the volume occupied in the cylinder. For the tapped density, the cylinder was tapped vigorously by hand until no further change in volume occurred.

Cohesiveness: Cohesiveness of the SDLJ powders was evaluated in terms of **Hausner ratio *(HR) and it is*** calculated by the ratio of the bulk loose *(dL)* and tapped *(dT*) densities using the expression ***HR = dT/dL***.

Hygroscopicity: Hygroscopicity of the SDLJ samples was determined as per the method[32]. Approximately 1 g samples of SDLJ powder was placed in a desiccator under the following conditions: 25°C and 75% relative humidity (saturated NaCl solution). The gain in weight after 2 h was recorded and the hygroscopicity was expressed as the amount of water absorbed by 1 g of powder solids.

Solubility: The solubility of SDLJ powders was carried out as per the method[32]. 2g of the material was added to 50 ml of distilled water in a low form 100ml glass beaker. The mixture was agitated with a magnetic stirrer at 890 rpm (stirring bar 4 mm × 10 mm), the time required for the material to dissolve completely was recorded.

Total reducing sugars: Total sugar in the SDLJ powder was estimated by phenol-sulphuric acid method[33]. To 1 ml of sample (10% of SDLJ Powder), 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 in percentage.

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

Results and discussion

Moisture content: The variation in the moisture content during storage for six months was reported in Table-1. Moisture content of fresh SDLJ powder was in the range from 1.08 % to 1.28%. The values were typical for spray dried sugar-rich products such as fruit juices and honey[34]. After storage of 6 month the net change (%) in the moisture content was in the range of 1.32% to 3.30%. The minimum variation in moisture content (1.32%) was observed in the P3AV4 and the maximum variation in moisture content was observed in control P1JNC (3.30%). It is observed that the SDLJ powder stored in aluminium pouches (P3) showed least variation in moisture content than HDPE Covers (P2) and LDPE Covers (P1) respectively. SDLJ powder prepared by *Aloe vera* mucilage

(AV) as clarificants received least variation in moisture in the packaging materials followed by fenugreek mucilage (FG), flax seeds mucilage (FS) and control (NC) in the order respectively. The highest moisture content in the LDPE packed SDLJ powder may be due to high moisture absorption capabilities when compare to HPDE and aluminium Pouches which have relatively less moisture absorption capabilities. Similar studies of effect of packaging materials on quality of jaggery products were reported by various researchers and obtained results are in line with the reported values for moisture content[35-37]. Similar trend was also reported for the spray dried honey powder[34]. Therefore the application of plants mucilage as clarificants in the preparation of liquid jaggery can be beneficial in reducing the moisture content of SDLJ powder.

Bulk density and Cohesiveness: The variation in the bulk density during storage was reported in Table-2. The bulk properties (loose and tapped densities) of the powder are highly dependent on the particle size and its distribution[38]. The loose bulk density of powders is strongly linked to moisture content of the powder[23]. With high moisture content, it creates greater volume of package and also lowers the bulk density. Therefore in the powders with low bulk densities there will be possibility of spaces between the particle which creates the opportunity for accumulation of air and greater possibility for oxidation during storage[39]. The bulk density of the sample showed variation in all the packing materials and reduced after 6 month storage (Table-2). It was observed that SDLJ powder prepared using *Aloe vera* mucilage as clarificants showed least variation packed in aluminium pouches (0.47 g/cm^3) after six months of storage from fresh (0.52 g/cm^3). Control received maximum variation in bulk density (0.35 g/cm^3) packed in LDPE covers after 6 months of storage (Table-2). Flowability of SDLJ powders can be accessed by determining cohesiveness using Hausner ratio (HR). The results were reported in the Table-2. The Cohesiveness of the SDLJ powder was reported in Table-2. The Cohesiveness of the SDLJ powder obtained after 6 month of storage was in the range of 1.32 to 1.07. The lowest cohesiveness value was observed in sample P3AV (1.07) and highest was observed in the P1NC (1.32). As per the classification the powder with HR below 1.25 are classified as low cohesive[40]. Cohesiveness of powders determines their consistency and flow properties – lower the cohesiveness, better would be the flowability of powders[41]. All the samples found to be low cohesive except P1NC (1.32). However the SDLJ powder prepared using *Aloe vera* was found to be superior with least cohesive value (1.07) followed by fenugreek and flax seeds. Among packing materials aluminium found to be more effective in maintaining low cohesive value compare to HDPE and LDPE covers respectively. Similar trend of cohesiveness for honey dried powder with maltodextrin was observed and reported in the range of 1.2 to 1.4[34].

Table-1: Variation of moisture content during storage of SDLJ powder.

Variation of Moisture content (%) in SDLJ powder packed in LDPE Covers					
Sample	Fresh	2nd Month	4th Month	6th Month	Net Change (%)
P1NC	1.28 ± 0.02	1.69 ± 0.03	2.35 ± 0.05	4.58 ± 0.17	3.30
P1AV	1.11 ± 0.04	1.26 ± 0.04	1.73 ± 0.04	3.22 ± 0.05	2.11
P1FS	1.25 ± 0.08	1.55 ± 0.04	2.16 ± 0.05	3.82 ± 0.09	2.57
P1FG	1.20 ± 0.05	1.39 ± 0.04	1.90 ± 0.07	3.55 ±0.07	2.35
Variation of Moisture content (%) in SDLJ powder packed in HDPE Covers					
P2NC	1.21 ± 0.04	1.45 ± 0.04	2.12 ± 0.07	3.83 ± 0.10	2.62
P2AV	1.14 ± 0.04	1.23 ± 0.03	1.54 ± 0.05	3.02 ± 0.08	1.88
P2FS	1.21 ± 0.07	1.40 ± 0.03	1.92 ± 0.05	3.47± 0.07	2.25
P2FG	1.17 ± 0.05	1.34 ± 0.05	1.68 ± 0.04	3.25 ± 0.08	2.08
Variation of Moisture content (%) in SDLJ powder packed in Aluminium Pouches					
P3NC	1.23 ± 0.04	1.35 ± 0.03	1.83 ± 0.03	3.26 ± 0.21	2.03
P3AV	1.08 ± 0.03	1.19 ± 0.02	1.37 ± 0.02	2.40 ± 0.11	1.32
P3FS	1.19 ± 0.06	1.34 ± 0.06	1.64 ± 0.03	2.95 ± 0.10	1.76
P3FG	1.17 ± 0.03	1.29 ± 0.07	1.49 ± 0.03	2.74 ± 0.06	1.57

Values are the mean ± SD of three replicates.

Hygroscopicity: The variation in the hygroscopicity of SDLJ powder after 6 month storage was reported in Table 3. The variation in hygroscopicity of the SDLJ powders ranged between 1.37% to 3.15%. The sample (P1NC) received highest variation of hygroscopicity (3.15%) and least variation was observed in P3AV (1.37%). It was found that the sample packed in LDPE covers showed most susceptibility to moisture absorption when compared to HPDE and Aluminium pouches (Table-3). The hygroscopicity is correlated with the particle size, as the particle surface area are smaller, lesser would be the moisture absorption. The more absorption of moisture leads to agglomeration of product during storage and affect flowability of the product[42-43]. Similar hygroscopicity values have been reported in studies on honey drying with maltodextrin[34], Mango pulp drying with maltodextrin[44] and tomato pulp drying[23].

Solubility: The variation in solubility of SDLJ powder during storage was reported in Table-4. All the SDLJ powder samples were found to be soluble in water. The variation of solubility of the SDLJ powders after 6 months was observed in the ranged from 13 Sec to 40 Sec. The minimum time variation for solubility was observed in the sample P3AV (13 Sec) and the maximum time variation for solubility observed in sample P1NC (40 Sec). Among the packaging materials, the SDLJ powders packed in aluminium pouches received minimum variation for solubility where as SDLJ powders packed in HDPE and LDPE covers received maximum variation for solubility respectively (Table-4). The similar sort of research was reported in spray drying of tomato for the better solubility of powder with lower moisture content[23]. In the present study, the same trend was obsererved for solubility where the powder with higher moisture content showed least solubility.

Table-2: Variation of bulk density and cohesiveness of SDLJ powder during storage.

Variation of bulk density and cohesiveness of SDLJ powder packed in LDPE Covers												
Sample	Fresh		Month 2		Month 4		Month 6		Cohesiveness*			
	dL	dT	dL	dT	dL	dT	dL	dT	Fresh	Month 2	Month 4	Month 6
P1NC	0.44± 0.02	0.49 ± 0.02	0.40 ±0.02	0.48 ±0.01	0.38 ± 0.03	0.48 ± 0.02	0.35 ± 0.03	0.47 ±0.02	1.12 ±0.02	1.20 ±0.04	1.27 ±0.04	1.32 ±0.05
P1AV	0.55 ± 0.03	0.57 ± 0.02	0.52 ±0.02	0.56 ±0.01	0.51 ± 0.02	0.56 ± 0.01	0.48± 0.02	0.54 ±0.01	1.04 ±0.01	1.08 ±0.02	1.09 ±0.03	1.13 ±0.03
P1FS	0.48 ± 0.03	0.51 ± 0.01	0.45 ±0.03	0.50 ±0.01	0.43± 0.03	0.49± 0.01	0.40 ± 0.01	0.48 ±0.02	1.07 ±0.05	1.10 ±0.05	1.14 ±0.06	1.19 ±0.05
P1FG	0.53 ± 0.03	0.56 ± 0.02	0.51 ±0.03	0.56 ±0.02	0.49 ± 0.03	0.55 ± 0.02	0.47 ± 0.03	0.54 ±0.02	1.06 ±0.01	1.09 ±0.03	1.12 ±0.04	1.16 ±0.03
Variation of bulk density and cohesiveness of SDLJ powder packed in HDPE Covers												
P2NC	0.48 ± 0.02	0.52 ±0.02	0.44 ±0.02	0.51 ±0.02	0.42 ± 0.02	0.51 ± 0.01	0.40 ± 0.03	0.50 ±0.02	1.09 ± 0.02	1.17 ±0.02	1.22 ±0.03	1.24 ±0.03
P2AV	0.55 ± 0.02	0.58 ±0.01	0.54 ±0.02	0.57 ±0.01	0.53 ± 0.02	0.56 ± 0.01	0.51 ± 0.01	0.56 ±0.01	1.04 ±0.01	1.06 ±0.01	1.06 ±0.01	1.09 ±0.01
P2FS	0.52 ± 0.04	0.55 ±0.03	0.49 ±0.03	0.54 ±0.03	0.48 ± 0.03	0.54 ± 0.01	0.46 ± 0.03	0.53 ±0.02	1.06 ±0.02	1.09 ±0.02	1.13 ±0.04	1.15 ±0.03
P2FG	0.54 ± 0.02	0.57 ±0.02	0.51 ±0.02	0.55 ±0.01	0.50 ± 0.02	0.54 ± 0.02	0.49 ± 0.03	0.54 ±0.02	1.05 ±0.01	1.07 ±0.02	1.07 ±0.01	1.11 ±0.03
Variation of bulk density and cohesiveness of SDLJ powder packed in Aluminium Pouches												
P3NC	0.52 ± 0.04	0.55 ± 0.03	0.50 ±0.03	0.54 ±0.02	0.48 ± 0.04	0.53 ± 0.02	0.47 ± 0.03	0.53 ±0.02	1.06 ±0.02	1.08 ±0.02	1.12 ±0.04	1.14 ±0.04
P3AV	0.60 ± 0.02	0.62 ± 0.02	0.59 ±0.02	0.61 ±0.02	0.58 ± 0.02	0.60 ± 0.02	0.56 ± 0.02	0.60 ±0.02	1.03± 0.01	1.03 ±0.01	1.05 ±0.01	1.07 ±0.02
P3FS	0.52 ± 0.02	0.54± 0.01	0.50 ±0.02	0.53 ±0.01	0.49 ± 0.02	0.52± 0.01	0.47 ± 0.02	0.53 ±0.02	1.05 ±0.01	1.06 ±0.02	1.08 ±0.01	1.11 ±0.02
P3FG	0.57 ± 0.02	0.59 ± 0.01	0.55 ±0.02	0.58 ±0.01	0.53 ± 0.02	0.56 ± 0.01	0.52 ± 0.02	0.56 ±0.01	1.04 ±0.02	1.05 ±0.02	1.06 ±0.02	1.08 ±0.02

Note: dL- Loose bulk density (g/cm3); dT- Tapped bulk density (g/cm3) * Cohesiveness is calculated by Hausner ratio (HR) = dT/dL**.** Values are the mean ± SD of three replicates.

Table-3: Variation of Hygroscopicity (%) in SDLJ powder during storage.

Variation of Hygroscopicity (%) in SDLJ powder packed in LDPE Covers					
Sample	Fresh	2nd month	4th month	6th month	Net change (%)
P1NC	1.20 ± 0.03	1.69 ± 0.03	2.35 ± 0.05	4.44 ± 0.06	3.15
P1AV	1.11 ± 0.04	1.26 ± 0.04	1.73 ± 0.04	3.22 ± 0.05	2.11
P1FS	1.25 ± 0.08	1.55 ± 0.04	2.16 ± 0.05	3.82 ± 0.09	2.57
P1FG	1.20 ± 0.05	1.39 ± 0.04	1.90 ± 0.07	3.55 ± 0.07	2.35
Variation of Hygroscopicity (%) in SDLJ powder packed in HDPE Covers					
P2NC	1.24 ± 0.03	1.45 ± 0.04	2.12 ± 0.07	3.80 ± 0.08	2.56
P2AV	1.14 ± 0.04	1.23 ± 0.03	1.54 ± 0.05	3.04 ± 0.08	1.90
P2FS	1.21 ± 0.07	1.40 ± 0.03	1.92 ± 0.05	3.45 ± 0.07	2.24
P2FG	1.17 ± 0.05	1.34 ± 0.05	1.68 ± 0.04	3.24 ± 0.08	2.07
Variation of Hygroscopicity (%) in SDLJ powder packed in Aluminium pouches					
P3NC	1.22 ± 0.04	1.35 ± 0.03	1.83 ± 0.03	3.24 ± 0.13	2.02
P3AV	1.08 ± 0.03	1.19 ± 0.02	1.37 ± 0.02	2.45 ± 0.04	1.37
P3FS	1.19 ± 0.06	1.34 ± 0.06	1.64 ± 0.03	2.99 ± 0.10	1.80
P3FG	1.17 ± 0.03	1.29 ± 0.07	1.49 ± 0.03	2.74 ± 0.06	1.57

Values are the mean ± SD of three replicates.

Table-4: Variation of Solubility (Sec) in SDLJ powder during storage.

Variation of Solubility in SDLJ powder packed in LDPE Covers					
Sample	Fresh	2nd month	4th month	6th month	Net change (Sec)
P1NC	82 ± 2	93 ± 2	106 ± 3	121 ± 3	40
P1AV	65 ± 3	73± 3	79 ± 2	84 ± 3	19
P1FS	76 ± 1	83 ± 3	92± 2	108 ± 3	32
P1FG	72± 2	78 ± 2	86 ± 2	92 ± 2	20
Variation of Solubility in SDLJ powder packed in HDPE Covers					
P2NC	78 ± 2	90 ± 2	96± 2	112 ± 4	34
P2AV	62 ± 2	70 ± 2	75± 3	78 ± 2	16
P2FS	72 ± 2	81± 3	89± 3	97± 3	25
P2FG	69 ± 3	75± 3	81 ± 3	87± 4	17
Variation of Solubility in SDLJ powder packed in Aluminium pouches					
P3NC	72 ± 2	86 ± 2	91 ± 2	102 ± 4	30
P3AV	55 ± 2	58 ± 3	63 ± 3	68 ± 2	13
P3FS	70 ± 2	77 ± 3	83 ± 4	90 ± 2	20
P3FG	64 ± 2	70 ± 2	75 ± 3	81 ± 4	17

Values are the mean ± SD of three replicates.

Table-5: Variation of total reducing sugars (%) during storage.

Variation of total reducing sugars (%) in SDLJ powder packed in LDPE Covers					
Sample	Fresh	2nd month	4th month	6th Month	Net Change (%)
P1NC	52.49 ± 0.06	51.69 ± 0.04	50.33 ± 0.04	49.41 ± 0.07	3.08
P1AV	53.38 ± 0.04	53.00 ± 0.05	52.14 ± 0.04	51.63 ± 0.03	1.75
P1FS	52.31 ± 0.04	51.95 ± 0.05	50.67 ± 0.07	50.05 ± 0.05	2.27
P1FG	53.10 ± 0.05	52.76 ± 0.04	51.87 ± 0.02	51.13 ± 0.04	1.96
Variation of total reducing sugars (%) in SDLJ powder packed in HDPE Covers					
P2NC	52.77 ± 0.06	52.24 ± 0.04	51.86 ± 0.05	49.92 ± 0.02	2.85
P2AV	53.72 ± 0.04	53.23 ± 0.03	52.58 ± 0.03	52.24 ± 0.04	1.48
P2FS	53.28 ± 0.04	52.72 ± 0.02	52.05 ± 0.05	51.24 ± 0.04	2.04
P2FG	53.37 ± 0.03	53.05 ± 0.05	52.13 ± 0.03	51.72 ± 0.03	1.65
Variation of total reducing sugars (%) in SDLJ powder packed in Aluminium Pouches					
P3NC	53.05 ± 0.05	52.81 ± 0.04	52.48 ± 0.03	50.68 ± 0.04	2.36
P3AV	54.48 ± 0.03	53.46 ± 1.13	53.40 ± 0.56	53.28 ± 0.03	1.20
P3FS	53.42 ± 0.03	53.12 ± 0.03	52.45 ± 0.05	51.48 ± 0.03	1.95
P3FG	53.91 ± 0.04	53.38 ± 0.03	52.95 ± 0.05	52.45 ± 0.05	1.46

Values are the mean ± SD of three replicates.

Total reducing sugars: The variation in the total reducing sugars after 6 month of storage was reported in the Table-5. The variation in total reducing sugars of SDLJ powder during 6 month was in the range of 1.20% to 3.08%. The maximum variation was found in P1NC (3.08%) and the minimum variation was reported in P3AV (1.20%). The total reducing sugars content of SDLJ powder after 6th month storage was found in the range of 49.41% to 53.28%. The SDLJ powder prepared using *aloe vera* showed highest total reducing sugars (53.28%) when packed in aluminium pouches (P3AV). Control P1NC showed least total reducing sugars of 49.41%. The SDLJ powder packed in aluminium pouches found to be superior compared to HDPE covers, LDPE covers respectively. The results showed that application of mucilage during liquid jaggery preparation helps to retain more sugars by eliminating the maximum non-sugars impurities.

Conclusion

From the study it was found that spray drying technique can be used extending shelf life of liquid jaggery. The SDLJ powders prepared by using plant mucilage as clarificants were characterised by good physical properties such as low water content, low cohesiveness, low hygroscopicity, good solubility and maximum total sugars content. It was also found that SDLJ powders stored in different packaging materials were stable during the storage studies and they are in line with the properties of spray dried products of honey and other high sugar content products. Hence spray drying of liquid jaggery can resolve the problem that may frequently encountered during handling and storage of liquid Jaggery.

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