IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

# VALUE ADDITION OF STANDARDISED LIQUID JAGGERY

**[1]Akshaya C, [2]Dr Rahul Cyriac**

[1]Assistant Professor, [2]Department Head
[1,2]Department of Food Technology,
[1,2]Nirmala College of Arts and Science, Chalakudy, Kerala, India

## 1. ABSTRACT:

Production of jaggery is seasonal, hence its storage and preservation are important. Large scale storage of jaggery becomes critical during winter and monsoon. Hence there is need for alternative procedure for production of good quality jaggery with reducing the application of chemical additives. Liquid jaggery is produced using different treatment and environment to obtain product of good quality. Assessment of physicochemical, nutritional, storage and microbial quality is done using AOAC and other procedures. Liquid jaggery is evaluated for acceptability. pH of liquid jaggery ranged from 3.47 to 5.30 and reducing sugar5.81 to 12.82 percent. S1(Control) is a better treatment. Moisture ranged from 2.28 to 17.89 percent, Brix 73.4 to 78.8, and Viscosity 10.1 to 75.5centipoise respectively. Potassium content ranged from0.050 to 0.061mg, Phosphorus 0.0031 to 0.040 percent, Nitrogen from 50.600 to 137.200 mg respectively. Overall acceptability ranged from 8 to 9. It could be concluded that shelf life of liquid jaggery can be increased by standardizing and also acceptability and need for liquid jaggery can be increased by value addition and thus increasing their nutritional and nutraceutical value. Microbial and Nutritional quality were good. Therefore, with standardizing and value addition by using specific physical techniques, good quality liquid jaggery can be produced as a small-scale enterprise and income generating activity.

## 2. INTRODUCTION

Sugarcane belongs to the genus Saccharum and has six major species namely S. officinarum, S. barberi, S. sinense, S. robustum, S. Sponteneumand S. elude (Verma, 2004). Sugarcane is a vital raw material to a wide range of agro processing industries to produce sugar, jaggery, khandsari and other industrial products. India is the largest consumer and second largest producer of sugar in the world (Singhal, 2003). About 90 per cent of the production comes from Andhra Pradesh, Bihar, Haryana, Karnataka, Punjab, Maharashtra, Tamil Nadu and Uttar Pradesh; while Uttar Pradesh being the maximum producer. Sugarcane is cultivated in an area of about 4.0 lakh hectares in Karnataka with a cane production of 42 million tonnes. It is one of the important commercial crops in southern Karnataka comprising mainly Cauvery and Bhadra command areas, where an area of about 1.5 lakh hectares is under sugarcane.

30 per cent of the world's sugarcane produced is used for jaggery production. Jaggery is a natural sweetener made by concentration of sugarcane juice and subsequent crystallization in moulds. India produces more than 70 per cent of the total jaggery of the world [13]. About 32 per cent demand of the total sweetener consumption in the country is met with jaggery and khandsari, mostly in rural areas. In Cauvery command area alone, 4.3 million tonnes of canes are produced and more than 53 per cent of this goes for jaggery making (Anon, 2002). Jaggery making is exclusively a domestic industry in rural areas fetching better income to sugarcane growers.

The majority Indian population, being rural, suffers due to under nutrition and/ or malnutrition, as the common Indian diet is deficient in nutrition. Jaggery, a produmalnutritionne, is such a product which is rich in important minerals (viz Calcium-40-100 mg, Magnesium-70-90 mg, Potassium-1056 mg, Phosphorus-2090 mg, Sodium-19-30 mg, Iron-10-13 mg, Manganese-0.2-0.5 mg, Zinc-0.2- 0.4 mg, Copper-0.1-0.9 mg, and Chloride-5.3 mg per 100 g of jaggery), vitamins (viz Vitamin A-3.8 mg, Vitamin B1-0.01 mg, Vitamin B2-0.06 mg, Vitamin B5-0.01 mg, Vitamin B6-0.01 mg, Vitamin C-7.00 mg, Vitamin D2-6.50 mg, Vitamin E111.30 mg, Vitamin PP-7.00 mg), and protein-280 mg per 100 g of jaggery, which can be made available to the masses to mitigate the problems of mal nutrition and under nutrition.

Nutraceutical is regarded as the bio active substance and the constituents are either of known therapeutic activity or are chemically defined substances generally accepted to contribute substantially to the therapeutic activity of the drug. Phytochemical screening involves botanical identification, extraction with suitable solvents, purification and characterization of the bioactive constituents of pharmaceutical importance. Quality control of herbal products, both official and safe, is essential. the quality control of photochemical may be defined as the status of a drug which is determined either by identity, purity, constant and other chemical physical biological properties or by manufacturing process. compound with synthetic drug. The critical and approach for herbal drug is much more complex. Phytopharmaceutical are always mixtures of many constituents and are therefore vary variable and difficult to characterize. The active principles in Phytopharmaceutical are not always known. The quality criteria for herbal drugs are based on a clear scientific definition of the raw material. Depending on the type of preparation, sensory properties, physical constants, moisture, ash content, solvent residues and adulterations must be checked to prove identity and purity.

## 3. MATERIALS AND METHODS

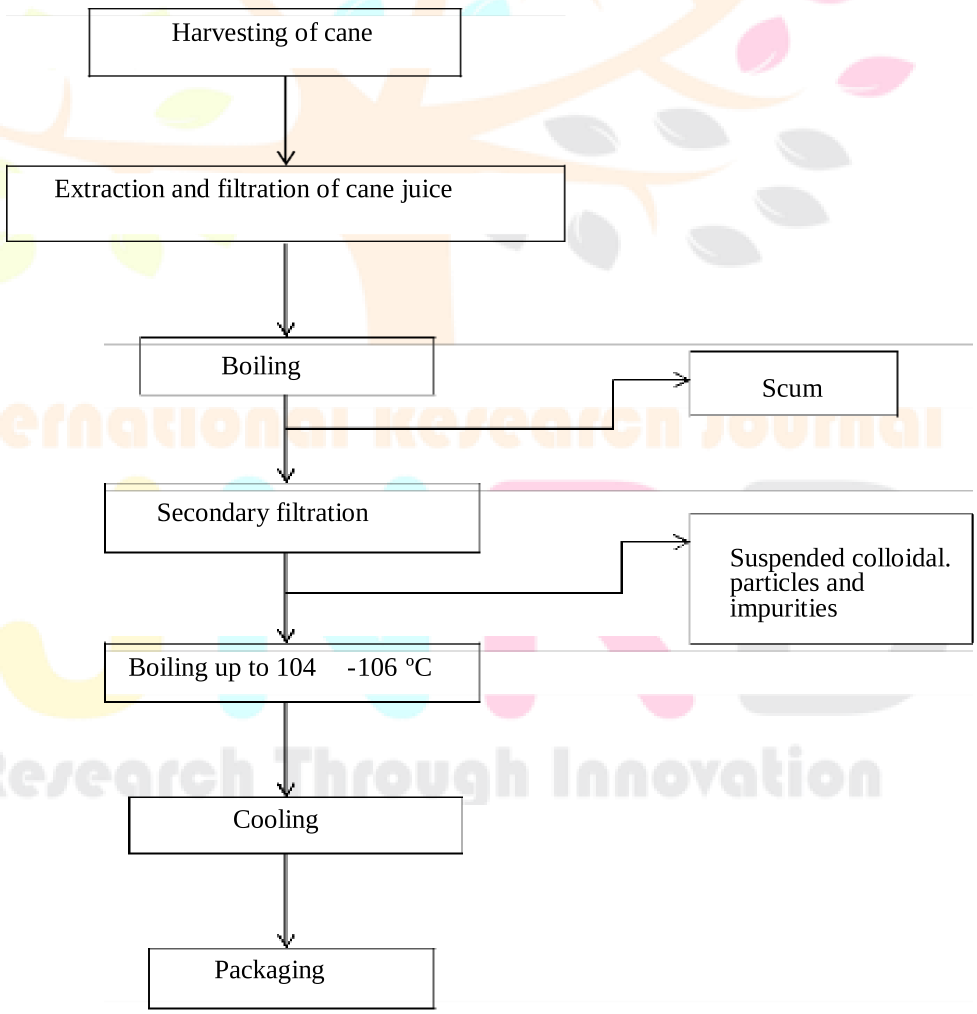
### 3.1 PROCUREMENT OF RAW MATERIAL

To evaluate the physicochemical and microbial parameters in the laboratory, the sugarcane juice was procured from the experimental farms of Sugarcane Breeding Institute, Coimbatore. The juice is extracted by using horizontal screw press fitted with three rollers.

### 3.2 STANDARDISATION OF LIQUID JAGGERY PRODUCTION

Harvesting of sugarcane is the first process involved in the preparation of liquid jaggery. To avoid deterioration due to inversion of sugars, the cane should be crushed within 24 hrs after harvesting. The cane juice after extraction was filtered through a muslin cloth and collected in container. The pH of the juice was measured using pH paper which should be in the range of 5.5 - 6.5. The filtered juice was then poured (2 litres) in an open pan, and juice was heated to facilitate the coagulation of the suspended particles into gummy colloidal substance. When the temperature reached 80 –85 ºC, which takes 20-30 minutes, the impurities present in juice started coagulating and floating on the surface, which were removed using sieves. The juice is then filtered using a 1-micron fiber cloth to remove the suspended impurities. After complete filtration, the boiled juice became clear, transparent and light brownish yellow in colour. Upon further heating, a gold-colored substance called scum appeared on the surface, which was once again removed. The juice was concentrated at 99 -100 ºC. The juice began to froth. In order to avoid this frothing and charring, continuous stirring was done and at the striking temperature of 104 -106 ºC, the juice became viscous and then the heating was stopped. The concentrate can be added with citric acid and sodium metabisulphate to prevent crystallization and deterioration. This concentrate was cooled, packed in sterilized bottles. The liquid jaggery finally resembled honey without any deterioration in quality.

Flow diagram for production of liquid jaggery.




### 3.3 PARAMETERS STUDIED

#### 3.3.1 Physiochemical parameters

**pH**

pH meter was used for pH measurements. The pH meter was calibrated using pH 7 and pH 4 standard solutions.

**Water Activity**
The Water activity of the sample is measured using a Water activity analyzer.

**Total Soluble Solids (TSS)**
The Total Soluble Solids of the sample are determined using a refractometer which measures the index of refraction and is indicated with the unit degree Brix. The sample was made up to 250ml because it was so viscous for obtaining the value in the original value.

**Electrical Conductivity**
EC meter is used to determine the Electrical Conductivity of the sample. It is expressed in micro-Siemens.

**Viscosity**
The Viscosity of the sample is determined using a vibro viscometer and is expressed in the unit centipoise.

**Moisture**
The moisture content of the sample is determined by using a Moisture analyser.

**Reducing sugars**
Reducing and total sugars were determined by the method of Lane and Eynon (AOAC, 1965) For obtaining the value of the original value that is in 25ml the following calculation is used. (Annexure -I).

### 3.3.2 Nutritional parameters

**Estimation of Nitrogen (AOAC, 1980)**

Weigh 0.5 g of sample and place it in 250ml digestion tube. Add 20ml concentrated$H_2SO_4$ plus salicylic acid mixture and keep it overnight. Add 1.5g sodium thiosulphate allow it stand for 30 minutes and heat gently till frothing stops. Cool the contents and add heat gently for few minutes. Digest at full heat till clear or apple green. Cool the contents and make up to 500ml in the volumetric flask. Check the distillation set up for all connections and water levels. Add 25ml 4% boric acid indicator solution in 250ml conical flask and keep it at the receiver end of the distillation system. Take 5ml aliquot of digested sample and add 30ml of 40% NaOH.Distillate till free of ammonia at the receiver end. Titrate the contents of the conical flask with standard h2so4 till purplish pink end point. Run a blank analysis as that of sample.

Nitrogen in % = $[(S-B) *0.014*N*500*100]/W*5$
S =titre value of sample
B = titre value of blank
N = normality of $H_2SO_4$
W= weight of sample

**Estimation of phosphorous (AOAC, 1980)**

Determination of phosphorous was carried out by measuring calorimetrically. The blue color is formed when the ash solution is treated with ammonium molybdate and thus phosphomolybdate formed is reduced.

To an aliquot, 0.4 ml of mineral solution was added with 1mL of ammonium molybdate, 1mL of hydroquinone and 1mL of sodium thiosulphate solutions in this order, mixing well after each addition. The volume was then made-up to 15 ml with water and the solution mixed thoroughly. After 30 minutes the optical density of this solution is measured, and solution mixed thoroughly. After 30 minutes the optical density of this solution is measured in a Photoelectric calorimetric against a reagent blank prepared in the same way as the test, except that the test solution is omitted, at 660nm. The phosphorous content of sample was obtained from a standard curve prepared with standard phosphate solution (range0.01 to 0.1 mg phosphorous).

Estimation of Potassium (AOAC, 1980)

Standard potassium solution of KCl of concentrations of 10, 20, 30, 40, and 50ppm were prepared and the flame photometer (systronics, model-127) reading was adjusted to zero with blank and 100 with maximum concentration of K Standard and intermediatory standards were fed. The readings thus recorded were plotted against the concentration of standards to draw the standard curve.

### 3.3.3Microbial Examination

**Viable Bacterial Count**
Dilution plate method was followed for estimating the bacterial content in the samples using Nutrient Agar.

### 3.3.4 Organoleptical Examination:

The organoleptic scoring was done by a panel of 10 members in the laboratory of ICAR – Sugarcane Breeding Institute using a score card developed for the purpose. The Score card was prepared keeping in view the quality characteristics of the products. Descriptive terms were given to various quality attributes like appearance, colour, flavour, taste and overall acceptability. Numerical scores were assigned to each attribute (Periaym and Pilgrim, 1957). A nine-point hedonic scale was used to evaluate liquid jaggery samples.

## 4. RESULTS

The present study was carried out to standardize the procedure for liquid jaggery and analyse physiochemical, nutritional and sensory characteristics of liquid jaggery and for their acceptability.

**Standardisation of liquid jaggery production**

The samples S2 and S3 were standardised with potassium metabisulphate and citric acid respectively and they were found with zero percentage crystal free and was found without any mold growth and longer shelf life,S1 was taken as control and no preservative was added into it and hence it was found to be more viscous and with presence of crystal formation was seen.S3 and S2 were found to be good in terms of acceptance and they seems to be highly acceptable because of its clarity and quality.

**4.1 Physiochemical characteristics of liquid jaggery**

Table 4.1, 4.2 and 4.3 shows the physical characteristics of the liquid jaggery such as moisture, viscosity and electrical conductivity. The moisture content of maximum was found in S3 in first and second preparation (7.15-15.83), Ph. was found high in S2 in all three preparations (Ph. to 5.08-5.30).

The Electrical conductivity of the sample ranged from 0.217-0.794µS (Siemens). The maximum is found in S1 (control) (0.794µs) and the minimum is found in S3 (citric acid) (0.217 µs).

Table 4.4, 4.5 and 4.6 shows the chemical characteristics of the liquid jaggery such as water activity, Total Soluble Solids, reducing sugars and sucrose.

The water activity of the samples ranged from 0.621 – 0.803. The maximum is found in S2 (KMS) (0.803) and the minimum is found in S1(control) (0.621).

The Total Soluble Solids of the sample ranged from 73.4 to 78.8 ºBrix. The maximum is found in S1 (78.8ºBrix) and the minimum is found in S2 and S3 (KMS and citric acid) (73.4ºBrix).

Reducing sugar content of the sample ranged from 5.81 to 12.82 %. Maximum was found in S3 (citric acid) (12.82 %) and lowest was found in S2 (KMS) (5.81 %).

Sucrose content of the samples ranged from 20.54 to 40.62. Maximum was found in S1 (40.62) and lowest was found in S3 (20.54)

Table 4.1 Physical characteristics of liquid jaggery (1st preparation)

| Sample | Moisture (%) | Electrical Conductivity (µS) | Viscosity (centipoise) |
|---|---|---|---|
| S1 | 2.28 | 0.794 | 75.5 |
| S2 | 3.62 | 0.350 | 73.2 |
| S3 | 7.15 | 0.217 | 71.5 |

Table 4.2 Physical characteristics of liquid jiggery 2nd preparation

| Sample | Moisture (%) | Electrical Conductivity(µS) | Viscosity (centipoise) |
|---|---|---|---|
| S1 | 9.43 | 0.464 | 10.2 |
| S2 | 12.33 | 0.690 | 13.5 |
| S3 | 14.33 | 0.450 | 10.1 |

Table 4.3 Physical characteristics of liquid jaggery 3rd preparation

| Sample | Moisture (%) | Electrical Conductivity(µS) | Viscosity (centipoise) |
|---|---|---|---|
| S1 | 17.01 | 0.427 | 10.9 |
| S2 | 17.89 | 0.781 | 10.2 |
| S3 | 15.83 | 0.587 | 10.4 |

Table 4.4 Chemical characteristics of liquid jaggery (1st preparation)

| Sample | pH | Water activity | TSS (ºBrix) | Reducing sugars (%) | Sucrose |
|---|---|---|---|---|---|
| S1 | 4.72 | 0.621 | 78.8 | 7.69 | 40.62 |
| S2 | 5.08 | 0.664 | 77.9 | 9.09 | 34.48 |
| S3 | 4.56 | 0.665 | 76.2 | 6.66 | 31.39 |

Table 4.5 Chemical characteristics of liquid jaggery (2nd preparation)

| Sample | pH | Water activity | TSS (°Brix) | Reducing sugars (%) | Sucrose |
|---|---|---|---|---|---|
| S1 | 5.5 | 0.774 | 75 | 5.81 | 31.01 |
| S2 | 5.30 | 0.803 | 74.3 | 4.31 | 27.97 |
| S3 | 4.17 | 0.767 | 74.5 | 12.82 | 27.60 |

Table 4.6 Chemical characteristics of liquid jaggery (3rd preparation)

| Sample | pH | Water activity | TSS (°Brix) | Reducing sugars (%) | Sucrose |
|---|---|---|---|---|---|
| S1 | 4.90 | 0.777 | 75.8 | 6.09 | 33.15 |
| S2 | 5.00 | 0.803 | 73.4 | 6.84 | 29.70 |
| S3 | 3.47 | 0.756 | 74.2 | 8.33 | 20.54 |

**4.2 Nutritional composition of liquid jaggery**

Table 4.7 shows the mineral content of liquid jaggery samples such as Nitrogen, Potassium, and Phosphorus. The Nitrogen content of the sample ranged from 50.400 – 137.200 mg. The highest Nitrogen content is found in S2 (kms) (137.200) and the lowest is found in S1 (control) (50.400).

The Phosphorus content of the sample ranged from 0.0031 – 0.040 %. The highest Phosphorus content is found in S2 (kms) (0.040%) and the least is found in S3 (citric acid) (0.0031%).

The Potassium content of the sample ranged from 0.050 - 0.061 mg. The highest phosphorus content is found in S2 (KMS) (0.061) and the least is found in S3 (Citric acid) (0.050).

Table 4.7 Mineral content of liquid jaggery

| Sample | N (mg) | P (%) | K (mg) |
|---|---|---|---|
| S1 | 50.400 | 0.0044 | 0.059 |
| S2 | 137.200 | 0.040 | 0.061 |
| S3 | 61.600 | 0.0031 | 0.050 |

**4.3 Microbial analysis of liquid jaggery**

The samples are tested at 10-3 and 10-4 dilutions. The bacterial and coliform estimation showed no differences among all treatments. No microbial load was recorded in any of the samples at room temperature (30±5°C). As heating destroys microorganisms, heat treated samples have shown reduced or no microbial growth. Moreover, the addition of potassium meta bisulphite and citric acid had reduced the pH further limiting the growth.

**4.4 Value addition in liquid jaggery**

A total of 6 litres of concentrated sugar cane juice was taken into two vessels 2 liters each for the preparation of two lot of value added liquid jaggery. They were further concentrated, and the scum was removed at intervals for the better-quality product. Ata definite concentration 1 litres of grape juice was added into first lot and was mixed well it was again concentrated and the scum was removed. Then about one third of the prepared isabol was added which provides a gelling consistency to the product. After all the isabol was mixed and adjoined the jaggery it was further concentrated and once it reached a temperature of 108-110°C it was added with roasted cashew nuts and ghee. Ghee was added to prevent stickiness and once it was mixed well and concentrated the grape juice liquid jaggery was ready it weighed 1.404 kg, it was cooled and bottled. In the second lot, Almond was taken, soaked in water overnight and then the peel was removed, and it was well ground, and the juice was extracted, and it was added into the concentrated sugarcane juice and concentrated further. Then the remaining one third of the isabol was added to this one too. Once it is mixed well and concentrated to 110°C roasted cashew nuts were added into it and ghee was added into it and mixed thoroughly and concentrated and now the Almond liquid jaggery was ready and it weighed 2.422 kg, it was cooled and bottled. The nutritional values and nutraceutical values were discussed in the introduction and review of literature part.


Figure: 1 Value added liquid jaggery

**4.5 Sensory evaluation of value added liquid jaggery products.**

The results of mean sensory score of best liquid jaggery are presented in Table 4.8. The liquid jaggery was prepared under different treatments as mentioned earlier and compared with each other. With respect to appearance, almond liquid jaggery scored 8 whereas grape juice jaggery scored 7. With respect to color, both almond liquid jiggery and grape juice liquid jaggery scored 8. With respect to flavors, grape juice liquid jiggery scored 9 whereas almond liquid jiggery scored 7. With respect to taste grape juice liquid jaggery scored 9 whereas almond liquid jiggery scored 8. Overall acceptability was better for grape juice liquid jaggery (9) over the other liquid jaggery sample almond liquid jaggery (8). However, the sample almond liquid jaggery scored more than 7scores out of nine with good acceptance.

Table 4.8 Mean sensory score of value-added liquid jaggery product.

| Sample | Appearance | Colour | Taste | Flavour | Overall Acceptance |
|---|---|---|---|---|---|
| Grape juice liquid jaggery | 7 | 8 | 9 | 9 | 9 |
| Almond liquid jaggery | 8 | 8 | 8 | 7 | 8 |

**5. DISCUSSION**

Jaggery is an important sweetening agent and utilizes about 53 per cent of cane produced. The production of jaggery involves extraction, boiling, clarification, evaporation and concentration as well as cooling. The solid jiggery is hygroscopic due to presence of fructose and glucose. Rampant use of chemical additives adversely affects the keeping quality of jaggery. The production of jaggery is seasonal, therefore its preservation and storage become essential (Roy, 1951). Indiscriminate use of chemical additives in jaggery making, improper handling, processing and non-availability of good quality jaggery are the important reasons for decline in jiggery consumption. Moreover, hygroscopic nature of solid jaggery promotes growth of microbes, brings changes in colour, aroma and acceptability of solid jaggery (Shahiet al., 1999 and Sinha et al., 1999), Therefore, alternative method for jaggery making is the urgent need. Liquid jaggery is an intermediate product obtained from sugarcane with good shelf life and it is a good substitute for jaggery. The results of the previous chapter are discussed under the following headings.

**5.1 Standardization of liquid jaggery production**

Jaggery is an important sweetening agent and utilizes about 53 per cent of cane produced. Indiscriminate use of chemical additives in jaggery making, improper handling, processing, and non-availability of good quality jaggery are the important reasons for decline in jaggery consumption. Therefore, alternative methods for jaggery making are urgently need. Liquid jaggery is an intermediate product obtained from sugarcane with good shelf life. Hence, the process of liquid jaggery production is refined by physical treatment and by altering the environment in which liquid jaggery is produced. Among the three preparations S2and S3 (kms added and citric acid added) is more effective than the other, because no crystal formation was seen in the preservative added liquid jaggery and no presence of mold growth or deterioration was observed. But the taste of liquid jaggery from S2 and S3 was slightly sour than the taste of S1 which is as sweet as S1 because S1 was pure and natural without any preservatives. Filtration of sugarcane juice with a micron fiber cloth is very effective because as much as the impurities and scum are removed from the juice the more the shelf life will the liquid jaggery will have. Since, suspended matters present in cane juice, if allowed to remain would impart a disagreeable colour and taste to the resulting product (Joshi and Pandit 1959). The striking temperature of liquid jaggery lies around 104 – 106ºC. And at this stage value addition to the standardised liquid jaggery could increase the nutritional and nutraceutical value of the product and the acceptability and sale of the jaggery could also increase and it is well known that jaggery is a much better and nutritious product than normal white sugar because only sucrose is being processed to obtain white sugar.
With respect to flavors, grape juice liquid jiggery scored 9 whereas almond liquid jiggery scored 7. With respect to taste grape juice liquid jaggery scored 9 whereas almond liquid jiggery scored 8. Overall acceptability was better for grape juice liquid jaggery (9) over the other liquid jaggery sample almond liquid jaggery (8). However, the sample almond liquid jaggery scored more than 7scores out of nine with good acceptance.

Table 4.8 Mean sensory score of value-added liquid jaggery product.

| Sample | Appearance | Colour | Taste | Flavour | Overall Acceptance |
|---|---|---|---|---|---|
| Grape juice liquid jaggery | 7 | 8 | 9 | 9 | 9 |
| Almond liquid jaggery | 8 | 8 | 8 | 7 | 8 |

Table 4.8 Mean sensory score of value-added liquid jaggery product.

| Sample | Appearance | Colour | Taste | Flavour | Overall Acceptance |
|---|---|---|---|---|---|
| Grape juice liquid jaggery | 7 | 8 | 9 | 9 | 9 |
| Almond liquid jaggery | 8 | 8 | 8 | 7 | 8 |

## 5. DISCUSSION

Jaggery is an important sweetening agent and utilizes about 53 per cent of cane produced. The production of jaggery involves extraction, boiling, clarification, evaporation and concentration as well as cooling. The solid jiggery is hygroscopic due to presence of fructose and glucose. Rampant use of chemical additives adversely affects the keeping quality of jaggery. The production of jaggery is seasonal, therefore its preservation and storage become essential (Roy, 1951). Indiscriminate use of chemical additives in jaggery making, improper handling, processing and non-availability of good quality jaggery are the important reasons for decline in jiggery consumption. Moreover, hygroscopic nature of solid jaggery promotes growth of microbes, brings changes in colour, aroma and acceptability of solid jaggery (Shahiet al., 1999 and Sinha et al., 1999), Therefore, alternative method for jaggery making is the urgent need. Liquid jaggery is an intermediate product obtained from sugarcane with good shelf life and it is a good substitute for jaggery. The results of the previous chapter are discussed under the following headings.

### 5.1 Standardization of liquid jaggery production

Jaggery is an important sweetening agent and utilizes about 53 per cent of cane produced. Indiscriminate use of chemical additives in jaggery making, improper handling, processing, and non-availability of good quality jaggery are the important reasons for decline in jaggery consumption. Therefore, alternative methods for jaggery making are urgently need. Liquid jaggery is an intermediate product obtained from sugarcane with good shelf life. Hence, the process of liquid jaggery production is refined by physical treatment and by altering the environment in which liquid jaggery is produced. Among the three preparations S2and S3 (kms added and citric acid added) is more effective than the other, because no crystal formation was seen in the preservative added liquid jaggery and no presence of mold growth or deterioration was observed. But the taste of liquid jaggery from S2 and S3 was slightly sour than the taste of S1 which is as sweet as S1 because S1 was pure and natural without any preservatives. Filtration of sugarcane juice with a micron fiber cloth is very effective because as much as the impurities and scum are removed from the juice the more the shelf life will the liquid jaggery will have. Since, suspended matters present in cane juice, if allowed to remain would impart a disagreeable colour and taste to the resulting product (Joshi and Pandit 1959). The striking temperature of liquid jaggery lies around 104 – 106ºC. And at this stage value addition to the standardised liquid jaggery could increase the nutritional and nutraceutical value of the product and the acceptability and sale of the jaggery could also increase and it is well known that jaggery is a much better and nutritious product than normal white sugar because only sucrose is being processed to obtain white sugar.

### 5.2 Physiochemical characteristics of liquid jaggery

In this study, the physiochemical characteristics of liquid jaggery such as pH, moisture, water activity, viscosity, Electrical conductivity Total Soluble Solids, and reducing sugar are important parameters that influence the quality of liquid jaggery. The pH of the sample ranged from 3.47 – 5.30 (Table). The moisture content of the sample ranged from 2.28% – 17.89% (Table). The Electrical conductivity of the sample ranged from 0.217 – 0.794 µS (S-siemens) (Table). The viscosity of the sample ranged from 10.1 – 75.5p (poise) (Table). The water activity of the sample ranged from 0.621 – 0.803 (Table). The Total Soluble Solids of the sample ranged from 73.4 – 78.8 ºBrix (Table). Reducing sugar content of the sample ranged from 5.81 to 12.82% with an average of 6.68% (Table). The value of Electrical conductivity is proportional to the dirt and impurities present in the sample. Dirt and impurities ranged from 20 to 23g. Observations of the present study are similar to the observations recorded by Roy et al., (1951), Joshi and Pandit (1959) reported that the raw cane juice contains highest amount of moisture as well as all the soluble matter in the cane including dirt, impurities and glucose etc. Removal of dirt and impurities during liquid jaggery processing is essential to get highly clarified end product. Since usage of chemicals should be avoided, Aruna et al., (1997), treatment S1 will be suitable as it has an Electrical conductivity value (Table). The Total Soluble Solids of the sample ranged from 73.4 – 78.8 ºBrix. The findings are similar to the results reported by Vermeshwar Dubey and Lal, (1989) that jaggery having higher Total Soluble Solids value i.e., 75 and above in solid jaggery keeps better on storage. There may be variation in Brix content due to the striking temperature i.e., 104 to 106º C in liquid jaggery when compared to solid jaggery which reaches end point at 118 to 120 º C. It may also vary due to variation in stage of harvesting and in variety. Reducing sugar content of the sample ranged from 5.81 to 12.82 %. Asokan (1983) opined that higher reducing sugar content, dirt and impurities, moisture and reduced sucrose content will limit the shelf life of the jaggery. The same applicable to liquid jaggery. Thus, it could be concluded that the end product which has an optimum pH, lesser moisture content, viscosity, Electrical conductivity and water activity, Brix value above 75 and lesser reducing sugar is good in quality which is achieved through treatment S1.

### 5.3 Nutritional composition of liquid jaggery

Large number of minerals and trace elements are required by human beings. Some of these form part of body structural components such as calcium, phosphorus and iron are component of blood. Whereas sodium and potassium are important nutrients present in fluids within and outside the cells to keep water and acid base balance. The nutritional composition of liquid jaggery prepared was estimated and results are discussed below.

**Phosphorus:** Phosphorus content was more and ranged from 0.0031 to 0.040 mg per 100 gm. Ravindraet al., (2004) reported that phosphorus is an important element after calcium. Calcium and phosphorus are also components of nucleic acids. These values are lower than those reported by Ravindraet al., (2004) (177 to 246 mg) and phosphorus content was much higher than the researcher (18 to 21 mg). As per the food composition table, the calcium content of solid jaggery is reported to be 80 mg and phosphorus at 40 mg. The daily requirement of calcium and phosphorus for adults is 400 mg and about 1gm of phosphorus should be supplied in the diet (Gopalanet al., 2007). Nearly half of this amount of phosphorus is easily obtained when jaggery is added to the diet.

**Potassium:** The health benefits of potassium include relief from stroke, high blood pressure, heart and kidney disorders, and anxiety and stress. It helps enhance muscle strength, metabolism, water balance, electrolytic functions, and the nervous system. It is the third most abundant mineral in the human body and is a powerful element in improving health. It contains the components for maintaining a high level of well-being and an improved lifestyle. The Adequate Intake recommendation for potassium is 4,700 milligrams (mg) per day for adults. Here it ranged from 0.050-0.061 which is much lower but as a single source it is helpful.

**Nitrogen:** Nitrogen is an important part of our bodies. Amino acids all contain nitrogen, and these are the building blocks that make up the proteins in your hair, muscles, skin and other important tissues. Nitrogen is an important part of your DNA, which defines what you are like in many ways. As we know nitrogen makes up a large part of the Earth's atmosphere. Humans can't utilize nitrogen through respiration but can absorb it through the consumption of plants or animals that have consumed nitrogen rich vegetation. The air we breathe is around 78% nitrogen, so it is obvious that it enters our body with every breath. This nitrogen helps in protein synthesis, amino acids that influence growth, hormones, brain functions and the immune system. In liquid jaggery the nitrogen content was found ranging from 50.600mg to 137.200mg which plays a crucial role in better uptake of nitrogen in the human body.

**5.4 Microbial analysis of liquid jaggery**

In this study, the microbial quality of liquid jaggery is tested. The samples are tested at 10-3 and 10-4 dilutions. No growth is seen at room temperature at 30±5°C.Thus all the samples were at good terms in microbial quality. This is because of the high processing temperature at which microorganisms could not survive. Thus, it could be concluded that no microbial growth is seen in any samples and are safe for use.

**5.5 Sensory evaluation of value added liquid jaggery products.**

Jaggery is an important part of the dietaries of very large population in all parts of India. Jaggery is not only a sweetening agent in food stuffs and drinks but is itself an article of food and is partly taken as such at the end of the meals of selected rural communities. Since jaggery is solid and hygroscopic in nature, liquid jaggery could be used as a substitute for jaggery. On a nine-point hedonic scale, the sample Grape juice liquid jaggery which is filtered got a higher score than the other samples.

The overall acceptability is higher for grape juice liquid jaggery whereas the other sample Almond liquid jiggery got a comparatively higher score for overall acceptability which had a slight acidic taste.

**The findings are summarized below:**

Among the treatments, S2 (KMS) and S3 (Citric acid) were good in terms of taste and consistency. But S1 (control) was better in terms of appearance and acceptability. Physical properties like moisture ranged from 2.28 to 17.89 percent, Electrical conductivity ranged from 0.217 to 0.794 µS and viscosity ranged from 10.1 to 75.53 p.

Chemical properties like pH ranged from 3.47 to 5.5, water activity ranged from 0.621 to 0.0.803, Total soluble solids ranged from 73.4 to 78.8. ºBrix and reducing sugars ranged from 5.81 to 12.82 %.

Mineral composition of liquid jaggery: The Phosphorus content ranged from 0.0031 – 0.040%. Potassium content ranged from 0.050 – 0.061mg. The nitrogen content ranged from 50.400-137.200 mg.

Sensory scores for color ranged from 8. Sensory scores for flavour ranged from 7 to 9. Sensory scores for taste ranged from 8 to 9. Sensory scores for appearance ranged from 7 to 8. Overall acceptability ranged from 8 to 9.

Microbial quality was good with no growth of microorganisms at room temperature 30±5°C

**REFERENCES**

**[1]** Anonymous (2013). Utilisation of sugarcane for different purposes. Cooperative sugar 42(7): 63.

**[2]** ALUM, A., 1999, Industrial and policy Issues Including Export Potential of Jaggery and Khandasari, Industry in India, Res. Digest. pp: 1-8.

**[3]** ANONYMOUS, 1995, Annual Progress Report of Lucknow Centre of AICRP on jaggery and Khandasari Processing, Handling. AICRP on Processing and Storage of Jaggery and Khandasari for 1992-95, IISR, Lucknow.

**[4]** ANONYMOUS, 1998, Liquid Jaggery and Powder Jaggery. Jaggery and Khandasari Res. Digest IISR Lucknow. Pp : 67-72.

**[5]** BABU, B. AND ANWAR, S.I., 1995, Technical Bulletin, (IISR/JRS/94/9), AICRP on Processing, Handling and Storage of jaggery and Khandasari,IISR, Lucknow.

**[6]** DAKSHINADAS, D.G. AND KALE. R.A., 1961, Studies on Factors Affecting Gur Quality. Ind.j.Sugarcane Res. And Development. (VI-Part-I) 1-11.

**[7]** Dr.GururajHunsigi, Sugarcane in agriculture and Industry, Karnataka Institute of Applied Agricultural Research (KIAAR),Bagalkot.

**[8]** FLORA, S.J.S. AND SINGH, S., 1988, influence of simultaneous supplementation of jaggery on Lead Intoxification in rats. PakisthanJ.Scientific and Industrial Res.31(10): 722-724.

**[9]** GANGAL, R.G., 2002, Clear Production Assessment in JaggerymanufacturingUnits in and Around Belgaum District. Assessment Report.

**[10]** JADHAV, S.Y., LONDHE, M.B., 1989, Effect of State Cane on Clarification.IndianSug. Jan. Pp: 801-807.

**[11]** KALE, R.A. AND CHINCHORKAR, S.V., 1964, Studies on Quality of Gur.Proc. Of 5th Conf. Sug. Res. Dev Workers.468-478.
**[12]** KALE, R.A., 1957, Preparation of Gur. Book or Sugarcane Cultivation in Bombay State.
**[13]** KAMATH, A. AND NARASIMHAN. S., 1998, Physico-Chemical Properties of Sweeteners, Poster Abstracts. IFCON, 4th International Food Convention, 23rd to 27th November 1998, Mysore, India, Pp: 100.
**[14]** LAKASHMINARAYANA, L. AND RAO, R.S., 1999, Effect of somephysicalCharacteristics on National Drying and storage of jaggery. Souvenir with Abstracts national Seminar on Status, Problems and Prospects of jaggery and Khadasari Industry in India. Pp: 47.
**[15]** LAL, U. AND SHARMA, R.K. 1983. Role of Gur Shape in its DeteriorationDuring Storage. Co-op. Sug. 15 (1):7-9. MUNSHI, K.M., 1951,
Monograph on theGur Industry of India. IISR, Kanpur.Pp:1.