Jaggery is a natural sweetener made by concentrating the sugarcane juice with clarification to remove impurities and uniform heating in open pan. It is a sensitive product, getting affected by number of factors right from cultivation practices of sugarcane to processing and storage. The jaggery industry is still at cottage level because of some technological drawbacks in its export quality processing and storage. The per cent utilization of sugarcane for production of jaggery and khandsari is considerably declining from 37.20 in the year 2008-09 to about 16.90 in 2011-12. This implies the need of research in jaggery sector to produce a quality jaggery and thus to change the scenario. However, some research workers and institutes like IISR, Lucknow, RSJRS, Kolhapur, RARS, Anakapalle, reported some technological developments in the processing, storage and packaging of jaggery. A value added jaggery, with enrichment of nutritional ingredients such as aonla, milk powder, wheat flour, whey etc., has a great export potential in turn fetching good market prices. The organic jaggery is becoming popular in the market because of its health benefits and good quality attributes, thus herbal clarificants play a key role in jaggery production.

Keywords: Jaggery, clarification, storage, packaging, value addition

ABSTRACT

Jaggery is a natural sweetener made by concentrating the sugarcane juice with clarification to remove impurities and uniform heating in open pan. It is a sensitive product, getting affected by number of factors right from cultivation practices of sugarcane to processing and storage. The jaggery industry is still at cottage level because of some technological drawbacks in its export quality processing and storage. The per cent utilization of sugarcane for production of jaggery and khandsari is considerably declining from 37.20 in the year 2008-09 to about 16.90 in 2011-12. This implies the need of research in jaggery sector to produce a quality jaggery and thus to change the scenario. However, some research workers and institutes like IISR, Lucknow, RSJRS, Kolhapur, RARS, Anakapalle, reported some technological developments in the processing, storage and packaging of jaggery. A value added jaggery, with enrichment of nutritional ingredients such as aonla, milk powder, wheat flour, whey etc., has a great export potential in turn fetching good market prices. The organic jaggery is becoming popular in the market because of its health benefits and good quality attributes, thus herbal clarificants play a key role in jaggery production.

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INTRODUCTION

Sugarcane contributes about 90 per cent of the world’s sweeteners production. The 70 per cent of the world’s sugarcane produced is being used for jaggery manufacturing. Jaggery is a natural sweetener made by heat concentration of sugarcane 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. The per cent utilization of sugarcane for production of jaggery and khandsari is considerably declining from 37.20 in the year 2008-09 to about 16.90 in 2011-12 [1]. Uttar Pradesh has the largest area (120.54 million hectares) under sugarcane, which is 35.02 per cent of the total area in the country. However, the production per hectare is the highest in Tamil Nadu followed by Kerala, Karnataka, Andhra Pradesh, Maharashtra and Gujarat [1]. Average sugarcane production of Maharashtra in 2011-12 is 8.982 million tonnes [25]. About 90 per cent of the India’s total production comes from Andhra Pradesh, Bihar, Haryana, Karnataka, Punjab, Maharashtra, Tamil Nadu and Uttar Pradesh.

Composition of jaggery

The proximate composition of sugar, sulphur processed khandsari, non sulphur processed khandsari and jaggery as given by [21] is presented in Table 1. Rao et al. [13] reported that the jaggery is a wholesome diet, that contains 0.6 -1.0 per cent mineral and some of the important minerals are 11.4 per cent iron, 8.0 per cent calcium and 4.0 per cent magnesium and phosphorous. It also contains reducing sugar including 10-15 per cent glucose and fructose 0.40 per cent protein and 0.1 per cent fat.

Jaggery, a product of sugarcane, is such a product which is rich in important minerals (viz., calcium-40-100 mg, magnesium-70-90 mg, potassium-1056 mg, phosphorus-20-90 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 E-111.30 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 malnutrition and under nutrition [20].

Table 1

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Quantity (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>40-100</td>
</tr>
<tr>
<td>Magnesium</td>
<td>70-90</td>
</tr>
<tr>
<td>Potassium</td>
<td>1056</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>20-90</td>
</tr>
<tr>
<td>Sodium</td>
<td>19-30</td>
</tr>
<tr>
<td>Iron</td>
<td>10-13</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.2-0.5</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.2-0.4</td>
</tr>
<tr>
<td>Copper</td>
<td>0.1-0.9</td>
</tr>
<tr>
<td>Chloride</td>
<td>5.3</td>
</tr>
</tbody>
</table>

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Introduction

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According to prevention of food adulterates rules (PFA, 1955) of the Government of India, section A. 07.05. Gur /jaggery mean the product obtained by boiling or processing juice crushed out of sugarcane. It shall be free from substances deleterious to health and can confirm to the following standard analysis on dry weight basis.

1. Total sugars not less than 90% and sucrose not less than 60%,
2. Extraneous matter insoluble in water 2.0%.
3. Total ash not more than 6% and ash insoluble in HCl not more than 0.5%.
4. Gur or jaggery other than that of liquid or semisolid variety shall not contain more than 10% moisture.

**Medicinal importance**

Rao et al. [13] reported that the dietary intake of jaggery prevents the atmospheric pollution related toxicity and the incidence of lung cancer. Jaggery, a product of sugarcane, is such a product which is rich in important minerals and vitamins. The magnesium strengthens the nervous system, helps to relax our muscles, gives relief from fatigue and takes care of our blood vessels. The potassium and low amount of sodium present in jaggery maintain the acid balance in the body cells, and also combat acids and acetone, and control our blood pressure. Iron helps to prevent anaemia. It also helps to relieve tension and takes care of asthma, as it has anti-allergic properties. The preventive ability of jaggery on smoker’s smoke-induced lung lesions suggest the potential of jaggery as a protective food for workers in dusty and smoky atmosphere, even for those who are engaged in woollen industries, the wool dust clogged in the food pipe could be cleared with jaggery. Thus, jaggery helps to breathe easier and counters the pollution problems naturally. The moderate amount of calcium, phosphorous and zinc helps to maintain optimum health. It also purifies the blood, prevents rheumatic afflictions and bile disorders and thus helps to cure jaundice [20].

**Processing of jaggery**

The processing techniques of the jaggery are mostly traditional. However, the condition is being changing with some advancement in processing such as new and uniform methods of heating to produce quality jaggery, automatic jaggery manufacturing plant, trend to produce chemical free called as organic jaggery and attempts to produce jaggery [12]. The general traditional unit operations of jaggery making reported by [13, 14, 17] are depicted in Fig. 1.

**Factors determining jaggery quality**

Quality of jaggery is very sensitive to various parameters such as sugarcane variety, cultivation practices, fertilizers used, stage of harvest, method of juice extraction etc. The composition of extracted juice in terms of its pH, purity, TSS affects the quality of jaggery. Juice extracted from the canes turns dark brown and marked sedimentation appears during storage.

Chauhan et al. [3] in his studies reported the range of physiochemical properties of sugarcane juice. Sugarcane juices contained very small quantities of protein (0.39-0.60 %) and fat (0.14-0.19 %). However, it contained very high moisture (80.00-81.70 %), crude fiber (13.24-16.62 %) and ash (0.2870.48%). Sugarcane juice also contained 18.0-19.5 % total soluble solids which include mainly total sugars (17.6-19.0 %). The sugar was mostly non reducing sucrose and small amount of reducing sugars (0.20-0.65 %) were also present. Sugarcane juice also contained appreciably high content of calcium, phosphorus and iron. Juice was acidic in nature (pH 5.28-5.54 and acidity 0.24-0.39%). The viscosity
values of juices obtained from different varieties ranged between 3.64-3.90 Centipoise at 30°C. The studies of Mungare et al. [9] reveals that the sugarcane varieties viz., Co 8041, Co 86032, Co 7527 gave the highest sucrose, purity in juice and good quality jaggery. The Regional Sugarcane and Jaggery Research Station, Kolhapur recommended that the jaggery manufactured from variety Co 92005 fulfils all the quality requirements of the jaggery.

The method of sugarcane juice extraction determines the purity of the juice. The juice purity is amount of sucrose present in total soluble solids. A higher purity level gives better quality jaggery. The juice extracted in sugar industry has higher purity level than the crushers used for jaggery juice extraction. Usually 2-5 roller crusher is used for extraction of the juice which may be power operated or animal driven. The type of roller may be vertical or horizontal. A vertical three roller has the juice extraction capacity 50-55 %, whereas, same for horizontal crusher has 55-60 % [14]. The horizontal roller crusher is mostly used.

One of the important steps in jaggery making is juice clarification to remove the chemical impurities. However, the insoluble impurities are removed by physical means such as settling or filtering through muslin cloth of wore mesh. The production of attractive colour jaggery in turn depends on the extent of clarity of sugarcane juice. The fresh cane juice contains appreciable quality of colloidal impurities and these are to be removed for manufacturing the quality jaggery. Different chemical and herbal clarificants are used for the purpose. The chemical clarificants such as hydros (sodium hydrosulphite), lime, sodium carbonate, super phosphate, di-ammonium phosphate and alum are used owing to their easy availability [18]. However, the trend is now changing to use the herbal clarificants replacing the chemical clarificants especially, hydrous considering its health hazards. Several plant extracts like deola (Hibiscus ficilenues), bark of semal (Bombox malabaricium), extracts of groundnut (Arachis hypogea) and caster (Ricinus comunis), guar gum powder and bhendi powder are commonly used depending on their availability. Quality of jaggery prepared with guar gum powder was superior, possessed improved overall acceptability and preserved better for 6 months on storage at 27°C compared to those prepared with deola and hydrous ([18]. The synthetic clarificant like bhendi powder or SNi @ 2 ppm with herbal clarificant bhendi plant @ 2 kg/1000 lit. were found effective in improving NRS, colour, jaggery recovery and maximum removal of scum, showing better effect on quality of jaggery and also helped in maintaining higher NRS and better colour jaggery during storage than the control treatment[11]. These herbal clarificants play an important role in the production of organic jaggery. Jain [4] used the modern

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**Fig. 1 Process flow chart for solid jaggery manufacture**

The process of jaggery manufacture involves the following steps:

1. **Sugarcane** → **Juice extraction** → **Bagasse**
2. **Settling** → **Impurities**
3. **Clarification**
4. **Cooling and moulding** → **Solid jaggery in different**
5. **Storage**

---
techniques of membrane separation and centrifugal separation of removing the impurities of the cane juice thus, tried to avoid the use of chemicals. The pH of the juice determines the crystalline texture of the jaggery. The quality crystalline jaggery can be produced by adjusting the pH above 6.0. The natural sugarcane juice has a pH of 5.5. It can be adjusted by using the lime for the purpose. The low levels of pH cause inversion by hydrolyzing the sugar and thus affecting the jaggery quality [7, 16].

FORMS OF JAGGERY
Jaggery is basically available in three forms viz., solid (lumped), liquid and granular jaggery. Of this 80 per cent is in solid lump form while remaining 20 per cent constitute liquid and granular jiggery [13]. The composition of these forms (Table 2) is reported by [14].

<table>
<thead>
<tr>
<th>Composition per 100g</th>
<th>Types of jaggery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Solid (lumped)</td>
</tr>
<tr>
<td>Water (g)</td>
<td>3-10</td>
</tr>
<tr>
<td>Sucrose (g)</td>
<td>65-85</td>
</tr>
<tr>
<td>Reducing sugars (g)</td>
<td>9-15</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>0.4</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>0.1</td>
</tr>
<tr>
<td>Total minerals</td>
<td>0.6-1.0</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>8.0</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>4.0</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>11.4</td>
</tr>
<tr>
<td>Energy (Kcal)</td>
<td>383</td>
</tr>
</tbody>
</table>

Manufacturing of solid and liquid jaggery is a conventional practice. The various unit operations such as storage, handling, packaging and distribution are difficult with traditional large sized lumps of jaggery. Hence, emphasis is being given to standardized technology for granular, free flowing jaggery. The Indian Institute of Sugarcane Research (IISR), Lucknow and Regional Agricultural Research Station (RARS), Anakapalle has tried to develop a technology for granular jiggery (Plate 1).

**Solid jaggery in uniform shape and size**

The diversity in shape of single commodity does not attract any one of the development of equipment/gadgets for the product handling, therefore for the uniformity of shape and size jaggery moulding frames were developed at IISR, Lucknow to manufacture brick shaped jaggery weighing 125 g, 250 g and 500 g and 2.5 cm cube weighing about 20 g. The juice extracted through mechanical crushers is boiled, clarified and concentrated. The concentrated semi-solid mass after puddling in cooling pan is poured into these frames and levelled up with ladle. After about 40-45 minutes when jaggery is set, brick and cubes are removed by dismantling the frame. (Technologies developed by IISR, [24]).

**Liquid jaggery**

It is an intermediate product obtained during concentration of purified sugarcane juice during jaggery making, and is semi liquid syrup like product. The quality of liquid jaggery largely depends upon quality and composition of cane juice, type of clarificants used, and striking temperature at which concentrating juice is collected. For quality liquid jaggery, the juice concentrate is removed from boiling pan, when it reaches striking point temperature of 103-106°C, depending upon the variety and agro-climatic zone. To avoid crystallization and to make liquid jaggery attractive in colour, citric acid is added @ 0.04% (400 Pawar et al.}
nutritional and organoleptic quality of jaggery on one side

Utilization of whey, a dairy industry waste containing proteins, lactose and minerals increase the nutritional value of wheat flour, cocoa powder containing proteins, vitamins and minerals etc. This will not only increase the shelf life by 210 days. Results revealed that the jaggery stored in PET films with MAP technique using LDPE, polypropylene (PP), atmospheric packaging (MAP) techniques have also been used along with packaging materials by some research workers. Jaggery cubes 2.5 cm were stored with MAP technique using LDPE, polypropylene (PP), and low density polyethylene film (LDPE) absorbs moisture water less than 0.01 % in 24 hours. The earthen pots can also be used for storage of jaggery. Mandal et al. [8] reported that the heat sealed LDPE packets of 150 gauge was best suitable followed by glass jar and PET jar.

IISR, Lucknow has developed a drying cum storage bin for the purposes. The quality deterioration of jaggery stored in drying cum storage bin is less than that stored in polythene bags and open storage. The use of drying cum storage bin reduced moisture content to 6-7 per cent during summer from initial moisture of 13-14 per cent [2]. The storage period can also be increased by using a low temperature of 7-9°C [23]. Three ply (PET+Al. Foil +PE) packaging material helped more in checking of inversion rate. The lowest inversion of 4.35 and 2.67 % was recorded with three ply followed by four ply packaging material (4.53 and 3.43 %) in lump and brick shaped jaggery, respectively [19]. Superiority of three ply is due to its higher strength with low water vapour transmission rate (0.14 g/m²/24 hr) and low oxygen transmission rate (207.00 ml/m²/24hr). The coarse jaggery powder having particle size in the range 0.500-0.780mm was found more acceptable after six months of storage in three ply and polyethylene of 300 gauge in terms of chemical and organoleptic characters [22].

The use of some advance techniques such as irradiation, modified atmospheric packaging was also found to be successful for increasing the storage period of jaggery. An irradiation dose of 7.0 kGy along with LDPE is best suitable for increasing the storage life of jaggery without deterioration [5, 15]. Modified atmospheric packaging (MAP) techniques have also been used along with packaging materials by some research workers. Jaggery cubes 2.5 cm were stored with MAP technique using LDPE, polypropylene (PP), low density polyethylene film (LDPE) and laminated aluminium film for a period of 210 days, to enhance the shelf life by [6]. Results revealed that the jaggery stored in PET films with MAP (70% N₂+30% CO₂) at ambient condition was best with all quality parameters including colour. They also reported that PET film with MAP as 100 per cent nitrogen gas is the best combination to enhance the shelf life of jaggery cubes up to 210 days.

Value addition with jaggery

Jaggery is called as medicinal sugar because of its richness with minerals and vitamins. Its quality can still be increased by incorporating it with material such as aonla pulp, whey, cashew, almond, groundnut, wheat flour, cocoa powder containing proteins, vitamins and minerals etc. This will not only increase the nutritional potential of the jaggery but fetch more market prices increasing its export potential as well. Utilization of whey, a dairy industry waste containing proteins, lactose and minerals increase the nutritional and organoleptic quality of jaggery on one side and also mitigate the problem of disposal of...
REFERENCES

An automatic jaggery making plant with new uniform heating techniques are also need to be developed. Technological advancement in processing of granular jaggery and its storage and value added products. Potential. The organic jaggery is gaining a kind of products from jaggery increases the nutritional quality, fetch better market price and inverses the export and free flowing nature. However, jaggery. The granular form offers advantages over lumped jaggery because of its less moisture content.

Organic jaggery

Use of chemicals such as hydros, phosphoric acid, for jaggery manufacturing resulted in health hazards. Concept of organic jaggery is therefore emerged with the use of herbal clarificants such as bhendi mucilage, deola extract along with lime and citric acid. Jaggery samples prepared organically using citric acid showed superior keeping quality.

Institute and Research Stations working on jaggery processing

- AICRP (All India Coordinated Research Project) on Post harvest Technology, RSJRS (Regional Sugarcane and Jaggery Research Station), Kolhapur
- IISR (Indian Institute of Sugarcane Research), Lucknow
- RARS (Regional Agricultural Research Station), Anakapalle
- GBPUAT, Pantnagar
- VC Farm Mandya
- TNAU, Coimbatore

CONCLUSION

Jaggery, called as a healthiest sugar because of its number of health benefits. The sector is expanding now-a-days with some advancement in its processing, storage and packaging techniques. It is trying to be an alternative to refined sugar. Jaggery is very sensitive product, getting affected by number of factors right from cultivation practices of sugarcane to processing and storage. The technology has been developed to produce a quality crystalline jaggery by altering the processing parameters such as pH, striking point temperature and method of clarification. The herbal clarificants have replaced the use of chemicals. Some packaging materials and storage techniques such as MAP enhances the shelf life of jaggery. The granular form offers advantages over lumped jaggery because of its less moisture content and free flowing nature. However, the technology has not commercialised so far. The value added products from jaggery increases the nutritional quality, fetch better market price and inverses the export potential. The organic jaggery is gaining a kind of popularity. The jaggery sector still needs some technological advancement in processing of granular jaggery and its storage and value added products. An automatic jaggery making plant with new uniform heating techniques are also need to be developed.

REFERENCES


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