Energy Losses in Traditional Jaggery Processing

M Esther Magdalene Sharon*, CV Kavitha Abirami and K Alagusundaram
Indian Institute of Crop Processing Technology, Thanjavur-613 005, India
*E-mail: esther_pfe11@iicpt.edu.in

Abstract
Jaggery is a traditional Indian sweetener prepared using sugarcane. Farmers make jaggery in their own farms using juice obtained after crushing sugarcane with a crusher. The settled juice is boiled in open pans with continuous stirring and, simultaneously clarificants are added in required quantity. The consistency of the juice becomes thick on concentration by boiling and then it is poured into moulds to make jaggery blocks on cooling. The efficiency of crushing and concentration process is 60% and 14.75% respectively. The low efficiency is due to the use of open pans for concentration and using moulds for cooling. Adopting alternative technologies like a steam jacketed vessel which will get preheated water from the cooling and moulding section. Hot water can also be used in improving the crushing efficiency thereby making the jaggery processing energy efficient.

Keywords
Jaggery, Indian sweetener, energy efficient.

Introduction
Jaggery is a traditional Indian sweetener with several uses in daily food preparations and it is also used to make many sweet food preparations. According to prevention of food adulteration rules: Jaggery means, the product obtained by boiling or processing juice crushed out of sugar cane. 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.

Jaggery is called as Gur in India, Desi in Pakistan, Panela in Mexico, rapadura in Brazil, chancaca in Chile and Peru, Hakuru in Sri Lanka, and Naam Taan Oi in Thailand. Although the word jaggery is used for the products of both sugarcane and the date palm tree, technically, Jaggery refers solely to unrefined form of sugar made from sugarcane juice. In India, jaggery has been used as in the making of traditional dishes like chakkari pongal, milk pongal, paayasa obbattu, tilgul, kakvi, laddus and puran poli.

Jaggery is produced in 25 countries with a world annual production of 11.05 million tonnes (FAOSTAT, 2003). The manufacture is concentrated in Asia and South America, the major producers being India with 6.89 million tonnes. In India, nearly 35% of about 250 MT of sugarcane produced is crushed for Jaggery preparation (Indian Sugar, 2005). The amount of sugarcane utilized for the Jaggery preparation is being decreased significantly in last decade because of the growing number of sugar mills and market’s preference towards more and more refined products. But again due to the increase in the health consciousness of the people, the trend is slightly reversing in the last few years (www.indiansugar.com).

Jaggery when used daily may increase human life span. In jaggery consuming areas less incidence of diabetes is reported compared to sugar consuming areas (Kumar K, 1999; Jaswant Singh, 1998). Jaggery from time immemorial has been reported to have many health benefits. Ancient medical scriptures, Sushruta Sanhita (Chapter 45, sloka 146), dating back to 2500 years states how Jaggery is useful in purification of blood, prevents rheumatic afflictions and disorders of bile and possess nutritive properties of high order. It supplements the requirement of iron and calcium in women and children, prevents anemia and increases vitality in men and help in digestion. Magnesium in jaggery strengthens the nervous system and potassium conserve the acid balance in the cells and combats acids and acetones. The preventive action of jaggery on smoke-induced lung lesions (Sahu and Saxena 1994) and the presence of micronutrients in jaggery have antitoxic and an anticarcinogenic property suggests the potential of jaggery as protective agent for workers in industry in smoky environments (Nrashant Singh et al., 2008). In addition, it has potential antioxidant activity owing to the presence of polyphenolic compounds in cane juice (Harish et al., 2009).

Jaggery is marketed in different shapes, colour and texture. The three forms in which Jaggery is available are solid jaggery, liquid jaggery and granular jaggery. Most of the jaggery is prepared in solid form 80% and the remaining 20% is prepared in liquid as well as granular form. Jaggery may be light golden, golden, dark golden, light brown or brown in colour. People from different region have different criteria for the best quality Jaggery. While in north India Jaggery with amorphous texture with
slightly lower sucrose content is preferred, in south India crystalline jaggery with characteristic yellow color is liked (Jagannadha et al., 2006).

Jaggery manufacturing is done on a small scale by a group of farmers creating employment opportunities to the millions of people in rural areas. From time immemorial, sugarcane crop has been known as a cash crop by Indian cultivators and so also the preparation of jaggery. The production of jaggery ranges between five million tonnes to seven million tonnes. It is estimated that two thirds of the sweetening requirement in rural areas is met by jaggery. The jaggery industry in the country has thus, been continued to be an industry of great importance and relevance.

Traditional production process

The unit operations involved in jaggery manufacturing process from sugarcane is presented in the flowchart (Figure 1). It involve juice extraction, juice clarification, juice concentration by boiling, cooling of concentrated juice followed by moulding and storage.

Juice Extraction

The first step in jaggery manufacture is the extraction of juice by crushing sugarcane. Three roller cane crushers (vertical/horizontal) are used to extract juice. Vertical three roller crusher has the juice recovery efficiency of 50-55%, whereas, the same for horizontal crusher is 55-60%. Therefore, the horizontal three-roller crusher is preferable (Figure 2). In sugar factories, the same technique of crushing is used but with multiple crushing and application of hot water during crushing, which increases the efficiency to the extent of 77-80%. This method is not practiced by the jaggery farmers due to more energy requirement for producing hot water and evaporation of this water during boiling process.

One tonne of sugarcane crushed yields 650 kg of juice and 350 kg of bagasse (50% M.C., wb). The bagasse was sun dried to bring down the moisture from 50% to 20% (wb) and after drying, 245-250 kg was obtained from 350 kg bagasse which is used as furnace fuel for concentration of the juice.

Juice Concentration and clarification

The extracted juice is collected in a masonry-settling tank and rested for few minutes for separation of light and heavy particles. The clear juice is drawn from a middle port of settling tank and transferred to an iron open boiling pan made to fill only 1/3rd of its capacity (Figure 3). In general, jaggery quality, storability and its acceptability depend on the clarity of the juice used in preparation.

The juice collected from settling tank is clarified during the boiling stage. It is mostly done by using lime (calcium hydroxide) Calcium acts complexing agent and form scum, which is time to time removed during boiling. Lime addition simultaneously increases the normal pH of juice, i.e. 5.2 – 5.4 (which depend on harvesting status, variety of cane and soil condition) to around 6.0 to 6.4 (Chockalingam. C, 1985). Addition of lime also improves the consistency of jaggery by increased crystallization of sucrose, but at the same time it darkens the colour if added in excess. For preparation of jaggery from over matured canes where sucrose content decreases due to inversion, addition of lime improves the jaggery consistency. The quantity of lime to be added depends upon the quality of lime. One kg of lime (with purity of 80-90%) is mixed with 4L water, and about 60-70 ml of the resulting solution, i.e. milk of lime is proportionate to every 100 kg of cane juice.

Among the other chemical clarificant, hydros are preferred next. However, hydros being a bleaching agent has a decolourisation effect. Addition of super-phosphate, phosphoric acid, chemiflocks and alum are also reported. Use of these chemical clarificants is specific depending on the juice as they may function as bleaching agent, electrolyte or pH adjusting agent. Vegetable clarificants like mucilage’s of bhendi, chikani, kateshevari, etc. were used in early period. Now a days, use of natural clarificants is encouraged due to the problems in exceeding the permitted level for chemical clarificants.

Dried bagasse is utilized as fuel, additionally other fuels like wood, agricultural residues and even old tyres are used. The thermal efficiency of the furnace is as low as 14.75% since the juice is boiled for longer periods at very high temperature (Sada S Rao K., 2003). Vacuum pans, or steam jacketed kettles are an alternative to open pans to make the process energy efficient.

To prevent excess frothing during boiling, small quantity of ground nut/ mustard oil is sprinkled. It also facilitates easy flowing of hot syrup during transfer from one container to another in the following process. Boiling is continued for 2-2.5 h, end point is judged by taking a small quantity of hot syrup from the pan, cooling it in cold water taken in a container, and finally shaping with finger. Shape formation indicates that the pan can be removed from the furnace.

Cooling and Moulding

After the juice is concentrated to 92° Brix it is taken out of fire. Hot syrup is worked out for some time and then let to solidify. For solidification, the contents are transferred to a wooden/aluminum moulds or earthenware pots (Figure 4). This serves both the purpose of cooling and moulding. The shape of solid jaggery may vary from small round balls to large lumps. Some of the common shapes preferred in different parts of the country are listed in Table 1.

During cooling there is a considerable amount of heat lost to the environment. Manually pouring the viscous
Fig. 1. Process flowchart for solid jaggery production

1. Sugarcane
2. Harvesting
3. Extraction of Juice (Crushers)
4. Settling
5. Clarification
6. Concentration (Open Furnace)
7. Cooling
8. Moulding
9. Packaging
10. Storage

Fig. 2. Horizontal three roller crushers
Fig. 3. Juice Boiling in open pan
Fig. 4. Wooden moulds
Fig. 5. Solid Jaggery
jaggery to wooden moulds can be replaced by cooling cum moulding systems which will circulate cold water. The water used for cooling can be circulated for steam production for the concentration process using steam jacketed kettles making the processes efficient and hygienic. This simple method will further reduce the energy load on the farmer.

Packaging and storage

Jaggery is usually stored in earthen pots, metal drums, wooden boxes etc. However, the method of storage varies from region to region. Sometimes, heaps of jaggery is just kept covered with cane trash, bagasse, wheat straw, palmyra leaf mat, cotton seed, furnace ash, rice husk, etc. to protect the jaggery from ambient humidity, without using any container (Figure 5). Moisture content should not exceed 6% and be kept at a relative humidity of 43–61% for good keeping quality of jaggery (Chockalingam. 1985).

Unhygienic Jaggery storage conditions result in change of colour, texture, taste, hardness, flavor and overall quality of jaggery. It is, therefore, important that the jaggery production and storage management should be given utmost care, keeping in view its large scale consumption by masses.

Conclusion

Jaggery processing units in India employ different methodology depending on the variety of raw material, location and availability of energy sources. The farmer’s family is usually involved in jaggery production so the low efficiency is neglected. Low energy efficiency for jaggery production was due to the traditional methods of preparation. The energy consumption pattern revealed the scope for saving of energy during the concentration, cooling and moulding processes. Using steam jacketed vessels for concentration, circulation of cooled water for cooling the hot jaggery and recirculating it for steam production and during crushing will make the jaggery processing energy efficient.

Further Reading


FAOSTAT., 2003. Production of cane sugar using centrifugation, Database FAO


Jaswant Singh., 1998. Proximate composition of Indian sweeteners, Jaggery., Khandarsi Res Digest, 6


