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Preservation and value addition of jaggery

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ABSTRACT : Sugarcane has mainly three processed products *viz*., *Sugar*, *Jaggery* and *Khandsary*, of which jaggery is traditional Indian sweetener. The jaggery industries are grown in different parts of country such as Andhra Pradesh, Bihar, Haryana, Karnataka, Punjab, Maharashtra, Tamil Nadu and Uttar Pradesh. Over 37.2 per cent of the total sugarcane produced was processed for making jaggery and *Khandsari*. Various institutes and number of scientists are working on the jaggery processing and preservation. Many of them have been developed new processing technologies, equipments for production of jaggery, different storage methods for preservation of jaggery, and the value added products to enrich the jaggery. The IISR, Lucknow had developed various processing equipments (pan) and standardized the manufacturing process for hygienic preparation of jaggery. Due to nutritious as well as medicinal value of jaggery, it is more popular in world with great export potential.

KEY WORDS : Jaggery; Value addition, Sugarcane, Processing, Preservation

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Sugarcane, member of grass family, has potential to grow upto 4.5m high under tropical conditions (Yadira *et al*., 2005). Sugarcane which belongs to the genus *Saccharum* has six species namely *S. officinarum, S. barberi, S. sinense, S. robustum, S. sponteneumand* and *S. elude* (Verma, 2004). Sugarcane is the 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 contributes about 90 per cent of the sweeteners' production. About 32 per cent demand of total sweeteners' consumption in the country is met out with jaggery and *Khandsari*, mostly in the rural areas. India produces more than 70% of the total jaggery of the world (Statistics, 2002). In 2008-09, about 37.2 per cent of the total sugarcane produced was processed for making jaggery and *Khandsari* (Anonymous, 2011). Jaggery making is an important cottage industry in India from time immemorial as over 3 million people earn their livelihood from jaggery and *Khandsari* sector, but unfortunately very little has been organized to streamline the production, storage and marketing.

Jaggery commonly known as *Gur* in India, *Desi* in Pakistan, *Panela* in Mexico and South America, *Jaggery* in Burma and African countries, *Hakuru* in Sri Lanka and *Naam Taan Oi* in Thailand. Jaggery is also termed as "*Gur*" in North India and "*vellum*" or "*bellam*" in South India. By definition, Jaggery is the natural sweetener obtained on concentrating the sweet juices of sugarcane with or without prior purification of juice and without use of any chemical/ synthetic additives or preservatives, into a solid or semi-solid state. Although labeled as the poor man's sugar, most Indians consume Gur in some form or the other. Of these, jaggery is considered as a food material, as it contains a large quantity of minerals in addition to energy and is consumed directly as sweetener, and also in different preparations including animal feed mixtures (Singh, 2001). Jaggery is one of the ancient sweetening agents known to man and is an integral part of the rural diet in many countries.

There are mainly three forms of jaggrey which are available in market *viz*., solid jaggery, liquid jaggery and granular jaggery. In India, approximately 80 per cent of jaggery prepared is solid jaggery (in the form of solid structure) and remaining 20 per cent includes liquid and granular jaggery. While concentrating, when solid content reaches to 60-70 ^{0}Brix with a corresponding temperature of 105-108^{o}C (depending upon cane varieties and agro-climatic

zones), the intermediate product collected is popularly known as liquid jaggery (Rao *et al*., 2007 and Nevkar, 2008). The preservatives like benzoic acid (0.1 %) and citric acids (0.5 %) are added which serves dual purpose *i.e*. as a preservative to increase self life and also to check crystallization. The liquid jaggery is a part of diet in most parts of Maharashtra, Gujarat, Kerala, Andhra Pradesh, West Bengal and Tamil Nadu, where it has being used as sweetening agent in most foods and drinks. Also it is being used in pharmaceutical formulations. The granular jaggery is also popular particularly among rural regions. The quality crystalline granular jaggery is prepared by adjusting juice pH to 6.0 – 6.2 by adding lime solution followed by juice boiling and clarified simultaneously using deola (*H. ficulneus*) mucilage as clarificant. The striking point temperature for powder jaggery ranges between 120 and 122°C (Rao *et al*., 2007; Sridevi, 2008 and Singh *et al*, 2011). The hot mass is cooled in the cooling pan with thorough puddling and left without stirring for 5-10 minutes for crystal and slurry formation. The semi cooled mass containing seed crystals is then transferred from pan to aluminium tray and the mass is converted into granules by applying severe shearing action using wooden or stainless steel scrappers. The shearing action exposes the maximum surface to atmosphere results in faster cooling and moisture evaporation. The product is then dried to the moisture level of 1-2 per cent and sieved through 3 mm size sieve to get uniform sized granules. It is then packed into moisture proof polyethylene-polyester laminates and PET bottles.

A quality jaggery is golden yellow in colour, hard in texture, crystalline in structure, sweet in taste, less in impurities and low in moisture. The quality jaggery is influenced by the variety of cane grown, quantity of fertilizers used, quality of irrigation water and method of processing adopted. The importance of jaggery is enhanced due to its low cost and high nutritive value. The composition of all forms of jaggery per 100 g is given in Table 1.

The jaggery contains an enormous wealth of minerals, protein and vitamins inherently present in sugarcane juice and this crowns it as one of the most wholesome and healthy sugars in the world. More importantly, jaggery has great nutritive and medicinal value because daily use of jaggery may increase human life span. It has the reputation of being a medicinal sugar and is prescribed as ayurvedic medicine in health problems like dry cough, cough with sputum, indigestion, constipation, etc. There are scanty numbers of reports available on occurrence of diabetes patient in jaggery consuming areas. Ancient medical scripture, *Sushrata Samhita* state how it purifies the blood which prevents rheumatic afflictions and bile disorders. The preventive action of jaggery on smoke-induced lung lesions suggests the potential of jaggery as protective agent for workers in industry in smoky environments. Magnesium found in jaggery strengthens the nervous system and potassium conserve the acid balance in the cells and combats acids and acetones. Jaggery is very rich in iron and prevents anemia. So, it supplements the requirement of iron and calcium in women and children and also increases vitality in men and help in digestion. Jaggery contains 28g/kg of mineral salts, as against only 300mg/kg is found in refined sugar. The micronutrients present in jaggery have antitoxic and anti-carcinogenic properties. Its dietary intake can prevent the atmospheric pollution related toxicity and the incidence of lung cancer (Rao *et al*., 2007).

Processing of jaggery:

Gur (jaggery) manufacturing starts from October and continues up to May, depending on the location and is stored both for marketing and human consumption during the remaining part of the year. However, the manufacturing process depends on the ultimate form to be produced. Also the processing of jaggery varies widely from state to state, in the state from one district to another and some cases within the district also. Jaggery making from sugarcane

Table 1 : Composition of different forms of jaggery

Composition per 100g	Types of jaggery		
	Solid	Liquid	Granular
Water (g)	3-10	30-35	1-2
Sucrose (g)	65-85	40-60	80-90
Reducing sugar (g)	9-15	15-25	5-9
Protein (g)	0.4	0.5	0.4
Fat (g)	0.1	0.1	0.1
Total minerals (g)	0.6-1.0	0.75	0.6-1.0
Calcium (mg)	8.0	300	9.0
Phosphourous (mg)	4.0	3.0	4.0
Iron (mg)	11.4	8.5-11	12
Calorific value (Kcal)	383	300	383

Source: Jaswant Singh, 1998; Rao *et al.*, 2007 and Wood, 1978

involves mainly four unit operations *viz*., juice extraction, juice clarification, juice concentration by boiling/heating, cooling of concentrated juice followed by molding and storage, and the process flow is as shown in flow chart *i.e*. Fig. 1.

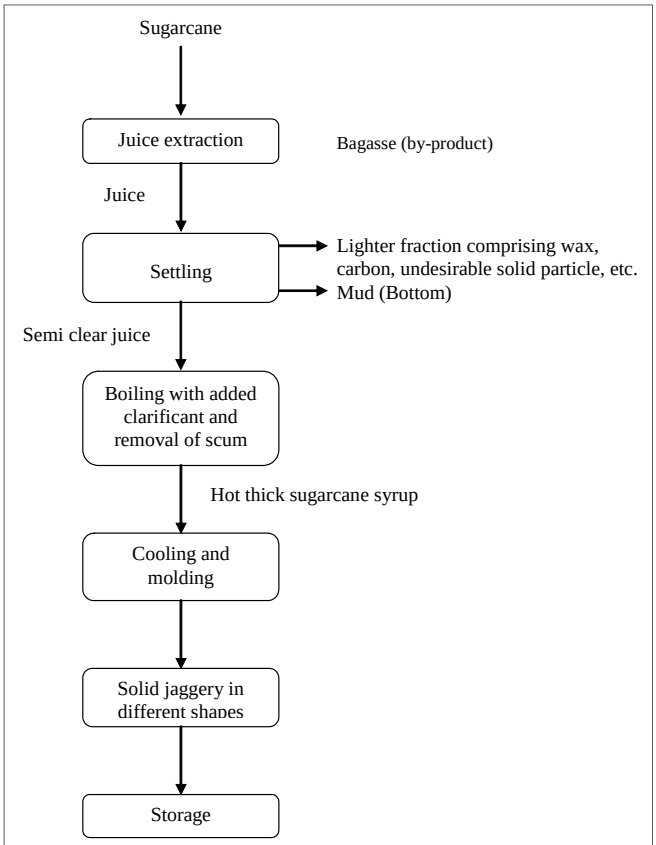

Fig. 1 : Process flow chart for solid jaggery manufacture (Rao *et al.*, 2007 and Singh *et al.*, 2011)

The unit operations involved in jaggery manufacturing is described as below:

Juice extraction :

Juice extraction by crushing sugarcane is first step towards jaggery manufacturing. Usually, 2-5 roller crusher is used for extraction of juice which may be power operated (engine/electric) or animal driven vertical/horizontal crusher. Vertical three roller crusher has the juice extraction efficiency of 50-55%, whereas same for horizontal crusher has 55-60%. Therefore, horizontal crusher is preferable. The juice extraction (%) depends upon crusher setting, crop parameter and operating conditions.

Juice clarification:

The extracted juice collected through underground PVC pipeline into a masonry-settling tank covered with muslin cloth for removal of heavy impurities and rested for few minutes for separation of light and heavy particles. The clear juice is then drawn from a middle port of settling tank and pumped into boiling pan kept on furnace to fill 1/3rd of its capacity for concentration. In general, jaggery quality, storability and its acceptability depends on the clarity of the juice used in preparation. The clarification is mostly done during boiling stage. It is mostly done by using lime (Calcium hydroxide) which not only clarifies juice but also improves the consistency of jaggery by increased crystallization of sucrose, but at same time it darkens the colour if added in excess. Among the other chemical clarificant, hydros super-phosphate, phosphoric acid, chemiflocks and alum are reported. Vegetative clarificants like mucilage's of *bhendi*, *chikani*, *kateshevari*, deola (*Hibiscus ficulneus*), etc. were used in early period. Out of these vegetative clarificants deola was found to be the most effective (Singh, 1998 and Banerji, 2008). The application of synthetic clarificants *viz*., *Bhendi* powder or SN_2 @ 2 mg/litre (2 ppm) with *bhendi* plant @ 2 kg per 100 litre of sugarcane juice is recommended for maximum removal of scum, improving the colour and higher jaggery recovery and also helpful in maintaining quality of jaggery during storage (Patil *et al*., 2005).

Juice concentration :

The boiling of sugarcane is second important stage. After clarification, juice is boiled vigorously over the furnace. It is usually done using bagasse of cane as a fuel. A little quantity of oil (ground nut/mustard/coconut) is added to prevent excess frothing which facilitates easy flowing of hot syrup during transfer from one container to another. However, based on requirement of jaggery production, furnace design varies from place to place *i.e*. the furnace may have 1-5 pans. In coastal region of Andhra Pradesh, one pan is placed on the furnace, while 2 to 3 pans are placed in Rayalaseema and Telangana region, respectively. Such variation is also found in other states also. The overall heat utilization efficiency of the traditional type furnaces used by farmers is very low and needs drastic improvement. Indian Institute of Sugarcane Research (IISR), Lucknow has developed improved/efficient two and three pan furnace which saves bagasse (Singh *et al*., 2009; Singh, 2009). The two pan furnace having fins at the bottom improves the efficiency and also saves fuel (28%) and juice processing time (17%) (Anwar, 2010; Anwar *et al*., 2009). The triple pan furnace developed by IISR, Lucknow has heat utilization efficiency of 34.3% which is obtained by trapping waste heat going along flue gases through chimney and is utilized for pre-heating of juice.

The boiling is continued for 2-2.5 hr till the juice attains temperature of 118^{o}C. The 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. If shape is formed it means that the pan can be removed from the furnace. The moisture content of this syrup is somewhat higher than 10-12% (d.b.)

Molding :

Properly concentrated juice with appropriate consistency *i.e.* hot syrup is worked out for some time and then allowed to solidify by transferring into a wooden tray and puddle using ladle. The concentrate is then transferred in to the mould of desired shape for shaping purpose. The shape of jaggery is varies with place to place; some common shape preferred in different parts of country like, rectangular (0.25-1 kg), bucket shaped (10-20 kg), trapezoidal lumps (5 kg), round balls, etc. Some these shapes are complicated and create problem while molding, drying, packaging and distribution, etc. IISR lucknow has developed different molding frames and techniques for molding jaggery in to different shapes and sizes *viz*., brick (250 and 500 g), cubes (20-25 g) and rectangular (10-11 g).

Grading :

The physical properties *viz*., colour, hardness and texture are important as these affect marketing of jaggery. The chemical properties like taste, flavor, sucrose content, reducing sugars, moisture, water insoluble matter, sulphated ash SO_2, etc. based on which different jaggery grading have been takes place. Indian standard for Jaggery grading is given in Table 2.

Table 2 : Indian standard for different grades of jaggery

Composition	Grade I	Grade II
Sucrose (%, (d.b.), min)	80	70
Reducing sugar (%, (d.b.), max)	10	20
Moisture content (%, (d.b.), max)	5	7
Water insoluble matter (%, (d.b.), max)	1.5	2.0
Sulphated ash (%, (d.b.), max)	3.5	5.0
Sulphur dioxide (ppm, (d.b.), max)	50	50
Ash insoluble in dilute HCl (%, (d.b.), max)	0.3	0.3

Source: IS 12923: 1990

Preservation of jaggery:

The keeping quality of jaggery largely depends on the atmospheric humidity and temperature. Jaggery is mostly spoiled during the monsoon period because of presence of higher humidity in the atmosphere. The major problem associated with jaggery storage is the presence of invert sugars and mineral salts which having hygroscopic nature. The hygroscopicity arises from non-sucrose constituents like glucose, fructose and protein, etc. For good keeping quality, moisture content of jaggery should not exceed 6% and be kept at a relative humidity of 43-61%. In the coastal region of the country, where atmospheric humidity is very high as well as the higher monsoon rainfall, it is very difficult to store jaggery. The study showed that about 5-10 % of stored jaggery get spoiled every year leading to a huge loss of 800 m rupees.

The moisture absorption sets up favorable condition for growth of different types of bacteria and fungi which ultimately leads to the production of alcohols, organic acids and complex decomposition products. The yeast and contaminating microorganisms *viz*., *Leuconostoc mesentroides, Leuconostoc dextranicum, Aerobactor arogenes,* and *Bacillus mesenteries* have been identified in fresh sugarcane juice (Owen, 1990). The species of microorganisms most commonly occurring in raw sugars are *Bacillus subtilis, B. mesentericus, B. vulgatus, Aerobacter aerogens, Actinomyces, Saccharomyces, Penicillia, Mucor, and Aspergillus* (Owen, 1990). Aline *et al*. (2006) determined heterotrophic bacteria, thermo-tolerant coliform, *Salmonella*, and other parasites in the sugar cane juice being sold by street vendors without any heat treatment. There are nine microbial isolated from jaggery *viz*., *Alcaligenes, Xanthomonas, Acinetobacter, Micrococcus, Corynebacterium, Alteromona, Bordetella and Enterococcus* (Singh *et al*., 2009). Out of these nine isolate *Acinetobacter, Bordetella, Corynebacterium, Enterococcus* and *Xanthomonas* may be pathogenic to some extent. It is, therefore, important that the jaggery manufacturing and post harvest quality management of jaggery should be given utmost care, keeping in view its large scale consumption by rural masses.

In India, the jaggery storage facilities at producer/ farmer level are very poor as it is stored in godowns, household kitchens, and cheap storage systems where hygienic conditions are not strictly maintained, which attracts several pathogenic and non-pathogenic microorganisms. In the western and eastern region of country, jaggery traditionally stored in matka, gunny bags or kept as it is in open atmosphere. Cold storage godown is being used in west Godavari and Vishakhapatnam district of Andhra Pradesh, Kolhapur district of Maharashtra and Muzaffarnager area of Uttar Pradesh. But for small farmers storing jaggery in the cold storage is very difficult due to cost and energy consumption factor. Keeping these problems in the view, IISR, Lucknow had developed drying cum storage bin, which is made up of galvanized iron sheet. It is cylindrical in shape with lid covering and chimney at center of the lid. The developed bin is as shown in Fig. 2.

The comparative study of matka, glass jar, polythene bags, urea bags and IISR bins for storing jaggery lumps showed that IISR bins are good for storage of jaggery in hilly, Tarai as well as plain regions in terms of quality. Using IISR

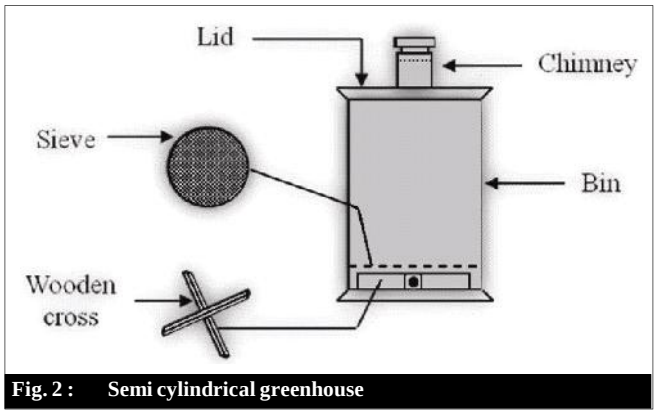

Fig. 2 : Semi cylindrical greenhouse

bins the moisture content decreases upto 6-7 per cent during summer from initial moisture of 13-14 per cent. Before rainy season the lid and holes of the bin are closed tightly so that moisture migration from outer environment to jaggery will not takes place (Chand *et al*, 2011; Chand *et al*, 2012).

Shinde *et al*. (1983) reported that by using the polythene film of any colour, moisture absorption and liquefaction of jaggery can be avoided. Low density polyethylene film (LDPE) absorbs the water less than 0.01% in 24 h. Jaggery irradiated at 7.0 kGy stored in low density polyethylene (LDPE) pouches was found to be best till the end of the storage period when compared to 3 and 5 kGy treated samples (Sankhla *et al*., 2011). Kapur and Kanwar (1983) reported that the jaggery stored in tin containers absorbed much less moisture compared to earthen pots. Singh (1998) reported that the plastic containers recorded good retention of shape of jaggery with less reduction in hardness. Jaggery packed with hessian cloth lined with polyethylene sheet alone or packed with tin foil covered with polyethylene or hessian cloth was found better than wooden and card board boxes, thick gunny bags, plastic containers and earthen pots. Three ply (PET/Al FOIL/POLY) packaging material helped more in checking the 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 (bheli) and brick shaped jaggery, respectively (Singh and Singh, 2008). The three ply packaging material was superior because of higher strength low water vapour transpiration rate (0.14 g/ m^2/24 h) and least oxygen transmission rate (207.0 ml/m^2/ 24 h). Mandal *et al*. (2006) reported that the best packing material in terms of preventing ingress of atmospheric moisture and for maintaining the keeping quality of *Gur* stored at village/ domestic level during the monsoon season was heat sealed LDPE packet of 150 gauge followed by glass jar, PET jar and used canisters of kerosene/edible oil with lid. Gupta *et al*. (2002) observed that nitrogen packaging of solid jaggery maintained freshness for longer period compared to vacuum packaging which hardened the jaggery samples.

Value addition of jaggery:

Addition of an aonla :

Phyllanthus emblica (syn. *Emblica officinalis*), the Indian gooseberry, or *aamla*, five out of the six tastes recognized by Ayurved. It is extensively used as a rejuvenator in ayurveda. Aonla fruit is highly nutritive with a great medicinal use and the richest source of vitamin C, the pulp of fresh fruit contains 200-900 mg of vitamin C. In living organisms ascorbate acts as an antioxidant by protecting the body against oxidative stress. Due to its strong, cooling and laxative properties it has been widely used in hemorrhage, diarrhea and dysentery. It also prevents infection due to the antibacterial and astringent attributes present in it. It has been widely used for treatment of leucorrhea and atherosclerosis. Gooseberry juice has great strength to replenish your lost energy source.

Value-added jaggery may fetch better market prices and will have great export potential. Addition of aonla (*Emblica officinalis*) in jaggery has been done to improve its taste, nutritional value and ultimately to make value added product. The process for making jaggery with aonla as a natural source of vitamin C includes processing of aonla in suitable form, quantity to be added and the suitable stage for addition in jaggery. Analysis of samples indicated incorporation of 75.4mg of vitamin C/100 g of jaggery sample. (Anwar and Singh, 2010).

Miscellaneous value added products :

Value addition to solid jaggery by inclusion of nutritive substances through puffed rice, gram, sesame and various kinds of nuts (cashew, almond), vitamins, iron, and taste enhancers like chocolate powder will increase demand for this kind of jaggery. The nutritive value and palatability can be enhanced by preparing different kinds of jaggery with the addition of puffed rice, gram and groundnut in different proportions of 1:0.75, 1:1, 1:1.25, 1:1.5, 1:1.75 (Jaggery patti), mixing with wheat flour in proportions 90:10, 80:20, 70:30, 60:40, 50:50 and 40:60 (Jaggery-wheat flour extruded snacks) and mixing with gram flour (Jaggery-besan snacks). The jaggery with 10% cocoa powder yielded a product (chocolate) which was very much acceptable as a substitute for chocolate. Value added jaggery will be a cheap source of nutrition to the poor and malnourished.

Conclusion:

The jaggery production industries, ancient and one of the important rural based cottage industries creates new way of employing unemployed people. Even though IISR bin is very good for storage of jaggery, there is need to study jaggery storage using alternative techniques and materials.

Preservation can be enhances by incorporating different natural preservatives. The value addition of jaggery has tremendous scope as there was lack of past work on value addition. The value addition improves the nutritional value of the jaggery by adding various vitamins, minerals which are not present or in fewer amounts.

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