Indian Journal of Traditional Knowledge
Vol. 6(1), January 2007, pp. 95-102

Jaggery – A Traditional Indian Sweetener

PVK Jagannadha Rao, Madhusweta Das & SK Das*

Department of Agricultural and Food Engineering, Indian Institute of Technology, Kharagpur 721 302, West Bengal
Email: pvkjrao@rediffmail.com
Email: madhu@agfe.iitkgp.ernet.in
Email: skd@agfe.iitkgp.ernet.in

Received 28 September 2005; revised 14 September 2006

Jaggery is the sugarcane based traditional Indian sweetener. At present, 24.5% of the cane produced in India is being utilized for producing jaggery. Jaggery is nutritious and easily available to the rural people. Compared to white sugar, it requires low capital requirement in production and is manufactured at the farmer's individual units itself. Of the total world production, more than 70% of the jaggery is produced in India. To meet the future sweetener requirement, the scope of jaggery seems to be promising.

Keywords: Jaggery, *Khandsari*, Indian sweetener, Traditional sweetener, Traditional sweetening agent
IPC Int. Cl.[8]: A61K36/00, A01G1/00, A01G17/00, A47G19/00, A23L1/00, A23L1/06

India is the largest consumer and the second largest producer of sugar in the world[1]. Sugar industry is the second largest organized sector industry in the country[1]. Among the sugar yielding crops like sugarcane, sugarbeet, palms and sorghum, sugarcane is the most important. Presently, sugarcane is cultivated in an area of about 4.361 m ha producing about 281.575 m tonnes of sugarcane annually[2] (Table 1). 90 % of the production comes from Bihar, Haryana, Punjab, Uttar Pradesh, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu; Uttar Pradesh being the maximum producer[3]. During the past five decades though sugarcane production has increased around three-fold (Table 2), the sugar recovery has not shown any upward trend[1,2,4]. It has always been hovering around 10%. Therefore, the Indian sugar industry, presently, is facing a tough competition in the international market. The cost of sugar production in India is about 30 % higher than the international market price[3].

Jaggery (also called as *Gur* in India, *Desi* in Pakistan, *Panela* in Mexico and South America, Jaggery in Burma & African countries, *Hakuru* in Sri Lanka, and *Naam Taan Oi* in Thailand) and *khandsari* are traditional Indian sweeteners, which are produced in addition to sugar from sugarcane[5]. These traditional sweeteners are the natural mixture of sugar and molasses. If pure clarified sugarcane juice is boiled, what is left [usually possessing sucrose (65-85%)] as solid is jaggery. *Khandsari* sugar is a finely granulated, crystallised sugar that contains 94-98 % sucrose[6]. In the early 1930's, nearly 2/3rd of sugarcane production was utilized for production of these alternate sweeteners, jaggery and *khandsari*. With the introduction of sugar mills and their multiple growth, better standard of living and higher per capita income, the sweetener demand has shifted to white sugar, which contains purely sucrose (99.7%)[6]. Therefore, jaggery and *khandsari* production got a set back to some extent. In spite of this, still, at present about 32.5% of cane produced (Table 3) is being utilized for producing jaggery and *khansari*, which is a dominant cottage industry in rural India, engaging over 2.5 million people[2,4,6,7]. The per capita consumption of different sweeteners (Table 4) indicates that out of total consumption of 26.47 kg/annum, 8.72 kg/annum (~33%) is met by jaggery and *khandsari*; however, mostly it is consumed by the rural population, which is in the tune of 72% of the total population in India[8,9]. State wise production of jaggery and *khandsari* is presented (Table 5). However, being in the small-scale sector, these two sectors are completely free from controls and taxes, which are applicable to the sugar sector[10]. It is estimated that, by 2020 AD, the per capita consumption of sweeteners would increase to about 40 kg/annum from the current level of 26.47 (Tables 4 & 6)[2,8,11]. Thus, the country would need about 50.75 m tonnes of sweeteners (Table 6), of which jaggery and *khandsari* would be about 23.75 m tonnes against today's production level of 9.978 m tonnes (Table 5).

*Corresponding author

Table 1—State wise area and production for sugarcane in India (2002-2003)

State	Cane area (m/ha)	Cane production, (m/ tonnes)
Andhra Pradesh	0.234	15.387
Assam	0.025	0.916
Bihar	0.187	4.601
Chhattisgarh	0.009	0.021
Goa	–	–
Gujarat	0.203	14.071
Haryana	0.18	8.000
Jharkand	0.007	0.13
Karnataka	0.385	32.479
Kerala	0.003	0.273
Madhya Pradesh	0.053	2.084
Maharashtra	0.599	37.015
Orissa	0.014	0.753
Pandichery	–	–
Punjab	0.154	9.29
Rajasthan	0.01	0.422
Tamil Nadu	0.284	30.282
Uttar Pradesh	1.852	116.324
Uttaranchal	0.13	7.708
West Bengal	0.02	1.281
Others	0.012	0.538
Total	4.361	281.575

Source: Nerkar, YS (2004)

Table 2—Decade wise production of sugarcane in India

Year	Production (m/ tonnes)	Sugar recovery (%)
1950-51	74.8	–
1960-61	110.5	–
1970-71	126.368	–
1980-81	154.248	–
1990-91	241.045	9.85**
2000-01	295.96*	10.48
2001-02	298.422*	10.27

Sources: Anwar Alam (1999); **Vikas Singhal(2003); *Nerkar, Y.S(2004)

Table 3—Production and utilization of sugarcane in India

Year	Production (m tonnes)	Percentage of sugar cane utilized for production of white sugar	Jaggery and *Khandsari*	Seed, feed and chewing
1950-51	74.8	19.6	59.5	20.9
1960-61	110.5	29.6	51.7	18.7
1970-71	126.368	30.2	57.8 12.0	
1980-81	154.248	33.44	54.76	11.8
1990-91	241.045	52.25	35.55 12.2	
2000-01	295.96	62.5	29.1	8.40
2001-02	298.422	57.4	31.5	11.1
2002-03	281.575	68.9 20	1 11.0	
2003-04	236.00	56.1	32.5	11.4

Sources: Anwar Alam (1999); Nerkar, Y.S (2004); http://www.indiansugar.com/sugarstn.htm.

Table 4—Per capita consumption of Indian sweeteners

Sugar Year	Per capita consumption (kg/annum)		Total per capita consumption (kg annum)
	Sugar	Jaggery & *Khandsari*	
1975-76	6.06	13.74	19.80
1980-81	7.28	12.46	19.74
1985-86	11.12	10.99	22.10
1990-91	12.60	10.66	23.25
1994-95	13.44	12.01	25.45
1995-96	13.85	9.08	22.93
1996-97	14.47	9.00	23.47
1997-98	15.56	8.99	24.55
1998-99 (P)	16.13	9.00	25.13
1999-00 (P)	16.92	8.88	25.80
2000-01 (P)	17.75	8.72	26.47

Source: http://www.indiainfoline.com/sect/suin/ch07.html

Table 5—State wise estimates of jaggery production (including khandsari) Jaggery production, million tonnes

State	1992-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	2000-01	2001-02
Andhra Pradesh	0.617	0.612	0.575	0.519	0.657	0.475	0.391	0.559	0.673	0.792
Assam	0.126	0.114	0.124	0.123	0.124	0.108	0.103	0.096	0.083	0.089
Bihar	0.168	0.137	0.055	0.037	0.110	0.111	0.136	-	0.039	0.115
Haryana	0.229	0.238	0.241	0.164	0.234	0.248	0.143	0.153	0.117	0.268
Karnataka	1.064	1.624	1.645	0.053	1.298	1.657	1.380	1.038	1.131	1.294
Madhya Pradesh (B)	0.056	0.056	0.047	0.030	0.066	0.074	0.050	0.070	0.045	0.111
Punjab	0.122	0.076	0.101	0.071	0.274	0.261	0.170	0.130	0.169	0.283
Tamil Nadu	1.07	1.172	1.182	1.064	1.203	1.316	1.141	1.262	1.182	1.443
Uttar Pradesh (C)	5.915	6.075	5.672	5.304	6.442	7.052	5.913	5.022	4.880	4.918
Uttaranchal	--	--	--	--	--	--	--	--	--	1.80
Others	0.488	0.422	0.455	0.080	1.153	0.496	0.478	0.389	0.290	0.485
All India	9.862	10.526	10.09	7.445	11.561	11.798	9.905	8.719	8.609	9.978

B = includes Chattisgarh; C= includes Uttaranchal
Source: Indian Sugar (March, 2004)

Thus, there are strong indications that the jaggery and *khandsari* cottage industry would continue to play an important role in processing sugarcane at rural level and in creating employment opportunities to the millions of people in rural areas.

Compared to *khandsari*, jaggery is a wholesome diet. It contains 0.6%-1.0% minerals[12]; important among them are iron (11mg%), calcium (0.4%), magnesium and phosphorous (0.045%). Jaggery also contains reducing sugars including glucose and fructose (10-15%), protein (0.25%), and fat (0.05%). *Khandsari* owing to only a thin film of molasses coating on sugar crystal contains lower quantity of such ingredients. Daily use of jaggery may increase human life span[12]. Incidence of less diabetes is reported in jaggery consuming areas compared to sugar consuming areas. The nutritive value of jaggery and *khandsari* as compared to sugar is presented (Table 7) [13]. Sugar needs extra heat for digestion. It takes calcium and potassium from the body without which it just cannot be digested[14]. Jaggery is often called the medicinal sugar and possesses nutritive properties of high order. Ancient medical scripture, *Sushrata Samhita* state how it purifies the blood, 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[15]. 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. Jaggery supplements the requirement of iron and calcium in women and children and also increases vitality in men and help in digestion[15]. The micronutrients present in jaggery have antitoxic and anticarcinogenic properties. Its dietary intake can prevent the atmospheric pollution related toxicity and the incidence of lung cancer[16].

The jaggery recovery ranges from 10.00 to 11.84; whereas the recovery of *khandsari* ranges within 4.5-5.5% and 6.5-7.5% in traditional non-sulphur process and semi-modernized process, respectively[7,17]. *Khandsari* units are small-scale sector units and jaggery manufacturing is done at the farmer's individual units[18]. Capital requirement in jaggery making is very less. Probably for these reasons, in the total share of sugar cane utilized for jaggery and *khandsari*, only about 8 % is being utilized for production of *khandsari* and based on this, the estimated jaggery production (Table 8) is shown[2,4,17,19]. Jaggery industry is one of the old and one of the large agro processing industries in India under decentralized sector[4].

Jaggery is available in the market mainly in three forms namely solid jaggery, liquid jaggery and granular jaggery (Figs. 1-3). Of the total production of jaggery in India, approximately 80% of the jaggery is prepared in solid form and the remaining 20% is prepared in liquid as well as granular form. Liquid jaggery is a part of diet in most parts of Maharashtra & West Bengal and is gaining commercial importance[20]. The liquid jaggery is being utilized as sweetening agent in foods and drinks in Maharashtra, Gujarat, Kerala, Andhra Pradesh, West Bengal and Tamil Nadu. Also it is being used in pharmaceutical formulations[21]. The granular jaggery is also popular particularly among rural masses[20]. Sugarcane juice is an opaque liquid and varies in colour from gray dark green to light yellow depending upon the colour of cane. In addition to various nutritional constituents, it also contain mud, wax and several other soluble and in soluble impurities. To maintain proper quality in jaggery, all these soluble and in soluble undesirable fractions should be removed. However, the manufacturing process depends on the ultimate form to be produced. Also, the minute detail of the process varies widely from state to state, in the state from one district to another, and in some cases within a district also. Jaggery manufacturing process consists of the following unit operations, i.e., juice extraction, juice clarification, juice concentration by boiling, cooling of concentrated juice followed by moulding and storage (Fig. 4). Extraction of juice by crushing sugarcane is the first step in jaggery manufacture. Three roller cane crushers (vertical/horizontal) are used to extract juice (Figs. 5 & 6). 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. 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. 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

Table 6—Projections of sweetener requirement in India

Year	Expected population, million	Per capita expected Consumption, Kg/annum			Sweetener requirement, million tonnes including export		
		Sugar	Jaggery & *Khandsari*	Total	Sugar	Jaggery & *Khandsari*	Total
1998-99*	950	14.9	10.4	25.3	14.15	9.88	24.03
2010	1100	19.0	15.00	34.0	23.00	17.0	40.00
2020	1250	21.6	19.00	40.0	27.00	23.75	50.75

Source: Nerkar, Y.S (2004).
*Actual; projected data calculated on the basis of expected human population and per capita consumption of sugar

Table 7—Nutritive value of jaggery, *khandsari* and sugar per 100gm

Particulars	Jaggery	*Khandsari*		Sugar
		Sulphur Process	Non-sulphur process	
Sucrose,	65-85	97.5	96.0	99.5
Reducing sugars	10-15	-	-	-
Proteins, g	0.4	-	-	-
Fats, g	0.1	-	-	-
Total Minerals	0.6-1.0	0.05	0.2	0.05
Calcium, mg	8.0	100	100	-
Phosphorus, mg	4.0	-	-	-
Iron, mg	11	-	-	-
Moisture, g	3-10	0.3	0.5	0.2-0.4
Energy, Kcal	383	395	388	398

Source: Jaswant Singh (1998).

Table 8—Estimated figures of jaggery production in India (million tones)

Year	Sugarcane production	Percentage of sugarcane utilized for jaggery and *khandsari* production	Percentage of sugarcane utilized for *khandsari* production	Percentage of sugarcane utilized for jaggery production	Weight of sugarcane utilized for jaggery production	Sugarcane to jaggery recovery in percentage	Jaggery production,
1	2	3	4*	5 (3-4)	6 (2 × 5/ 100)	7**	8 (6 × 7/ 100)
1950-51	74.8	59.5	8	51.5	38.52	10	3.85
1960-61	110.5	51.7	8	43.7	48.29	10	4.83
1970-71	126.368	57.8	8	49.8	62.93	10	6.29
1980-81	154.248	54.76	8	46.76	72.13	10	7.22
1990-91	241.045	35.55	8	27.55	66.41	10	6.64
2000-01	295.96	29.10	8	21.10	62.45	10	6.25
2001-02	298.422	31.50	8	23.50	70.13	10	7.02
2002-03	281.575	20.10	8	12.10	34.07	10	3.41
2003-04	236.00	32.50	8	24.50	57.82	10	5.78

Sources: Anwar Alam (1999); Nerkar, Y.S (2004)
*Assumed that 8% of sugarcane production is being utilized for production of *khandsari* (Ref 19);** Assumed that sugarcane to jaggery recovery is 10% (Ref 17)

middle port of settling tank and transferred to boiling pan to fill only 1/3rd of its capacity. Boiling of sugarcane juice is the second important step. Boiling is usually done using bagasse of the cane as the fuel (Fig. 7). No supplementary fuel is used. However, furnace design varies from place to place. In Andhra Pradesh, in the coastal region, one pan is placed on the furnace, while 2 and 3 pans are placed in Rayalaseema and Telangana region, respectively. This type of variation is 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.

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 further clarified during the boiling stage. It is mostly done by using lime (calcium hydroxide) (Fig. 8).

Calcium acts complexing agent and form scum, which is time to time removed during boiling. Lime addition simultaneously increases the normal *p*H 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[22]. 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[22]. For preparation of jaggery from over matured canes where sucrose content decreases due to inversion, addition of lime improves the consistency of jaggery[22]. 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, hydro being a bleaching agent has a decolourisation effect. Addition of super- phosphate, phosphoric acid, chemiflocks and alum are also reported[23]. Use of these chemical clarificants is specific depending on the juice as they may function as bleaching agent, electrolyte or *p*H adjusting agent[23]. Problem of using chemical clarificants is that in most of the cases, limit of addition exceeds the permitted level. Vegetable clarificants like mucilage's of *bhendi*, *chikani*, *kateshevari*, etc. were used in early period. But, because of being natural material, now a days emphasis are given on clarificants. The quantum of juice boiled at a time is 350-400 kg, contained in one pan. Boiling is continued for 2–2.5 hrs till the juice attains a temperature of 118^{0}C. 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. Moisture content of this concentrated syrup is somewhat higher than 10-12% (d.b.). During boiling, small quantity of ground nut/ mustard oil is sprinkled to prevent excess frothing. Oil also facilitates easy flowing of hot syrup during transfer from one container to another in the following process.

Properly concentrated juice is taken out of fire. Hot syrup is worked out for sometime and then let to solidify. For solidification, the contents are transferred to a wooden/aluminum moulds or earthenware pots (Fig. 9). This serves both the purpose of cooling and moulding. The shape of solid jaggery may vary from small round balls to large

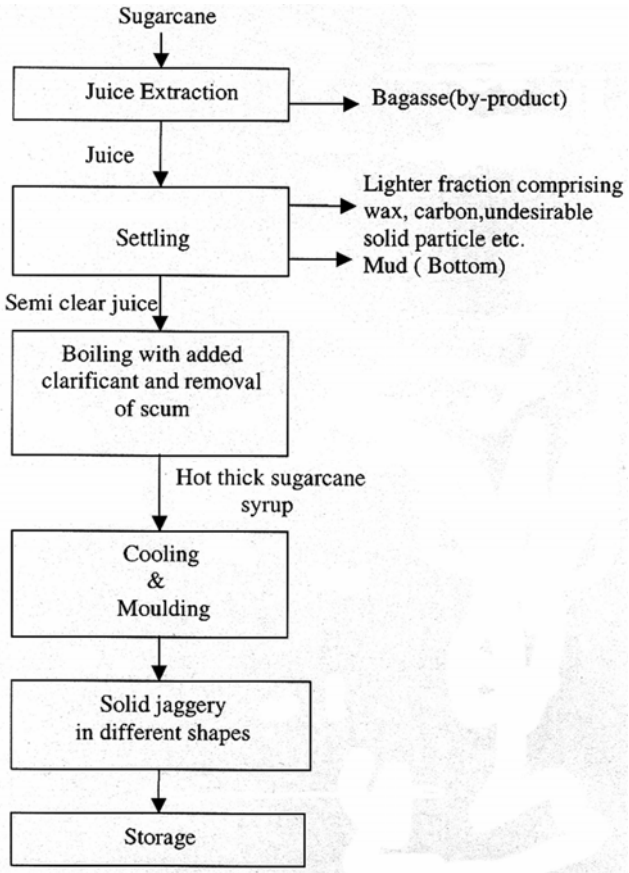

Fig.4 Process flow chart for solid jaggery manufacture

lumps. Some of the common shapes preferred in different parts of the country are shown (Fig. 10). These are rectangular (250 gm-1 kg), bucket shaped (10-20 kg) and trapezoidal lumps (5 kg), etc. After solidification, the moisture content of solid jaggery reduces to 10-12% (d.b.). Storage of jaggery varies from region to region such as in earthen pots, wooden boxes, metal drums, etc. Sometimes, without any container, heap of jaggery is just kept covered with cane trash, bagasse, wheat straw, cotton seed, furnace ash, palmyra leaf mat, rice husk, etc. to protect the jaggery from ambient humidity. Jaggery deteriorates fast and become watery within 3 or 4 months because of presence of moisture, invert sugar and its hygroscopic nature[24]. The hygroscopicity arises from non-sucrose constituents like glucose, fructose, protein, etc. For good keeping quality, moisture content of jaggery should not exceed 6 % and be kept at a relative humidity of 43–61%[24]. It is very difficult to store jaggery during monsoon, especially in coastal areas of high rainfall and humidity. It is estimated that, about 5-10% of stored jaggery get spoiled every year leading to a colossal loss to the tune of 800 m

Fig.1 Solid jaggery

Fig. 2 Liquid jaggery

Fig. 3 Granular jaggery

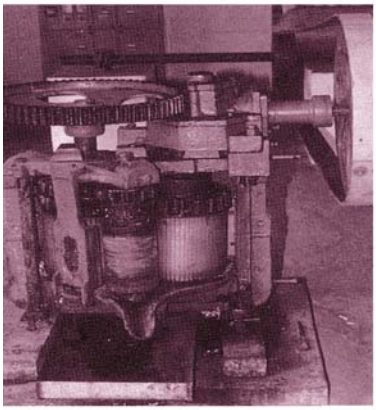

Fig. 5 Vertical three roller crusher

Fig. 6 Horizontal three roller crusher

Fig. 7. Juice boiling in open pan

Fig.8 Lime addition for juice clarification

Fig. 9. Transferring hot thick syrup into wooden moulds

Fig.10 Shapes & sizes of jaggery

Fig.11. Stirring of hot thick syrup for uniform cooling

Fig.12 Hot thick syrup transferred to tray for scrapping

Fig.13 Scrapping into granules with wooden scrappers

Fig.14 Drying of granular jaggery

rupees. Cold storage godown is being used in West Godavari & Visakhapatnam districts of Andhra Pradesh, Kolhapur district of Maharashtra and Muzaffarnagar area of Uttar Pradesh.

While concentrating, when solid content reaches to 60-70 Brix with a corresponding temperature of 105-106°C, the juice is collected[25]. This is popularly known as liquid jaggery. The composition per 100 gm of liquid jaggery is: water 30-35 gm, sucrose 40-60 gm, invert sugar 15-25 gm, protein 0.5 gm, fat 0.1 gm, total minerals 0.75 gm containing usually 300 mg calcium, 3.0 mg phosphorous and 8.5-11 mg iron. Calorific value is 300 Kcal/100 gm of liquid jaggery. However, preservatives like 0.1% potassium meta-bisulphite or 0.5% benzoic acid is added to increase the shelf life[21]. Care is taken to control temperature because the juice collected before and after the exact end point have more moisture and more solid, respectively. Fresh juice after lime addition is boiled till the juice attains temperature of 120-122°C. The pan containing hot mass is removed from the furnace and kept on a platform for 10-15 min. During that time, hot mass is thoroughly stirred with flat wooden stirrer for uniform cooling of hot mass by natural air (Fig. 11). Then, it is left for 5-10 min without any further stirring to facilitate crystal formation. The moisture content of this semi cooled mass is around 9-10% (d.b.). The semi cooled mass containing seed crystals is then transferred from pan to aluminium tray (Fig. 12) and the mass is converted into granules by applying severe shearing action using wooden or stainless steel scrappers (Fig. 13). The shearing action exposes more surface for atmospheric cooling. At this stage, to prepare 35-40 kg granules from 350-400 kg cane, 3 or 4 labourers are required for 15-20 min to make the mass into granules. Otherwise the mass gets solidified into different size of agglomerates or pieces. Jaggery granules after preparation is dried (Fig. 14) to 1-2% (d.b.) moisture content, sieved through 3 mm sieve and packed in 400 gauge polythene sheet or polyethylene terephthalate (PET) bottles. The composition per 100 gm of granular jaggery is: 80-90 gm sucrose, 5-9 gm reducing sugars, 0.4 gm protein, 0.1 gm fat, 0.6-1.0 gm total minerals containing usually 9 mg calcium, 4 mg phosphorous and 12 mg iron[26]. The calorific value of granular jaggery is almost same as solid jaggery[26]. Granular form of jaggery with its low moisture content (1-2% d.b) offers the advantages like long shelf life up to 2 yrs, easy handling, formulation of product free from hazardous chemicals like hydros, super phosphate and phosphoric acid (these chemicals reduces crystallization, in turn produce soft textured granular jaggery with poor keeping quality) and better export potential[27].

The usefulness of jaggery has been recognized at the international level[3]. Of the total world production, more than 70% of the jaggery is being produced in India[4]. Status of jaggery export from India is

Table 9—Status of jaggery export from India

Year	Quantity of jaggery exported to other countries (tonnes)	Value (Rs. Millions)
1998-1999	7,323	97.602
1999-2000	6,168	82.242
2000-2001	1,24,054	1592.568
2001-2002	1,84,017	2130.056

Source: Vikas Singhal (2003)

presented (Table 9)[1]. Jaggery is exported to Afghanistan, Angola, Germany, Ghana, Greece, Hong Kong, Ireland, Japan, Kenya, Sultanate of Oman, Canada, Mauritius, Pakistan, Bangladesh, Sri Lanka, Malaysia, China, Philippines, Qatar, Saudi Arabia, UAE, Australia, Bahrain and Indonesia[20].

Conclusion

Jaggery industry has been one of the most ancient and important rural-based cottage industries in the country. It provides jobs to the unemployed rural people in their vicinity with minimum capital investment. It is cheaper than white sugar. It also have higher medicinal and nutritional values and easily available to the rural people. Also, it may not be possible for sugar factories alone to meet total demand of sweeteners with increase of the population. It is, therefore, essential to safeguard the interest of jaggery manufacturing unit and improve and modernize the activities for more purposeful ends.

References

1 Singhal Vikas, Sugarcane, In: *Indian Agriculture*, (Indian Economic Data Research Centre, New Delhi), 2003,772-778.

2 Nerkar YS, Present scenario and thrust areas for making sugarcane and sugar productivity in India, *Finan Agric*, Oct-Dec, 2004, 29.

3 Dahiya Suraj Bhan, Indian *gur* gets global glory, *The Tribune*, Chandigarh, (January15, 2001). Http://www.tribuneindia.com/2001/20010115/agro.htm#1.

4 Alam Anwar, Industrial and policy issues including export potential of jaggery and *khandsari*, *Proc Ntl Seminar Status, Problems and Prospects of jaggery and khandsari industry in India*, Lucknow, 1999, 7-12.

5 Thakur AK, Potential of jaggery (*Gur*) manufacturing in Punjab state, *Proc Ntl Seminar on status, problems and prospects of jaggery and khandsari industry in India*, Lucknow,(1999, 71.

6 Mungare TS, Jadhav HD, Shinde US, Jadhav BS & Jaswanth Singh, Status of *khandsari* industry in Maharashtra, *Proc Ntl Seminar on status, problems and prospects of jaggery and khandsari industry in India*, Lucknow, 1999, 60-61.

7 Http://www.indiansugar.com/sugarstn.htm

8 Http://www.indiainfoline.com/sect/suin/ch07.html

9 Http://www.censusindia.net/results/rudist.html

10 Indian Sugar, (March, 2004) 3, 12.

11 Singh Jaswath, Perspective for 2020 AD, *Jaggery Khandsari Res Digest*, (1998) 96.

12 Kumar K, Oscillation in jaggery and *khandsari* industry, *Proc Ntl Seminar on status, problems and prospects of jaggery and Khandsari industry in India*, Lucknow, 1999, 87.

13 Singh Jaswant, Proximate composition of Indian sweeteners, *Jaggery Khandsari Res Digest* (1998) 6.

14 Singh Jaswant, Historical background of the project, *Jaggery Khandsari Res Digest* (1998) 7.

15 Http://www.sugarindia.com/jag.htm.

16 Sahu AP & BN Paul, The role of dietary whole sugar jaggery in prevention of respiratory toxicity of air toxics and in lung cancer, *Toxicol Lett*, 95(1) (1998) 154.

17 Jadhav HD, Mungare TS, Patil JP, Hasare RR, Jadhav BS & Jaswanth Singh, Effect of harvesting age on juice, jaggery quality and yield of different sugarcane varieties under pre seasonal planting conditions, *Proc Ntl Seminar on status, problems and prospects of jaggery and khandsari industry in India*, Lucknow, 1999, 242.

18 Deshpande VV, Industrial and policy issues and export potential of jaggery

19 and khandsari, *Proc Ntl Seminar on status, problems and prospects of jaggery and khandsari industry in India*, Lucknow, 1999, 314.

20 Singh Jaswant, *Khandsari* manufacturing process: status and problems,

21 *Proc Ntl Seminar on status, problems and prospects of jaggery and khandsari industry in India*, Lucknow, 1999, 55.

22 20 Shahi, HN, Sustainability of jaggery and *khandsari* industry in India, Proc *Ntl Seminar on status, problems and prospects of jaggery and khandsari industry in India*, Lucknow, 1999, 20-26.

23 21 Singh Jaswath, Development of processes-Liquid jaggery, *Jaggery Khandsari Res Digest*, (1998) 69.

24 22 Chockalingam C, *Gur* manufacture in Tamil Nadu- A review, *Proc Ntl Seminar cum-group discussion on jaggery manufacture and storage*, Lucknow, 1985, 95.

25 23 Mungare TS & HD Jadhav, Clarification technique for producing quality jaggery, *Proc Ntl Seminar on status, problems and prospects of jaggery and khandsari industry in India*, Lucknow (1999) 153.

26 24 Singh M, KM Bharadwaj & MLAgarwal, Storage of jaggery, *Co-Operative Sugar* (1978a) 3.

27 25 Patil JR, Wandre SS & Gojare DG, Kakavi quality in relation to sterilization and preservatives, *Proc Ntl Seminar - cum-group discussion on jaggery manufacture and storage*, Lucknow, 1985, 84.

28 26 Singh Jaswanth, Research contributions of All India Coordinated Research

29 Project on Processing, Handling and Storage of jaggery and *Khandsari*, Proc *Ntl Seminar on status, problems and prospects of jaggery and khandsari industry in India*, Lucknow, 1999, 53.

30 Ramakrishna Rao S & Lakshminarayana C, Cane jaggery in cube, powder

31 and liquid forms for increased shelf life and export, *Proc Ntl Seminar on status, problems and prospects of jaggery and khandsari industry in India*, Lucknow, 1999, 119.