



**Terms of Reference for Evaluation of RKVY project on
"Establishment of Jaggery Park in Southern Karnataka" by the
Department of Agriculture (Period -2008-09 to 2012-13).**

1. Title of the Evaluation Study:

The title of the Evaluation study is "*Establishment of Jaggery park in Southern Karnataka*" established with the funding from RKVY financed through the Department of Agriculture in Karnataka from 2008-2009 to 2012-13.

2. Department/Agency implementing the Scheme:

The Department of Agriculture in Karnataka through the University of Agricultural sciences, Bangalore, Zonal Agricultural Research Station, V.C. Farm, Mandya.

3. Background Information:

Sugarcane is one of the important commercial crops cultivated in the command areas of Karnataka state. In the State it is cultivated in an area of 4.25 lakh hectares annually giving a production of 357.3 lakh tonnes of sugarcane with a productivity of 84 tonnes / hectare (Ministry of Agriculture, 2014-15). Karnataka ranks 3rd amongst all the States of the country in respect of area of under Sugarcane cultivation. In the southern districts of Karnataka, on an average across the years, out of the total sugarcane produced, around 60 per cent has been utilized for sugar extraction in the sugar mills and 30-35 per cent in Jaggery making. On an average, 25 per cent of the total sugarcane produced in the country is utilized for Jaggery preparation. As such, Jaggery preparation is an important cottage industry of Karnataka. In simple terms Jaggery is the solidified mass of sugarcane juice. Sugarcane juice is boiled and condensed in open pans removing impurities to obtain the solidified mass called Jaggery.

Jaggery is an important natural sweetener widely used in confectionaries, culinary preparations and Ayurvedic medicines. Jaggery has got nutritive as well as medicinal values unlike white sugar and is much more sweetening than white sugar, by virtue of its higher content of reducing sugars. Cauvery command area in southern Karnataka is an important sugarcane growing belt, with over 5000

Jaggery boiling units under operation during 1999-2000. However the number of Jaggery boiling units has been reducing gradually because of market price fluctuations over the years. APMC market in Mandya is the major Jaggery market in the Cauvery command area.

Utilization of sugarcane for different purpose

Period Years	Sugar cane production ('000' tons)	Sugarcane utilized for production of ('000' tons)			% of Sugarcane utilized for production of		
		White sugar	Seed, feed, chewing etc.	Jaggery & Khandsari	White sugar	Seed, feed, chewing etc.	Jaggery & Khandsari
1970 to 1980	1,30,096	45,713	16,675	77,708	35.29	11.90	55.81
1980 to 1990	1,85,659	78,527	22,005	85,125	41.85	11.85	46.31
1990 to 2000	2,65,452	1,37,557	30,408	97,487	51.57	11.59	37.07
2000 to 2010	2,91,370	1,85,706	34,313	70,589	62.92	11.79	25.29

* Source: Lucknow Jaggery Manual 2014.

The National Commission Agriculture (1976) estimated that per capita consumption of sweeteners would increase to about 40 kg/head/annum from current consumption of approximately 25 kg/head/annum.

Table-1: Projections of Sweetener Requirement vis-a-vis sugarcane production in India by 2020

Year	Sweetener Requirement (MT)			Sugarcane Requirement (MT)	Sugar Production (MT)
	Sugar	Jaggery	Total		
1990-91	12.40	9.00	21.40	241.00	12.05
2000	18.00	13.70	31.70	300.00	18.90
2010	22.17	16.81	38.98	348.50	22.48
2020	27.29	20.69	47.98	415.00	27.39



Nutritional and Medicinal value of Jaggery

The acceptable taste and nutritive value of Jaggery has attracted human population since ancient times. Jaggery is also called “*Non Centrifugal Sugar*” or Artisan Sugar. White sugar contains only sucrose (99.70%). Jaggery has sucrose (51.00%), protein (0.25%), glucose (21.20%) and minerals (3.40%) in addition to trace amount of fats (0.02 to 0.03%), calcium (0.39%), vitamin A, vitamin B, Phosphate (0.025%) and provides 383 K cal/100g.

Dietary sucrose (sugar) is a mixed blessing which makes food more attractive and appetizing, but excessive consumption often leads to various kinds of pathological conditions like., dental caries, coronary thrombosis, ischemic heart disease, diabetes, hyperacidity, depression, obesity etc., Some studies have also shown that high sugar intake leads to increased cancer risk.

Jaggery is an alternative sweetener to sugarcane and eco-friendly too. In Ayurveda, Jaggery is considered to be the best of all the preparations made from sugarcane.

Jaggery contains the following nutritive elements which has made it a better sweetener than white crystal Sugar:

- Sucrose 60-85%
- Glucose and fructose 5-15%.
- Moisture 5-6%
- Protein 0.4%,
- Fat 0.1%
- Minerals 0.6 to 1.0%

(8 mg of Calcium, 4 mg of Phosphorus and 11.4 mg of Iron per 100 g along with traces of vitamins and amino acids).

- It serves as a cardiac tonic.
- It is used in Ayurvedic medicines
- Jaggery has a cooling and diuretic effect.
- 100 g of Jaggery provides 383 kcal of energy.

Constraints in Jaggery Industry:

- a) Non-availability of technology & existing research gap, low price for Jaggery due to poor quality are causing the closure of Jaggery units.

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- b) Cauvery command area is the only area in India where Jaggery is manufactured in the off-season (June-Sep.), apart from the regular crushing season (Oct-March). But the farmers in this area do not get appreciable price for Jaggery because of poor quality. Hence, there is a need to utilize the off-season crushing in a profitable manner through advanced research.
 - c) In the command area, usually farmers grow excess sugarcane without knowing the demand from the sugar industries. Under such circumstances, it is an extra burden on the sugar factory for crushing and they refuse to purchase excess sugarcane. Thus farmers incur loss both in terms of cane yield and quality. Under this situation, the best way to rescue the farmers and build confidence in them is by diverting excess sugarcane to Jaggery industries.
 - d) Many farmers are preparing Jaggery by age-old methods under highly Unhygienic conditions. It is considered that the process is scientifically inefficient to produce quality Jaggery.
 - e) There is no specific research Centre working exclusively on Jaggery production in Karnataka but for some research being carried out at ZARS, V.C. Farm, Mandya and ARS, Sankeshwar, to solve the problems faced by the farmers in Karnataka.
 - f) Jaggery making is a cottage industry operated at a decentralized level in unorganized rural sectors and needs institutional support for quality. Jaggery production, handling, storage, management which can accrue higher returns at lower cost.
 - g) Farmers in Karnataka are preparing Jaggery by using several chemicals (clarificants) like hydros (Sodium hydrosulphite), Sodium formaldehyde sulphoxylate (*Chakke*), and Sodium bicarbonate (Baking soda), Sodium carbonate (washing soda), Super phosphate, Phosphoric acid, alum and lime at higher concentrations and dose. Hydros (Sodium hydrosulphite) and Sodium carbonate (washing soda) are liberally used to get attractive bleached white color of Jaggery but causing deleterious effects on health of the consumers. Jaggery which is prepared by using higher quantity of hydros and Sodium formaldehyde sulphoxylate (*Chakke*) contains more than 500 ppm of Sulphur dioxide, which is well above the prescribed norms of 50 ppm by Indian standards (IS 12923):1990. This amount of Sulphur dioxide

is detrimental to the beneficial intestinal microflora leading to digestive disorders and gastrointestinal problems. It can also cause breathing problems in asthmatic patients, colon/rectal cancer and destroy the formation of vitamin A and vitamin B1. Hence, extensive research has to be carried out on use of clarificants of plant origin and safe chemical clarificants.

- h) The crushers that are being presently used are old, unsafe and highly inefficient to crush more quantity of cane and have less extraction efficiency (50%). Hence, there is a need for modification of existing crushers for effective juice extraction (65-70% efficiency). A 10 per cent increase in crushing efficiency will yield more than 10-15 kg extra Jaggery per tonne of cane to the farmers just by adopting improved crushers.
- i) The furnaces and boiling pans presently used have many disadvantages in getting higher Jaggery yield with good quality. The type of furnace for Jaggery making plays an important role in deciding the efficiency and quickness of juice boiling besides other factors. The overall heat utilization efficiency of these furnaces is merely 20 percent which is too low. Hence, it is very much essential to improve combustion and heat utilization efficiency of existing furnaces and development of furnaces working on forced draft system in order to reduce the boiling time is the need of the hour.
- j) Fuel use efficiency in traditional methods is very poor. In some cases farmers are using old vehicle tyres and tubes as fuel source which emit toxic gases which are directly absorbed in the process of Jaggery making and ultimately affect its quality. Development of bagasse gassifier to generate producer gas for concentrating juice over burners appears to be promising.
- k) Jaggery manufacturing units that are presently working harbour many harmful microorganisms due to unhygienic conditions where the whole Jaggery making process is carried out in one shed. There is a need to design scientific state of the art Jaggery manufacturing unit at low cost to produce quality Jaggery.

Considering the above constraints a detailed project report was prepared after thorough discussions, deliberations with experts in the fields and visiting various research stations and plants which are involved in Jaggery preparation. As a result, specific objectives were formulated to tackle many of the issues concerning Jaggery industry. To fulfill the objectives so designed, infrastructure

was created looking into the requirements including a modern open boiling Jaggery pilot plant.

4. Objectives:

The specific objectives of the project are as under-

1. Identification of sugarcane genotypes suitable for Jaggery production and to develop viable agro-techniques for improving juice content, quality and Jaggery yield.
2. Identification and modification of different types of crushers suitable for efficient juice extraction and safety.
3. Improvement of furnaces for heating the juice and sophisticated equipment for fuel use economy and reduced drudgery.
4. Mechanization in Jaggery processing to reduce manpower at different stages of Jaggery production.
5. Identification of different herbal and safe chemical clarificants for obtaining better texture, color, fragrance and quality of Jaggery.
6. To develop value added products of Jaggery suitable for local and export quality.
7. To develop packing and storage techniques for longer shelf life of Jaggery.
8. To provide trainings and conduct demonstrations on quality cane and Jaggery production.
9. To establish marketing network cell to cater the needs of Jaggery farmers.

5. Present Status of the Scheme:

The scheme was initiated in 2008-09 and the Jaggery Park was officially commissioned during April 2011. The pilot plant of the open boiling system of Jaggery preparation started during June 2011. The plant has the installed capacity of crushing 25 tonnes of Sugarcane that produces 2.5 tonnes of hygienic organic/chemical free Jaggery.

The laboratory for analysis of Sugarcane juice and Jaggery quality parameters has been established. HRD activities included training of Jaggery unit farmers on organic/chemical free Jaggery preparation and creating awareness among the visitors to Jaggery park on ill effects of chemicals used in Jaggery processing. Storage facilities have been created to stock 5 tonnes of Jaggery till it



is marketed. Demonstration on Sugarcane varieties and agronomic practices for production of quality Sugarcane for higher quality chemical free Jaggery production. Posters, folders/handouts have been prepared on various technologies of Sugarcane varieties, Sugarcane cultivation and Jaggery preparation.

A plant with a novel idea of indirect boiling of Sugarcane juice in the evaporators through the Steam generated from the boiler has been established for hygienic quality Jaggery production.

Three varieties viz. Co 86032, Co 92005 and VCF 0517 have been identified for better yield and quality Jaggery production. Nutrient management, particularly nitrogen management, for quality Jaggery production was evolved. Ratio of organic and inorganic nutrients for quality Jaggery was emphasized.

Creating awareness among farmers, farm women, house wives, students, delegates, officers of development departments and large number of visitors during *Krishimela* and other occasions is being done regarding chemical free/organic Jaggery preparation and ill effects of chemicals used in famers Jaggery units for Jaggery preparation on human health.

Outsourcing of Jaggery Preparation Facilities in PPP Mode

From 2015-16 the facilities for Jaggery preparation at Jaggery park Mandya were outsourced involving an organic group of farmers – Mandya Organic Farmers Co-Operative Society for organic/Chemical free Jaggery preparation in public – in the Private Participatory (PPP) mode. Since then they have been involved in commercial Jaggery production by scouting and procuring quality Sugarcane from the farmers' fields as well as the cane produced at V.C. Farm, Mandya.

6. Assets created and work under taken under Jaggery park:

Abstract of expenditure for establishment of Jaggery Park

Sl.no	Particulars	Expenditure in (Rs)
1	Contractual man power	2619300
2	Travelling expenses	214200
3	Other recurring contingency (Experiments, contractual	8983356

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	labour Jaggery processing cost chemicals, fertilizers & maintenance of Equipment)	
4	HRD activities (Training, field visits, demonstrations etc.)	605000
5	Purchase of Equipments (Laboratory Equipments, computer etc.)	15157000
6	Purchase of Equipment for mechanized sugarcane cultivation (Tractor, mini tractor, Dozer, ploughing equipments etc.)	1842000
7	Strengthening of infrastructure (Civil works)	50570000
	Total	79990856

Expenditure details for building and infrastructure

Sl. No	Particulars	Expenditure (Rs. In lakh)	Remarks
1	Jaggery Park Building	290.00	Building includes Jaggery production unit office facilities for the Scientists, Laboratory, Training hall and Jaggery store
2	Jaggery preparation Equipment	40.00	Equipment have been fabricated with food grade SS 304 for quality Jaggery
3	Steam based Jaggery boiling unit including Jaggery preparation equipment	71.06	Steam produced from the bagasse using boiler will be used for Jaggery preparation
4	Asphalting of roads in the Jaggery park premises	40.81	Roads in the Jaggery park premises have been asphalted
5	Construction of compound and watch cabin	25.00	Security to Jaggery park
6	Bagasse storage shed	20.00	To store dried bagasse
7	Box drain	17.50	To drain out excess rain water and canal water
8	Bagasse drying yard	10.00	To dry bagasse to increase the fuel efficiency



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9	Riveting of open well, construction of pump house and provision of irrigation pipes.	6.25	To provide irrigation to Sugarcane blocks for Jaggery preparation.
	Total	520.62	

The following are the details of the infrastructure created at Jaggery Park, ZARS, V.C. Farm, Mandya.

a) Civil work

1. Construction of Jaggery Park building.
2. Asphaltting of roads in the premises of Jaggery Park building.
3. Construction of compound and watchman shed in front of Jaggery Park.
4. Construction of box drains.
5. Riveting of open well and construction of pump house.
6. Barbed wire fencing.
7. Bagasse drying yard (735.20 m²).
8. Bagasse storage shed (457.25 m²).
9. Building to house Steam boiling unit.

b) Jaggery preparation pilot plant

1. Sugarcane crusher (15 HP).
2. Bagasse conveyer belt.
3. Stainless steel (SS 304) sunken tank (3000 L capacity).
4. Stainless steel (SS 304) screen mesh for juice filtering (2 Stage).
5. Stainless steel (SS 304) pump (1 HP).
6. Stainless steel (SS 304) sugarcane juice conveyance pipes.
7. Stainless steel (SS 304) over head juice collection tank (3000 L capacity).
8. Stainless steel (SS 304) rectangular pre heating pans (2000 L capacity) – 2 Nos.
9. Stainless steel (SS 304) main boiling pans (3000 L capacity) – 2 Nos.
10. Hydraulic system.
11. Furnaces (IISc designed) – 2 Nos.
12. Stainless steel (SS 304) scum collection tank – 2 Nos.
13. Jaggery cooling pit (granite) – 2 Nos.
14. Chimneys – 2 Nos.

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15. Jaggery moulds:

Wooden – 10 Nos.

Aluminum – 1 kg – 660 Nos.

5 kg – 30 Nos.

16. Double effect evaporators & accessories and Steam boiler.

c) **Sugarcane juice and Jaggery quality analysis laboratory**

Furnishing of the laboratory with island tables with chemicals and reagents, and instruments relating to sugarcane and Jaggery research has been done and the details of the equipment purchased for establishment of laboratory are given in *Annexure 3*.

d) **Storage structures** – Structures for storage of Jaggery from the pilot plant and samples prepared in the laboratory. Eight racks have been procured to store approximately 5 tons of Jaggery.

e) **Training hall** – Furnished with false ceiling and AC, audio visual aids, public address system with a seating capacity of 50 trainees.

f) **Office space** – For seating of scientists, research and supporting staff concerned to sugarcane and Jaggery research.

g) **Irrigation facilities** - Piped irrigation to an area of 8 acres of sugarcane for quality Jaggery preparation.

h) **Mechanization** - Purchase of tractor and tractor drawn implements for mechanization of sugarcane cultivation – *Kubota* mini tractor, Dozer, tractor drawn rotovator, inter cultivation implement and trash shredder.

7. **Utilization of the assets of Jaggery Park**

a) **Jaggery preparation pilot plant**

The pilot Jaggery preparation plant has been utilized for commercial production and demonstration of chemical free Jaggery to farmers and farm women, trainee farmers, trainees of water users associations of Bhadra and Cauvery CADA, officials and trainee farmers of the department of agriculture, school children, visitors of *Krishimela* of ZARS, V.C. Farm, Mandya, the delegates from within and outside the country visiting Jaggery park on various occasions, students from different universities and colleges.



In addition, the pilot Jaggery preparation plant has also been utilized for large scale Jaggery preparation. The Jaggery so prepared is sold locally and outside. This is as a result of the awareness created on the chemical free Jaggery in and around the villages of Jaggery Park that most of the Jaggery produced was sold out locally. Further, some Jaggery unit farmers have been influenced by the process of chemical free Jaggery preparation at Jaggery Park to venture into chemical free Jaggery preparation in their own Jaggery units.

b) Utilization of sugarcane juice and Jaggery quality analysis laboratory)

The laboratory equipments have been put to use by the sugarcane and Jaggery scientists working at Jaggery Park for analysis of sugarcane juice, physical, chemical, biological properties and grading of Jaggery. The laboratory is also attracting Jaggery samples for analysis and grading from Jaggery unit farmers. The UG and PG students from the Agriculture College, Mandya have also been utilizing the laboratory facilities at Jaggery Park. The laboratory is also very useful for analysis of soil samples from different experimental blocks of sugarcane and Jaggery.

c) Utilization of Storage structures

The storage structures are used for storage of Jaggery produced from large scale plant and the samples from different sugarcane and Jaggery experiments till their analysis, characterization and grading

d) Utilization of Training hall

A total of 200 Jaggery unit farmers have been trained on production of quality sugarcane for chemical free Jaggery preparation. The training facilities have also been put to use by the development departments, Sir MV Institute of Sugarcane research, Mandya and ZARS, V.C. Farm, Mandya for conducting training programmes, Seminars, conferences, meetings and lectures.

e) Utilization of Bagasse drying yard and bagasse storage shed

Bagasse drying yard and bagasse storage shed are being used for drying and storage of bagasse obtained after crushing sugarcane for better fuel efficiency.



f) Utilization of Piped irrigation and pump house

This is very useful for providing protective irrigation from the open well particularly during summer months when the canal water is off.

g) Utilization of tractor and tractor drawn implements

Availability of labour is a major constraint in sugarcane cultivation. Tractor and tractor drawn implements have been purchased for mechanization of sugarcane cultivation to carry out timely operations.

h) Jaggery production at Jaggery Park

Since inception of Jaggery Park, chemical free Jaggery production has been demonstrated to the Jaggery unit farmers. The Jaggery production details are as under

Year	Cane Crushed (metric tons)	Jaggery production (quintals)
2011-12	72.16	64.57
2012-13	170.89	161.46
2013-14	36.9	32.62
2014-15	85.78	75.33
2015-16 * (Till 16Dec 2015)	85.66	80.23

* *Year in which the facilities of Jaggery preparation were leased out to Mandya Organic Agricultural Co-operative Society, Mandya.*

8. Jaggery Research:

a) Field Research

The following are the field experiments conducted and results obtained under Jaggery Research:

1. Identification of Sugarcane varieties suitable for Jaggery preparation

The Elite Sugarcane genotypes from the different trials were evaluated for their Jaggery quality and yield. Sugarcane varieties viz., Co7804,



Co86032, Co92005, Co8371, VCF 0517, CoM 0265, CoSNK 07103 & Co9009 were found to be suitable for Jaggery preparation.

2. Integrated nutrient Management for quality Jaggery

Integration of organic and inorganic sources of nutrients was ideal for obtaining higher yield and quality of Jaggery. 75 per cent of nutrients through chemical fertilizers and 25 per cent through organic sources was better compared to either organic or inorganic source alone.

3. Nitrogen management for quality Jaggery:

Excessive use of nitrogen and late application of it results in inferior quality Jaggery. Balanced application of NPK was found to improve the quality of Jaggery.

b) Laboratory Research

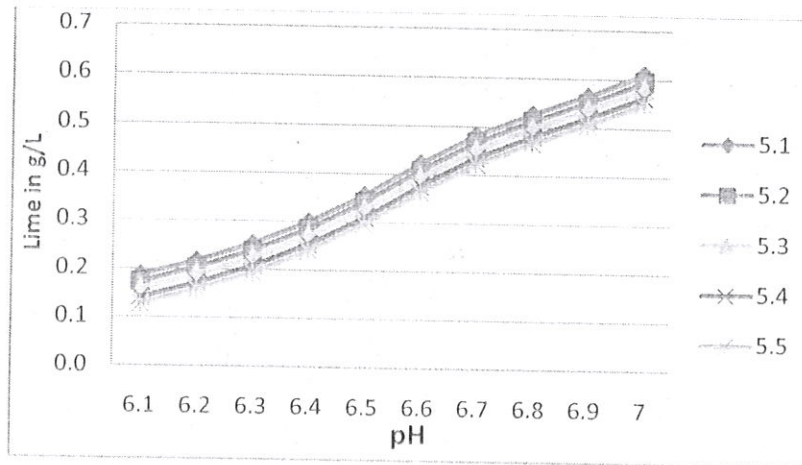
1. Standardization of lime requirement for adjusting of pH in Jaggery preparation

The lime requirement depends on the initial pH of the sugarcane juice which ranges from 5.1 to 5.5 and lime requirement was determined to raise the pH level from 6.1 to 7.0. On an average, to raise the pH from 5.1 to 6.4, 0.301 g of lime was required per liter of juice. Likewise for various pH levels, a ready reckoner was prepared and also a graph was plotted. Calcium hydroxide was the source of liming material used.

Ready reckoner for sugarcane juice pH adjustment (Lime requirement (g/lit juice))

Initial pH	Final pH									
	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7
5.1	0.189	0.219	0.255	0.301	0.357	0.424	0.483	0.528	0.568	0.611
5.2	0.174	0.205	0.240	0.286	0.342	0.409	0.468	0.513	0.553	0.596
5.3	0.159	0.190	0.225	0.271	0.327	0.394	0.453	0.498	0.538	0.581
5.4	0.142	0.172	0.208	0.254	0.310	0.377	0.436	0.481	0.521	0.564
5.5	0.128	0.158	0.194	0.240	0.296	0.363	0.422	0.467	0.507	0.550

Lime Requirement



2. Standardization of sources of liming material for adjustment of pH in Jaggery preparation (are in Annexure-1 and pH test using different liming materials for varieties of sugarcane are in Annexure-2).

Different sources of liming materials like calcium oxide, calcium hydroxide and calcium carbonate were used to find out the best source of liming material during Jaggery preparation. Different varieties of sugarcane viz., Co 92005, Co 62175, Co 86032 were used in the experiment. The Jaggery so prepared was analyzed for its physical and chemical parameters and grading was done.

With respect of quality of Jaggery from different sources of liming material, A1 and A2 grades were obtained with calcium oxide and calcium hydroxide. Calcium hydroxide is available in powder form and easy to use for neutralizing the pH of juice as its dissolution is faster.

However, with respect to price of liming material, calcium oxide is cheaper as given below:

Sl. No	Liming material	Cost per Kg (Rs.)
01.	Calcium hydroxide	35.00
02.	Calcium oxide	17.50
03.	Calcium carbonate	25.00



Among the different adjusted pH values of sugarcane juice at which Jaggery was prepared, Jaggery prepared with juice adjusted to 6.4 pH recorded sweet taste but had amorphous texture. At 6.6 and 6.8 pH, Jaggery was crystalline in texture. However at 6.8 pH, Jaggery was saltish in taste and dark in color.

3. Estimation of quantity of scum in different sugarcane varieties during Jaggery preparation

Seven released varieties were used for estimation of scum in different sugarcane varieties during Jaggery preparation. Jaggery was prepared with and without addition of *bhendi* (Lady Finger or Okra) mucilage to find out the quantity of scum removed in the process.

The scum percentage ranged from 0.694% (Co 86032) to 1.36% (Co 92005) with addition of *bhendi* and 0.65% (Co VC 99463) to 1.3% (Co 92005) without *bhendi*. Addition of *bhendi* was effective in the removal of scum, as the percentage of removal of scum was higher.

Estimation of scum in different varieties of sugarcane

Sl. No.	Variety	Juice weight (kg)	With <i>bhendi</i> mucilage		Scum % Fresh weight	Scum % Dry weight	Without <i>bhendi</i> mucilage		Scum % Fresh weight	Scum % Dry weight
			Scum fresh weight (g)	Scum dry weight (g)			Scum fresh weight (g)	Scum dry weight (g)		
1	Co 92005	4.5	154.66	61.27	3.43	1.36	151.60	58.23	3.36	1.30
2	Co 62175	4.48	76.32	41.20	1.7	0.92	128.94	24.33	2.82	0.54
3	Co 7804	4.5	99.88	37.71	2.21	0.84	94.64	36.38	2.10	0.81
4	VCF 517	4.49	124.05	43.20	2.76	0.96	120.26	41.90	2.67	0.93
5	Co 99463	4.7	124.12	32.01	2.64	0.68	125.29	30.61	2.66	0.65
6	Co 419	4.38	100.12	44.31	2.28	1.01	115.68	43.46	2.64	0.99

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7	Co 86032	4.49	125.27	31.20	2.78	0.69	113.90	32.69	2.53	0.73
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4. Studies on use of herbal clarificants for sugarcane juice clarification in Jaggery preparation

Different herbal clarificants were used for their efficacy in clarification of sugarcane juice during Jaggery preparation.

Among the clarificants used, the Jaggery was of A1 grade irrespective of clarificants. However, color was golden yellow with castor and soybean seed extract.

Jaggery with groundnut and hibiscus as clarificants recorded very sweet taste compared to other clarificants.

Studies on the use of herbal clarificants for sugarcane juice clarification in Jaggery processing.

A. Physical parameters

Treatments	Color	Taste	Hardness(kg/cm ²)
Hibiscus leaves	Light brown	Very sweet	2
Hibiscus flower	Light brown	Very sweet	2
Ground nut powder	Light brown	Very sweet	2
Ground nut extract	Light brown	Very sweet	2
Aloe Vera	Light brown	Sour	1.5
Badam powder	Pale yellow	Very sweet	1.5
Castor	Golden yellow	Sweet	2
Soybean extract	Golden yellow	sweet	2



B. Chemical parameters

Treatments	Moisture (%)	Porosity (ml/g)	Ash (%)	RS	Pol reading	Sucrose (%)	NR Value	Grade
Hibiscus leaves	5.61%	0.1	4.15	5.4	41	67.92	77.045	A1
Hibiscus flower	6.37%	0.15	4.28	4.9	41	75.61	85.69	A1
Ground nut powder	6.78%	0.15	3.86	5.8	40	77.46	85.17	A1
Ground nut extract	4.7%	0.15	3.12	5.2	39	67.23	65.51	A1
Aloe vera	3.99%	0.1	3.46	6.2	35	59.6	72.95	A1
Badam powder	6.66%	0.1	4.04	4.7	39	74.84	84.28	A1
Castor	6.25%	0.15	4.35	5.2	35	68.15	77.95	A1
Soybean extract	6.95%	0.15	4.31	4.3	40	77.04	87.82	A1

5. Studies on preheating of sugarcane juice and its effect on clarification.

Pre heating of sugarcane juice in clarification of juice was studied by heating sugarcane juice upto 60°, 65° and 70°C. One liter of juice was taken for the study and observations were made on floating and settled particles in the juice in preheated as well as cold juice. It is clear that heating of juice up to 70° yields more of scum (5.26 g of fresh weight) with higher floating particle (20ml) and settled particles (10ml) there by extraction of scum is made easier. When cold juice (raw) was observed for its floating and settled particles, only floating particles were observed (5ml) which was the lowest among all.

Sl. No	Juice pH	Temp (°c)	Total volume of juice	Volume of floating particles	Volume of suspended particles	Fresh weight of scum (g)
1	6.4	60	1L	10ml	15ml	2.58
2	6.4	65	1L	20ml	5ml	4.09
3	6.4	70	1L	20ml	10ml	5.26
4	6.4	cold	1L	5ml	-	2.05



c) Survey of farmers' Jaggery units

A Survey was conducted to study the status of Jaggery units run by the farmers in Mandya district. Jaggery units are either functional or non-functional depending on the Jaggery price in the market, unhygienic Jaggery production, injudicious use of very high dose of industrial chemicals in Jaggery preparation, inefficient crushers (45-50% juice extraction), inefficient furnaces, labour constraint and poor quality cane used for Jaggery making resulting in poor quality Jaggery were the main technical points that emerged during the survey. This is evidenced by large scale dwindling of Jaggery units from 5000 in 1990's to less than 1000 at present.

9. Objective wise Achievements:

Sl. No.	Objectives	Achievement
1	Identification of sugarcane genotypes suitable for Jaggery production and to develop viable agro-techniques for improving juice content, quality and Jaggery yield.	Sugarcane varieties suitable for Jaggery making viz., Co 86032, Co 92005, Co 8371, CoVC 99463 and VCF 0517 have been identified. Nutrient management especially nitrogen management for quality Jaggery production, Integrated nutrient management for better quality Jaggery have been evolved. 75 per cent nutrients through fertilizers and 25 per cent through organic manure was ideal for getting higher Sugarcane yield and quality. It is better to nourish the Sugarcane crop in an integrated way than depending on organic sources alone. The same has been imparted to farmers through training programmes.
2	Identification and modification of different types of crushers suitable for efficient juice extraction and safety.	Crusher with three rollers with food grade stainless steel 304 of 15 HP and planetary gear box has been installed. It has the crushing capacity of 1.4-1.6 tons/hour with safe and hygienic extraction of juice



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3	Improvement of furnaces for heating the juice and sophisticated equipment for fuel use economy and reduced drudgery.	Furnace has been designed in collaboration with IISc, Bangalore. The furnace is fuel efficient and as a result saving of bagasse is observed.
4	Mechanization in Jaggery processing to reduce manpower at different stages of Jaggery production.	Bagasse conveyor belt has been provided to convey bagasse to the drying yard. Hydraulic system has been provided to lift and tip the Jaggery syrup from the pan on furnace to the cooling pit
5	Identification of different herbal and safe chemical clarificants for obtaining better texture, color, fragrance and quality of Jaggery.	Ladies finger stem mucilage is identified as the herbal clarificant. In addition, seed extracts of castor, groundnut, soya bean were experimented with hibiscus and <i>aloe vera</i> as herbal clarificants. Castor and soybean were found to be good clarificants with better color and quality of the Jaggery.
6	To develop value added products of Jaggery suitable for local and export quality.	Experiments were conducted on preparation of liquid and powder Jaggery
7	To develop packing and storage techniques for longer shelf life of Jaggery.	Studies have been conducted on different packing material and duration of storage of Jaggery. Aluminum foil followed by paper box and sugarcane trash was better among the 10 packing materials tried. Jaggery can be stored for four months without spoilage
8	To provide trainings and conduct demonstrations on quality cane and Jaggery production.	Four training and awareness programmes have been conducted involving 300 Jaggeryunit farmers on chemical free Jaggery preparation. Field demonstrations were conducted on farmers' field to give wide publicity for sugarcane varieties (Co92005, VCF0517) suitable for Jaggery preparation and agronomic practices to

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		obtain quality Jaggery. These demonstrations were conducted in Mandya in an area of 80 acres
9	To establish marketing network cell to cater the needs of Jaggery farmers.	A network has been created among the Jaggery unit farmers who are in the field of chemical free Jaggery preparation.

10. Training/awareness Programme to Jaggery and Sugarcane farmers

Sugarcane Farmers and Jaggery unit owners of Mandya district were imparted training on Sugarcane cultivation for quality Jaggery production and chemical free Jaggery preparation by conducting demonstration at Jaggery Park. The details are as under

Sl. No	Date	No of Trainees
1	15.03.2013	40
2	06.12.2013	61
3	11.03.2014	40

Some of the Jaggery unit farmers so trained have started Jaggery units of their own for preparation of chemical free Jaggery.

In addition, the Farmers, Delegates, Students and other visitors who had visited the Jaggery Park on various occasions (which run up to 1000 numbers) were provided information on chemical free Jaggery preparation.

Extension folders on Improved Sugarcane varieties, Improved Sugarcane cultivation practices and chemical free Jaggery preparation have been prepared and distributed to farmers, department officers, students and other visitors.

11. Field Demonstrations in Farmers fields to popularize Sugarcane Production technologies and varieties suitable for Jaggery preparation:

A total of 54 farmers in area of 53 acres were selected for demonstration of Sugarcane production technologies and varieties in different villages of Mandya District. Improved Sugarcane varieties suitable for Jaggery preparation, Nutrient management particularly nitrogen management, Harvest management for quality



Jaggery preparation were demonstrated in the farmers' fields. Sugarcane yields recorded were 20-25 per cent higher compared to farmers practice in addition to 15-20 per cent increased Jaggery yield and better quality as a result of these demonstrations.

12. Establishment of Steam Based Jaggery boiling unit

The conventional system of Jaggery preparation is open boiling. Jaggery park has ventured into an innovative novel system of Jaggery preparation using steam boilers and evaporators.

The principle involved is that steam is generated with the help of a suitable boiler. The juice extracted is heated at 2-3 stages in the pans facilitated with steam jacket. In this system, the heat is totally under control which facilitates easy and efficient removal of scum. Caramelization and discoloration of juice and Jaggery are totally avoided and heat, fuel and labour efficiency are enhanced. Overall, there is an improvement in the quality of Jaggery.

Following are some of the advantages that could be achieved in steam boiling.

1. Effective Scum removal: In the production of organically processed Jaggery removal of scum is important and for clarification only organic clarificants and flocculants are used. Gradual heating of juice will allow ample time to remove the scum and other suspended materials in the juice.
2. Evaporator in the system under closed boiling enhances fuel efficiency and steam from evaporators is recycled for preheating and heating of juice. This also improves the fuel efficiency.
3. The down time of the plant, auxiliary power consumption of the equipment etc., are greatly reduced.
4. The hygiene and safety of the workmen are ensured.

Evaporators:

Sugarcane juice after initial clarification is let in to the evaporators for further evaporation of moisture in the juice till it is taken to the final pan before moulding.

Time span: Rate of evaporation of water is more in evaporators with steam compared to open pan boiling. This is because of the fact that the surface area exposed is more when juice is passed through the tubes containing steam.

This results in faster evaporation of water from the juice. The surface area exposed in open pans is lesser which results in more time for evaporation of same quantity of water. In the evaporators the vapour can be collected and recycled where as in open pan it is not possible.

Fuel efficiency: The package boilers have the fuel efficiency up to 72 per cent whereas in the open pan boiling it is merely 35 per cent. In addition, the steam boiling has got other advantages like hygienic conditions, good working environment, thermal efficiency and recovery of vapour which can be condensed for refeeding into the boiler. The comparison and contrast of important parameters of steam boiling and open pan boiling are as follows-

Advantages of Evaporator:

1. Heat transfer is quick because of condensation of steam
2. Since surface area provided is more, rate of heat transfer is higher, as a consequence the efficiency is also high
3. Since the juice is divided into thin vertical columns, the surface contact for heat transfer naturally increases
4. Heat transfer by convection is very fast
5. Time required in evaporator to attain required temperature, brix, viscosity etc., is very less

The Jaggery prepared from the steam boiling would result in higher quality Jaggery under most hygienic conditions. The plant set up at Jaggery park has installed capacity of producing one quintal of Jaggery per boiling.

13. Collaboration with other Institutes:

The Jaggery park has close association with Indian institute of Sugarcane research, Lucknow, Sugarcane Breeding Institute, Coimbatore, Regional Sugarcane and Jaggery research Institute, Kolhapur and Anakapalli and CFTRI, Mysuru for Jaggery related research and extension activities.

14. Deployment of staff at Jaggery park:

Jaggery Park does not have staff of its own. The university has given the additional responsibilities of Jaggery Park to existing Scientists working in Sugarcane crop. They have engaged the personnel on contractual basis for conducting research in Jaggery.



15. Commercial Jaggery production:

The Jaggery Park is engaged in preparation of Jaggery on commercial scale. In the initial years, Jaggery preparation was on a pilot basis and now it has reached commercial scale. Mandya organic Agricultural co-operative Society, a farmers group, has been entrusted with the responsibility of preparation and marketing of chemical free/Organic Jaggery by utilizing the facilities for Jaggery preparation at Jaggery Park on lease basis with the monitoring by the University Scientists.

16. Value addition :

Jaggery Park is also engaged in production of value added Jaggery products like powder Jaggery, liquid Jaggery and Jaggery in different size and shape though in a small scale in addition to regular production of lump Jaggery. The shelf life of powder Jaggery is substantially higher than other forms of Jaggery.

17. Utilization of the facilities by the farming community

- Sugarcane varieties (Co 86032, Co92005 and VCF0517) suitable for Jaggery preparation have been identified and these varieties were demonstrated in the farmers' field to convince the farmers that Sugarcane varieties are exclusively for Jaggery preparation and not all varieties are suitable for Jaggery making.
- The demonstrations were also utilized for demonstrating agronomic practices for quality Jaggery production by emphasizing the nutrient management particularly nitrogen.
- The chemical free Jaggery produced at Jaggery Park has attracted quite a good number of villagers in around V.C.Farm. They have given a very good feedback as far as the quality of Jaggery produced at V.C.Farm is concerned.
- Training programmes and demonstrations were conducted to Jaggery unit farmers on chemical free Jaggery preparation. This has convinced the farmers on the ill effects of chemicals used in Jaggery preparation by farmers. Some Jaggery unit farmers who were imparted training have started Jaggery units for chemical free/Organic Jaggery on their own.

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- Many dignitaries, farmers of Cauvery and Bhadra command area and students have been benefited by visiting Jaggery Park and witnessing chemical free Jaggery preparation.
- Handouts on chemical free Jaggery preparation and sugarcane cultivation have been prepared for wide circulation among the farmers and Jaggery unit owners to propagate sugarcane production and Jaggery preparation on scientific lines.
- Sugarcane from the farmers' field is being drawn for preparation of chemical free/Organic Jaggery. This has helped the Sugarcane farmers of the district particularly when the Sugar mills were off during the Sugarcane crisis period.

18. Evaluation Questions and minimum expectations (Inclusive not exhaustive):

1. Has the chemical free Jaggery preparation unit, the Jaggery Park V.C. Farm, Mandya, and the trainings provided by it in making chemical free Jaggery made any impact on Jaggery unit owners, APMC Merchants and consumers with regards to going in for only chemical free Jaggery production, marketing and consumption?
2. Are the Jaggery sellers and its consumers aware about the fact that chemicals are used in making Jaggery? Are they aware of the chemicals used and/or its ill effects on human health?
3. Does chemical free Jaggery have a different taste or appearance than usual Jaggery prepared with the usage of chemicals? (perception of Jaggery users may be used to answer this)
4. Are the Jaggery sellers and its consumers paying or willing to pay a higher price for chemical free Jaggery? If no, why not? If yes, what percentage more than the price of usual Jaggery are they paying, and what is the scope further in willingness to pay, for chemical free Jaggery?
5. What are the issues in hygiene in the Jaggery making units existing in the surroundings?
6. Is hygiene in the Jaggery Park certainly and surely better than the Jaggery making units existing in the surroundings?



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7. What are the views of Jaggery making unit owners on using chemical clarificants viz a viz herbal clarificants in Jaggery processing?
8. What are the opinion of Jaggery sellers and consumers of Jaggery about using herbal clarificants in Jaggery processing?
9. Does chemical free Jaggery have a longer shelf life than usual Jaggery prepared with the usage of chemicals? If yes, how much longer or shorter and why?(perception of Jaggery users may be used to answer this)
10. What has been the production, sale and utilization pattern of powdered Jaggery, Liquid Jaggery and Jaggery made into unique shapes and sizes?
11. Which States and districts (outside Karnataka and in Karnataka) are the main purchasers of chemical free Jaggery produced in the Jaggery Park?
12. Which Sugarcane varieties are better for Jaggery making from the point of view of Jaggery yield and quality as per Jaggery making unit owners of Mandya?
13. Is there a control mechanism (legal and procedural) for checking the usage of harmful chemicals in the making of Jaggery and the hygiene aspect in the process of making Jaggery? If not, what mechanism can be suggested? Please elaborate.
14. Please detail a few tests that can be done at home to check whether the Jaggery one is using is chemical free or not.
15. Has the present Jaggery farm fulfilled its objectives? Is a good case made out for having a few more Jaggery Parks in Karnataka? If no, why not? If yes, what further inputs need to be provided?

19. Time Schedule for the Study:

On the basis of the proposed time schedule outline in these Terms of Reference, the consultant organization shall prepare a brief work plan. The work plan should set out the Consultant Organization's approach for conducting research activities. The period for the consultancy should not exceed 3 months starting with day of signing the agreement. They are expected to adhere to the following timelines and deliverables or be quicker than the follows-

- a. Work plan submission : 15 days after signing the agreement.
- b. Field info Collection : One months from date of Work Plan Approval.

- c. Draft report Submission : One month after field data collection.
- d. Final Report Submission : 15 days from draft report approval.
- e. Total duration : 3months.

20 .Qualification of Consultant Evaluation Organization

Consultant Evaluation Organizations should have evaluation team members having minimum technical qualifications/capabilities as below-

- i. One Post Graduate in Agriculture/Sugar Technology having at least 10 years' experience in the academic field. (Principal Investigator)
- ii. One with masters in Health and Nutrition, Public health, Chemistry, Zoology, Medicine (only MBBS is enough, masters not needed), Bio-Chemistry, or Pathology (plant pathology excluded)only who will be a team member.
- iii. One Social Scientist with masters in Sociology, Social Work, Psychology or Environmental Science only who will be a team member.

Consultant Evaluation Organizations without teams of these minimum qualifications will not be considered.

20. Research Methodology:

The following methodology and research tools will be employed (but not limited to) during the assessment.

- ***Literature Review***

The Consultant Evaluation Organization will have to review the existing literature that deals with the history and production of Jaggery in Mysore/Karnataka. Further literature review should be done on the process followed in making Jaggery and how the constituents have changed over time. The chemicals used and its possible ill effects on human health too must be documented.

Interviews with key persons

The Consultant Evaluation Organization will have to interview the following types of persons-

- At least 50 those who own or run Jaggery making units in and around the Jaggery Park (25 who are continuously manufacturing and 25 who manufacture seasonally). These should include at least 5 who have been trained in the field of chemical free Jaggery making.
- The Jaggery manufactured in at least 15 units who are continuously manufacturing and at least 15 units who are manufacturing seasonally should be sample tested for the presence of chemicals and other impurities.
For this they have to declare as to in which laboratory and/or how the samples will be tested in the proposal to take up studies. A proposal lacking these or insufficiently or wrongly covering this will be rejected as for want of minimum capabilities/knowledge.
- At least 50 consumers of Jaggery, including at least 20 who have used or are using Jaggery prepared in the Jaggery Park.
- At least 10 sellers of Jaggery, including at least 5 who have sold or are selling Jaggery prepared in the Jaggery Park.
- At least 5 persons working in the Jaggery Park.

- ***Focus Group Discussions (FGD)***

The Consultant Evaluation Organization should conduct FGD of groups each consisting of 10 to 15 persons comprising of Jaggery Park Jaggery sellers and consumers.

Besides, at least 15 Jaggery making units in the vicinity of the Jaggery Park needs to be inspected.

21. The Final Report

The Consultant Evaluation Organization shall document the assignment in a final report; which should be in English and Kannada. The report shall include:

- Executive Summary (say about 1500 words).
- Details of the Assignment methodology and analysis.
- Findings and Recommendations.
- Lessons learned from the study.

- Annexures including questionnaire.

22. Contact persons for further details:

1. Dr. T. Sheshadri, Director of Research, UAS, GKVK, Bengaluru 560065.
Phone No. 9449866903.
2. Dr. Chandrasekhar Vaster, Professor, DR's Office and I/c, RKVY projects under UAS, Bengaluru, UAS, GKVK, Bengaluru 560065.
Phone No. 9945201306.
3. S.N. Swamygowda, Project Leader, Jaggery Park, ZARS, V.C. Farm, Mandya, Phone No. 9341156455.
4. Dr. K.V. Keshavaiah, Associate Professor (Agronomy-Jaggery) ZARS, V.C. Farm, Mandya, Phone No: 9900192322.

23. Cost and schedule of budget releases:

Output based budget release will be as follows-

- a. The **first instalment** of Consultation fee amounting to 30% of the total fee shall be payable as advance to the Consultant after the approval of the Work Plan, but only on execution of a bank guarantee of a scheduled nationalized bank, valid for a period of at least 12 months from the date of issuance of advance.
- b. The **second instalment** of Consultation fee amounting to 50% of the total fee shall be payable to the Consultant after the approval of the Draft report.
- c. The **third and final instalment** of Consultation fee amounting to 20% of the total fee shall be payable to the Consultant after the receipt of the hard and soft copies of the final report in such format and number as prescribed in the agreement, along with all original documents containing primary and secondary data, processed data outputs, study report and soft copies of all literature used in the final report.


Taxes will be deducted from each payment, as per rates in force. In addition, service tax will be paid as prescribed by law.

24. Selection of Consultant Agency for Evaluation:

The selection of evaluation agency should be finalized as per provisions of KTPP Act and rules and the Empanelment Manual of KEA.

The entire process of study shall be subject to and conform to the letter and spirit of the contents of the Government of Karnataka Order no. PD/8/EVN (2)/2011 dated 11th July 2011 and orders made there under.

The Terms of Reference were approved by the Technical Committee of KEA in its 26th Meeting held on 13th April 2016.


Chief Evaluation Officer
Karnataka Evaluation Authority

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Annexure - 1

Standardization of lime requirement for adjusting of pH in Jaggery preparation

pH	Ca(OH) ₂ (g)				
5.1	0.021	0.027	0.022	0.015	0.021
5.2	0.033	0.035	0.04	0.035	0.036
5.3	0.048	0.049	0.055	0.051	0.051
5.4	0.064	0.066	0.071	0.071	0.068
5.5	0.078	0.076	0.085	0.089	0.082
5.6	0.093	0.098	0.104	0.111	0.102
5.7	0.11	0.116	0.124	0.132	0.121
5.8	0.129	0.128	0.148	0.155	0.140
5.9	0.143	0.148	0.172	0.178	0.160
6	0.163	0.164	0.199	0.205	0.183
6.1	0.19	0.193	0.226	0.23	0.210
6.2	0.222	0.226	0.253	0.26	0.240
6.3	0.261	0.262	0.29	0.291	0.276
6.4	0.31	0.308	0.336	0.333	0.322
6.5	0.367	0.366	0.392	0.387	0.378
6.6	0.44	0.438	0.452	0.449	0.445
6.7	0.488	0.489	0.517	0.521	0.504
6.8	0.533	0.535	0.563	0.565	0.549
6.9	0.565	0.57	0.609	0.611	0.589
7	0.597	0.61	0.664	0.657	0.632

Annexure - 2

PH test using different liming materials for varieties of sugarcane

1 Lime source: Calcium carbonate [CaCO₃]

Variety: Co 92005

	Adjusted pH: 6.4			Adjusted pH: 6.6			Adjusted pH: 6.8						
	R1	R2	R3	Average	R1	R2	R3	Average	R1	R2	R3	R4	Average
Initial pH	5.15	5.13	5.12	5.13	5.14	5.13	5.12	5.13	5.13	5.12	5.15	5.12	5.13
Amount of lime (mg l ⁻¹)	0.271	0.278	0.285	0.278	0.364	0.360	0.369	0.364	0.455	0.450	0.441	0.447	0.448

Physical and Chemical properties of Jaggery

pH	Color	Texture	Taste	Hardness (kg/cm ²)	Moisture (%)	Porosity (ml/g)	RS	Ash (%)	Pol	Brix	Temp. (°C)	Sucrose (%)	NR Value	Grade	Quality
6.4	Golden yellow	Amorphous	Sweet	1.0	8.2	0.15	5.1	1.30	41	11.1	30.3	79.1	78.55	A1	Excellent
6.6	Pale yellow	Crystalline	Sweet	1.2	6.6	0.10	5.1	1.52	42	11.1	30.3	81.0	81.22	A1	Excellent
6.8	Dark	Crystalline	Slightly saltish	1.3	8.2	0.10	5.1	1.89	42	11.1	30.3	81.0	82.52	A1	Excellent

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Variety: Co 62175

	Adjusted pH: 6.4				Adjusted pH: 6.6				Adjusted pH: 6.8						
	R1	R2	R3	R4	Average	R1	R2	R3	R4	Average	R1	R2	R3	R4	Average
Initial pH	4.93	4.94	4.93	4.93	4.93	4.92	4.93	4.93	4.93	4.93	4.94	4.94	4.92	4.93	4.93
Amount of lime (mg l ⁻¹)	0.38	0.374	0.3723	0.372	0.375	0.46	0.464	0.468	0.471	0.466	0.673	0.662	0.665	0.67	0.668

Physical and Chemical properties of Jaggery

pH	Color	Texture	Taste	Hardness (kg/cm ²)	Moisture (%)	Porosity (ml/g)	RS (%)	Ash (%)	Pol	Brix	Temp. (°C)	Sucrose (%)	NR Value	Grade	Quality
6.4	Golden yellow	Amorphous	Sweet	1.0	6.5	0.15	5.8	1.33	39	11.5	30.4	75.9	70.44	A1	Excellent
6.6	Pale yellow	Crystalline	Sweet	1.2	5.7	0.10	7.6	1.56	39	11.2	30.4	75.4	68.18	A1	Excellent
6.8	Dark	Crystalline	Slightly saltish	1.5	7.7	0.10	3.5	1.90	40	11.0	30.4	77.0	73.90	A1	Excellent

Variety: Co 86032

	Adjusted pH: 6.4			Adjusted pH: 6.6			Adjusted pH: 6.8		
	R1	R2	Average	R1	R2	Average	R1	R2	Average
Initial pH	5.05	5.08	5.06	5.04	5.06	5.06	5.06	5.09	5.07
Amount of lime (mg l ⁻¹)	0.235	0.248	0.243	0.307	0.310	0.308	0.371	0.370	0.370

Physical and Chemical properties of Jaggery

pH	Color	Texture	Taste	Hardness (kg/cm ²)	Moisture (%)	Porosity (ml/g)	RS (%)	Ash (%)	Pol	Brix	Temp. (°C)	Sucrose (%)	NR Value	Grade	Quality
6.4	Golden yellow	Amorphous	Sweet	1.2	7.2	0.15	5.7	1.35	41	11.1	30.4	79.1	78.1	A1	Excellent
6.6	Pale yellow	Crystalline	Sweet	1.4	7.4	0.15	5.2	1.57	42	11.5	30.4	81.6	81.8	A1	Excellent
6.8	Dark	Crystalline	Slightly saltish	1.5	6.6	0.15	5.4	1.92	42	11.7	30.4	82.0	83.3	A1	Excellent

2 Lime source: Calcium hydroxide [Ca(OH)₂]

Variety: Co 92005

	Adjusted pH: 6.4			Adjusted pH: 6.6			Adjusted pH: 6.8		
	R1	R2	Average	R1	R2	Average	R1	R2	Average
Initial pH	5.23	5.28	5.24	5.25	5.23	5.23	5.27	5.27	5.26
Amount of lime (mg l ⁻¹)	0.160	0.168	0.164	0.210	0.207	0.209	0.239	0.241	0.241

Physical and Chemical properties of jaggery

pH	Color	Texture	Taste	Hardness (kg/cm ²)	Moisture (%)	Porosity (ml/g)	RS	Ash (%)	Pol	Brix	Temp. (°C)	Sucrose (%)	NR Value	Grade	Quality
6.4	Golden yellow	Amorphous	Sweet	2.0	7.0	0.15	3.5	0.81	44	11.8	29.2	84.53	78.195	A1	Excellent
6.6	Pale yellow	Crystalline	Sweet	2.0	6.5	0.20	5.2	1.04	39	11.4	29.2	75.07	66.23	A1	Excellent
6.8	Dark	Crystalline	Slightly saltish	2.2	5.2	0.25	3.7	1.62	42	10.5	29.2	79.07	69.7	A1	Excellent

Variety: Co 62175

	Adjusted pH: 6.4				Adjusted pH: 6.6				Adjusted pH: 6.8						
	R1	R2	R3	R4	Average	R1	R2	R3	R4	Average	R1	R2	R3	R4	Average
Initial pH	4.92	4.98	5.01	5.00	4.98	5.03	5.04	5.05	5.05	5.04	5.01	4.98	5.04	4.96	5.00
Amount of lime (mg l ⁻¹)	0.311	0.309	0.304	0.296	0.305	0.38	0.385	0.379	0.371	0.379	0.405	0.418	0.408	0.412	0.411

Physical and Chemical properties of Jaggery

pH	Color	Texture	Taste	Hardness (kg/cm ²)	Moisture (%)	Porosity (ml/g)	RS (%)	Ash (%)	Pol	Brix	Temp. (°C)	Sucrose (%)	NR Value	Grade	Quality
6.4	Golden yellow	Amorphous	Sweet	1.4	8.5	0.15	7.0	1.23	38	10.8	28.9	74.84	63.53	A2	Good
6.6	Pale yellow	Crystalline	Sweet	2.4	7.9	0.20	7.9	1.44	38	10.7	28.9	74.69	61.75	A2	Good
6.8	Dark	Crystalline	Slightly saltish	2.5	7.6	0.25	5.2	1.78	38	11.1	28.9	73.38	61.95	A2	Good

Variety: Co 86032

	Adjusted pH: 6.4				Adjusted pH: 6.6				Adjusted pH: 6.8				
	R1	R2	R3	Average	R1	R2	R3	Average	R1	R2	R3	R4	Average
Initial pH	4.8	4.83	4.82	4.82	4.84	4.83	4.84	4.84	4.85	4.84	4.82	4.83	4.84
Amount of lime (mg l ⁻¹)	0.252	0.258	0.262	0.257	0.318	0.322	0.323	0.321	0.365	0.371	0.375	0.374	0.371

Physical and Chemical properties of Jaggery

pH	Color	Texture	Taste	Hardness (kg/cm ²)	Moisture (%)	Porosity (ml/g)	RS (%)	Ash (%)	Pol	Brix	Temp. (°C)	Sucrose (%)	NR Value	Grade	Quality
6.4	Golden yellow	Amorphous	Sweet	1.8	8.2	0.2	6.5	1.29	40	10.9	29.8	78.8	76.81	A1	Excellent
6.6	Pale yellow	Crystalline	Sweet	2.0	8.0	0.15	6.3	2.79	40	10.3	29.8	76.0	79.46	A1	Excellent
6.8	Dark	Crystalline	Slightly saltish	2.2	7.9	0.15	6.2	2.1	41	10.1	29.8	75.6	76.75	A1	Excellent

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3 Lime source: Calcium oxide [CaO]

Variety: Co 92005

	Adjusted pH: 6.4				Adjusted pH: 6.6				Adjusted pH: 6.8			
	R1	R2	R3	Average	R1	R2	R3	Average	R1	R2	R3	Average
Initial pH	5.06	5.07	5.06	5.06	5.07	5.09	5.06	5.07	5.09	5.07	5.09	5.08
Amount of lime (mg l ⁻¹)	0.475	0.493	0.481	0.483	0.635	0.65	0.642	0.642	0.769	0.8	0.773	0.781

Physical and Chemical properties of Jaggerly

pH	Color	Texture	Taste	Hardness (kg/cm ²)	Moisture (%)	Porosity (ml/g)	RS	Ash (%)	Pol	Brix	Temp. (°C)	Sucrose (%)	NR Value	Grade	Quality
6.4	Golden yellow	Amorphous	Sweet	1.4	6.8	0.20	2.7	0.92	42	11	29.2	80.84	74.92	A1	Excellent
6.6	Pale yellow	Crystalline	Sweet	1.5	6.2	0.20	2.7	1.82	40	11.4	29.2	77	67.93	A1	Excellent
6.8	Dark	Crystalline	Slightly saltish	2.0	5.0	0.25	2.6	1.98	42	10.7	29.2	79.07	69.54	A1	Excellent

Variety: Co 62175

	Adjusted pH: 6.4				Adjusted pH: 6.6				Adjusted pH: 6.8					
	R1	R2	R3	Average	R1	R2	R3	Average	R1	R2	R3	Average		
Initial pH	4.91	4.85	4.88	4.86	4.88	4.86	4.88	4.88	4.89	4.86	4.85	4.85	4.84	4.85
Amount of lime (mg l ⁻¹)	0.368	0.372	0.359	0.38	0.370	0.519	0.516	0.521	0.519	0.618	0.625	0.639	0.639	0.627

Physical and Chemical properties of Jaggery

pH	Color	Texture	Taste	Hardness (kg/cm ²)	Moisture (%)	Porosity (ml/g)	RS (%)	Ash (%)	Pol	Brix	Temp. (°C)	Sucrose (%)	NR Value	Grade	Quality
6.4	Golden yellow	Amorphous	Sweet	1.5	8.7	0.20	4.6	1.02	40	10.4	28.4	76.15	66.51	A1	Excellent
6.6	Pale yellow	Crystalline	Sweet	2.4	8.4	0.20	4.9	1.44	41	11.3	28.3	78.92	70.45	A1	Excellent
6.8	Dark	Crystalline	Slightly saltish	2.6	7.8	0.25	2.8	1.69	42	11.3	28.3	81.46	72.74	A1	Excellent

Variety: Co 86032

	Adjusted pH: 6.4				Adjusted pH: 6.6				Adjusted pH: 6.8					
	R1	R2	R3	R4	Average	R1	R2	R3	R4	Average	R1	R2	R3	Average
Initial pH	4.85	4.89	4.9	4.92	4.89	4.92	4.9	4.89	4.88	4.90	4.91	4.92	4.89	4.91
Amount of lime (mg l ⁻¹)	0.285	0.28	0.279	0.286	0.283	0.355	0.361	0.364	0.365	0.361	0.448	0.446	0.453	0.449

Chemical and Physical parameters of Jaggery :

pH	Color	Texture	Taste	Hardness (kg/cm ²)	Moisture (%)	Porosity (ml/g)	RS (%)	Ash (%)	Pol	Brix	Temp. (°C)	Sucrose (%)	NR Value	Grade	Quality
6.4	Golden yellow	Amorphous	Sweet	1.7	8.5	0.20	6.8	2.47	39	10.8	28.5	76.76	61.31	A2	Good
6.6	Pale yellow	Crystalline	Sweet	2.5	8.2	0.20	6.6	1.98	39	10.6	28.5	76.38	62.85	A2	Good
6.8	Dark	Crystalline	Slightly saltish	2.8	7.9	0.15	5.8	2.8	40	10.2	28.5	75.76	60.16	A2	Good

Annexure - 3

Details of Equipments purchased at Jaggery Park:

Sl. No	Particulars	Total Quantity
01	Flame Photometer	01
02	Spectrophotometer	01
03	Digital Jaggery Moisture meter	01
04	Water bath	01
05	Precision balance (electronic)	01
06	Hot plate	01
07	Hot air oven	
	(a)24"x24"x42"	01
	(a)24"x24"x48"	01
08	(a)Water meter + Durt box 3"	03+03
	(b)Water meter + Durt box 2"	03+03
09	GPS	01
10	Rapipol extractor	01
11	Crystal measuring microscope	01
12	Brix hydrometer with thermometer	
	Range - 10-20° &	01
	20-30°	01
13	Digital Hand refractometer 0 - 32%	04
14	Lux meter	01
15	(a)Muffle furnace Size :10x10x23 cm	01
	(b)Silica crucible without lid cap-50 ml	01
	(c) Silica crucible without lid cap-100 ml	01
16	(a)Revolutionary high speed Centrifuge	01
	(b)6x50 ml angle head with polypropylene tubes	01
17	Single Distillation unit	01
18	Thermo-hygrometer with temperature probe	01
19	Field balance (Electronic precision balance)	
	(a)60 Kg capacity	01
	(b)600 Kg capacity	01
20	Online pH transmitter cum controller	01
21	Digital thermometer with temperature sensor	01
22	Infrared thermometer USA make	01
23	Sony Digital camera	01

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24	Refrigerator	01
25	(a)Shrink wrapping machine	01
	(b)L - Sealer	01
	(c)Hand operated sealing machine 12"	01
	(d)Hand operated sealing machine 16"	01
	(e)Revo bag closer (stitching machine)	01
26	Handy cam	01
27	Duro + UV Water purification system	02
28	Temperature and monitoring system (Temp. controller)	01
29	Magnetic stirrer with hot plate (2 lt)	01
30	3 KVA offline UPS Cosmic make with 12V tubular batteries (3 No.)	01
31	Kirloskar make 7.5 HP monoblock pump with accessories	01
32	Supply of GI accessories commissioning of pump set and electrification	01
33	1.5 KVA Luminous UPS	01
34	Stickering name boards	15
35	HP Laser Jet Printer	01
36	Automatic N Analyzer	01
	Digital burette	01
	pH meter	01
	EC+TDS meter	01
37	Plant canopy imager	01
38	Advance Polarimeter	01
39	LCT make electronic aerated steam therapy unit	01
40	62.5 KWA/50 KW Mahindra Powerol DG set with accessories	01
41	Furnishing research laboratory	1 unit
42	Furnishing audio visual components for training hall	1 unit
43	Furnishing storage hall with multiplex storage racks	1 unit
44	Furnishing fume hood /ducking/blower with wooden table and adjustable stands	1 unit
45	Purchase of office and training hall furniture	1 unit
46	Providing aluminum partition to the laboratory	1 unit

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47	Eco solvent display sun boards	35 No.
48	Mechanization implements (Farm)	1 set
49	Providing False ceiling in training hall	1 unit
50	Construction of stage in training hall	1 unit
51	Air Conditioner for training hall	1 unit
52	Laying out irrigation pipes in the sugar cane fields of Jaggery Park	1 set
53	Refrigerator	01