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Jaggery Yield and Nutritional Quality as Influenced by Sugarcane Varieties Suitable for Andhra Pradesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Jaggery is produced from sugarcane in addition to sugar. It plays a great role in rural economy of India. However, till date the jaggery producers are dependent on the sugarcane varieties which are released for those areas. The major factor that governing the consumer preference and marketing of jaggery is its external appearances i.e., colour, texture and storability which in turn depend on sugarcane varieties having high sucrose content, purity and low colloids. Hence this study was taken up to identify suitable sugarcane varieties for high yield and good quality jaggery. A study was conducted at Agricultural Research Station, Perumallapalle, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India to identify the sugarcane varieties most suitable for quality jaggery production. Ten promising sugarcane varieties were planted in randomized block design with three replications. All cultivation practices had followed equally for all varieties. The sugarcane varieties were harvested at proper maturity, crushed to extract juice and prepared jaggery. The jaggery was evaluated qualitatively for pH, EC, reducing sugars, ash content, sucrose, moisture, micronutrients *viz*., Fe, Mn, Zn and Cu and calculated net rendement value (NRV). The jaggery was found to have 70.6 to 86.9% sucrose, 5.12 to 6.80% of reducing sugars, 3.52 to 4.32% of ash, 5.0

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to 6.1% of moisture, 9.58 to 11.20 % of recovery, 49.85 to 67.70 of NRV values, 98.6 to 114.1 kg jaggery t^{-1} of sugarcane. The jaggery prepared from 2012 T 115 had recorded significantly the highest jaggery yield (114.1 kg t^{-1} of cane), high recovery percent (11.20%) and high NRV (67.70) than other varieties. The varieties *viz.*, 2012 T 183, 2012 T 88 and 2012 T 53 were produced Grade 1 jaggery with high NRV as per Indian standards. The variety 2012 T 115 had higher Fe and Mn (12.15 and 0.38 mg of Fe and Mn/ 100g of jaggery, respectively).

Keywords: Jaggery yield; sugarcane varieties; minerals; nutritional quality; NRV; Andhra Pradesh.

1. INTRODUCTION

"Sugarcane is the main source of sweetener's in India. Jaggery is one of the oldest and most important cottage industries in India. Jaggery is a natural, traditional sweetener made by the concentration of sugarcane juice and is known all over the world" [1] in different local names [2]. "In India, of the total sugarcane produced, 53% is processed into white sugar, 36% into jaggery and khandsari, 3% for chewing as cane juice, and 8% as seed cane" [3]. "India produces more than 70% of the total jaggery production of the world" [4]. Nearly 40% of cane grown in Andhra Pradesh is utilized towards jaggery manufacture. Jaggery is not only used as sweetening agent but also used in several sweet food preparations. In Rayalaseema region of Andhra Pradesh, an appreciable percentage of cane is being utilized for jaggery manufacture. Being an eco friendly sweetener with additional nutritional value jaggery holds good export potential. Jaggery is far complex than sugar, as it is made up of longer chains of sucrose. Hence, it is digested slower than sugar and releases energy slowly and not spontaneously. This provides energy for a longer time and is not harmful for the body. "The dietary intake of jaggery prevents the atmospheric pollution related toxicity and the incidence of lung cancer" [3]. "Quality of jaggery is very sensitive to various parameters such as sugarcane variety, cultivation practices, fertilizers used, stage of harvest, method of juice extraction etc" [5,6]. "The composition of extracted juice in terms of its pH, purity, TSS affects the quality of jaggery. To sustain the market and export potential of jaggery it is imperative that the jaggery yield and quality need to be sustained" [7]. "In general sugarcane farmers face several problems such as low extraction percentage of juice, low recovery and poor quality of jaggery. Quality jaggery comprises of high sucrose and purity with less reducing sugars. It has been found that there is wide variation in quality of jaggery depending on varieties used in its preparation" [8,9]. "Jaggery quality depends mainly on juice and hence factors affecting juice quality also affect the jaggery quality. Studies showed that jaggery quality preferable depends on chemical composition of juice irrespective of method of boiling and clarification" [10]. Keeping this in views, a study was taken up to identify a variety with high jaggery yield and good quality of jaggery which is suitable for Andhra Pradesh and South India.

2. MATERIALS AND METHODS

Ten sugarcane varieties *viz.*, 2012 T 53, 2012 T 73, 2012 T 88, 2012 T 98, 2012 T 106, 2012 T 115, 2012 T 180, 2012 T 183, 2003 V 46 and Co C 671 were planted in randomized block design with three replications at Agricultural Research Station, Perumallapalle, ANGRAU, Andhra Pradesh, India. Planting was taken up in the month of February, during both the years (2017 and 2018) and harvested at December of the same year for jaggery preparation. The cane was weighed after harvest and crushed for juice extraction. Jaggery was prepared from extracted juice of all the varieties by using traditional open pan system. In jaggery preparation, juice clarification is most important process for acquiring good colour [11]. Clarification of juice was carried out by using bhendi plant extract as natural juice clarificant (250g /120 lit of juice). Lime (40g / 120 lts of juice) was added at the time of boiling of juice during jaggery preparation to bring juice pH to neutral from acidic state.

For stock solution of jaggery, 65 g of jaggery sample was weighed and dissolved in 500 ml of water to make a homogeneous solution (0.5*M*) and then the analysis was carried out with this solution. Brix reading was recorded with brix hydrometer; pol reading was noted by polarimeter using lead acetate as juice clarificant. Physico-chemical properties were assessed by the method developed by [12]. pH and electrical conductivity of jaggery solution was determined by using pH meter and conductivity meter, respectively. Reducing sugars measured by the method described by [13]. The chemical method adopted for the determination of reducing sugars

reduce copper in the is based on the property of sugars to reduce copper from cupric state to cuprous state. Total reducing sugar (inert sugars) can be measured by colorimetric method using Nelsons alkaline copper reagent. The colour of jaggery was determined by percent transmission of light by using UV-VIS spectrophotometer [11]. The jaggery samples were digested and used for estimation of nutrients (Fe, Mn, Zn and Cu) by using atomic absorption spectrophotometer (Varian AAS 42). Moisture percent was estimated by the method described by [14].

As per Indian standards (IS 1923; 1990), the jaggery shall be prepared in the form of solid lumps with firm consistency. The colour of jaggery should be golden yellow to light brown, free from dirt, other extraneous matter and also substance harmful to health. It should be sweet to taste and should not be sour, salty or any other objectionable taste. Besides grade I and II (Table 1), jaggery should confirm the characteristics, requirements and methods of test for grading Indian jaggery. Specific characteristics and grading designation of Agmark standard are given in Table 1.

Net rendement value was calculated as NRV= (Sucrose % -Reducing sugars %) – 3.5 x ash %). Based on NRV, the quality of jaggery was considered as follows:

List 1. Range of net rendement value

Range of net rendement value	Grade	Quality
>65	A1	Excellent
60 - 65	A	Good
45 - 60	B	Medium
<45	C	Poor

Source: Sugarcane chemistry, sugar and gur technology, TNAU

3. RESULTS AND DISCUSSION

The data was presented in Table 2 showed that jaggery yield had significantly affected by all varieties. The variety 2012 T 115 recorded significantly the highest jaggery yield (114.1 kg of jaggery t^{-1} of sugarcane) followed by 2012 T 183 (112.8 kg t^{-1} of cane). This might be due to high recovery percent from cane with 2012 T 115 (11.20%) followed by 2012 T 183 (10.98%) and also due to high cane yield [15,16]. The sucrose content in jaggery has significantly differed with varieties. The sucrose content in varieties 2012 T 115 (86.9%) and 2012 T 53 (86.5%) was on par with each other. For superior jaggery (Grade 1), the variety should posses high sucrose content (>80%) and low reducing sugars (<10%). The jaggery prepared from all the varieties had low reducing sugars i.e. less than 10% which is one of the important parameter for grade I jaggery. The variety 2012 T 53 had low reducing sugars (5.12%) and it was at par with 2012 T 115 (5.26%). Low reducing sugar is preferable for better quality of jaggery because it is generally high hygroscopic [8]. The moisture content in jaggery of various varieties ranged between 5.2% (2012 T 115) and 8.1% (2012 T 98) (Table 3). According to Indian standard, the jaggery with 5 - 6%^ moisture content was categorised under Grade 1 (Table 1). Another important feature of the variety for quality jaggery production is low fibre content that should improve the extraction percent of juice and ultimately the recovery percent [1]. Higher jaggery recovery from cane juice was obtained in 2012 t 115 (21.08%) followed by 202 T 183 (20.86%). The purity of jaggery of the varieties 2012 T 183, 2012 T 53, 2012 T 106 and 2012 T 115 was at par with each other. Regarding ash content, 2012 T 115 showed less ash content (3.46%) followed by 2012 T 106 (3.52%). Electrical conductivity of jaggery which shows salt content owing to its hygroscopicity is lowest in 2012 T 183 (0.182 dS m-1) followed by 2012 T 115 (0.208 dS m^{-1}) (Table 3). Highest EC values were recorded with CoC 671, Co 94008, 2012 T 53 which are more hygroscopic compared to other varieties. Higher values indicated that susceptibility of jaggery for moisture absorption. As far as colour is concerned, the most suitable varieties were found to be 2012 T 115 (20.50), Co 94008 (21.56) and 2012 t 53 (21.60). These varieties could be used for producing light golden coloured jaggery. The production of attractive colour jaggery in turn depends on the extent of clarity of sugarcane juice. The fresh cane juice contains appreciable quantity of colloidal impurities and these are to be removed for manufacturing the quality jaggery. The pH of the juice determines the crystalline texture of the jaggery. The different varieties of sugarcane were showed non significant effect on pH of jaggery. The quality crystalline jaggery can be produced by adjusting the pH above 6.0. The natural sugarcane juice has a pH of 5.5. It can be adjusted by using the lime for this purpose. The low levels of pH cause inversion by hydrolyzing the sugar and thus affecting the jaggery quality [7,16].

The higher NRV was obtained with varieties 2012 T 115 (67.70), 2012 T 106 (66.15), 2012 T 183 (66.78) and 2012 T 88 (65.69). It indicated

that these varieties grouped under A1 grade with excellent quality jaggery [17]. The Fe and Mn content in jaggery were significantly affected by varieties (Table 4). The Fe content from jaggery produced with 2012 T 115 (12.15 mg/100g) was at par with 2012 T 183 (11.92 mg/100g). However high Mn content (0.39 mg/100g) was recorded with 2012 T 183 and it was at par with 2012 T 115 (0.38mg/100g). The Zn and Cu content in jaggery produced from different varieties was not significantly influenced by varieties [18].

Table 1. Standard specifications for cane jaggery

Parameters	Requirements for	
	Grade I	Grade II
Sucrose % (minimum)	80	70
Reducing sugars % (maximum)	10	20
Moisture % (maximum)	5	7
Sulphated ash % (maximum)	3.5	5.0

Table 2. Quality parameters and yield of jaggery as affected by elite sugarcane varieties

Variety	Jaggery yield (kg t^{-1})	Sucrose (%)	Purity (%)	Reducing sugars (%)	Moisture (%)	Recovery % from cane	Recovery % from juice
2012 T 53	109.8 ^{c}	86.5 ^{a}	92.5 ^{a}	5.26 ^{a}	7.6 ^{c}	10.25 ^{c}	20.54 ^{a}
2012 T 73	101.3 ^{de}	81.2 ^{cd}	86.5 ^{d}	5.94 ^{bc}	6.0 ^{b}	10.86 ^{a}	19.25 ^{ab}
2012 T 88	112.2 ^{b}	84.5 ^{b}	90.2	6.35 ^{d}	7.8 ^{c}	10.02 ^{cd}	20.80 ^{a}
2012 T 98	99.12 ^{f}	70.6 ^{e}	88.5 ^{bc}	6.0 ^{c}	8.1 ^{de}	9.98 ^{cd}	17.26 ^{e}
2012 T 106	107.6 ^{c}	84.4 ^{b}	91.6 ^{a}	5.92 ^{bc}	7.4 ^{c}	10.56 ^{b}	20.04 ^{ab}
2012 T 115	114.1 ^{a}	86.9 ^{a}	91.0 ^{a}	5.12 ^{a}	5.2 ^{a}	11.20 ^{a}	21.08 ^{a}
2012 T 180	102.7 ^{d}	79.1 ^{cd}	92.0 ^{a}	6.74 ^{e}	6.8 ^{b}	10.57 ^{b}	18.55 ^{cd}
2012 T 183	112.8 ^{b}	86.6 ^{a}	92.8 ^{a}	5.81 ^{b}	6.2 ^{b}	10.98 ^{a}	20.86 ^{a}
Co94008	101.5 ^{de}	72.5 ^{d}	89.2 ^{bc}	6.01 ^{c}	8.0 ^{de}	9.94 ^{cd}	19.36 ^{bc}
CoC 671	98.6	77.2 ^{cd}	94.1 ^{e}	5.96 ^{bc}	5.5 ^{a}	9.58 ^{e}	18.62 ^{cd}
Treatments	*	**	*	*	*	*	*8
p-value	0.042	0.008	0.032	0.027	0.014	0.034	0.044

**significant at p=0.05 level; ** significant at p=0.01 level*

Note: Same letter or set of letters indicated that those values were on par with each other

Table 3. Physico chemical properties and recovery percent of jaggery as influenced by sugarcane varieties

Variety	Ash (%)	pH	Electrical conductivity (dS m^{-1})	Colour intensity (OD value)	Net Rendement Value (NRV)
2012 T 53	3.46 ^{a}	5.82	0.264 ^{bc}	21.60 ^{ab}	62.83 ^{ab}
2012 T 73	4.12 ^{de}	5.77	0.251 ^{b}	23.53 ^{cd}	60.84 ^{b}
2012 T 88	3.56 ^{a}	5.60	0.260 ^{bc}	22.47 ^{ab}	65.69 ^{a}
2012 T 98	4.21 ^{de}	5.74	0.258 ^{bc}	29.10 ^{e}	49.85 ^{cd}
2012 T 106	3.52 ^{a}	5.94	0.250 ^{b}	30.40 ^{e}	66.18 ^{a}
2012 T 115	3.91 ^{cd}	5.81	0.208 ^{a}	20.50 ^{a}	67.70 ^{a}
2012 T 180	3.89 ^{cd}	5.77	0.262 ^{d}	22.10 ^{ab}	58.75 ^{b}
2012 T 183	3.72 ^{ab}	5.87	0.182 ^{a}	23.13 ^{cd}	66.78 ^{a}
Co94008	4.32 ^{e}	5.34	0.288 ^{de}	21.56 ^{ab}	51.36 ^{c}
CoC 671	4.02 ^{d}	5.91	0.352 ^{e}	25.42 ^{d}	57.17 ^{b}
Treatments	*	N.S.	*	*	*
p-value	0.041	0.102	0.034	0.048	0.042

**significant at p=0.05 level; ** significant at p=0.01 level*

Note: Same letter or set of letters indicated that those values were on par with each other

Table 4. Nutrient content (mg /100g of jaggery) of jaggery prepared from elite sugarcane varieties

Variety	Iron	Zinc	Manganese	Copper
2012 T 53	10.85 [b]	0.48	0.32 [ab]	0.28
2012 T 73	11.62 [ab]	0.52	0.28 [bcd]	0.20
2012 T 88	8.62 [c]	0.46	0.35 [a]	0.26
2012 T 98	9.74 [bc]	0.59	0.26 [bcd]	0.30
2012 T 106	7.58 [d]	0.41	0.31 [ab]	0.27
2012 T 115	12.15 [a]	0.50	0.38[a]	0.24
2012 T 180	10.56 [b]	0.41	0.30 [ab]	0.32
2012 T 183	11.92 [a]	0.48	0.39 [a]	0.28
Co94008	8.20 [cd]	0.50	0.22 [cd]	0.26
CoC 671	7.02 [e]	0.44	0.32 [ab]	0.24
Treatments	*	N.S.	*	N.S.
p-value	0.026	0.094	0.041	0.124

**significant at p=0.05 level; ** significant at p=0.01 level*

Note: Same letter or set of letters indicated that those values were on par with each other

4. CONCLUSION

At present, jaggery is graded at national level on Agmark system of solid jaggery grading (based on physical characteristics) and BIS standards IS:1923. Out of ten varieties 2012 T 115 proved to be suitable regarding maximum jaggery yield, high NRV, low electrical conductivity, low reducing sugars and light colour. The study revealed that quality grade 1 jaggery with high sucrose, low ash content, low reducing sugars were obtained from 2012 T 183, 2012 T 88 and 2012 T 53. The variety 2012 T 115 had higher Fe and Mn (12.15 and 0.38 mg of Fe and Mn/ 100g of jaggery, respectively).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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