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Validation of Sugarcane Clones for Quality Jaggery Production in North Coastal Zone of Andhra Pradesh

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ABSTRACT

The study was conducted at Regional Agricultural Research station, Anakapalle, Andhra Pradesh, India during two consecutive years i.e. 2020–2021 to identify suitable sugarcane varieties for quality jaggery production. Six promising early varieties (2016 A 332, 2016 A 480, 2016 A 291, 2016 A 151, 2016 A 387, 2016 A 275) along with one check variety (87 A 298) were studied for cane yield, jaggery recovery. Jaggery making is age-old cottage industry prevailing in rural India. It is the traditional sweetener produced by evaporating sugarcane juice in conventional open boiling system. The quality of jaggery mainly depends on the quality of sugarcane seed used for jaggery making. Generally farmers are preparing jaggery using the cane variety recommended for that area for high sugar recovery. The major factors that govern the jaggery farmer's preference are color, texture, shelf-life and high jaggery recovery which mainly depends on sugarcane variety. The quality parameter of the jaggery prepared from these varieties was evaluated for sucrose %, reducing sugars %, color and moisture content. The variety 2016 A 332 recorded highest cane yield (129 t ha^{-1}) with jaggery recovery of 11% with highest sucrose % (86.7) and bright color. Among the varieties under study, 2016 A 332 followed by 2016 A 480 and 2016 A 387 are recommended for large scale production of quality jaggery in North coastal region of Andhra Pradesh.

KEYWORDS: Jaggery, screening, jaggery recovery, cane yield

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1. INTRODUCTION

India emerged to be second largest sugar producing country in the world next to Brazil producing 439 million tonnes of sugarcane (Anonymous, 2021). Typically, about 79.9% of India's total sugarcane is used for white sugar, 11.29% for jaggery and khandasari, which is unrefined sugar with strong molasses, and 8.8% as cane juice and seed cane (Gayathry et al., 2021). Jaggery is the traditional sweetener with nutritional and medicinal properties. The chemical composition of jaggery primarily consists of sucrose (65–85%), reducing sugar including glucose and fructose (10–15%), non-sugars such as calcium (0.4%), magnesium and phosphorus (0.045%), protein (0.25%) and fat (0.05%) (Rao et al. 2007). The high medicinal qualities of jaggery pave way for its extensive use in traditional medicine (Sardeshpande et al., 2010). Furthermore, it is very good cleansing agent and cleans lungs, stomach, intestines, oesophagus and respiratory tract (Sinha et al., 2015). Jaggery serves several health benefits such as improves immune system, helps in overcoming cold and to women during menstruation (Prasad and Shivay, 2020).

In Andhra Pradesh, jaggery was considered to be main ingredient in making traditional foods from ancient times and continuous to be important cottage industry. With all its inherited nutritional qualities jaggery has high export potential. India is also the largest producer of jaggery under unorganized agro-processing sector and shares 70% of the total world jaggery production (Singh et al., 2013; Lal et al., 2018). Compared to sugar, jaggery is made of longer chains of sucrose and hence digested slowly and releases energy slowly. It was reported that the nutritive intake of jaggery prevents atmospheric pollution related toxicity and the occurrence of lung cancer (Kumar et al., 2022). Though, India is the world's leading jaggery manufacturer, but could not be export jaggery to other countries as it does not meet international quality standards according to Prevention to Food Adulteration rules, 1995. Hence to sustain in national and international markets, quality jaggery making is a mandatory. Quality jaggery implies selection of a good sugarcane variety with proper management and preparation of jaggery under hygienic conditions. The TSS, pH and the purity of the juice extracted from a particular cane variety are the major factors affecting the quality of juice. Generally, the jaggery farmers face several problems such as low extraction percentage of juice, low recovery and poor jaggery quality and ultimately fetching low price for jaggery in the market. Many a times, the jaggery farmers incur the problem of setting of jaggery during jaggery making which mainly depends on variety of sugarcane used for jaggery preparation. It was found that there is wide range of variation in quality of jaggery produced depending on the variety used for jaggery making. The quality of jaggery mainly depends on composition of juice and hence the parameters affecting the juice quality also affect jaggery quality. Previous studies reported that the quality of jaggery mainly depends on chemical composition of juice irrespective of method of preparation (Kumar et al., 2022). It was reported that high yielding sugarcane varieties are not rich in sucrose content and are not fit for jaggery making (Singh et al., 2019). The sugarcane variety with high sucrose content and more purity with less invert sugars gives quality jaggery. The selection of specific sugarcane variety that produces best jaggery in terms of its quality and recovery will benefit jaggery farmers (Pawar et al., 2022). Jaggery is available in solid blocks, liquid form, and granular form. However, the shelf-life of solid jaggery prepared from poor quality of sugarcane juice is very limited and gets spoiled easily due to the microbial contamination making it unfit for consumption. Especially in the coastal regions of Andhra Pradesh, where the relative humidity is very high, maintaining the quality of jaggery is a major problem (Sreedevi et al., 2021). Hence, selection of suitable variety for preparation of quality jaggery is very much essential for marketability. The demand for high quality, organic, nutritious food products such as jaggery among the consumers paved way to look for quality jaggery production in food processing sector through identification of suitable sugarcane variety.

Hence, the present study was carried out at Regional Agricultural Research station, Anakapalle to identify suitable sugarcane varieties for quality jaggery production with high jaggery recovery.

2. MATERIALS AND METHODS

Six early varieties (2016 A 332, 2016 A 480, 2016 A 291, 2016 A 151, 2016 A 387, 2016 A 275) were planted in randomized block design with three replications along the check variety 87 A 298 at Regional Agricultural Research Station, Anakapalle, Andhra Pradesh, India (16° 30'N latitude and 18 ° 20'E longitude). The planting was done in the month of February, during two consecutive years 2020 and 2021 and harvested in the month of December of the same year. The canes after attaining maturity were crushed and used for jaggery making. About 10 liters of sugarcane juice was taken from the cleaned canes, filtered using muslin cloth to remove coarse impurities. Jaggery making is done in traditional open pan. During boiling of juice, clarification of juice was done to remove impurities from sugarcane juice. The addition of lime in sugarcane juice improves the consistency of jaggery by increasing the crystallization of sucrose, however, excess addition will impart dark color to the final product (Kumar and kumar, 2018). The flow chart

for preparation of jaggery was depicted in figure 1. During boiling, milk of lime was added as clarificant to separate the scum and also to adjust the pH of the juice from 5.2 to 5.8 (Sreedevi et al., 2022). While boiling, continuous stirring was done manually using wooden ladles and boiling was continued till striking point is reached (118 °C, 82° Brix). The semisolid jaggery concentrate is then moulded in to required shapes in SS moulding frames. The jaggery thus prepared was weighed for calculating jaggery recovery and the sample of it was used for quality analysis. The quality of jaggery mainly depends on juice quality. Hence, the quality parameters of juice such as sucrose %, °brix were recorded. Portable hand refractometer (Models PAL-1, 0-53_Brix: Make: Atago, Japan) having resolution of 0.1 Brix was used to measure brix of the juice. The moisture content of the jaggery samples was calculated by Gravimetric method as per AOAC (Anonymous, 2000) and expressed as percentage dry basis. The percent sucrose of juice and jaggery samples was recorded using polarimeter (Antanpaar, Model: MCP 500 Sucromat). The percent reducing sugars are estimated by Lane and Eynon method (1923) using Fehlings A and Fehlings B solutions. The Purity (%) was determined by Spencer and Meade (1977). The color of jaggery was measured using portable colorimeter (Model: Spectro-guide 45/0 gloss; Make: BYK Gardner, Geretsried, Germany) calibrated against a white and black tile. Color of the sample is expressed in CIE scale (Commission Internationale de l'Echairages) in terms of L*, a* and b*, where L* denotes lightness, a* indicates red/green value and b* denotes yellow/blue value. The values of L*, a* and b* were taken at various locations in jaggery sample, and the average of the three readings was recorded. The fibre content of sugarcane variety was estimated using rapipol extraction method (Rao et al., 2003). The top, middle and bottom portion of six canes were sampled and cut into small bits. Later, 250 g of chopped cane bits were mixed and placed in the cup of the Rapipol extractor. Two liters of water is added and disintegrated in Rapipol extractor for 5 minutes. After decantation, 2 litres of water is added and mixed well for about 2 to 3 minutes and decanted without any loss of fibre. The above procedure is repeated once again, filtered quantitatively through a fine mesh filter and finally transferred quantitatively to a bag of known weight. It is dried at 110° C to constant weight. The per cent dry weight to fresh weight of material is calculated and expressed as fibre per cent cane. The quality analysis of jaggery prepared from different varieties was performed in triplicates and the results are presented as mean ± standard deviations.

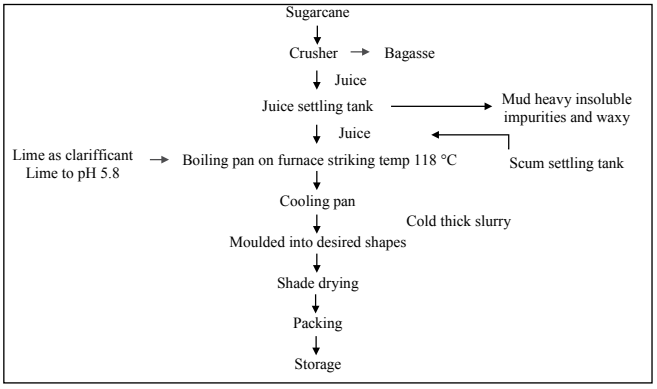

Figure 1: Flow chart for preparation of Jaggery

3. RESULTS AND DISCUSSION

The quality parameters of sugarcane juice obtained from six clones was given in Table 1. The sucrose percent of sugarcane juice varied from 16 to 19%. Among the varieties, the sucrose % of the sugarcane juice from the variety 2016 A 332 (19.11%) recorded highest and 2016 A 151(16.08%) recorded lowest. It was reported by Xiao et al., 2017 that the nutrients present in the juice tend to accumulate sucrose, brix and purity thereby improving the quality of juice. Therefore, among the sugarcane varieties under study, the varieties 2016A 332, 2016 A 480 and 2016 A 387 recorded high sucrose%, brix % and purity %. Also, it was observed that highest cane yield (129 t ha^{-1}) was recorded for the variety 2016 A 332 followed by 2016 A 387. Subsequently,

Table 1: Quality parameters of sugarcane juice and jaggery recovery from early sugarcane Varieties

Sl. No	Variety	Brix %	Sucrose %	Purity (%)	Cane yield (t ha^{-1})	Jaggery yield (t ha^{-1})	Jaggery recovery (%)	Fiber (%)
1.	2016 A 332	20.56±0.4	19.11±0.6	92.9±0.3	129±5	14.2±0.5	11.0±0.3	20.5±1.1
2.	2016 A 480	20.17±0.2	19.02±0.6	95.2±0.3	120±5	12.5±0.3	10.4±0.4	20.9±1.2
3.	2016 A 291	20.82±0.2	17.63±0.5	84.6±0.3	123±4	9.1±0.2	7.3±0.2	23.3±1.0
4.	2016 A 151	19.34±0.2	16.08±0.4	83.1±0.3	122±5	9.8±0.2	8.0±0.3	16.2±0.9
5.	2016 A 387	20.16±0.3	18.13±0.5	89.9±0.6	126±4	12.8±0.4	10.1±0.4	21.9±1.2
6.	2016 A 275	20.13±0.3	17.31±0.5	85.9±0.4	110±3	7.9±0.2	7.2±0.2	17.4±0.9
7.	87 A298 (check)	20.19±0.2	18.29±0.5	90.5±0.3	91±2	8.9±0.2	9.7±0.3	21.6±1.2

Values are reported as mean± standard deviation (N=3)

highest jaggery recovery was recorded (11%) in 2016A 332. However, the purity was recorded to be high in 2016 A 480 followed by 2016 A 332. The highest sucrose % of 86.7 and reducing sugars of 8.23% was recorded for the jaggery prepared from 2016 A 332. As per the Food Safety and Standards Authority of India (Anonymous, 2017), the jaggery prepared from the varieties under the study was found to contain all the three constituents namely sucrose (>70%), reducing sugar (<20%) and the moisture content (<5%). For a quality jaggery, the variety should possess high sucrose and purity with less reducing sugars (Selvi et al., 2022). The jaggery with sucrose percent more than 80% and reducing sugars less than 10% comes under Grade-I according to Indian standard cane gur (jaggery) specification IS 12923:1990 (Singh et al., 2019). The quality parameters of jaggery prepared from different varieties in presented in Table 2. It was reported by Gayathry et al. (2021) that sucrose percent of the jaggery is an important component to improve the keeping quality of the jaggery. Among the varieties evaluated, 2016 A 332 recorded highest sucrose of 86.73%. The reducing sugars of jaggery prepared from varieties varied from 6.92 to 8.8%. Jaggery with low reducing sugars has more shelf-life as it is less hygroscopic in nature (Venkatesan et al., 2022). Of all the varieties evaluated 2016 A 387 recorded low reducing sugars, but the jaggery recovery is low compared to 2016 A 332. The moisture percent of jaggery prepared from the varieties varied from 2.9 to 6.6%. Lower the moisture of the sample, lower will be chance for the microbial infestation and longer will be the shelf-life. According to Indian standards (IS 12923: 1990), jaggery with moisture content less than 5% comes under Grade I. Expect 2016 A 275 and 2016 A 151, all the varieties evaluated were recorded moisture content less than 5%. Out of six varieties tested, lowest moisture content is recorded for 2016 A 332 followed by 2016 A 480 and 2016 A 387.

The fibre content of the variety is important factor for screening of sugarcane variety for high jaggery recovery. The variety with low fibre content will have high juice extraction percent, thereby results in high jaggery recovery. The fibre content of the varieties under study varied from 16 to 23%. Though the variety 2016 A 151 recorded lowest fibre content (16.2%), the sucrose % in the juice recorded is low (16%) and also the jaggery recovery is low (8%). Similarly, the variety 2016 A 291 recorded highest fibre content (23%), low sucrose (17%) and subsequently jaggery recovery is low. It was already reported by Singh et al. (2019) that high juice yielding varieties are not promising in juice quality especially in sucrose percent and are not fit for jaggery production Among the varieties tested, 2016 A 332 having moderate fibre content of 20% with high sucrose content of 19% resulted in high jaggery recovery. Similarly, the jaggery produced from this variety recorded highest sucrose (86%), lowest reducing sugars (8.23%) and low moisture content (2.9%) which are very much desirable qualities for Grade I jaggery. The color of the jaggery is the major factor that governs quality as well as marketability. The color of jaggery should be golden yellow to light brown and should be free from dirt, other extraneous matter (Singh et al., 2019). Grading of jaggery in India is performed based on its color; light-colored jaggery is reported to be preferred by consumers and has high commercial value (Pandraju et al., 2021). Hence light yellow colored jaggery prepared from the promising sugarcane clone should be selected for quality jaggery making. The color values of jaggery were presented in Table 2. The value of L^* which represents lightness is more in 2016 A 332(53.4) and low in 2016 A 275(47.0). The lower the L^* value, the darker will be the color of jaggery. The value of a^*, b^* represents redness and yellowness of the jaggery respectively. The b^* value is recorded highest in 2016 A 332 representing more yellowness followed by 2016 A 480. The jaggery prepared from a particular variety with higher L^* and b^* values were found to be more acceptable by the consumers in terms of its color and similar findings were reported by Kumar et al.,

Table 2: Quality parameters of jaggery produced from early sugarcane varieties

Sl. No	Variety	Sucrose %	Reducing sugars %	Moisture content (% db)	Color		
					L^*	a^*	b^*
1.	2016 A 332	86.73±3.1	8.23±0.5	2.9±0.1	53.4±2.1	1.44±0.03	4.79±0.2
2.	2016 A 480	80.58±2.5	8.79±0.5	3.8±0.2	50.7±2.2	2.38±0.05	2.82±0.1
3.	2016 A 291	79.57±2.5	8.8±0.5	4.9±0.2	48.4±1.5	0.136±0.01	0.03±0.001
4.	2016 A 151	81.70±2.1	8.15±0.3	5.4±0.3	47.1±1.2	-0.19±0.02	-1.60±0.05
5.	2016 A 387	82.14±2.3	7.26±0.2	4.8±0.2	49.8±1.4	0.81±0.01	1.98±0.04
6.	2016 A 275	78.81±2.0	9.62±0.6	6.6±0.4	47.0±1.1	-0.44±0.02	-1.93±0.05
7.	87 A298 (check)	83.03±2.2	6.92±0.3	4.8±0.3	51.4±0.2	1.12±0.03	3.37±0.06

Values are reported as mean±standard deviation (N=3)

2013. Hence, of all the varieties tested, bright yellow color is recoded for 2016 A 332 followed by 2016 A 480 and 2016 A 387. Hence based on Indian standards for quality jaggery, of all the six varieties tested, 2016 A 332 followed by 2016 A 480 and 2016 A 387 are proved to be suitable cane varieties with high sucrose %, (>80%), low reducing sugars (<10%), low moisture content (<5%) along with high cane yield, jaggery recovery and color. Also, during jaggery preparation, as no chemical was used as clarificant, quality jaggery free from chemicals was produced from the selected promising varieties.

4. CONCLUSION

Among all the six early promising varieties tested, Grade I jaggery with good color was prepared from varieties 2016 A 332, 2016 A 480 and 2016 A 387. Hence, these varieties may be recommended for large scale production of jaggery.

5. ACKNOWLEDGEMENT

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