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Production of bioethanol from banana scuitched sap

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Abstract
A field experiment was laid out at Banana Research Station Nanded during 2013 and 2014 in randomized block design with six treatments and four replications. For the said experiment cv. Ardhapuri and Grand Naine was selected. The scuitched sap from pseudostem, midrib and peduncle were utilized. For fermentation fungus strain *saccharomyces cerevisiae* was used. From the experiment it was observed that Minimum time required (72.35) for fermentation of scuitched sap was recorded from peduncle of cv. Ardhapuri. Maximum bioethaenol recovery (28.37) was recorded from peduncle of cv. Ardhapuri as well as fermentation efficiency (39.10) from peduncle of cv. Ardhapuri. The highest alcohol percentage (9.75) was found to be from peduncle of cv. Ardhapuri. The present study revealed that the weight and length of fiber and from cv. Grand Naine and strength, elongation of fiber, fermentation efficiency, bioethanol recovery and alcohol percentage from cv. Ardhapuri was found to be significantly best.

Keywords: Banana bioethanol, enzymatic hydrolysis, fermentation, saccharification

Introduction
Banana (*Musa* Spp.) is the most important staple food in the globe. Banana plant is considered as the symbol of prosperity and fertility. Bioethanol is the most dominant biofuel. Considered as a good alternative for liquid transportations fuels with powerful economic. Although the energy equivalent of ethanol is 68% lower than that of petroleum fuel. The combustion of ethanol is clean (because it contains oxygen). Worldwide production capacity of ethanol in 2005 and 2006 were about 45 and 49 billion liters per year respectively and total projected demand in 2015 is over 115 billion liters. At present sugar and starch based raw material is used for the production of bioethanol. But increasing human population and fuel demand make these raw materials insufficient for bioethanol production (Chittibabu *et al*., 2011) [5]. The world ethanol production has reached about 51000 million liters being the USA and Brazil the first producers and India stands fourth among the top fuel ethanol production (Arumugam and Manikanand, 2011) [2]. Banana waste has been used to produce bioethanol with the goal of developing a low-cost, sustainable production method. The production of fuel lignocellulosic biomass requires several distinct stages including hydrolysis which is high lighted because at this stage the fermentable sugars become available for fermentation. There are various possible methods for this process and the most commonly used methods can be classified in to two groups: chemical hydrolysis and enzymatic hydrolysis (Taherzadeh and Karimi, 2007) [18]. Several strains of indigenous yeasts capable of producing bioethanol have been isolated from different local sources such as fermented foods and banana waste but in most of the studies the preferred candidate for industrial production of bioethanol has been *saccharomyces cerevisiae* (Okunowo *et al*., 2005) [15]. This yeast has the ability to produce bioethanol with no contamination by other products present in the substrate (Brooks, 2008) [4].

Materials and Methods
The present investigation was carried out at banana research station (BRS) Nanded during 2013 and 2014 The scuitched waste of different plant parts were used for the production of bioethanol like pseudostem, mid-rib and peduncle of banana cv. Grand Naine and Ardhapuri after harvesting. After extraction of fiber the scotched sap of respective plant part was used for the production of bioethanol by anaerobic fermentation. The baker's yeast fungus i.e. mutant strain of *Saccharomyces cerevisiae* was used for fermentation and time required for fermentation and fermentation efficiency was studied. After bioethanol production bioethanol recovery and alcohol percentage was also estimated.

Results and Discussion

Bioethanol observations

The bioethanol observations include the time required for fermentation of scuitched sap, bioethanol recovery from scuitched sap, fermentation efficiency of scuitched sap and alcohol percentage of bioethanol obtained from scuitched sap. These parameters are responsible for affecting the yield and quality of bioethanol. The present findings are in conformity with results obtained by Mohapatra *et al.* (2010) [13], Chittibabu *et al.* (2011) [5], Goncalves Filho (2011) [7], Bernstad *et al.* (2012) [3], Priscila *et al.* (2013).

Time required for fermentation of scuitched sap

Time pertaining to fermentation of scuitched sap of various parts of banana plant were recorded and presented in the (Table 1). However, numerically, the treatment T_6 (72.35) had taken the minimum time for the fermentation which had scuitched sap of peduncle of cv. Ardhapuri. T_1 was followed by treatment T_4 (72.45) and T_1 (72.48) hours had taken respectively. While the treatment T_2 (73.00), T_5 (72.82) and T_3 (72.75) had taken maximum hours for fermentation. The more numbers of hours for fermentation may be due to adequate availability of inhibiting substances which inhibites activity of yeast fungus *S. cervisiae.* Similar trend was observed in both the year of experimentation. The results are in agreement with findings reported by Manikandan *et al.* (2008) [11], Alvarenga *et al.* (2011) [1], Mena-Espino *et al.* (2011) [12], Yan Lin *et al.* (2012) [20].

Table 1: Time required for fermentation and Bioethanol recovery of scuitched sap of pseudostem, mid-rib of leaves and peduncle of banana

T. No.	Treatment details	Time (hrs)			Bioethanol recovery (per cent)		
		2012-2013	2012-2013	Pooled	2012-2013	2013-2014	Pooled
T_1	Extraction of fiber from pseudostem of Grand Naine ($V_1 P_1$)	72.43	72.53	72.48	25.00	24.57	24.78
T_2	Extraction of fiber from midrib of leaves of Grand Naine ($V_1 P_2$)	73.30	72.70	73.00	04.63	04.23	04.43
T_3	Extraction of fiber from peduncle of Grand Naine ($V_1 P_3$)	72.70	72.80	72.75	27.23	28.57	27.91
T_4	Extraction of fiber from pseudostem of Ardhapuri ($V_2 P_1$)	72.43	72.47	72.45	20.67	20.73	20.70
T_5	Extraction of fiber from midrib of leaves of Ardhapuri ($V_2 P_2$)	72.50	73.13	72.82	04.60	03.63	04.11
T_6	Extraction of fiber from peduncle of Ardhapuri (V_2P_3)	71.87	72.83	72.35	28.63	28.10	28.37
	S.E. $\pm$	00.70	00.59	00.19	00.86	00.89	00.26
	C.D. at 5%	02.21	01.87	00.52	02.80	02.81	00.71

Bioethanol recovery from scuitched sap

The data related to bioethanol recovery from scuitched sap of various parts of banana plant in (Table 2) indicated that there were significant differences in respect to all treatments. Whereas, maximum bioethanol recovery (28.37) was observe in treatment T_6 where peduncle of cv. Ardhapuri was used. T_6 was followed by treatment T_3 (27.91) and minimum bioethanol recovery was recorded in treatment T_5 (4.11) where mid-rib of leaves of cv. Ardhapuri was used. T_5 was followed by treatment T_2 (4.43). The highest bioethanol recovery recorded in treatment T_6 might be due to the presence of more pectin's lignocellulose and carbohydrates. Similar trend was observed in both the year of experimentation. The present findings are in conformity with results obtained by Dhabekar and Chandak (2010) [6], Palacios-Bereche *et al.* (2011) [16], Luiz Carlos *et al.* (2013) [10].

Table 2: Fermentation efficiency and Alcohol percentage of scuitched sap of pseudostem, mid-rib of leaves and peduncle of banana

T. No.	Treatment details	Fermentation efficiency (per cent)			Alcohol (per cent)		
		2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled
T_1	Extraction of fiber from pseudostem of Grand Naine ($V_1 P_1$)	31.03	31.53	31.28	07.90	08.07	07.98
T_2	Extraction of fiber from midrib of leaves of Grand Naine ($V_1 P_2$)	27.37	27.10	27.23	06.47	06.57	06.51
T_3	Extraction of fiber from peduncle of Grand Naine ($V_1 P_3$)	33.00	33.30	33.15	09.23	09.07	09.15
T_4	Extraction of fiber from pseudostem of Ardhapuri ($V_2 P_1$)	31.27	32.27	31.76	07.06	07.30	07.18
T_5	Extraction of fiber from midrib of leaves of Ardhapuri ($V_2 P_2$)	28.03	28.07	28.04	06.20	06.40	06.30
T_6	Extraction of fiber from peduncle of Ardhapuri (V_2P_3)	38.90	39.30	39.10	09.77	09.73	09.75
	S.E. $\pm$	01.60	01.63	00.47	00.31	00.39	00.12
	C.D. at 5%	05.03	05.11	01.29	00.99	01.57	00.33

Fermentation efficiency of scuitched sap

The results with regards to fermentation efficiency of scuitched sap of various parts of banana plant in indicated that the differences in fermentation efficiency are significant due to different treatments. The highest fermentation efficiency (39.10) was noticed in treatment T_6 where peduncle of cv. Ardhapuri was used. T_6 was followed by treatment T_3 (33.15). The next better treatments in this regards were T_4, T_1 and T_5 which were at par with each other. The lowest fermentation efficiency (27.23) was noticed I treatment T_2 which had mid-rib of leaves of cv. Grand Naine.

The highest fermentation efficiency was noticed in treatment T_6 might be due to more activity of yeast fungus. The similar trend was noticed in both the year of experimentation. The results are supported by the findings reported by Zacchi and Axelsson (1989) [21], Lima *et al.* (2001) [9] and Waltaer Boezani (2006) [19].

Alcohol percentage

The results pertaining to alcohol percentage in indicates that the significant differences among the treatments during experimentation. In the present investigation significantly higher alcohol percentage (9.75) was recorded in the treatment T_6 where peduncle of cv. Ardhapuri was used. T_6 was followed by treatment T_3 (9.15) which were found superior over all other treatments. The next better treatments in this regard were T_1 and T_4 which were at par with each other. The lowest alcohol percentage (6.30) was observed in treatment T_5 where mid-rib of leaves of cv. Ardhapuri was used. T_5 was followed by treatment T_2.

The highest alcohol percentage was recorded in treatment T_6 might be due to more availability of alcohol derivatives in the substrats. The similar trend was noticed in both the year of experimentation. The present findings are in conformity with results obtained by Jackson and Badrie (2003), Mojovic *et al.*

(2006) [14], Bilba *et al*. (2007) [18] and Byaruagaba-Bazirake (2013).

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