

SUGARCANE PROCESSING AT THE VILLAGE LEVEL

Part VI: Cane Preparation and its Effect on Juice Extraction

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Sugarcane when crushed at the village level is not prepared in any way before crushing. The effects of cane preparation before its crushing at the village level with regards to juice extraction and the quality of the sugarcane products obtained, in respect of taste, texture, colour and shelf-life have been studied. The method of cane preparation evaluated are grading, peeling, slicing and shredding. A laboratory-scale shredder with a capacity of 10 tons/day has been designed and fabricated and its performance has been found to be satisfactory.

Grading of sugarcane exercises a positive effect and improves juice recovery. Juice recovery from the cane of the largest diameter is about 30% more than that from cane of the smallest diameter.

Shredded cane can only be fed to a horizontal crusher, which is not in common use at the village level in the sub-continent, resulting in increased crushing capacity but decreased juice recovery. Peeling and slicing, too, have an adverse effect. Peeling reduces juice recovery by 2-7% and slicing by 3-7%. Therefore, cane preparation other than grading cannot be recommended at the village level cane crushing because it yields poor quality and low purity juice and in lesser amounts. Sugarcane should be prepared in such a way that the rind should provide protection to juice storage cells.

INTRODUCTION

Recovery of sugar from sugarcane requires the separation of juice from fibrous materials. Sugarcane is composed of two types of fibrous materials, the pith and the fibre bundles. There are also two types of juices, namely, storage or static juice and transit or dynamic fluid [1]. Storage juice is the first to be expressed when the sugarcane is milled. This juice is of high brix and high purity. Transit fluid is in sturdy vascular bundles. It is low in purity. It can only be extracted by an extensive milling. At the mills, for getting maximum of extraction, the cane is prepared before milling. The knives, crushers, shredders and fibrizers are placed ahead of the mills for preparing the canes.

At the village level the cane fed to the crusher is not prepared in any way. Two to four stalks [2] are fed to the crushers, subject to the physique of the animal. There is hardly any known attempt where cane is prepared before it is fed to the mill at the village level.

The present study explores the methods and other means necessary for preparing the cane before feeding it

to the horizontal or vertical crushers. Effects of cane-preparation have also been studied.

MATERIALS AND METHODS

(1) A sugarcane preparation machine (Fig. 1) having ten tons per day capacity, was designed and fabricated such that it could be used ahead of the horizontal crushers. This machine is a prototype design of a big shredder used in big sugar mills. The quality of shredded cane obtained from the machine is quite comparable with the shredded cane of big mills.

(2) A specially designed curved knife was used for peeling the cane while an ordinary knife was used for splitting it. The cane was graded according to the circumference which varied from 5 cm to 13 cm. The canes were graded into three lots according to thickness; the first lot with a circumference ≤ 5 cm., the second with a circumference 7 ~ 9 cm and the third with a circumference ≥ 11 cm. Analysis and results recorded in the tables have been determined according to the methods reported previously [2, 3].

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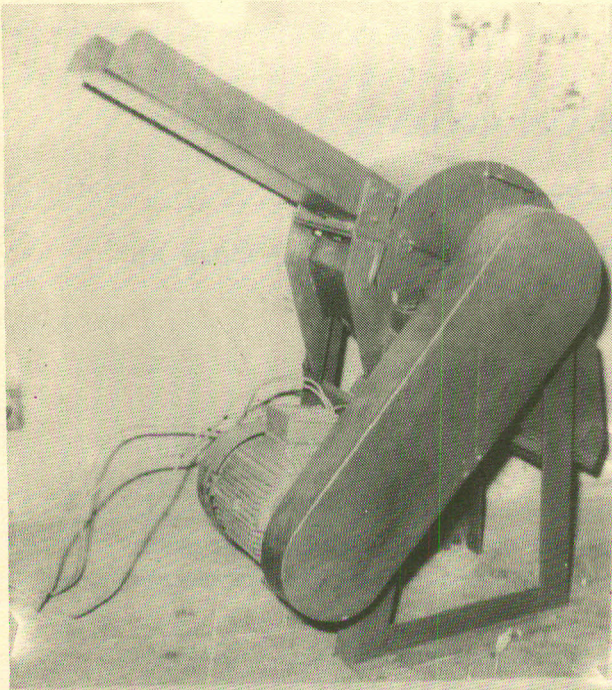


Fig. 1: Pakistan made cane shredder with 5 HP. Motor.

DISCUSSION

Before the introduction of cane-preparation devices, sugarcane was mostly crushed by feeding it to the mill as a whole stalk. The rotating knives for the preparation of sugarcane were introduced as far back as in the mid-nineteenth century [4]. No big mill can now be installed without the cane preparation machinery, whereas, all the open pan mills developed in India for crushing sugarcane at the village level have no cane preparation devices [5]. The farmer uses vertical crusher while the use of horizontal cane crusher is very rare. It is difficult to feed a vertical crusher with shredded cane. It was necessary to adopt some techniques whereby cane could be prepared in such a way that it would be fed to a vertical crusher. The following methods of preparation of cane were evaluated.

1. Grading
2. Peeling
3. Slicing
4. Shredding

The thickness of sugarcane, commonly available in Pakistan is around 5–9 cm in circumference and in some cases it goes upto 13 cm. (Table 1). It has been observed that if sugarcane is graded before extraction according to its thickness it will improve the juice extraction. The results recorded in Tables 1 and 2 indicate that the juice

% cane increases with the increase in sugarcane circumference. Thick cane contains more juice and less fibre whereas thin contains lesser amount of juice and higher fibre content.

Table 1. Juice percentage cane recovery according to the circumference of sugarcane

Circumference	Juice from (per cent) cane
5 cm	52.2
	53.9
	55.5
	56.8
7–9 cm	61.4
	61.9
	62.5
	62.7
	63.7
	63.0
	63.4
11 cm	63.5
	64.0
	66.7
	67.3

Table 2. Effects of grading on cane juice (per cent)

No. Circumference	Cane Juice (per cent)	Improvement in Cane Juice (per cent)
(1) Mixed	8 cm	+2.3
	4 cm	-0.2
(2) Mixed	7 cm	+3.5
	4 cm	-0.0
(3) Mixed	8 cm	+2.1
	4 cm	-0.7
(4) Mixed	7.9 cm	+2.0
	7.9 cm	-1.0

It has been observed that fibre % cane has a marked effect on the juice extraction i.e. with the increase on fibre content of the sugarcane the extraction % cane decreases [6].

In Louisiana, USA, the fibre % cane varies from 10 to 16 % depending upon the variety of the cane. Reported juice extraction from cane with 10% fibre is 93.76% and from cane with 16% fibre is 89.17%. In Pakistan a number of cane varieties are being grown and there is no information available concerning the fibre content of sugarcane crushed at the village level. The villagers prefer the varieties which give a product better in yield, colour, taste and texture.

If the crusher has been in use for sometime the juice recovery falls down due to the progressive concavity of the crushing roll, (Fig.2). Reconditioning of the rollers is necessary to remove the concavity of the crushing rolls

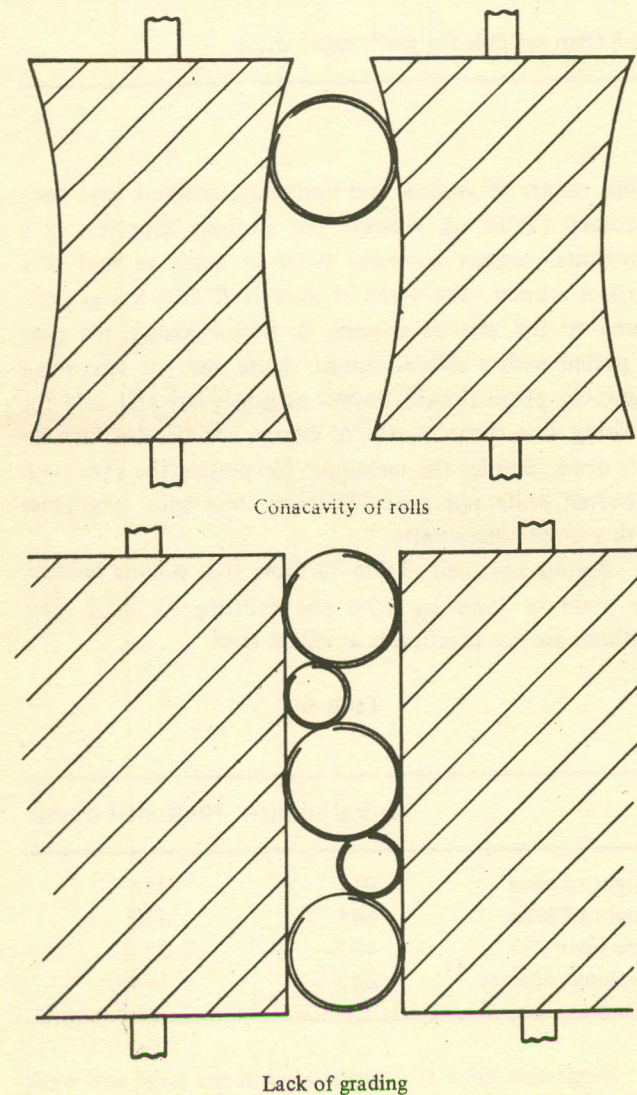


Fig. 2 Some defects in cane crushing.

after a lapse of two to three years as the concavity of compression rolls reduces the recovery of juice. It has been observed that juice % cane is reduced from 60 to 50%. Graded cane improved the juice % cane. Juice recovered from cane of the largest diameter is about 30 % more than that from cane of the smallest diameter. Improvement by grading of the sugarcane is self-explanatory.

A shredder tears the cane with the knives into shreds, without extracting any juice. The shredded cane appears fluffy but has a bulk density greater than loose cane because of the absence of voids.

It gives a more even feed to the mill, ensures an increased mill capacity and sucrose extraction and results in less sucrose in bagasse. A laboratory-scale shredder has been fabricated by a local firm. The shredder gives perfect results as far as shredding is concerned but the shredded cane reduces juice extraction (Table 3). In the big mills the shredded cane passes through a tandem of six or more mills in succession. After the first mill the bagasse is steeped in excess of water and the shredded cane can easily be steeped in water as compared to the unshredded cane. Water is applied to the bagasse going to the last mill. The last mill juice is returned to the bagasse going next to the last mill. This juice in turn goes back to the bagasse from the preceding mill and so on. The shredded cane can improve the extraction only when more than one mill is used in succession. At the village level this cannot be practised because it needs more power to operate the mills and more fuel to concentrate thin juice. Shredded cane can be fed only to a horizontal crusher but at village level in Indo-Pakistan the use of horizontal crusher is not very common. A comparative study carried out under identical conditions showed that the horizontal crusher always yielded less extraction as compared to the vertical crusher (Tables 3, 4 and 5).

Table 3. Comparison of shredded and unshredded cane on Indian horizontal cane crushers

Shredded Cane	Unshredded Cane
(Cane Juice percentage)	
50	54
48	50
49	
47	
49 on case basis	

Table 4. Evaluation of the Indian horizontal cane crusher

Circumference	Cane Juice (Percentage)			
	At 6 rpm	At 8 rpm	At 12 rpm	At 33 rpm
4-6 cm	42.9	53.2	42	27.7
	45.9	52.2	44	
		47.0		
6-8 cm		54.8	51	
		56.0	49.7	
11 cm (L-29)*		60.4	58.6	
		60.0		
		60.5		
13 cm (soft)		72.8 (Not suitable for gur*, sugar, etc.)		

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* A variety of cane.

Table 5. Comparison of cane juice (percentage)
(Under identical conditions in
respect to day, time, variety, etc.).

Horizontal cane crusher (at 8 rpm)	Vertical cane crusher (at 8 rpm)
60.4	63.0
52.1	56.8
52.9	58.7
56.9	62.4
52.2	57.8
60.5 (Best quality cane)	66.62
	65.20

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* Inspissated juice expressed from sugarcane is known as gur in Pakistan, Jaggery in India and Panila in South America.

The horizontal crusher is not suitable at village level because it requires a heavy foundation. Its crushing capacity is more than that of a vertical crusher. Its handling is difficult. It cannot be driven by the animals unless some modifications are made. This means that with the change of crusher the whole set up for the village level cane crushing has to be changed [7]. In Colombia, Latin America, where the horizontal crusher is in use in large numbers, the village level cane processing is on a rather large scale [8].

Field results of vertical and horizontal crushers have been recorded (Table 6), whereas the crushing capacity of a horizontal crusher is nearly twice as much as that of a vertical crusher. The yield of juice is 20-23% less as compared to the vertical crusher. In Indo-Pakistan, the cane is peeled with a special curved knife and cut into small chewable pieces (locally known as *ganderies*) and sold for chewing as a cheap source of energy and a substitute for soft drink. Similar the technique for peeling the cane with a curved knife was used. The cane was split lengthwise with a simple sharp knife.

Results obtained (Table 7) show that peeling reduces the yield of juice by 2.7% and splitting by 3.7%. The methods are not practicable at village level.

Table 6

	Vertical crusher	Horizontal crusher
Weight of cane	912	916
Weight of juice	445	340
Cane juice (%)	48.8	37.2
Crushing capacity	842	1680

Sugar-rich juice is concentrated in the large and weak storage cells of cane. Non-sugars are largely in the relatively strong fibro-vascular bundles. A theoretically sound

Table 7

Circumference	Cane juice (%)	Improvement in Cane juice percentage
Peeled	39.9	- 1.0%
	39.2	
Mixed	39.9	
	40.0	
Split	36.2	- 4.9%
	36.9	

preparation procedure should permit the rupturing and stripping of the storage cells with minimum damage to the fibre bundles. Thus the desirable juice would then result as a mixture of the sugar-rich juice and fibre containing a large percentage of low purity material. Any suitable preparation of the cane before village level crushing will yield very poor quality and low purity juice and thus will produce very inferior quality products in respect of taste, texture, colour and shelf-life.

It has been observed that shredding, peeling and slicing yield lesser amounts of juice. Most probably the tissue inside the rind is exposed by peeling, shredding and slicing. The pith has a lot more absorptive capacity than the wax-coated rind. It may be mentioned here that the dry bagasse can absorb water 5 to 10 times its weight. The bagasse from the crusher contains 50-60% moisture and this is far from being saturated. The most probable explanation of the negative results of the prepared cane is the reabsorption of the juice.

It has been further observed that with the reduction of face speed, juice extraction improves but at still lower face speed the improvement is very small. This also con-

firms that at lower speeds the reabsorption of juice is at its maximum. Villagers in Pakistan use animal-driven vertical crushers. A suitable balance of optimum face speed and reabsorption can improve juice extraction. The design of the crusher should be so modified that it would drain the maximum of the available juice and reduce its reabsorption. The cane should be prepared in such a way that the rind should provide protection to juice storage.

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