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SUGAR-CANE PROCESSING AT THE VILLAGE LEVEL

Part I. State of Art Study

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The parameters of the sugarcane processing at the village level have been determined. It has been observed that time-lapse between harvesting and crushing is 12 hours at the village level as compared to 72 hours in case of big mills. The cane is crushed near the fields in the villages, while trucks, trolleys and bullocks carts have to be employed for transporting the sugarcane to the distant mills which causes 6-21% loss in weight. The villagers use crushers of different sizes which are worked by bullocks, tractors and motors. 90% of the total canes are crushed by bullocks. Juice % extraction varies from 50-65 and it depends upon a number of factors. The sugar factories extract 77 % juice through different processes. Juice is concentrated in mild steel open-pans having 144cm. diameter and depth as 28th cms. The capacity of the pan is generally 144 litres in the Punjab while it is 250 litres in the N.W.F.P. Bagasse is the major hand-fired fuel for burning in mono or di hearth clay-grate furnance.

Many chemicals and vegetable extract are used to clarify the juice and other products. Hazardous chemicals like rongolit are used when the products are manufactured for sale. Juice is concentrated at 100-120°, and it results in caramalization of the final products. Processing time per batch of 144 litres varies from 90-120 min. subject to weather conditions.

INTRODUCTION

Ever since the inception of human civilization on earth, man has been using technology to his benefit. Such technology was developed through experience, but improved with the passage of time. The technology that was adopted by a large section of people, was termed traditional technology. This type of technology, was responsible for the establishment of large mills later on. But there are certain fields, where traditional technology continued its existence. The technologies involved in food-processing are generally traditional because foods have short shelf-life and cannot undergo long treatment in the big mills especially under the conditions prevailing in the developing countries. Pakistan does not have necessary infra structure to process perishables such as milk, poultry, fresh fruit and vegetables etc. on large scale so are processed at the cottage level.

Traditional technologies are discarded by the economic experts[1] on the plea that these are labour intensive, give poor yield and the quality of the products are not upto the required standards. Despite these drawbacks, these technologies have survived till today which fully speaks for their utility at the local level, thus there is a need of studying them scientifically. No effort has ever been made to apply scientific sophistications to the common technology and improve it where there is a such possibility. Present study deals with sugarcane processing at the village level and to effect improvements so as to get better yield and standards products.

This paper contains all the parameters about traditional technology which have been determined experimentally and compared with large sugar mills.

MATERIALS AND METHODS

Research workers with some experience of field work were selected as members of survey team and senior persons with recognised background of R&D were selected as Group Leaders of the teams. The team members had sufficient knowledge of the rural area they surveyed.

Each team was required to undertake a number of experiments relating to :

1. Rate of crushing.
2. Recording Brix value.
3. Rate of evaporation.

4. Temperature of massecuite and chimney.
5. Type of chemicals used for clarification of sugarcane juice.

Technical details regarding the experiments were worked out and demonstrated to the team members before they were sent out. The following equipments duly standardized in the Laboratory were provided to each team;

(a) Spring balance
(b) Brix hydrometer
(c) Thermometer
(d) Measuring cylinders, flasks and other glassaware
(e) Sample bags
(f) Sample bottles of 500ml each with 10 g of lead sub acetate.
(g) Buckets for weighing juice and
(h) Rope

The equipment were rechecked against standards after the return of the team, to avoid all possible sources of error (spring balance used were "guaranteed best quality" made in Germany). Spring balances of different capacity (50 + 75 kg) were provided to each team for weighing juice and products. These spring balances were standardized against laboratories balances.

RESULTS AND DISCUSSION

The entire process of making khandsari and gur consists of four steps :

1. Cane preparation
2. Juice extraction
3. Juice clarification & concentration
4. Solidification for gur and khandsari

Cane Preparation: Hand-cutting is the only mode of harvesting for the sugarcane crop in Pakistan. Stalks are cut close to the ground with knives and tops are removed just about the highest point. Dry leaves are removed to clear the canes from unwanted material. Whole process of harvesting and cleaning is carried out by 8-12 hours before crushing.

Sugarcane taken to large mills is cut by similar fashion and then taken to the mills by means of trucks, trolleys etc. Modes of transport are given in Table 1.

Time-lapse between harvesting and crushing is not less than 72 hours in case of large mills. The mode of transport also varies at different places. Village technology has one advantage over the large mill that the cane is crushed within the time limit approved by the experts[3].

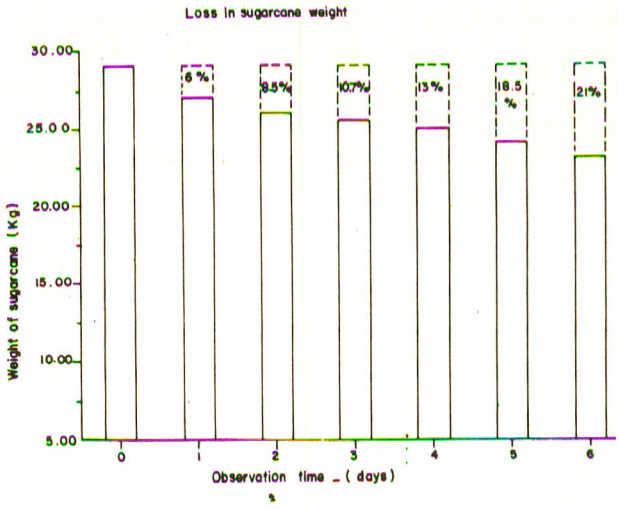
Table 1. Time lapse-harvest to processing comparison between modes of transportation.

Sr. No.	Province	Truck hours	Trolley hours	Bullock hours
1.	Punjab	77	67	60
2.	Sind	32	42	37
3.	N.W.F.P.	53	–	–

From Table 1 it is evident that mode of transportation of sugarcane from field to sugar mill is one of the important aspects in sucrose recovery. More time is taken by truck or trolly as compared to bullock-cart. It is an indication of unsuitable road conditions. Cultivation of sugarcane is not only restricted along the pucca road side. Usually most of it is deep from the roads and is difficult for a truck or trolley to collect the crop from the site.

Comparitively, time lapse in the provinces of Sind and N.W.F.P is much less due to better road conditions.

It has been observed that the hauling time to mills affects the weight of the canes and this results in substantial loss of sugarcane weight. It has been experimentally established (Graph-I) that this loss in weight is from 6-21.4%.



Graph I.

Juice Extraction: The crusher or the 'Belna" as it is locally known, is a three-roller vertical juice extraction machine. It is mounted on wooden or angle iron foundation and is carefully levelled with the help of a water levelling

cup on its top. Construction of the Belna is simple and consists of a strong and heavy frame into which are fitted three rollers A,B and C as shwon in the following diagram.

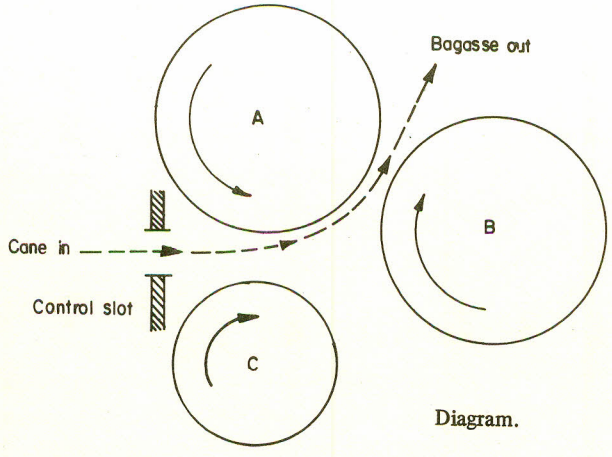


Diagram.

In the local languages, rolls A and B are celled "Gagars" and roll C is called Belni. Rolls A and B are identical and act as main crushing rolls. Roll C has a smaller diameter and acts as a feed roll. In front of the A and C rolls a cane feed control slot is provided to optimize the extraction of juice. Roll A is the main drive roll. Motor or animal power is applied to it. Power is then transmitted from it to rolls B and C through a set of gears or levers.

The number of gear teeth on rolls A and B indicate the size of the Belna and is indicated by Nos. 17, 18, 20, and 22. Size of the rolls also varies. Crusher specifications in all over the world are given in Table 2. The crushing capacity of commonly used crusher in the villages is one ton per day of eight hours. Table 3.

The amount of juice that can be extracted from sugarcane depends on a number of factors. Some of the important ones are as follows:

i. Variety of sugarcane,
ii. Conditions of soil and its maintenance,
iii. Maturity of sugarcane and its condition
iv. Fiber content of sugarcane,
v. Type and age of the crusher and its performance, and
vi. Speed at which the crusher is run.

The average value of juice percent of cane observed during the study is found to be 61.4% for country crushers. This average should be higher if all these six factors are optimized. Various investigators[6] have pointed out the fact that juice content of sugarcane extracted by a country crusher should be around 65%.

The study also showed that the average value of juice percent cane was about 74 (70-77) for big mills[7]. Farmers are, therefore, losing about 16% of the juice which remains in the bagasse. This is a serious loss and shows an excellent opportunity for improvement of the technology through research.

Compared to extraction at the mill, village processing is inefficient. Losses at the village are very high. A comparative loss study is given below in Table 4. The Table also shows some of the crusher being used all over the world and their juice extraction.

Table 3. Juice percentage cane.

Sr. No.	Juice %	No. of units surveyed	percentage of unit
1.	Below 55	23	23.41
2.	55–60	36	36.7
3.	61–65	16	16.3
4.	above 65	23	23.4

Table 4. Loss of sucrose in extraction and processing.

Process	Extraction	Loss in Extraction	Loss in processing
Sugar mills	90	10	21
Garge-mini mills	80	20	23
Khandsari	72	28	25
Gur-making units	72	28	26

Juice Concentration Clarification: Clarification and concentration are carried out simultaneously at rather high temperatures over direct fire.

The usual custom followed in the village is to add the sugarcane juice to the boiling pan without filtration. The "Cush cush", or suspended particles, are not removed. It was observed, however, in a few cases that the juice was filtered through a cloth.

"Cush cush" and bagasse fibres float and are generally removed during boiling of the juice. Heavy particles of dust and dirt generally settle down at the bottom of the boiling pan.

The chemicals most widely used at the village level for adjusting the pH of juice are sodium bicarbonate, sodium hydrosulphite, and rongolit. These chemicals are added in

Table 2. Specifications of sugarcane crushers

	A and B rolls rpm	Dia x face drive T A + B roll.	A&B rolls (face speed)	Dia x face drive T/C roll.	C roll rpm.	C. roll face speed	Manufactures rated capacity kg/hr and (gross weight kg)	Remarks
Crusher Pakistan	16	10x10¾ (22)	ft/min. 42	7½ x 9½ (17)		ft/min. 38.1		10 HP drive preliminary test 1000 Kc/hr.
Sultan India	3	$8^{9}/14$ x 8½(17)	6.7	7 x 7½	3.6	6.6	205	5 HP when mechanically driven weight of power driven unit 530 kg. Crush rate 480-500 Kc/hr
Krishi India	8 6.5	12 x 9 (23)	25.1 20.4	$8^{13}/16$x8 (14)	13.1	23.2	23.4 (56)	7.5 HP.
Horiz-H.2	8-10 13.5	8½ x 8 (12)	21.2 28	8½ x 8 (12)	8-10 13.5	16.8 28	550	MFC 8.10 HP.
Pakistan	8 15	9½ x $8^{5}/8$ (18)	19.9 37.3	$7^{1}/8$x$8^{5}/8$ (14)	10.3 13.3	19.2 34.0	400	Lab. Now operating at 8 rpm.
Pakistan	3	9½ x $8^{5}/8$ (18)	7.5	$7^{1}/8$x$8^{5}/8$ (14)	3.88	7.24	100	
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Pakistan	3	9½ x $8^{5}/8$ (17)	7.5	$7^{1}8$x$8^{5}/8$	3,64	4.79	–	
Horiz-H-1.1 India	8-10	8½ x $9^{5}/8$ (12)	17.8 22.3	8½x$9^{5}/8$ (12)	8-10	17.8 22.3	700	10 mp.
Nahan-Horiz India	–	11x4 10x15	–	11x14 10x15	–		1875 (2625)	15 HP.
Ponelero Columbia-Horiz R-5	13	$9^{1}/8$x10	31.1	$6^{5}/4$x10	–	–	1200	5.7 HP.
Ponelero Columbia-Horiz R-8	13	8½ x 10	28.9	$8^{3}/8$x10	–	–	1500	6.8 HP.

small amount and the scum skimmed off from the top after each addition. Temperature of the boiling juice during concentration varies between 100° to 125°. Sodium bicarbonate starts giving off carbon dioxide at 20° and is converted into sodium carbonate at 100°.

During the field survey, it was noticed that sodium bicarbonate and/or other chemicals are indiscriminately added when juice is about to boil. No village processor was concerned with the acidity or other characteristics of juice. This results in either inversion at low pHs or browning of the mass due to decomposition of invert sugar at pHs above 7. Improper pH control destroys the vitamins present in the juice, in addition to affecting the colour and storage quality of the final product.

Quantities of chemicals used by selected commercial producers of gur are shown in Table 5.

Table 5. Amount of chemicals used in gur making field survey results.

Total production of gur in a season per unit	Consumption of chemicals		
		Sodium	
	Rongolit	Bicarbonate	Gaozaban
230 maunds	20 kg	20 kg	25 kg
150 maunds	12 kg	12 kg	15 kg
25 maunds	4 kg	4 kg	5 kg

The survey data clearly shows that villagers have no idea or concern regarding the amounts of chemicals or temperature that should be used. Even toxic chemicals such as rongolit are used indisriminately without considering their harmful effects. Termperatures above 75° are detrimental for liming and sulphitation. But village level gur manufacturers are treating juice with chemicals above 100° and, at the end, the temperature reaches upto 120° Graph II. Those farmers who manufacture gur for marketing even use these chemicals in the massecuite.

Besides the neutralizing and reducing chemicals, village processors also use certain mucilage-containing plants for clarifying the juice. The most commonly used plant is Suklai. In some cases, Gaozaban and Bhindi are also used. Other plants, seeds, barks and roots that are used in India for clarification are not used in Pakistan.

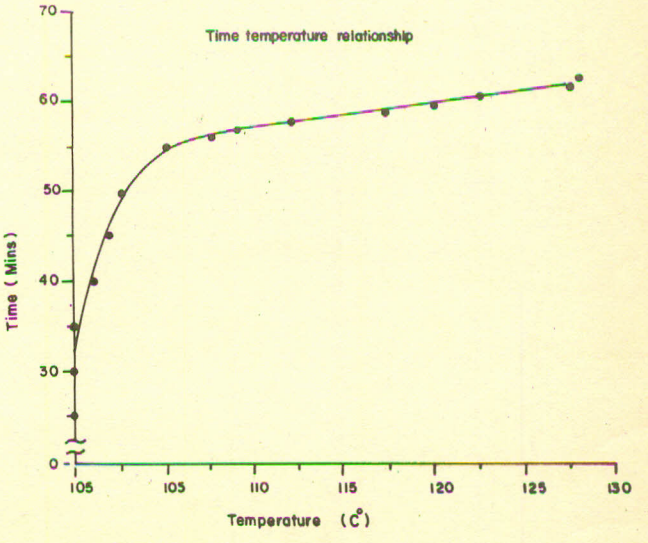
The dry twigs and branches of Suklai are soaked in water overnight. About one pound of the twigs are twisted in the shape of a small bundle and are put in the juice. The bundle is removed when skimming is finished but can be re-used for two to three additional batches.

Bhandi and Gaozban are soaked in water for a few hours, then pounded in water and rubbed with the hands. The liquid is screened through a cloth, mixed with sodium bicarbonate or sodium hydrosulphite and added to boiling juice during clarification and concentration.

Furnaces: The furnaces used in gur and khandsari-making are hand-fired, mono-hearth, clay grate furnances. Their design and construction is similar in the Punjab and Sind. The differences, if any, are in the size and the grate. In the Punjab, furnances in some units were provided with grates made of mild steel bars. In Sind, baked clay grates were used in all of the units visited. In N.W.F.P, the furnance is like an ordinary wood-burning Choola, and no grate is used. Bagasse is fired on the floor of the furnance.

Fuel: At the village level, bagasse is used in a semi-moist state. It is partially dried by spreading it out near the hearth for convenience. Because of varying moisture contents, the BTU content is highly variable and is probably in the neighbourhood of 2500-3500 BTUs per pound. Farmers, in addition to burning all the bagasse, also use strippings and dry leaves. Not a single unit was found with surplus bagasse in the Punjab.

Concentration Pan: Cane juice concentration pans used in the Punjab and Sind are similar in design and construction. The pan has spherical shape and is made of thin (4-6mm) mild steel plate using forge welding or riveting. It has two handles made of mild steel bars. The diameter of the pan at its periphery is about 144cm and the depth at its centre is about 28 cm. It has a total capacity of 144 litres but only 70-75 litres of juice are added for clarification and concentration. The overflow space is left for frothing. In the



Graph II.

Dera Ismail Khan, Hazara and Swat District of N.W.F.P. evaporating pans are similar in shape and capacity to the one used in the Punjab and Sind. In the Peshawar, Charsadda, Mardan, and Malakand, flat bottom evaporating pans with a bottom diameter of 193 cm are used. It is larger and has a capacity of about 250 litres.

Generally, the units visited had single pan concentration. In some units, double pans were used to make use of the hot flue gases and to save on fuel. The efficiency of the double-pan system has not been evaluated and needs further study. Inversion rate is proportional to temperature, as well as to time of processing, and could be a problem with the double-pan system. In Colombia, South America, all installations are multi-pan types with apparantly no adverse effect on product quality. However, the multi-pan practice does not seem to provide any increase in fuel utilization efficiency.

Total time for processing each batch of 100 kg juice varies from 90-120 min. Temperature of flue gases escaping from the chimney is observed to be above 300^{O} which could be used for drying bagasse or initial boiling.

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