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Technological and Management options for optimizing sugar recovery in India: A Review

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Abstract— **Sugar is an important commodity of human consumption as well as trade. In view of growing demands and little scope expanding the area under sugarcane in India, apart from raising the productivity of the crop, improvement in sugar recovery is extremely important. The sugar recovery rates in the country are low compared to international standards. A fully mature crop loses its sugar content very rapidly once harvested. Such losses increase during storage, transport and processing; especially in the units that do not maintain proper hygienic conditions. Rich literature is available on causes of post-harvest deterioration and possible measures to contain it. In India, cultivation of sugarcane and production of sugar is distributed in various states that broadly represent tropical and subtropical conditions. The choice of varieties and their maturity periods and associated agronomy vary in on account of differences in climatic, soil, water resources and other infrastructural facilities like mill management, its capacity, machinery etc. Although sugarcane is primarily cultivated in 9 states of India, the five states viz., Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra and Uttar Pradesh account for over 85 per cent of sugar production. Estimates indicate that in recent years higher proportion of sugarcane crop is diverted for sugar production in these five states as well as whole of the country as compared previously on account of targeted utilization of end products and by products. Based on our available knowledge, present state of sugar recovery in the country and major states is reviewed. Some general as well as state specific strategies are outlined in this paper so as to maneuver sugar recovery scientifically.**

***Index Terms*— Biocide, Mill sanitation, Sour cane, Stale cane, Sugarcane varieties**

I. INTRODUCTION

In India, sugarcane is the main source for sugar production. This crop is cultivated in about 5.2 million ha (2.6% of country's gross cropped area) and its share is around 7 per cent of total value of agricultural output. Thus the sugar industry is the second largest agro based industry of the country, after cotton textile industry with annual installed sugar production capacity of over 30 million tonnes[1]. Its annual output is worth over ₹ 800 billion and likely to increase around ₹ 1022 billion by 2020. This sector supports 50 million farmers and their families, and delivers value addition to their farm side as well[2]. However, this industry has several issues that require

attention and rational solutions. These include low yields of sugarcane, short crushing season, increasing cost of production, fluctuating production trends, uneconomic size of mill, old and obsolete machinery and low recovery rates. The average rate of sugar recovery as per cent of cane crushed weight is around 10 per cent in India. This is considered low when compared to other sugar producing countries like Brazil, Australia, Mexico, South Africa and Thailand (Fig.1)[3].

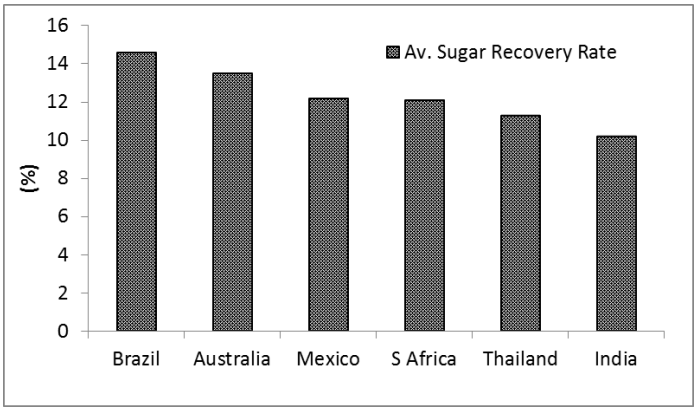

Fig.1. Average sugar recovery rates in major sugar producing countries in the world

India is the second largest producer of sugar in the world after Brazil. It is also the largest consumer. Since 2009-10 sugar year cycle, the amended provisions of the Sugarcane (Control) Order, 1966 provides for fixation of fair and remunerative price (FRP) of sugarcane having regard certain factors that include recovery of sugar from sugarcane. In order to ensure that higher sugar recoveries are adequately rewarded and considering variations amongst sugar mills, the FRP is linked to a basic recovery rate of sugar (9.5%), with a premium payable to farmers for higher recoveries of sugar from sugarcane[3,5].

As per projections in domestic and international markets, this sector will need to produce more sugar that the current levels. While there will be pressures to expand area under sugarcane cultivation so that adverse impact is not there on other crops, the challenge will be to manage the existing sugarcane areas and improve the cane yields by 10-20 per cent and sugar recovery by 50-100 basis points[3]. In order to realize the improvements on the recovery front, it is important to strengthen farmer-miller relationship that enhances mill efficiency and quality improvement at farm side. In this paper based on our present state of knowledge, especially on improving sugar efficiency a

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review is presented on present scenario and likely approaches required for meeting the future challenges and the targets.

II. SUGARCANE PRODUCTION

In India, sugarcane (*Saccharum officinarum*) cultivation dates back to the Vedic period. The earliest mention of sugarcane cultivation as found in ancient writings is traced to the period 1400 to 1000 BC. It is now widely accepted that India is the original home of *Saccharum* species[6]. Most of the sugarcane is utilized for production of sugar and remaining is used for other purposes like jaggery (*Gur*, juice (*Raswanti*), fodder (immature green tops), thatching of huts (trash), mulching (trash), compost (trash and stubbles), fuel (stubbles). Various by products obtained from cane like bagasse, molasses, and pressmud cake are also used fovarious purposes like fuel and paper making, alcohol and other chemicals, manure, respectively[7].

Sugarcane is primarily grown in nine states of India viz., Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Uttar Pradesh and Tamil Nadu. The sugar industry caters to an estimated 12 per cent of rural population in these nine states through direct and indirect employment. However, five states viz., Andhra Pradesh, Karnataka, Maharashtra, Uttar Pradesh and Tamil Nadu contribute about 85 per cent of the sugar production, Uttar Pradesh being at the top (30.1%) followed by Maharashtra (27.%)[8].

Sugar making through sugarcane was discovered thousands of year ago in New Guinea and then the route was traced to India and Southeast Asia. India was the first to begin with the production of sugar through the process of pressing sugarcane to extract the juice and boil to get crystals. In 1930 there was advent of modern sugar processing industry in India[9, 10]. Gradually, number of sugar mills, sugarcane crushed per day, sugar production and sugar recovery increased during 1930-31 to 2015-16 (Fig2A and Fig 2B). Average duration of crushing season in India is 137 days[8].

Analysis of proportion of sugarcane actually diverted for sugar production in recent years (2006-07 onwards) reveal that there is a large variation among major sugarcane producing states and also in different years (Table 1).

Table 1
Range of state wise utilization (%) of sugarcane for sugar production in some major states of India

State	2006-07 – 2011-12	2012-13 – 2015-16
Maharashtra	70-94	71-97
Uttar Pradesh	37-67	45-68
Tamil Nadu	47-67	53-63
Karnataka	79-93	83-95
Andhra Pradesh	39-80	42-82
All India	**51-72**	**67-74**

The other purposes include jaggery, *khandasari*, seed etc. The trends indicate that there is more diversion towards sugar production in recent years in all the major sugar producing states as well as all India average[1, 8].

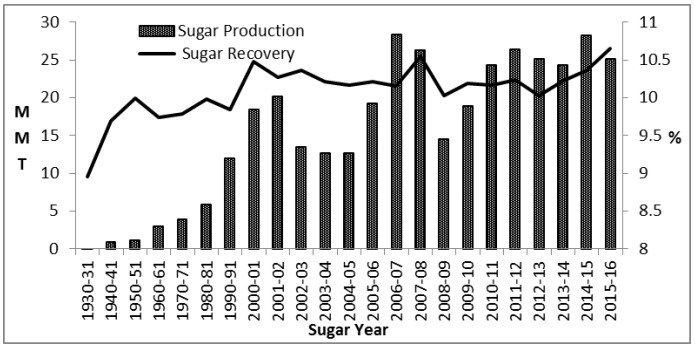

Fig.2a. Patterns of average sugar production and recovery rates in India

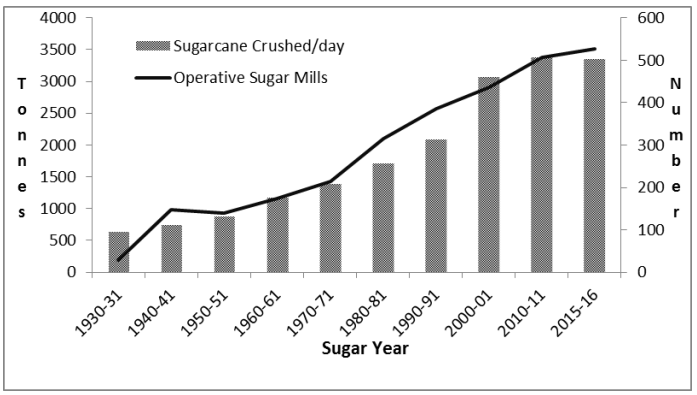

Fig.2b. Trend in increase in sugarcane crushed per day and number of operative sugar mills in India

III. SUGAR MILLS

Rapid increase in number of sugar mills in India occurred after 1930 with introduction of tariff protection to the sugar industry. Presently, total number of mills established so far in the country is 716[11]. However, number of factories presently in operation is 526[12]. The growth of Indian sugar industry has been horizontal with a large number of sugar plants established many parts of the country in contrast to other major sugar producing countries in the world where more emphasis is towards consolidation and larger capacity of fewer plants[3].

The Indian sugar sector is composed of three distinct categories - public mills, private mills and cooperative mills. The proportion of operational cooperative mills was highest in 2000-01 (53 %) followed by private mills (47 %) and public mills (6 %). Presently (2015-16) the number of operational private mills have increased (50 %) and a decline has occurred in operational cooperative (45 %) and public mills (3 %) (Fig.3). Ownership and management has changed during the last 15 years towards private compared to the cooperative ones and there has been a considerable decline in public mills. Also there is a trend of cooperative and public mills being run under joint management with private companies. The share of sugar production by private mills is on an increase. Presently it occupies more than 54 per cent share. The share of cooperative mills has come down to 43 per cent from 57 per cent in 2001[3].

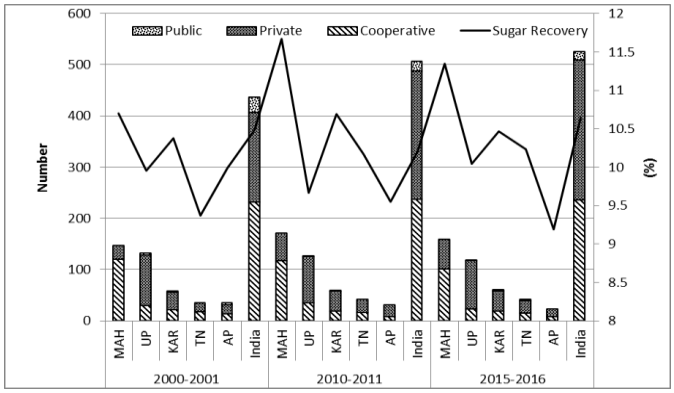

Fig.3. Changing patterns of sugar mill ownership and sugar recovery rates in five leading sugar states in India

IV. SUGAR RECOVERY

Accumulation of sugar in the stem sugarcane represents a balance between synthesis of sugar and its utilization[13]. Soon after harvest, there is a tendency of decline in sugar content. Staling beyond 24 hours results in considerable loss in cane weight on account of moisture loss and reduction in juice sucrose content due to inversion[14] and it is one of the most serious problems for the sugar mills in India[15]. There are reports that due to staling of canes for 96 hours, there is reduction in cane weight (7.4-17.0 %)[16] and sugar recovery (2%)[17]. Apart from reduction in sugar recovery it creates losses by reducing mill and boiling house capacities[18]. It also leads to increased loss of sugars in molasses[19].

The quality deterioration in harvested cane is essentially a biochemical process. This deterioration is caused by microorganisms. Such organisms enter through cut ends and convert sucrose into polysaccharides, such as dextran. Presence of dextran in even small amounts creates problems of filtration, clarification, crystallization and alters the shape of sugar crystals thereby affecting the quality of sugar[15, 20].

The sucrose content of Indian cane is one of the lowest among major sugar producing countries of the world. The realized rate of sugar recovery of the country is around 10 per cent only for over several decades in the country, despite modernization efforts in the sugar mills[3, 21]. The data indicate that for quite long time (1933-1990) the recovery rates were below 10 per cent. Thereafter, there was some improvement and it ranged between 10.03–10.48 (1991-2014). During 2015-16, an average recovery of 10.65 was achieved (Fig. 4A). The analysis of recent sugar production and sugar recovery data (2009-10 onwards) across India and its impact on sugar prices (ex-Mill) is depicted in Figs 4A and 4B. There is variation in ex-mill prices through the sugar-year, therefore both the low and high values are shown. Although, sugar pricing depends on several factors, a linear relationship between sugar production and sugar recovery is indicated with sugar recovery. This highlights the point that if we exploit the potential of higher sugar recovery in India, the sugar prices will remain under check.

Sugar recovery varies in different states of the country on account of climatic and other factors[8, 21]. An analysis of recent sugar recovery rates (2002-03 to 2015-16) achieved in five major sugar producing states of India reveals that Maharashtra and Karnataka have higher recovery rates compared to all India average while Uttar Pradesh, Tamil Nadu and Andhra Pradesh follow it. During this period peak sugar recovery has been achieved at 11.67 per cent (Maharashtra), 10.95 per cent (Karnataka), 10.65 per cent (Uttar Pradesh), 10.23 per cent in Tamil Nadu and 10.05 per cent in Andhra Pradesh (Fig.5)[3, 1, 22]. The sugar recovery is basically dependent on cane quality and post-harvest management at farm side and the efficiency of the mill on the miller side and potentially it can be increased from 0.4 to 0.6 per cent with efficient operations of the mill and from 1.5 to 2.0 per cent with high cane quality and appropriate post-harvest management[3].

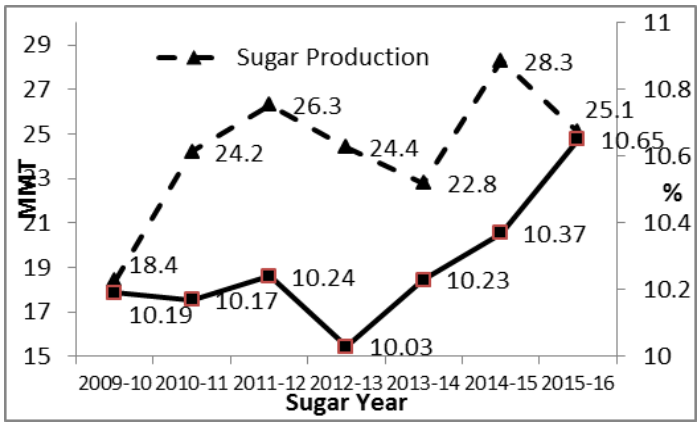

Fig.4a. Depiction of sugar production and sugar recovery from sugar season 2009-10 till 2014-15

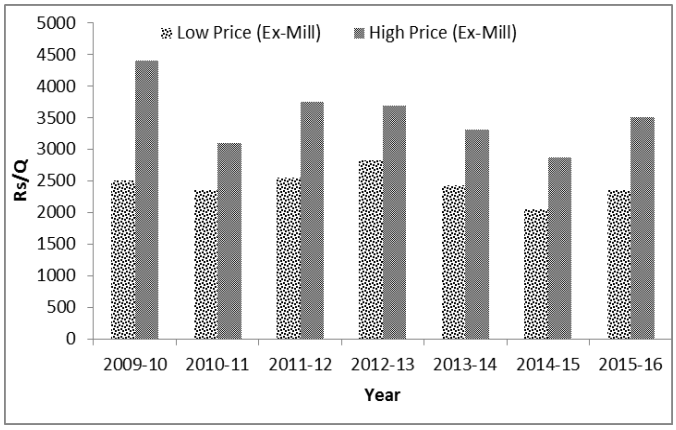

Fig.4b. Sugar prices (ex-Mill) during sugar season 2009-10 till 2014-15

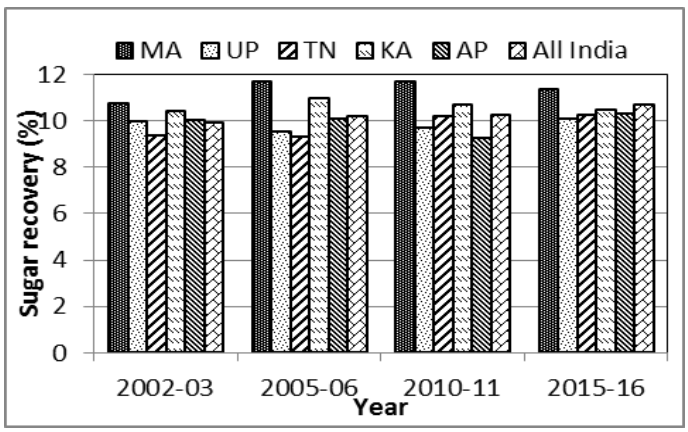

Fig.5. Comparison of patterns of sugar recovery rates in five leading states of India from 2002-2003

V. FACTORS IN POST-HARVEST CANE DETERIORATION

There are two areas of post-harvest quality losses leading to low sugar recovery. The primary losses include sucrose inversion process following harvesting of sugar cane and subsequent delays in delivery of cane to the sugar factory. The terms *Stale cane* and *Sour cane* are two different stages of cane deterioration after harvest. The stale cane is the aging of harvested stalks which have depleted their sucrose *via* continuing inversion and respiration, whereas sour cane is microbiological deterioration of sugarcane stalks by lactic acid bacterium *Leuconostoc* species which converts sucrose into organic acids of typical sour odour[23]. However, both types of deterioration seem to operate simultaneously in cane and milled juice. The secondary losses include factory losses due to inversion, dextran, alcohol and acid formation in the extracted juice incident to inefficient and unhygienic processing.

Table 2
List of ruling sugarcane varieties used for commercial cultivation in five major sugar producing states in India

State	Early Ripening varieties	Mid-season and late ripening varieties
Uttar Pradesh	CoS 687, CoS 8436, CoS 88230, CoS 95435, CoSe 91232, CoLk 94184, Co0238	Co 1148, CoS 767, BO 91
Maharashtra	Co 419, Co 775, Co 7219, CoC 671	Co 740, Co 7219, CoM 0265, Co 7527, Co 86032
Karnataka	Co 6415, Co 7704, CoC 671, Co 85002	Co 62175, Co 740, Co 8014, Co 8021, Co 8011, Co 8371, Co 7804, Co 86032
Andhra Pradesh	Co 6907, Co 7805, CoT, 8201, Co 8013, Co 8014, CoC 671, CoOr 03151	Co 62175, CoA 7602, Co 7219, 85 R 186, Co86032
Tamil Nadu	Coc 671, CoC 8001, Coc 85061, Co 7704, Co 8208, CoC 92061, CoC 90063	Co 6304, CoSi 776, CoSi 86071, Co 8021, Co 85019, Co 86032, Co 86010, Co 86249, CoSi 95071, CoSi 96071, CoSi 98071, CoG 93076

[Note: Co-Coimbatore, A-Anakapalle (AP), C-Cuddalore (TN), BO-Bihar, G-Gudiyatham (TN), KHS-Karnataka Hybrid Sugarcane, LK Lucknow (IISR), M-Maharashtra, R-Rudrur (AP),S-Shahjahanpur (UP), Se-Seorahi (UP), Si-Sirugamani (TN), T-Tirupati (AP), Or - Orissa].
(Source: Compiled from multiple sources[3, 8, 21, 58, 59])

The major factors that affect lead to post-harvest deterioration in sugarcane include cane variety, environment, crop ripening, biotic and abiotic stresses besides several management issues like harvest mode, transport and storage systems in mills.
Sugarcane varieties play a crucial role in sugar recovery, depending upon the climate and management practices followed. Due to genetic variability different genotypes behave differently to post-harvest deterioration. The genetic nature of the variety and the morphological features of the cane such as cane thickness, rind hardness, wax coating etc. decide the extent of post-harvest deterioration[24, 25, 26]. The list of main sugarcane varieties used for commercial cultivation in five major sugar producing states of India is presented in Table 2.

There are ample evidences to show that weather is of prime importance in determining the rate of deterioration. Deleterious effects of high temperature (around 40^{o}C) and low atmospheric humidity (25-35%) on juice quality have been reported by many workers[24, 27]. In India, loss in CCS is reported highest in late-crushing period during summer (1.32 unit per day) followed by mid-season crushing during spring (1.0 unit/per day) and early crushing during winter (0.35 unit per day) [28]. Muddy conditions add to post harvest deterioration on account of multiplication of polysaccharide producing bacteria such as species of *Leuconostoc*[29]. Higher night time temperature is reported to trigger off dextran production in stored cane. These observations support that environment play a major role in quality decline after harvest, however variety factor also influences deterioration process, but to a certain extent[27].

The rate of post-harvest deterioration is also dependent upon the cane maturity. Immature or over mature canes deteriorate rapidly as compared to matured canes. Cane maturity is a major factor governing the rate of inversion in harvested cane. This deterioration is relatively faster in hot weather [15, 17].
Method of harvesting of cane has some influence on deterioration process. In India in most of the places cane is harvested manually and in full green cane. Full green cane is less susceptible to post harvest deterioration as compared to chopped/burned cane [15, 30]. Delaying the harvesting of brunt cane for more than 24 hours resulted in marked loss in sugar yield[31].

The mechanical harvesting of burnt or un-burnt cane has been shown to reduce cane quality *vis-à-vis* sugar recovery in many countries. In mechanically harvested sugarcane with high trash content, drop in purity, sucrose and phosphate content is reported[32]. In a study from India with sugarcane billets during late-milling period indicated over 1.0 unit decline in CCS per day whereas in conventionally harvested whole-stalk green cane it was relatively less[33]. In biotic and abiotic stress affected canes the process of deterioration sets in before the harvest which leads to steep loss in quality if cut-to crush delay is more. In stress affected crop, major physiological and chemical alterations have been noticed which are conducive to further deterioration of cane quality[34].

Cane transport from farm to mill and storage systems in the mill do govern the quality of harvested cane. The time factor during transport, storage conditions, degree of damage from loading equipment and size and shape of transport containers are important factors in governing cane quality. Transport of fresh cane in small storage containers is less prone to deterioration. The cleanliness and hygiene in the yard is therefore, an important factor and first cane in should be the first cane out[15]. In India, cane supplied by the animal driven carts is usually considered fresh and of better quality. On the other hand, cane supplies routed through intermediate cane agencies are usually of sub-optimal quality[35].

VI. MANAGEMENT GUIDELINES

Decades of research on understanding the causes of post-harvest sucrose losses have conclusively proved that the cut-to-crush delay and internal and external temperature are most important factors which determine the rate of sucrose loss through inversion, organic acids, dextran and polysaccharides formation and respiration[36, 37]. The experiments demonstrated the presence of acid and neutral invertase in cane stalk and both the enzymes has the tendency to increase after harvest[38]. All invertases present in cane lose their tissue specificity once the stalk is ground and the enzymes are released into the milled juice[23]. Studies have also indicated that many hydrolytic enzymes get activated during storage of cane, which are responsible for decline in its quality[39,40].

The detrimental effects of dextran formation on sugar processing and recovery have been summarized by many researchers[41]. Control of dextran already present in juice extracted from deteriorated cane may be achieved using dextranase enzymes[42, 43].

However, research efforts to assess the extent of cane deterioration and contain its progress at the field and factory have met with only partial success. Some of the useful parameters to assess juice quality of cane arriving at the factory include are dextran, gum, oligosaccharides, ethanol, mannitol, reducing sugars, titrable acidity, invertase content, juice viscosity, purity drop, etc. Based on these indicators, quality of cane supplied to the mills could be assessed[44].

Once the deteriorated cane enters the mill, a high population of viable microorganisms find entry into the extracted juice and affect upstream process by direct destruction of sucrose or converting it to other products. Thus in order to minimize such losses it is imperative to use effective biocides in appropriate doses and at proper places viz., first and last mill and the imbibition-maceration water. Some important biocidal agents used in sugar industry include halogen compounds, ammonium bifluoride, formaldehyde, quaternary ammonium compounds (QUAT) and thio-carbamates[45]. Studies conducted in a sugar mill in India receiving consignments of brunt cane revealed that continuous mixed spraying of organo-sulphur based formulation by a power operated sprayer improved sugar recovery by 0.5 units (Figs 6a, 6b)[46].

Under normal milling conditions sugar loss is estimated to be around 1.0 to 2.5 kg of sucrose per ton of cane ground between crusher juice and mixed juice depending on the factory conditions. About 13 per cent of this loss is due to chemical inversion, 25 per cent is due to the activity of cell free enzymes and about 62 per cent is eaten up by the microorganism present in juice and mills. Therefore, proper mill sanitation use of effective biocide is important to enhance processing efficiency and sucrose recovery[47]. The extent of loss in Indian sugar mills is reported about 5 to 10 kilogram sugar per ton of cane ground, may be even more when crushing is extended in summer months[48].

Many research papers have been published to suggest ways to minimizing sucrose loss in the harvested cane through various approaches. This include identification and choice of proper varieties in a given sugarcane belt, application of pre harvest sprays, harvest management, application of post- harvest sprays and appropriate mill management (Table 3) .

However, probable on account of a general misconception amongst cane growers and cane development staff that sugarcane is a weather resilient crop and there are minimal

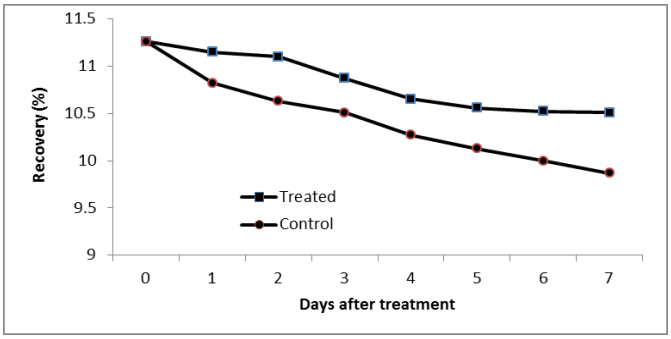

Fig.6a. Effect of post harvest treatment for better sugar recovery (Field management)[46]

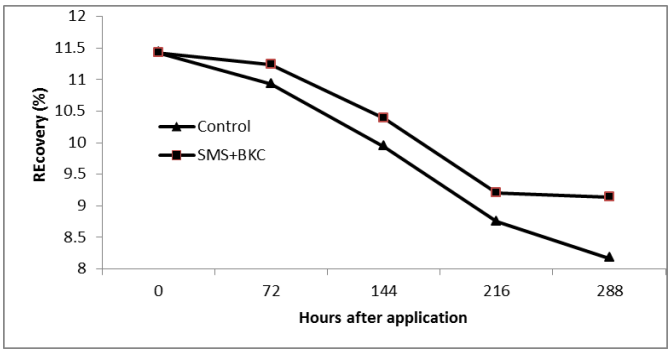

Fig.6b. Effect of application of organo sulpher based formulations during milling of cane in realising better recovery (Mill management) [46]

quantitative and qualitative losses after its harvest; recommendations are often not practiced. It is emphasized that an integrated strategy is devised in a given area based on local conditions so that sucrose losses are avoided to the extent possible.

There are specific issues in the 5 major sugar producing states of the country mainly account of specific varieties[8], agro-climatic climatic conditions[3], mill machinery and management[2,58], prevailing transport arrangements[50,51], policies of respective state governments[4] etc. After analysing these issues on the considerations of relative strength or weakness some specific suggestions are highlighted with a view to increase sugar recoveries (Table 4).

The point derived is the loss of sucrose content in cane as a result of cut-to-mill delays is quite high, especially during summer months in India. The recovery rate of the country is considered low when compared to other leading sugar producing nations. Also, the improvement in recoveries since 1930-31 till recent times is somewhat insignificant. The consequent result is economic losses to farmers as well as millers. Based on the findings of many years of study on understanding the causes of deterioration and measures to control it, it is suggested that now there is an urgent need to have specific strategies (state wise or even zone wise in the respective states) and that are in built into policy framework roping in various stakeholders viz., farmers, transporters, extension workers and millers to avoid such losses. Improved sugar recoveries are expected to meet growing sugar demands for the future with same land area allocation for the crop in view of difficulties in expanding it on account of other pressures on cultivable lands.

Table 3
Strategies to minimize stale cane losses in India

No.	Attribute	Strategy
1	Identification of varieties	• Identify sugarcane varieties with high sucrose content and less inclination towards post-harvest inversion (both biochemical and microbiological) [15]. • Varieties are screened for cane thickness, rind hardness, wax content, etc.[49].
2	Choice of varieties in a given area	• Preference to varieties having more resistance towards post-harvest deterioration in areas resistant where delay in transport is anticipated[50] • Preferential transport of varieties that are known susceptible to post-harvest deterioration[51].
3	Pre-harvest sprays	• Pre-harvest spray of chemical ripeners like polaris, ethrel, sodium metasilicate[52]. • Application of 2% sodium metasilicate (3 days prior to harvest) for maintaining juice quality of stored cane (up to 6 days)[15]. • Pre-harvest spraying of mercuric chloride (100 mg/litre) or cobalt chloride in suppressing invertase activity (up to 20 days of storage)[52].
4	Harvest management	• Avoiding harvesting of immature and over mature canes[15]. • Storing harvested cane under shade, especially during hot weather periods[53]. • Covering the harvested cane with trash and sprinkling of water periodically to keep the cane moist[48]. • In case of anticipated delays in crushing, topping is avoided[54]. • Dipping the cut ends of cane in certain biocides like polycide @v10 ppm or bactrinol @ 100 ppm and spraying the same on the stored cane to arrest deterioration (up to 120 hours) [55].
5	Post-harvest Sprays	• Spraying of harvested cane with benzonic acid (100 ppm) and formaldehyde (100 ppm) [56]. • Many bactericide (such as formaldehyde, Polycide, Bactrinol-100, BD Mill sanitizer, DBAC, IFOPOL, DNDT, ABF, Actin-ID, potassium permanganate and sodium metasilicate, Tsunami-100, Kcide 800, Sucroguard) may be used to check deterioration of cane and milled juice[57]. • Combined application of anti-bacterial (quaternary ammonium compounds/ thiocarbamates) and anti-inversion chemicals (sodium metasilicate/sodium lauryl sulphate) over freshly harvested cane followed by covering them with a thick trash (Fig 7)[57]. • Spray of formulation containing benzalkonium chloride (BKC) + sodium metasilicate (SMS) for improved sugar recoveries (by over 0.5 units) [57].
6	Mill Management	• Maintenance of a proper varietal balance (early, mid-late and late maturing varieties; ratoons, spring and autumn planted crop) [35]. • Following up of a scientific harvesting and crushing schedule based on crop/varietal maturity[58]. • Having a balance between daily crushing capacity and daily supplies reaching the mill[3]. • Cane yards are clean and follow the principle of first cane in should be first cane out[3]. • Follow recommended milling schedule (Mill full green/brunt cane within 48 h; Mill billets (green/burnt) within 12 h[16]. • Special focus on mill sanitation through an integrated approach to ensure minimum destruction of sucrose and achieve better processing efficiency[58].

VII. Future Directions

In future more emphasis is required on screening of commercial varieties of sugarcane for their ability to withstand post-harvest stress, especially in relation to moisture loss, inversion and dextran formation during early as well as late crushing periods. So all released varieties must be screened for their post-harvest quality during early through late crushing periods. In order to sustain profitability, it is imperative that sugar mills keep the post-harvest profile of each variety being grown in their areas. The other areas include (i) intensification of efforts in control of *Leuconostoc* and other dextran formation

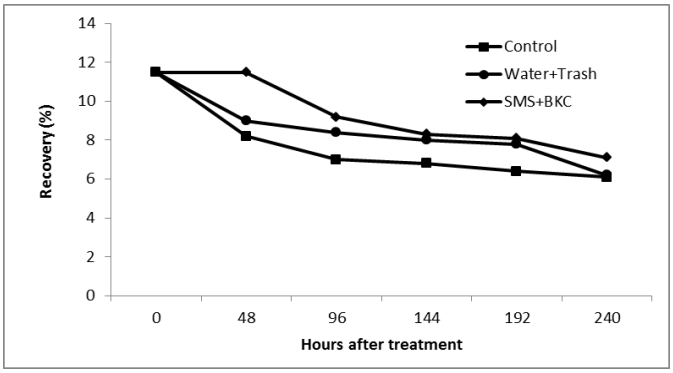

Fig.7. Effect of combined application of anti-inversion (sodium metasilicate) and anti-bacterial (benzalkonium chloride) during storage of cane before milling[57].

Table 4
Approaches for minimizing sugar losses in major sugar producing states of India

State	Approaches
Maharashtra	• Erratic cane supplies to mills is corrected through appropriate harvest and transport schedules • The issue of heavy handling and transport costs charged by the private mills is resolved amicably • Adoption of improved agro-practices and irrigation management • Improvement in mill sanitation and extraction efficiencies
Uttar Pradesh	• Promotion of improved sugar rich varieties less prone to rapid deterioration along with appropriate agro-techniques and irrigation scheduling • Develop an efficient transport system for quick lifting of harvested cane to mill • Improvement in mill sanitation and extraction efficiencies
Tamil Nadu	• Appropriate varietal planting and crushing schedules are practiced • Good management practices, optimization of irrigation and farm mechanization are adopted widely • Modernization drive of sugar mills with special focus on mill sanitization
Karnataka	• Promotion of improved sugar rich varieties less prone to rapid deterioration • Adoption of improved agro-practices and irrigation management • Minimize cut to crush delays following suitable harvest and transportation schedules • Emphasis on mill modernization and integrated mill sanitation
Andhra Pradesh	• Intensive efforts on identification and promotion of improved sugar rich varieties that are less prone to rapid deterioration • Appropriate agro-techniques and irrigation scheduling • Minimize cut to crush delays by developing an efficient system of harvest schedule and guided transport plans • Appropriate corrective measures in respect of lop sided taxation policy on exporting molasses to other states • Mill machinery up gradation and integrated mill sanitation are accorded priority

(Note: There is a need for developing a very organized system of harvesting schedule with cane growers, transporters and millers and care is taken that harvest is in order of ratoon crop followed by early maturing plant canes, late maturing plantcanes and finally late planted canes across all the mentioned states)

organisms after harvest through a suitable package of nutrients containing appropriate amount of Zn, Mn and Mg for a given area; (ii) developing a dextranase system from fungal sources; (iii) efforts for developing a cheap and effective field biocide or deterioration inhibitor that is able to control the growth and multiplication of *Leuconostoc* apart from the ability to minimize inversion losses; (iv) developing an anti-sense technology that reduces invertase activity soon after harvest; (v) investigations on efficacy of electrolyzed water (electrolyzing saline to create a disinfectant) fogging on harvested cane/ prepared cane juice are undertaken with the objective of reducing the use of hazardous sanitation chemicals in sugar industry. The strong chemical formulation with broad spectrum antimicrobial activity and inversion inhibition should be extensively used in the field and by millers in a well-coordinated manner to minimize the sugar losses. Also, priority is accorded to cane harvested in form of billets over manually harvested field canes in crushing and milling.

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